Department of Defense Manufacturing and Quality Body of Knowledge (M&Q BoK)

November 2022

Office of the Under Secretary of Defense
Research and Engineering

Washington, D.C.

The appearance of external hyperlinks does not constitute endorsement by the United States Department of Defense (DoD) of the linked websites, or the information, products, or services contained therein. The DoD does not exercise any editorial, security, or other control over the information you may find at these locations.

Department of Defense Manufacturing and Quality Management Body of Knowledge (M&Q BoK)

Office of the Under Secretary of Defense for Research and Engineering
Deputy Director for Engineering
3030 Defense Pentagon
Washington, DC 20301-3030
Email: osd.r-e.comm@mail.mil | Attention: SE&A
https://ac.cto.mil/engineering

Approved for public release. DOPSR Case # 23-S-0359.

Contents

This page is intentionally blank.

Introduction: How to Use the M&Q BoK

The Department of Defense (DoD) Manufacturing and Quality (M&Q) Body of Knowledge (BoK) is a compilation of best practices and lessons learned for completing M&Q activities across the DoD system acquisition life cycle. The office of the Executive Director, Systems Engineering and Architecture (ED, SE&A) prepared the BoK and will update the work periodically to reflect current policy, guidance, tools, and best practices. This document does not supersede DoD policy, guidance, or law.

The BoK details M&Q activities throughout the system life cycle but is not intended to be read from end to end. DoD Engineering and Technical Management (ETM) practitioners and managers may refer to the BoK to find information relevant to the phase of the program they are working on. Within a specific phase, the user may focus on the section and tasks that apply (with appropriate tailoring) for the M&Q activities the program is conducting.

The BoK chapters cover recommended M&Q activities and tasks during each acquisition life cycle phase to meet DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework.

The BoK includes 6 chapters:

- Chapter 1: Pre-Materiel Development Decision (Pre-MDD)
- Chapter 2: Materiel Solution Analysis (MSA)
- Chapter 3: Technology Maturation and Risk Reduction (TMRR)
- Chapter 4: Engineering and Manufacturing Development (EMD)
- Chapter 5: Production and Deployment (P&D)
- Chapter 6: Operations and Support (O&S)

Each chapter focuses on the DoDI 5000.02 activities and program documentation required for that phase. Each chapter uses the following format:

- **Introduction:** Discusses the objectives of that phase to allow the user to understand the environment and requirements.
- **Manufacturing and Quality Objectives:** Discusses roles, goals, and objectives of program M&Q during this phase.
- **Threads:** Twelve threads or topic areas include discussions of major M&Q functions based on the "5 Ms" (Manpower, Machines, Materials, Methods, Measurement); Manufacturing Readiness Level (MRL) criteria; and DoD-unique M&Q-related functions not found in industry (i.e., DoD acquisition system, defense contracting system, and surveillance system). The 12 threads are labeled with letters A through L as follows:

  A. DoD Acquisition System
  B. Defense Contracting System
  C. Surveillance System
  D. Technology and Industrial Base

E. Design
F. Cost and Funding
G. Materials Management
H. Process Capability and Control
I. Quality Management
J. Manufacturing Workforce
K. Facilities
L. Manufacturing Management and Control

Each thread includes several **Activities** represented by gray boxes in the corresponding chapter figure (Figure 1). Activities are numbered A.1, A.2, A.3 . . . B.1, B.2, B.3, etc. The BoK includes the following for each activity:

- Activity overview description
- **Tasks** that M&Q personnel could be expected to support or lead.
- **Tools** such as checklists, templates, and samples available to M&Q personnel intended to help them to accomplish these tasks.
- **Resources** including guidance documents, handbooks, manuals, instructions, memos, etc., that provide direction to M&Q personnel for tasks identified in the gray box.

Example: Figure 1 shows Threads, Documents, Activities, and Reviews for the EMD Phase.

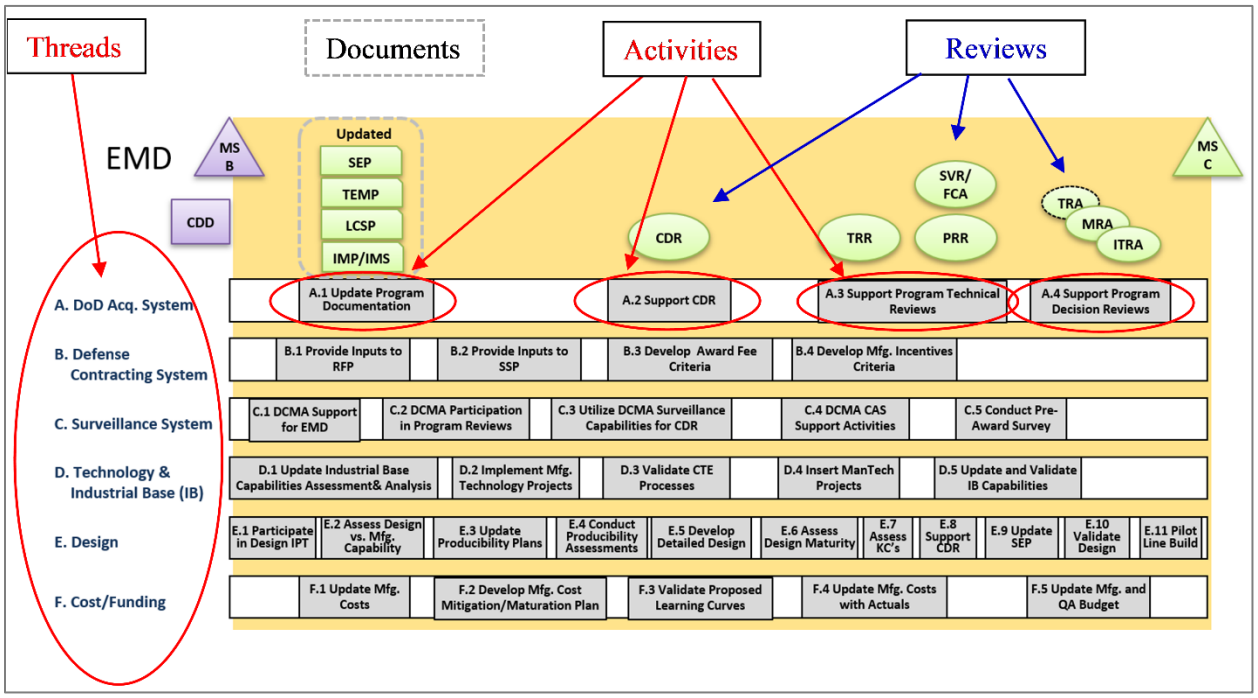
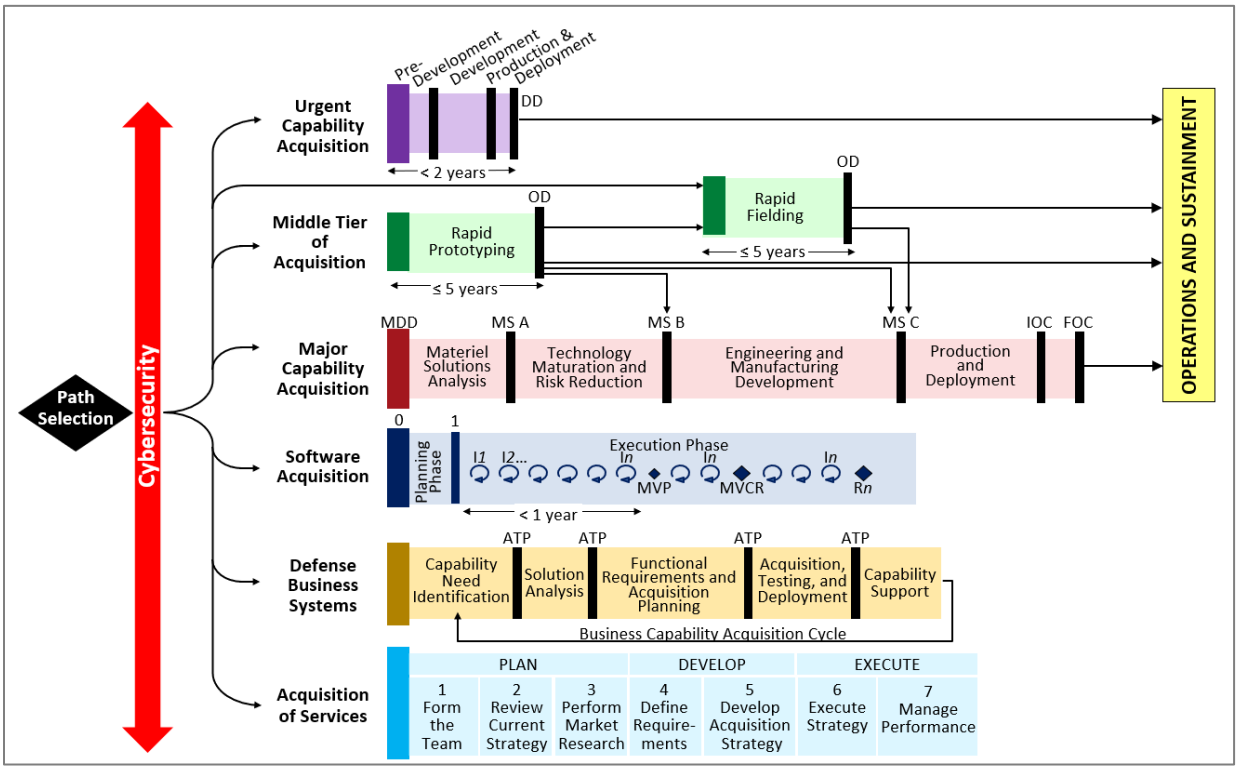


Figure 1. Sample Activity Chart

Adaptive Acquisition Framework (www.aaf.dau.edu)

This BoK follows DoDI 5000.02, Operation of the Adaptive Acquisition Framework (AAF), and for the most part will describe M&Q activities for the path labeled Major Capability Acquisition (MCA). This path includes a comprehensive and systematic approach for applying M&Q best practices; however, the M&Q BoK best practices are applicable to the alternative AAF pathways as well. AAF pathways are depicted in Figure 2.



Source: DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework, January 23, 2020

Figure 2. Adaptive Acquisition Framework Paths

For example, under the AAF, a program may have an Urgent Capability Acquisition (UCA) and may have less than 2 years to provide a solution to the Warfighter, or the program may be involved in a Middle Tier of Acquisition (MTA) approach focused on rapid prototyping or rapid fielding. If so, users can see how these efforts are aligned with the MCA process in Figure 2 and use those BoK chapters to identify and accomplish required tasks and activities.

In addition to DoDI 5000.02, the following associated policies provide information for the paths:

- DoD Instruction 5000.74, Defense Acquisition of Services
- DoD Instruction 5000.75, Business Systems Requirements and Acquisition
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.85, Major Capability Acquisition

- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation

With any acquisition model, the program office should include M&Q personnel on the technical Integrated Product Team (IPT) and to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

M&Q planning, control, and management activities represent an important and central effort that begins early in the life cycle (Pre-Materiel Development Decision (MDD) and/or Materiel Solution Analysis (MSA) phases) and continues throughout the life of a program though Operations and Support. Although planning is discussed in detail in each chapter, Figure 3 provides key elements of M&Q planning activities in relation to overall program life cycle activities.

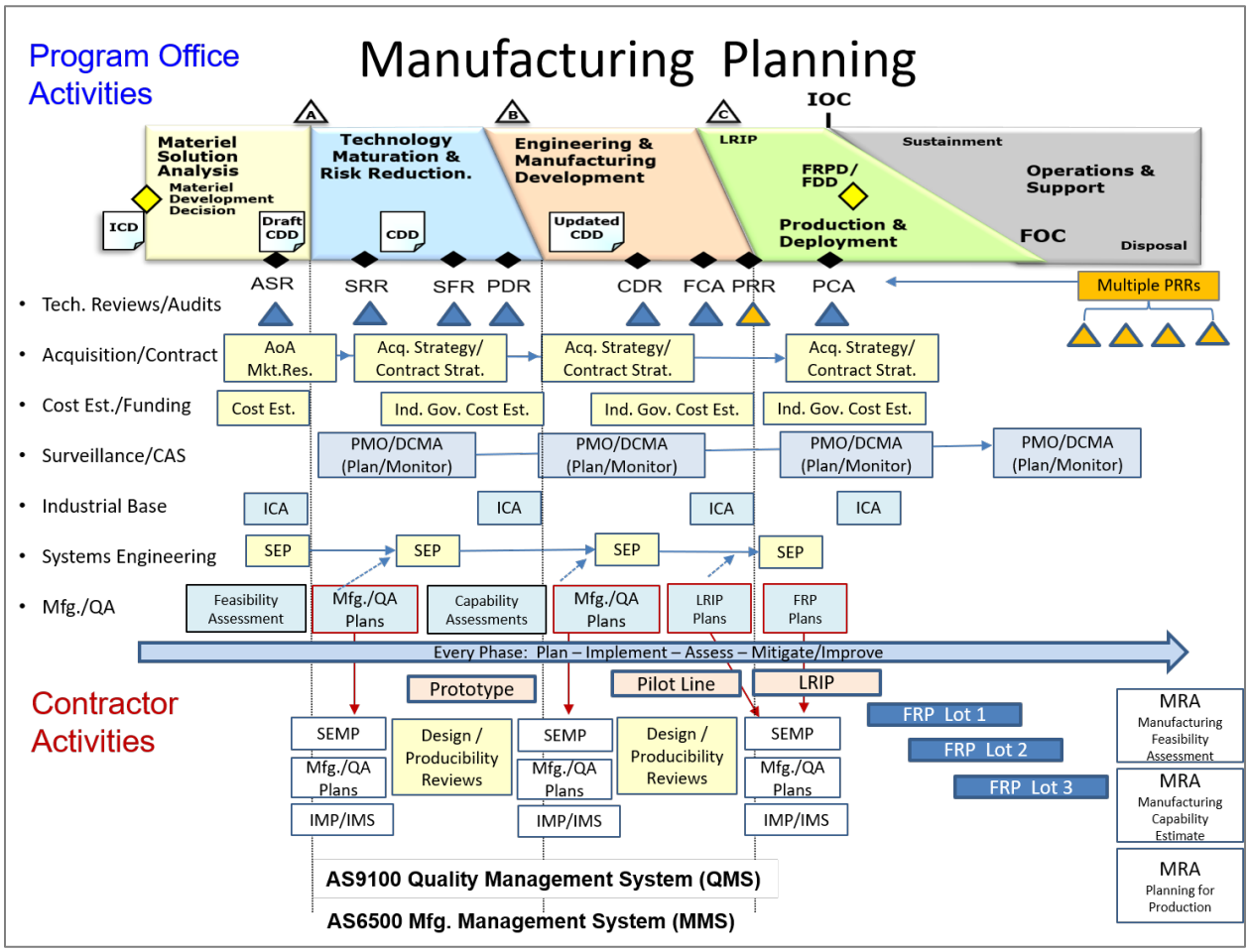


Figure 3. Typical Manufacturing and Quality Planning Activities

Most activities begin with the need to identify requirements, risks, and gaps, followed by planning activities. The top-most planning document is the Acquisition Strategy, and numerous documents feed into the Acquisition Strategy to include the Contracting Strategy and the Systems Engineering Plan (SEP). M&Q strategies should be a component of the SEP. Plans are then evaluated and updated on a recurring basis, usually just before a milestone decision.

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occur. The contractor is responsible for the execution of the program and in planning for success. The government Program Management Office (PMO), along with the Defense Contract Management Agency (DCMA) or other contract surveillance organizations and engineering support activities, is responsible for oversight and management of the acquisition. Risk assessment and mitigation is an ongoing effort that should be conducted throughout the system life cycle. Key references for DoD M&Q planning and management approaches include: MIL-HDBK-896, Manufacturing Management Program Guide; SAE Standard AS6500, Manufacturing Management Program; and Quality Management Systems standards ISO 9100 and/or AS9100. In addition, MRL criteria and assessments are a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

DoD tools and resources are available from many sources. Most should be available through open web-based links, but some may require a ".mil" address or a Common Access Card (CAC), or they may be available only to users in a specific community. Commercial tools and resources should be available to everyone but may require the organization to purchase a user's license/rights (e.g., ISO 9001 Quality Management System industry standard). In many cases, commercial resources and tools have been identified as a best practice. The M&Q BoK lists these tools for reference only; DoD does not necessarily endorse these resources or the publishing organizations. In addition, this document may reference a source for a specific tool (i.e., Pareto Chart), but there may be other widely available sources for this tool or for similar tools.

Sections labeled "Tools and Resources" are provided throughout the document chapters. The following section includes a summary of key references and links by publisher or topic. A more comprehensive list of references is included in Appendix B.

Key Manufacturing and Quality Body of Knowledge References and Resources

Department of Defense (DoD) Issuances, Directives Division https://esd.whs.mil/DD/

- DoD Directive 5000.01, The Defense Acquisition System
- DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- DoD Instruction 5000.81, Urgent Capability Acquisition

- DoD Instruction 5000.84, Analysis of Alternatives
- DoD Instruction 5000.85, Major Capability Acquisition
- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation
- DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD
- DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD
- DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
- DoD Directive 4400.01E, Defense Production Act Programs
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures

Defense Acquisition University (DAU) www.dau.edu

- DAU Guidebooks and References https://aaf.dau.edu/guidebooks/
- Acquisition Notes (AcqNotes) www.acqnotes.com
- Adaptive Acquisition Framework (AAF) https://aaf.dau.edu
- Analysis of Alternatives (AoA) www.acqnote/acquisitions/analsis-of-alternatives
- Market Research www.acqnotes/acqnote/acquisitions/market-research
- Acquisition Strategy (AS) Process/Guidance https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf
- Systems Engineering Plan (SEP) Outline https://ac.cto.mil/erpo/ (Engineering Guidance tab)
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

Defense Contract Management Agency (DCMA) www.dcma.mil

- DCMA Policies https://www.dcma.mil/Policy/
- DCMA Instructions https://www.dcma.mil/Policy/
- DCMA-INST 204, Manufacturing and Production
- DMCA-INST 205, Program Support
- DMCA-INST 207, Engineering Surveillance
- DMCA-INST 309, Government Contract QA Surveillance Planning
- DCMA-INST 401, Industrial Analysis
- DCMA-INST 3401, Defense Industrial Base Mission Assistance

Defense Federal Acquisition Regulation (DFAR) Supplement https://www.acquisition.gov/dfars

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS Subpart 242.7200, Contractor Material Management and Accounting

Defense Logistics Agency (DLA) Website www.dla.mil

- DMSMS Guidebook, SD-22 https://www.dsp.dla.mil/Programs/DMSMS
- ASSIST (Database of specifications and standards) https://assist.dla.mil
- ASSIST Quick search https://quicksearch.dla.mil/qsSearch.aspx
- DoD 4140.01, Supply Chain Materiel Management Regulation www.dla.mil

Federal Acquisition Regulation (FAR) https://www.acquisition.gov/

Manufacturing Readiness Levels (MRLs) www.dodmrl.org

- MRL Assessment Criteria Matrix www.dodmrl.org
- Interactive MRL Users Guide (MRL Assessment Criteria) www.dodmrl.org
- MRL Deskbook www.dodmrl.org
- MIL-HDBK-896, Manufacturing Management Program Guide www.dodmrl.org

National Institute of Standards and Technology (NIST) www.nist.gov

- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST Manufacturing https://www.manufacturing.gov

Office of the Director, Cost Assessment and Program Evaluation (CAPE) www.cape.osd.mil

OSD Manufacturing Technology (ManTech) Program Office https://www.dodmantech.mil

OUSD(R&E) Systems Engineering and Architecture (SE&A) https://ac.cto.mil/engineering

Relevant Government Publications (Available via Web/Internet Search)

- DoD 4245.7-M Manual, Transition from Development to Production, 1985
- NAVSO P-3687, Producibility Systems Guidelines, 1999
- MIL-HDBK-766, Design to Cost
- MIL-HDBK-727, Design Guidance for Producibility, 1984

Standards, Specifications, and Standards Organizations

- ASSIST (Defense Logistics Agency Database of Specifications and standards) https://assist.dla.mil
- ASSIST Quick Search https://quicksearch.dla.mil/qsSearch.aspx
- SAE International www.sae.org
- International Organization for Standards (ISO) www.iso.org
- Institute of Electrical and Electronics Engineers (IEEE) www.ieee.org
- *Note:* Many specifications and standards can be accessed at http://everyspec.com/

Technology Readiness Levels (TRLs)

- Technology Readiness Assessment Deskbook www.acqnotes.com
- Technology Readiness Assessment Calculator www.acqnotes.com
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

Department of Defense
Manufacturing and Quality Body of Knowledge
(M&Q BoK)

Chapter 1
Pre-Materiel Development Decision (Pre-MDD)

November 2022
Version 1.1

Office of the Under Secretary of Defense
Research and Engineering

Washington, D.C.

The appearance of external hyperlinks does not constitute endorsement by the United States Department of Defense (DoD) of the linked websites, or the information, products, or services contained therein. The DoD does not exercise any editorial, security, or other control over the information you may find at these locations.

Department of Defense Manufacturing and Quality Body of Knowledge (M&Q BoK)

Office of the Under Secretary of Defense for Research and Engineering
Executive Director, Systems Engineering and Architecture
3030 Defense Pentagon
Washington, DC 20301-3030
Email: osd.r-e.comm@mail.mil | Attention: SE&A
https://ac.cto.mil/engineering

Approved for public release. DOPSR Case # 23-S-0359.

Contents

Figures

Introduction: How to Use the M&Q BoK

The Department of Defense (DoD) Manufacturing and Quality (M&Q) Body of Knowledge (BoK) is a compilation of best practices and lessons learned for completing M&Q activities across the DoD system acquisition life cycle. The office of the Executive Director, Systems Engineering and Architecture (ED, SE&A) prepared the BoK and will update the work periodically to reflect current policy, guidance, tools, and best practices. This document does not supersede DoD policy, guidance, or law.

The BoK details M&Q activities throughout the system life cycle but is not intended to be read from end to end. DoD Engineering and Technical Management (ETM) practitioners and managers may refer to the BoK to find information relevant to the phase of the program they are working on. Within a specific phase, the user may focus on the section and tasks that apply (with appropriate tailoring) for the M&Q activities the program is conducting.

The BoK chapters cover recommended M&Q activities and tasks during each acquisition life cycle phase to meet DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework (AAF)

The BoK includes 6 chapters:

- Chapter 1: Pre-Materiel Development Decision (Pre-MDD)
- Chapter 2: Materiel Solution Analysis (MSA)
- Chapter 3: Technology Maturation and Risk Reduction (TMRR)
- Chapter 4: Engineering and Manufacturing Development (EMD)
- Chapter 5: Production and Deployment (P&D)
- Chapter 6: Operations and Support (O&S)

Each chapter focuses on the DoDI 5000.02 activities and program documentation required for that phase. Each chapter uses the following format:

- **Introduction:** Discusses the objectives of that phase to allow the user to understand the environment and requirements.
- **Manufacturing and Quality Objectives:** Discusses roles, goals, and objectives of program M&Q during this phase.
- **Threads:** Twelve threads or topic areas include discussions of major M&Q functions based on the "5 Ms" (Manpower, Machines, Materials, Methods, Measurement); Manufacturing Readiness Level (MRL) criteria; and DoD-unique M&Q-related functions not found in industry (i.e., DoD acquisition system, defense contracting system, and surveillance system). The 12 threads are labeled with letters A through L as follows:

  A. DoD Acquisition System
  B. Defense Contracting System
  C. Surveillance System

D. Technology and Industrial Base
E. Design
F. Cost and Funding
G. Materials Management
H. Process Capability and Control
I. Quality Management
J. Manufacturing Workforce
K. Facilities
L. Manufacturing Management and Control

Each thread includes several **Activities** represented by gray boxes in the corresponding chapter figure (Figure 1). Activities are numbered A.1, A.2, A.3 . . . B.1, B.2, B.3, etc. The BoK includes the following for each activity:

- Activity overview description
- **Tasks** that M&Q personnel could be expected to support or lead.
- **Tools** such as checklists, templates, and samples available to M&Q personnel intended to help them to accomplish these tasks.
- **Resources** including guidance documents, handbooks, manuals, instructions, memos, etc., that provide direction to M&Q personnel for tasks identified in the gray box.

Example: Figure 1 shows Threads, Documents, Activities, and Reviews for the EMD Phase.

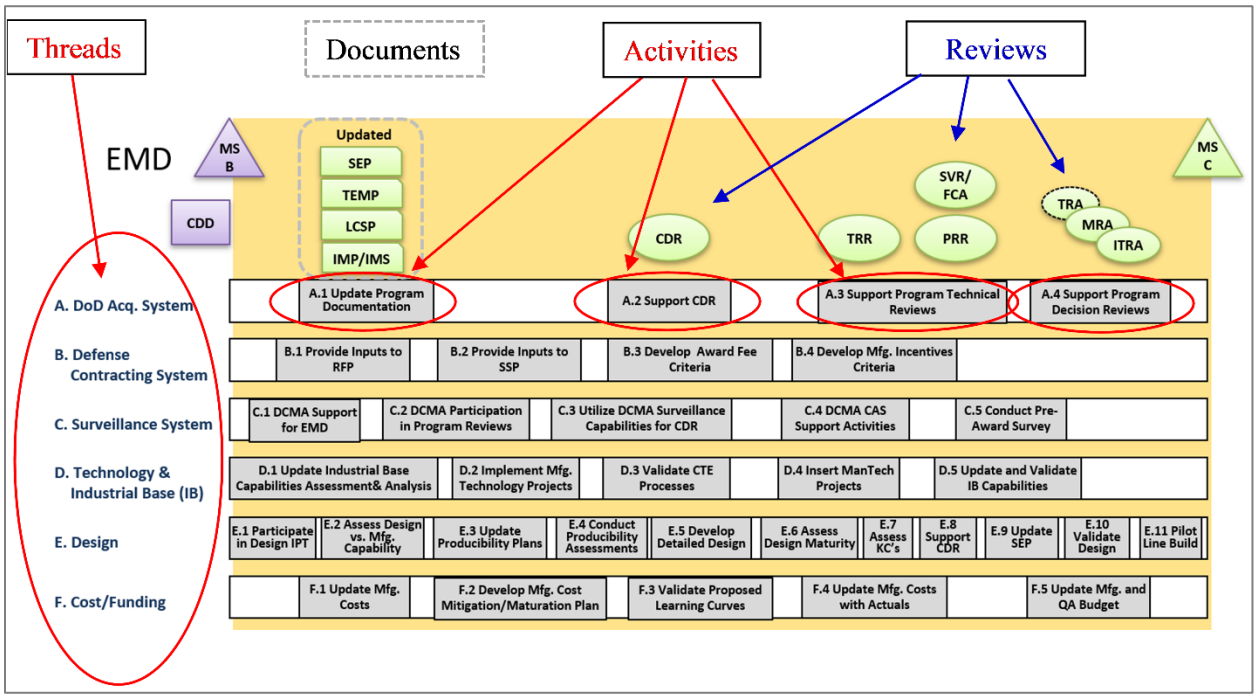
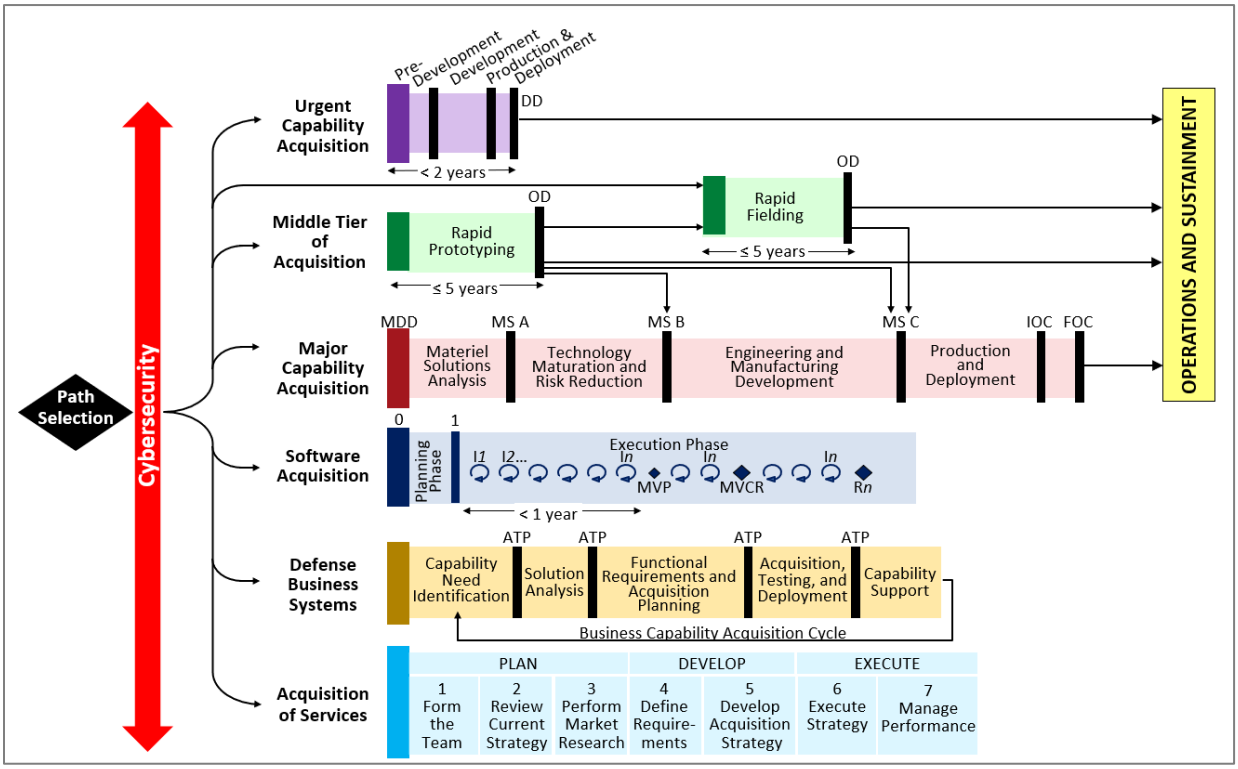


Figure 1. Sample Activity Chart

Adaptive Acquisition Framework (www.aaf.dau.edu)

This BoK follows DoDI 5000.02, and for the most part will describe M&Q activities for the path labeled Major Capability Acquisition (MCA). This path includes a comprehensive and systematic approach for applying M&Q best practices; however, the M&Q BoK best practices are applicable to the alternative AAF pathways as well. AAF pathways are depicted in Figure 2.



Source: DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework, January 23, 2020

Figure 2. Adaptive Acquisition Framework Paths

For example, under the AAF, a program may have an Urgent Capability Acquisition (UCA) and may have less than 2 years to provide a solution to the Warfighter, or the program may be involved in a Middle Tier of Acquisition (MTA) approach focused on rapid prototyping or rapid fielding. If so, users can see how these efforts are aligned with the MCA process in Figure 2 and use those BoK chapters to identify and accomplish required tasks and activities.

In addition to DoDI 5000.02, the following associated policies provide information for the paths:

- DoD Instruction 5000.74, Defense Acquisition of Services
- DoD Instruction 5000.75, Business Systems Requirements and Acquisition
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.85, Major Capability Acquisition

- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation

With any acquisition model, the program office should include M&Q personnel on the technical Integrated Product Team (IPT) and to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

M&Q planning, control, and management activities represent an important and central effort that begins early in the life cycle (Pre-Materiel Development Decision (MDD) and/or Materiel Solution Analysis (MSA) phases) and continues throughout the life of a program though Operations and Support. Although planning is discussed in detail in each chapter, Figure 3 provides key elements of M&Q planning activities in relation to overall program life cycle activities.

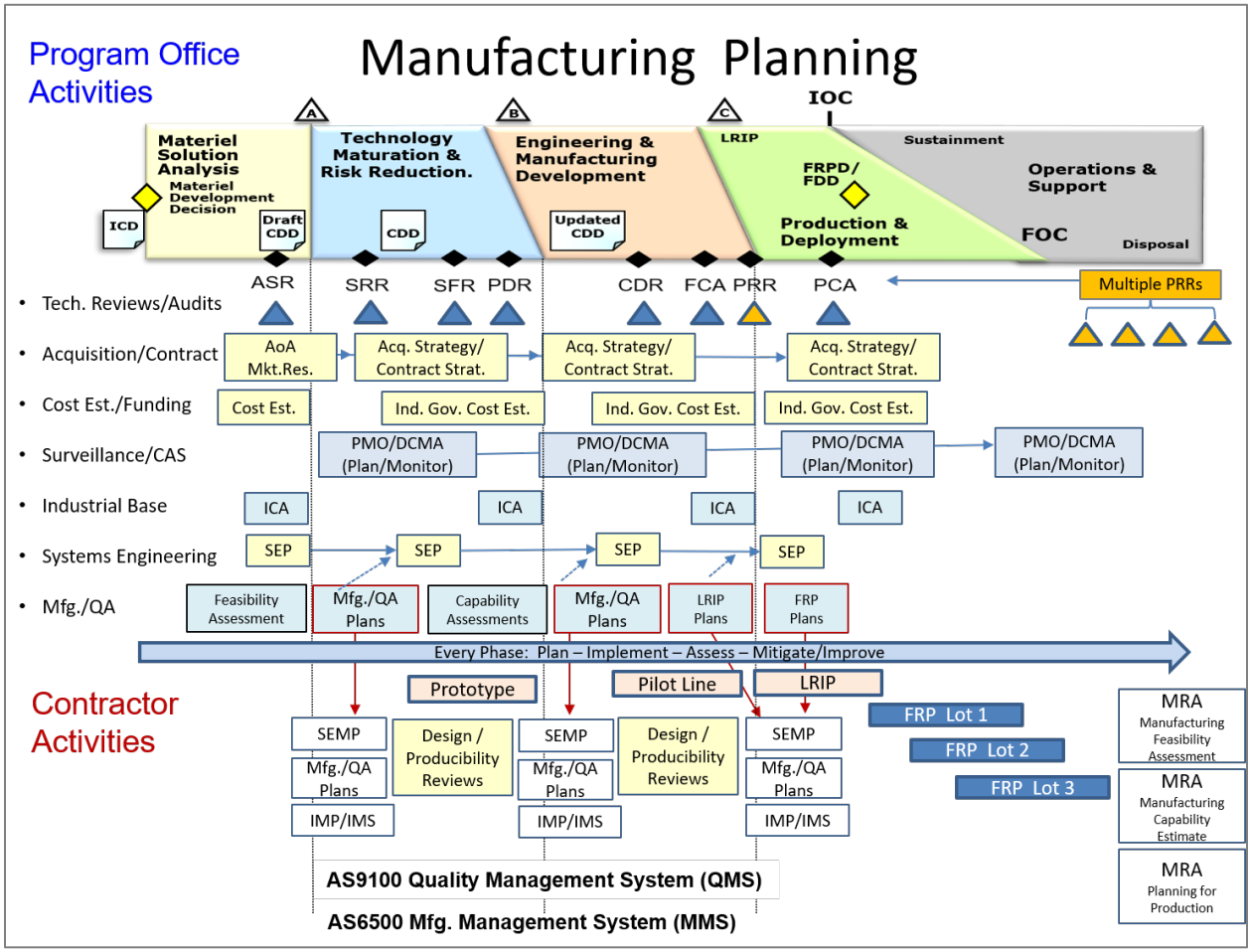


Figure 3. Typical Manufacturing and Quality Planning Activities

Most activities begin with the need to identify requirements, risks, and gaps, followed by planning activities. The top-most planning document is the Acquisition Strategy, and numerous documents feed into the Acquisition Strategy to include the Contracting Strategy and the Systems Engineering Plan (SEP). M&Q strategies should be a component of the SEP. Plans are then evaluated and updated on a recurring basis, usually just before a milestone decision.

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occur. The contractor is responsible for the execution of the program and in planning for success. The government Program Management Office (PMO), along with the Defense Contract Management Agency (DCMA) or other contract surveillance organizations and engineering support activities, is responsible for oversight and management of the acquisition. Risk assessment and mitigation is an ongoing effort that should be conducted throughout the system life cycle. Key references for DoD M&Q planning and management approaches include: MIL-HDBK-896, Manufacturing Management Program Guide; SAE Standard AS6500, Manufacturing Management Program; and Quality Management Systems standards ISO 9100 and/or AS9100. In addition, MRL criteria and assessments are a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

DoD tools and resources are available from many sources. Most should be available through open web-based links, but some may require a ".mil" address or a Common Access Card (CAC), or they may be available only to users in a specific community. Commercial tools and resources should be available to everyone but may require the organization to purchase a user's license/rights (e.g., ISO 9001 Quality Management System industry standard). In many cases, commercial resources and tools have been identified as a best practice. The M&Q BoK lists these tools for reference only; DoD does not necessarily endorse these resources or the publishing organizations. In addition, this document may reference a source for a specific tool (i.e., Pareto Chart), but there may be other widely available sources for this tool or for similar tools.

Sections labeled "Tools and Resources" are provided throughout the document chapters. The following section includes a summary of key references and links by publisher or topic. A more comprehensive list of references is included in Appendix B.

Key Manufacturing and Quality Body of Knowledge References and Resources

Department of Defense (DoD) Issuances, Directives Division https://esd.whs.mil/DD/

- DoD Directive 5000.01, The Defense Acquisition System
- DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- DoD Instruction 5000.81, Urgent Capability Acquisition

- DoD Instruction 5000.84, Analysis of Alternatives
- DoD Instruction 5000.85, Major Capability Acquisition
- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation
- DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD
- DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD
- DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
- DoD Directive 4400.01E, Defense Production Act Programs
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures

Defense Acquisition University (DAU) www.dau.edu

- DAU Guidebooks and References https://aaf.dau.edu/guidebooks/
- Acquisition Notes (AcqNotes) www.acqnotes.com
- Adaptive Acquisition Framework (AAF) https://aaf.dau.edu
- Analysis of Alternatives (AoA) www.acqnote/acquisitions/analsis-of-alternatives
- Market Research www.acqnotes/acqnote/acquisitions/market-research
- Acquisition Strategy (AS) Process/Guidance https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf
- Systems Engineering Plan (SEP) Outline https://ac.cto.mil/erpo/ (Engineering Guidance tab)
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

Defense Contract Management Agency (DCMA) www.dcma.mil

- DCMA Policies https://www.dcma.mil/Policy/
- DCMA Instructions https://www.dcma.mil/Policy/
- DCMA-INST 204, Manufacturing and Production
- DMCA-INST 205, Program Support
- DMCA-INST 207, Engineering Surveillance
- DMCA-INST 309, Government Contract QA Surveillance Planning
- DCMA-INST 401, Industrial Analysis
- DCMA-INST 3401, Defense Industrial Base Mission Assistance

Defense Federal Acquisition Regulation (DFAR) Supplement
https://www.acquisition.gov/dfars

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS Subpart 242.7200, Contractor Material Management and Accounting

Defense Logistics Agency (DLA) Website www.dla.mil

- DMSMS Guidebook, SD-22 https://www.dsp.dla.mil/Programs/DMSMS
- ASSIST (Database of specifications and standards) https://assist.dla.mil
- ASSIST Quick Search https://quicksearch.dla.mil/qsSearch.aspx
- DoD 4140.01, Supply Chain Materiel Management Regulation www.dla.mil

Federal Acquisition Regulation (FAR) https://www.acquisition.gov/

Manufacturing Readiness Levels (MRLs) www.dodmrl.org

- MRL Assessment Criteria Matrix www.dodmrl.org
- Interactive MRL Users Guide (MRL Assessment Criteria) www.dodmrl.org
- MRL Deskbook www.dodmrl.org
- MIL-HDBK-896, Manufacturing Management Program Guide www.dodmrl.org

National Institute of Standards and Technology (NIST) www.nist.gov

- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST Manufacturing https://www.manufacturing.gov

Office of the Director, Cost Assessment and Program Evaluation (CAPE)
www.cape.osd.mil

OSD Manufacturing Technology (ManTech) Program Office https://www.dodmantech.mil

OUSD(R&E) Systems Engineering and Architecture (SE&A) https://ac.cto.mil/engineering

Relevant Government Publications (Available via Web/Internet Search)

- DoD 4245.7-M Manual, Transition from Development to Production, 1985
- NAVSO P-3687, Producibility Systems Guidelines, 1999

- MIL-HDBK-766, Design to Cost
- MIL-HDBK-727, Design Guidance for Producibility, 1984

Standards, Specifications, and Standards Organizations

- ASSIST (Defense Logistics Agency Database of Specifications and standards) https://assist.dla.mil
- ASSIST Quick search https://quicksearch.dla.mil/qsSearch.aspx
- SAE International www.sae.org
- International Organization for Standards (ISO) www.iso.org
- Institute of Electrical and Electronics Engineers (IEEE) www.ieee.org
- *Note:* Many specifications and standards can be accessed at http://everyspec.com/

Technology Readiness Levels (TRLs)

- Technology Readiness Assessment Deskbook www.acqnotes.com
- Technology Readiness Assessment Calculator www.acqnotes.com
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

1. Pre-Materiel Development Decision (Pre-MDD)

Introduction

The Pre-Materiel Development Decision (Pre-MDD) phase can be considered the front-end of the DoD acquisition process. Pre-MDD objectives include: obtain a clear understanding of user needs, identify a range of technically feasible materiel solutions, consider near-term opportunities to provide a more rapid interim response, and develop a plan for the next acquisition phase—including the required resources. This knowledge supports the MDD by the Milestone Decision Authority (MDA), a decision to authorize entry into the acquisition life cycle and pursue a materiel solution.

The Pre-MDD manufacturing and quality (M&Q) activities are displayed below (Figure 1-1).

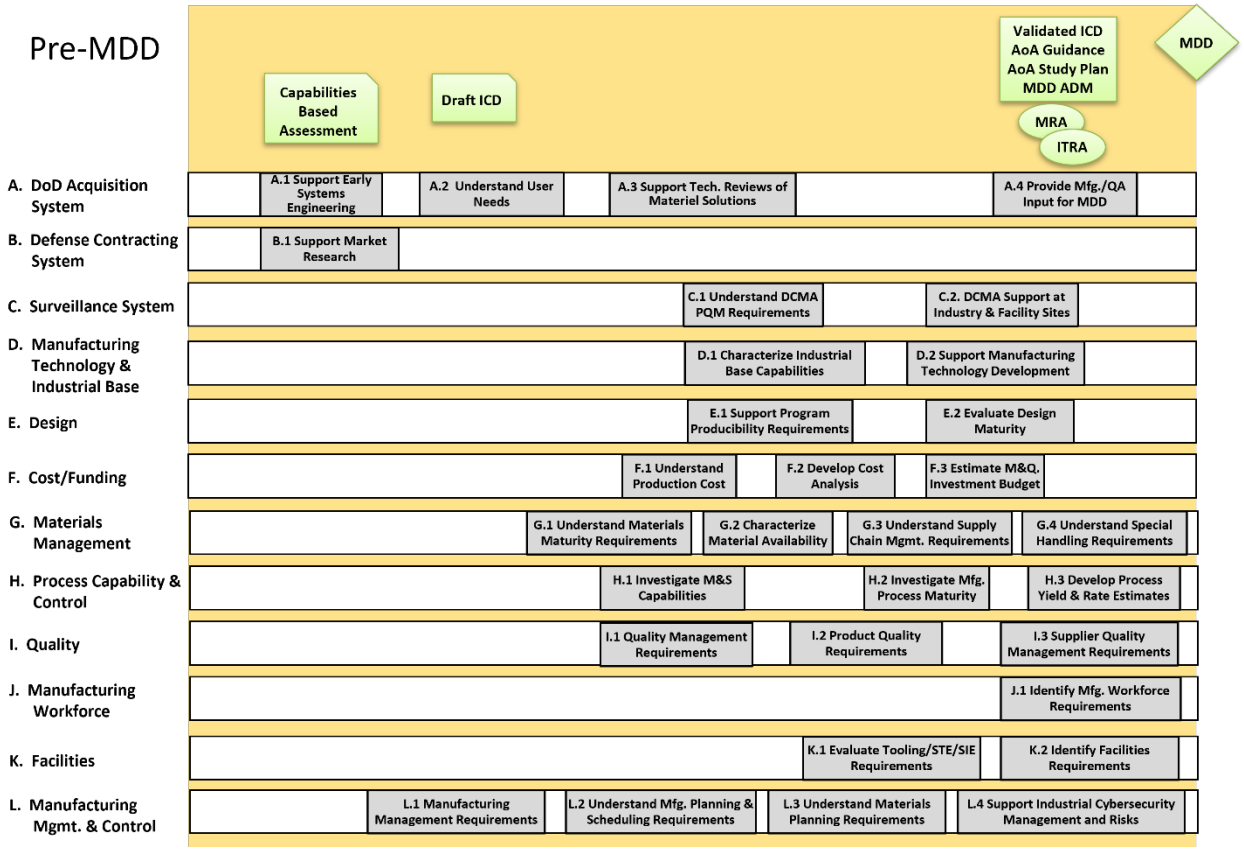


Figure 1-1. Pre-MDD Phase Manufacturing and Quality Activities

An important aspect of the Pre-MDD effort is narrowing the field of possible solutions to a reasonable set that is analyzed in the Analysis of Alternatives (AoA). Early recognition of constraints, combined with analysis of technical feasibility, can eliminate some initial ideas because they lack the potential to meet the need in a timely, sustainable, and cost-effective manner. Conversely, the range of alternatives analyzed in the AoA need to be selected from a sufficiently broad solution space. A Government Accountability Office (GAO) study states that *"programs that considered a broad range*

of alternatives tended to have better cost and schedule outcomes than the programs that looked at a narrow scope of alternatives." (*See* GAO-09-665 Analysis of Alternatives, page 6.)

To this end, DoD has many approaches to look at a broad range of technologies that could be used to satisfy a current or potential DoD need to include Basic Research, Applied Research, and Advanced Technology Demonstrations.

- Basic Research is a 6.1 Budget Activity directed toward a greater understanding of the fundamental aspects of phenomena and/or observable facts without specific applications toward processes or products.
- Advanced Research is a 6.2 Budget Activity directed toward gaining greater knowledge necessary to determine how a recognized and specific need may be met. It connects the technology with a user.
- Advanced Technology Development is a 6.3 Budget Activity directed toward efforts that will move the development and integration of hardware for field experiments and tests.

Many organizations and activities participate in these early studies, to include:

- Service Laboratories and Manufacturing Technology (ManTech) offices develop Technology Roadmaps (e.g., AFRL, NRL, ARL, DARPA, national laboratories, or ManTech centers).
- Service Centers of Excellence (CoEs) (e.g., Navy Metalworking CoE or Energetics CoE, Air Force Multi-Fidelity Modeling of Rocket Combustion Dynamics CoE, or the Army Cyber CoE).
- Service Assistant Secretaries of Defense all have Critical Technology Portfolios that the Services are investing in (e.g., Hypersonic, Non-Kinetic Warfare Capabilities, Soldier-Protection).
- Colleges and universities participate in thousands of studies, some with potential application for the DoD.
- Commercial businesses using Independent Research and Development (IRAD) funding are often on the leading edge of new material and process development that may have potential application for the DoD.

Manufacturing and Quality Objectives

Manufacturing is concerned with the conversion of raw materials into products based upon a detailed design. This conversion is accomplished through a series of M&Q procedures and processes. It includes major functions such as: manufacturing planning, cost estimating and scheduling; engineering; fabrication and assembly; installation and checkout; demonstration and testing; and quality assurance. M&Q considerations begin before the AoA during Pre-MDD, when the manufacturing feasibility and quality risks that are associated with each materiel solution must be understood and incorporated into study guidance for the next acquisition phase.

The first objective is to ensure that M&Q are part of the design process. The role of manufacturing is to influence the design so it is producible. The role of quality is to influence the design so it is reliable and robust. In other words, the material attributes, performance features, and characteristics of a product satisfy a given need. The result is an efficient design that can be manufactured using existing facilities, tools, equipment, and people, and meets quality needs. This role is critical because of the impact design decisions have on life cycle costs.

The second objective is to assess manufacturing feasibility and quality risks for the various materiel solutions identified.

The next objective is to support Knowledge-Based Acquisition to include the reduction of M&Q risks and demonstration of producibility.

To meet these objectives, M&Q strategy development must begin during the earliest stages of concept development. The M&Q strategy should be part of the Capabilities-Based Assessment (CBA) and the draft Initial Capabilities Document (ICD) and should be included in the AoA Study Guidance for the MDD.

Chapters 1-3 of this BoK (Pre-MDD through EMD) specify M&Q activities and tasks during early system development. The DoD Early Manufacturing and Quality Engineering Guide (www.ac.cto/maq) provides additional context for these activities within other early development activities (e.g., JCIDS, mission engineering, development planning, and systems engineering, digital engineering, acquisition planning). Increased M&Q practitioner involvement is encouraged during these early system development phases.

A. DOD ACQUISITION SYSTEM

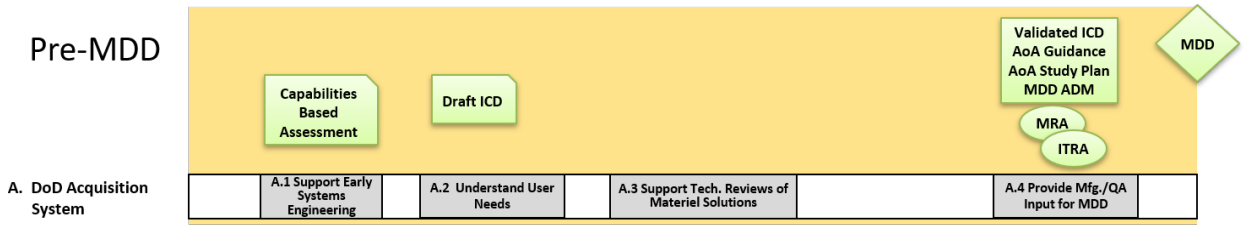


Figure 1-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

The Defense Acquisition System (DAS) is an event-based process. This includes a series of milestones (five phases), and risk-based reviews in which a Milestone Decision Authority (MDA) determines whether a program will proceed into the next phase. Major Defense Acquisition Programs (MDAPs) and major systems with production requirements should address industrial and manufacturing readiness in the Acquisition Strategy, during milestone reviews, and in program documentation as outlined in this Body of Knowledge (BoK).

This initial section ("thread") titled the "DoD Acquisition System" will focus on the following:

- Requirements (Joint Capabilities Integration and Development System (JCIDS))
- Program, Planning, Budget, and Execution (PPBE)
- DAS as implemented by DoDI 5000.01, The Defense Acquisition System; DoDI 5000.02, Operation of the Adaptive Acquisition Framework; and supporting instructions for each acquisition pathway.
- Analysis of Alternatives (AoA)
- User Requirements
- Acquisition Strategy
- Program Documentation
- Program Support
- Milestone Decisions

For major systems, during these early system development activities, the Joint Staff conducts a Capabilities-Based Assessment (CBA), and/or other studies as part of the JCIDS process, producing a draft Initial Capabilities Document (ICD). The draft ICD contains the initial Key Performance Parameters (KPP), Key System Attributes (KSA), and Additional Performance Attributes (APAs). The draft ICD is assigned to a lead Service or Services. Before determining if a materiel solution should be developed, the lead Service initiates activities to develop the AoA Study Guidance. These activities include manufacturing feasibility, studies from the science and technology (S&T) community, and other supporting studies (threat analysis, gap studies, etc.) contributing pertinent data and information for the MDD.

Another major early system development focus is mission engineering (ME): the deliberate planning, analyzing, organizing, and integrating of current and emerging operational and system capabilities to increase the likelihood of meeting warfighter requirements within cost, schedule, and performance constraints. ME facilitates the transition from JCIDS processes (requirements definition) to early systems analysis and architecture approaches, and to the SE development process. During Pre-MDD, ME is a top-down approach to provide mission-based outputs to the requirements process, guide design options, and inform investment decisions.

ME products and artifacts identify and quantify mission capability gaps and help the SE IPT to focus on technological solutions to meet future mission needs, inform requirements, prototypes, and acquisition; and support capability portfolio management. The ME practitioner needs to identify a well-established set of metrics that can be used to evaluate the completeness and efficacy of the components of mission-enabling activities.

M&Q studies are conducted prior to the MDD to assist the lead Service activities in identifying potential constraints, risks, and capabilities of the concepts to validate the draft ICD. These studies should be included in the AoA Study Guidance. After the MDD, DoDI 5000.02 specifies that the AoA

analyze cost, schedule, sustainment, and required capabilities associated with each proposed materiel solution, including technology maturity, integration risk, manufacturing feasibility, and, where necessary, technology maturation and demonstration needs.

In addition, the Office of the Under Secretary of Defense Research and Engineering (OUSD(R&E)) established policy (DoDI 5000.88, Engineering of Defense Systems) for the conduct of Independent Technical Risk Assessments (ITRAs) in accordance with 10 USC 2448b. Independent assessments should be conducted in accordance with the Defense Technical Risk Assessment Methodology (DTRAM). DTRAM focus areas include:

- Mission Capability
- Technology
- System Development and Integration
- Modular Open Systems Approach (MOSA)
- Software
- Security/Cybersecurity
- Manufacturing
- Reliability, Availability, and Maintainability (RAM) and Sustainment

To understand the implications of manufacturing feasibility, studies must address the feasibility, maturity, and quality risks of the proposed alternatives, including the need for:

- Industrial base (IB) development and impacts
- New materials and novel processing methods
- Additional research and development
- Manufacturing technology development and capital equipment
- Special test equipment and environments, special inspection equipment, and tooling
- New or expanded facilities
- New manufacturing skill sets

Development planning activities are initiated before the MDD, continue throughout the Materiel Solution Analysis phase, and eventually transition to the program environment. Development planning encompasses the engineering analysis and technical planning activities that provide the foundation for informed investment decisions that effectively, affordably, and sustainably meet operational needs.

Attention to critical systems engineering processes and functions is essential to ensure that programs deliver capabilities on time and on budget. The effective execution of Pre-MDD efforts provides technically feasible solution options that satisfy user-driven requirements for the AoA. At the MDD, the MDA not only decides whether an investment is made to fill the capability gap but also determines the fundamental path the materiel development will follow. This decision should be based on effective development planning.

A.1 Support Early Systems Engineering

As a best practice, M&Q personnel should to be actively engaged in the early systems engineering management and technical management processes. This includes developing early acquisition plans, identification of risks, and the development of risk mitigation plans.

Manufacturing and Quality Tasks

- Support the MDA MDD process to authorize entry into the acquisition life cycle and pursue a materiel solution.
- Analyze IB capabilities and manufacturing feasibility as part of a Capabilities-Based Assessment (CBA).
- Identify a range of materiel solutions across the entire solution space including user input as appropriate.
- Conduct a gap analysis for manufacturing feasibility to eliminate unfeasible materiel solutions based on factors such as timeliness, sustainability, cost-effectiveness, etc.
    - The gap analysis of manufacturing feasibility includes the use of near-term, commercial, or current systems as a materiel solution for rapid fielding
- Draft a top-level plan that includes scheduling, manpower, and cost projections based on the results of manufacturing feasibility analysis of materiel solutions.
- Develop technical planning with respect to performance characteristics and analysis of capability gaps in manufacturing as part of the analysis of materiel solutions.
- Assess materiel solutions for external dependencies and integration impacts on the industrial base.
- Analyze materiel solutions for producibility and manufacturability and associated costs for the AoA Study Guidance.
- Analyze the potential alternatives that address the feasibility of a rapid interim response to the need.

Tools

- Acquisition Decision Memorandum (ADM) Materiel Development Decision (MDD) Template
- Acquisition Strategy Outline
- Analysis of Alternatives (AoA) Study Plan Template
- AoA Study Guidance Template
- Capability Development Document (CDD) Template
- Defense Contract Management Agency (DCMA) Industrial Capability Assessment Survey
- Interactive MRL Users Guide
- Manufacturing Maturation Plan
- Market Research Reporting Template

- Pugh Matrix Template
- Quality Function Deployment Excel Spreadsheet
- Quality Function Deployment or House of Quality Matrix
- Requirements Roadmap Worksheet, DAU
- Requirements Traceability Matrix Template, DAU
- Tailoring Worksheet for Materiel Solution Analysis Phase
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- Air Force Analysis of Alternatives (AoA) Handbook
- Capabilities-Based Assessment (CBA) User's Guide
- DAU AcqNotes Market Research website
- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities
- DoD Market Research Guide
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Pre-MDD Analysis Handbook
- Requirements Traceability Matrix Guide
- Technology Readiness Assessment (TRA) Guide
- Technology Readiness Assessment Guide (GAO-20-48G)

A.2 Understand User Needs

M&Q personnel need to support the development of the Initial Capabilities Document (ICD), Capabilities-Based Assessment (CBA), AoA Study Plan, and AoA Guidance.

Manufacturing and Quality Tasks

- To obtain a clear understanding of user needs M&Q personnel need to:
    - Participate in development of draft Initial Capabilities Document (ICD) to provide M&Q inputs to development of KPPs, KSAs, and APAs, including inputs to Force Protection, System Survivability, Sustainment, and Energy KPPs (four of the six mandatory KPPs)

  - Participate in the CBA or equivalent to provide manufacturing perspective on IB capability and manufacturing feasibility for both processes
- Identify near-term opportunities that address user needs per the draft ICD and the CBA to provide a more rapid interim response.
- Develop understanding of user needs as they relate to materiel solutions and proactively collaborate with the user communities to:
  - Support Technical Reviews of materiel solutions
  - Initiate characterization of trade space, risks, and mission interdependencies as input to support the AoA Study Guidance.

Tools

- Capabilities-Based Assessment (CBA) Tool, DAU
- Capability Development Document Temp
- Initial Capabilities Document (ICD) Template
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- Pugh Matrix Template
- Quality Function Deployment Excel Spreadsheet

Resources

- AFI 10-601 Operational Capability Requirements Development
- Capability-Based Assessment User's Guide
- DAG Chapter 14.3.1.3, Build Requirements Roadmap
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- CJCSI 5123.01I, JCIDS Instruction
- CJCS JCIDS Manual
- DoD Mission Engineering Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Pre-MDD Analysis Handbook

A.3 Support Technical Reviews of Materiel Solutions

M&Q personnel may need to support an ITRA and/or a Manufacturing Readiness Assessment (MRA) to assess risks and to provide the MDA with information needed to approve entry into the Materiel Solution Analysis phase.

Manufacturing and Quality Tasks

- Provide manufacturing inputs to support the MDA MDD process to authorize entry into the DoD acquisition process and pursue a materiel solution.
    - Identify and provide inputs to the AoA Study Guidance that specify the minimum set of Concept of Operations (CONOPS) and ICD manufacturing and/or quality requirements that must be met for each of the materiel solutions
    - Assess each of the materiel solutions for manufacturing feasibility and producibility
    - Identify M&Q risks (technical/engineering) for each materiel solution
        - Identify the capability and capacity risks for rapid fielding of potential solutions
        - Identify source consideration risks for fragile, single, sole, domestic, and foreign sources
    - Identify M&Q scheduling impacts and constraints (risks and opportunities) for each materiel solution
- Identify initial M&Q Measures of Effectiveness for each materiel solution.
- Initiate characterization of trade space, risks, and mission interdependencies of each materiel solution as input to support the AoA Study Guidance.
- Analyze capability and gaps of each materiel solution approach to meet the need in a timely, sustainable, and cost-effective manner.
- Support the conduct of an MRA
- Support the conduct of an ITRA (when required by the MDA during Pre-MDD)

Tools

- Acquisition Decision Memorandum (ADM) MDD Template
- Analysis of Alternatives (AoA) Study Plan Template
- Critical to Customer/Critical to Quality Tree Template
- Defense Technical Risk Assessment Methodology (ITRA criteria)
- Interactive MRL Users Guide (Checklist)
- Manufacturing Capability Assessment Worksheet
- Manufacturing Maturation Plan
- MDD Development Planning Templates

Resources

- AcqNotes (DAU)
- Air Force AoA Guide
- Air Force AoA Handbook
- Defense Manufacturing Management Guide for Program Managers, Chapter 1.3 and 2.6 Industrial and Manufacturing Capability Assessments in the Acquisition Lifecycle

- Defense Technical Risk Assessment Methodology (DTRAM)\DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook
- MSA Guide

A.4 Provide Manufacturing Input for the Materiel Development Decision

M&Q personnel need to provide the MDA with M&Q information to support the MDD.

Manufacturing and Quality Tasks

- Support the MDA MDD process to authorize entry into the acquisition life cycle and pursue a materiel solution
- Identify a range of technically feasible materiel solution approaches that address considerations of industrial, production, manufacturing, and quality constraints
- Develop manufacturing inputs for the AoA Study Guidance and Study Plan planning for the next acquisition phase, including the required resources
- Develop draft guidance on the application and use of assessments of manufacturing readiness on the concepts under consideration
    - Identify target Manufacturing Readiness Levels (MRLs) that should be achieved at key milestones and decision points for MDAPs
    - Identify tools and models that may be used to assess, manage, and reduce risks that are identified during MRL assessments
- Initiate characterization of trade space, risks, and mission interdependencies as input to support the AoA Study Guidance.
- Conduct a complete and rigorous manufacturing analysis/assessment of alternatives and their non-materiel implications as part of a systems engineering analysis
- Assess alternatives for manufacturing and their non-materiel implications (cost, staffing, contracting, etc.) as an input to the MDD
- Assess the industrial base for production capability and capacity, and M&Q constraints to eliminate non-supportable materiel solutions (i.e., those that are not timely, sustainable, or affordable) as an input to the AoA Study Guidance

- Collaborate with the user communities to understand system performance requirements and with the S&T community to identify materiel solutions and potential manufacturing issues as an input to the AoA Study Guidance
- Technical Reviews have been conducted with M&Q support and address the following:
    - Assess the draft ICD, the AoA Study Guidance, and preliminary CONOPS for M&Q analysis of materiel solution alternatives
    - Support the ITR to provide detailed M&Q information and understanding of each concept or alternative for:
        - Engineering trades
        - Development of a Cost Analysis Requirements Description (CARD)
        - Cost drivers, material, and process risks

Tools

- Acquisition Decision Memorandum (ADM) Materiel Development Decision (MDD) Template
- AoA Study Plan Template
- DCMA Industrial Capability Assessment Survey Form
- MRL Users Guide
- Manufacturing Maturation Plan
- Multi-Attribute Tradespace Exploration (MATE)
- Pugh Matrix Template

Quality Function Deployment Resources

- Air Force AoA Handbook
- DCMA Instruction 3401, Defense Indusial Base Mission Assurance
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Pre-MDD Analysis Handbook

B. DEFENSE CONTRACTING SYSTEM

Figure 1-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

The contract is the vehicle used to establish the formal relationship between the government and a prime contractor. Government business processes include the business strategy or acquisition strategy, contracting approach, contracting strategies, contract language, and financial strategies. Programs should address manufacturing and quality considerations in their business processes starting with Pre-MDD. M&Q personnel often are called upon to support various contracting functions and activities.

This thread (Contracting) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Market Research
- Contract Strategy
- Source Selection Plan
- Request for Proposal
- M&Q Inputs to the Contract (Sections C, E, L and M) (refer to MIL-HDBK-245D)
- Contract Evaluation and Award

DoD contracting requirements and activities are outlined by the Federal Acquisition Regulation (FAR)/Defense Federal Acquisition Regulatino (DFAR) and DoD, Service, and Agency regulations, policies, and guidance documents.

M&Q resources should be focused on the entire acquisition cycle including areas such as production planning, transition to production, concurrent engineering, quality management, continuous improvement, could cost, and manufacturing technology. A clear understanding of these focus areas is key during Pre-MDD for contracting activities in the following acquisition phases. These activities include proactively collaborating with the S&T and user communities to develop understanding of materiel solutions to make necessary and substantive inputs to future contracts and acquisition planning.

Market research, as defined in Federal Acquisition Regulation (FAR) Part 2, “Definitions,” is the process of collecting and analyzing information about capabilities within the market to satisfy agency needs. To elaborate, market research is a continuous process of gathering data on business and industry trends, characteristics of products and services, suppliers’ capabilities, and related business practices.

The data resulting from market research are analyzed and used to make informed decisions about whether DoD's needs can be met by commercial products or services. When making such decisions, many factors are considered, such as the following examples:

- Degree to which commercial practices allow the products or services to be customized or tailored to meet DoD needs.
- Terms and conditions, such as warranties, discounts, and customer support, under which commercial sales are made.
- Ability of potential suppliers' distribution and logistics support systems to meet DoD's needs.

Market research information can be used to shape the acquisition strategy, to determine the type and content of the product description or statement of work, and to develop the support strategy, the terms and conditions included in the contract, and the evaluation factors used for source selection.

B.1 Support Market Research

Market research is a pre-solicitation activity that involves the identification of the market or market of interest, the sources of market information, the collection of market information, and the evaluation of the market's ability to satisfy the user needs. M&Q personnel need to support market research to identify suppliers and evaluate potential sources and opportunities to assess the risks associated with these opportunities. Trade studies can help users sort out what requirements can be fulfilled, what requirements can be fulfilled within cost objectives, and what requirements can be fulfilled given schedule constraints. By addressing all these issues, market research enables the user to make informed decisions about the trade-offs among all the alternatives. Users who fail to consider these issues when defining the requirements risk investing in a system that may encounter technical difficulties during manufacturing or operation, have long production lead-times, and be excessively costly to produce, operate, and support. Market research can be conducted at the weapon system, subsystem, component, or part level and during any phase.

Early market research can help to identify emerging or latest developments in their area of concern and leading to solicitation and award. Once market research has been completed, requirements may be defined in the form of Performance Work Statements, Statements of Work, or Statements of Objectives. The development of RFPs is included in the solicitation-award phase of the contracting process leading to contract evaluation, negotiation, and award. The contract at this point is used to bring that product further along, preparing it for further development and testing.

Manufacturing and Quality Tasks

- Develop and build the technical knowledge base for candidate materiel solutions based on inputs from the S&T community (across government, industry, and academia) as well as other collaborators.

- Survey the industrial base for necessary resources for the potential materiel solutions and the current state industrial practices.
- Support requests for information and solicit industry and academia responses to warfighter needs.
    - Provide M&Q inputs for sources sought activity, as appropriate.
    - Support the development of contracts as appropriate.
- Identify and characterize materiel solutions resulting from the sources sought to support Requests for Information (RFI) activities and Industry Day events.
    - Ensure the Request for Information (RFI) is open to alternative solutions
- Analyze potential trade space to identify performance versus cost benefit discriminators for potential materiel solutions.
- Initiate planning for the M&Q efforts required during the next phase.

Tools

- Market Research Reporting Template
- Pugh Matrix Template
- Systems Engineering Plan (SEP) Outline

Resources

- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- DoD Market Research Guide (*See* DAU AcqNotes Market Research website)
- FAR Part 10 Market Research
- SD-5 Market Research
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- SEP Outline

C. SURVEILLANCE SYSTEM

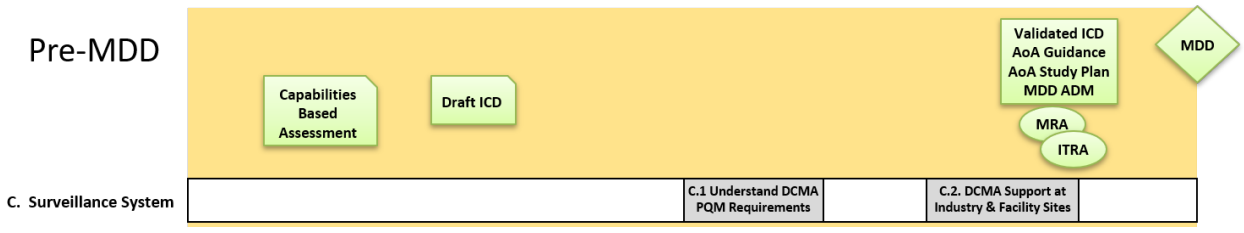


Figure 1-4. Surveillance System Manufacturing and Quality Activities

Introduction

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DoD contractor surveillance requirements and activities are further outlined by the FAR/DFAR and by many DoD, Service and Agency regulations, policies, and guidance documents. DFAR Part 242.2 Contract Administration Services; DFAR Part 242.3, Contract Administration Office Functions; and PGI 242.3 Contract Administration Functions outline the 70 CAS functions that are required and the many that may require M&Q support in order to accomplish. M&Q personnel often are called upon to support numerous CAS functions and activities.

- Contract Administration Service (CAS) Functions
- DCMA Support
- DCMA Documentation
- Monitor and Track Risks
- Participate in Program Reviews

Often these activities may be performed under mutual agreement by the program office and the Defense Contract Management Agency (DCMA). In many cases these contractor surveillance activities may be performed by on-site program office contract administrators, delegated Service contract surveillance offices, or a variety of engineering support activities (i.e., supervisor of shipbuilding (SUPSHIP), or development command field activities). The activity managing the concept, or the Program Manager, should maximize the use of DCMA and engineering support activity at personnel contractor facilities where there is delegation of authority and expertise available. They should request the DCMA Contract Management Offices jointly support development of program support plans for all Acquisition Category I program contracts to ensure agreement on contract oversight needs and perspectives.

C.1 Understand DCMA M&Q Data Inputs

DCMA maintains a presence in many contractor facilities that produce goods for the Department of Defense. As a result of their day-to-day presence, DCMA personnel can continuously review, assess, and document contractor performance. M&Q personnel need to understand and be able to use DCMA generated data to support the achievement of program objectives.

Manufacturing and Quality Tasks

- Contract requirements and agreements with other agencies (e.g., DCMA) developed and include quality and manufacturing requirements.
    - Request DCMA recommend the appropriate quality (i.e., ISO 9001 or SAE AS9100) and manufacturing management program requirements (i.e., SAE AS6500 or contractual) language to be included in solicitations, requests for proposals, and contracts and in appropriate agreements with other agencies (e.g., DCMA)

  - Request DCMA provide supporting rationale for recommendations on the emerging technology maturity

- Conduct manufacturing feasibility assessments of each concept being considered and include request information and data input for similar products and manufacturing processes from DCMA:
  - Assessment of manufacturing maturity of similar products and processes
  - Status and readiness of industrial capabilities
  - Current available facilities and equipment
  - Workforce availability and training
  - Quality system processes and results
- Identify the manufacturing and/or production, quality, engineering and software development risks for similar products and processes relevant to each concept being considered for the AoA Study.
  - Request DCMA provide data to support analysis of the identified risks including lessons learned

Tools

- AoA Study Plan Template
- DCMA Industrial Capability Assessment Survey Form
- DCMA Pre-Award Survey
- DCMA Program Support Plan per DCMA-ANX 205-02
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- Risk Assessment Template – DAU
- TRL Assessment Checklist

Resources

- Air Force AoA Handbook
- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook

- Technology Readiness Assessment (TRA) Guide

C.2 DCMA Support at Industry and Facility Sites

M&Q personnel need to develop program collaborative opportunities with DCMA in the form of Memorandums of Agreement (MOA) or Letters of Delegation (LOD) to gather their support and insight into:

- Manufacturing and Production Operations
- Quality Assurance Operations
- Property Management
- Engineering Surveillance
- Contract Administration and Oversight
- Quality Audits and Product Examination
- Technical Reviews
- Industrial Analysis

Manufacturing and Quality Tasks

- Develop MOAs or LODs with DCMA for support.
- Identify manufacturing investment programs based in part on inputs from DCMA (when requested and agreed to by DCMA) that support:
    - Develop and manage industrial base investment programs that create, expand, or preserve assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense
    - Assess and evaluate candidate programs
- Identify manufacturing technology investments and Title III initiatives based in part on DCMA inputs (when requested and agreed to by DCMA) and develop recommendations to program and contracting personnel.
- Assistance requests developed for DoD and/or component manufacturing technology programs based in part on DCMA (when requested and agreed to by DCMA) that support:
    - Identify new manufacturing processes associated with the program and candidate components for the identified processes
    - Identify low-yield processes and components
    - Request manufacturing technology (ManTech) assistance for identified processes and components
    - Develop request for information and academia responses to warfighter needs
- Evaluate and submit recommendations on an emerging manufacturing technology maturity based in part on DCMA (when requested and agreed to by DCMA).

- Conduct manufacturing technology assessments to evaluate an emerging manufacturing technology to determine feasibility for production
- Assess the emerging manufacturing technology to ensure it meets production requirements
  - Develop recommendations on the emerging manufacturing technology maturity
  - Document assessment of industrial capabilities and recommendations for applicability of emerging manufacturing technology, and provide to decision maker

Tools

- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- Pugh Matrix Template

Resources

- AFI 63-141, Defense Production Act ManTech, Air Force
- AR 700-90 Army Industrial Base Process
- DCMA Instruction 3401, Defense Indusial Base Mission Assurance
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDD 4200.15, DoD ManTech Program
- DoDI 5000.60, Defense Industrial Base Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook

D. MANUFACTURING TECHNOLOGY AND INDUSTRIAL BASE

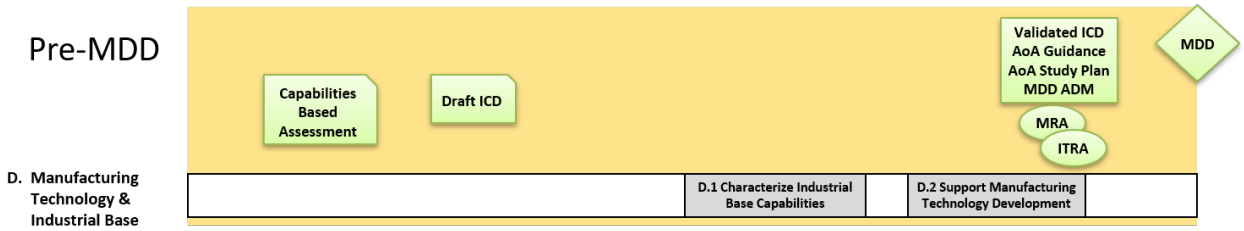


Figure 1-5. Manufacturing Technology and Industrial Base M&Q Activities

Introduction

10 USC 2440 requires the Secretary of Defense to consider the National Technology Industrial Base (NTIB) in the development and implementation of acquisition plans for each MDAP. The NTIB

consists of the people and organizations engaged in national security and dual-use research and development (R&D), production, maintenance, and related activities within the United States, Canada, the United Kingdom, and Australia. Acquisition planning and plans should include the following NTIB considerations for all MDAPs:

- The ability to support development and production (rates and quantities)
- The identification of IB risks in the supply chain
- The identification of single points of failure in the supply chain (sole source, foreign source, etc.)
- Support for a resilient supply base for critical defense capabilities
- Support for procurement surges and contractions

This thread (Manufacturing Technology and Industrial Base) requires an analysis of the capabilities of the NTIB to support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal (including environmentally conscious manufacturing). This thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Industrial Base Assessments (IBAs)
- Industrial Base Risks
- Critical Enabling Technologies
- ManTech Projects
- Industrial Base Mitigation Plans

D.1 Characterize Industrial Base Capabilities

10 USC 2440 and DFAR Subpart 207.1. require assessments of the capabilities of the U.S. industrial base (IB) to support defense operations. M&Q personnel need to assess and characterize the IB's capability for the types of commodities that may be expected to solve the warfighter needs.

Manufacturing and Quality Tasks

- Conduct industrial base sector studies (i.e., capabilities and capacities) relevant to potential and future needs inclusive of design, development, production, operation, and sustainment, and eventual disposal.
    - Identify and understand potential IB sources and needs
- Conduct an industrial base assessment to identify sources relevant to the concepts being considered for the ICD, AoA Study Guidance, and the MDD.
    - Identify unique manufacturing capabilities that are not readily accessible (i.e., require regeneration)
    - Request DCMA data that support the following:

    - Industrial Capability Assessments
    - Analytical Products
    - Defense Business and Economic Analysis
    - Acquisition Planning Support

- Analyze the capabilities of the identified IB sources to develop, produce, maintain, and support the concepts being considered for inclusion in the ICD, AoA Study Guidance, and the MDD:
    - Identify the external dependencies and integration impacts
    - Identify the availability of essential raw materials, special alloys, composite materials, components, tooling, and M&Q test equipment required to support the concepts being considered
    - Identify items that are sole or single sourced, fragile source, or available only from sources outside the NTIB
        - Analyze the effects on the sources for the concepts being considered that result from foreign acquisition of firms in the United States
    - Identify the availability of alternatives for obtaining such items from within the NTIB
        - Analyze the military vulnerability that could result from the lack of alternatives if such items become unavailable from sources outside the NTIB.
- Use models and simulations to develop required documentation for the MDD.

Tools

- AoA Study Plan Template
- DCMA Industrial Capability Assessment Survey Form
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- Air Force AoA Handbook
- DCMA Instruction 3401, Defense Indusial Base Mission Assurance
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDD 4200.15, Manufacturing Technology (ManTech) Program
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoD Systems Engineering Guidebook

- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook

D.2 Support Manufacturing Technology Development

The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. The manufacturing feasibility assessment should identify high-risk manufacturing process areas that represent technology voids or gaps and may require investments in ManTech or other programs. ManTech program investments should be directed toward areas of greatest need and potential benefit. These investments must be identified early so that these manufacturing capabilities will be matured on time to support rate production.

Manufacturing and Quality Tasks

- Survey M&Q technologies and capabilities relevant to potential and future needs as part of industrial base sector studies:
    - Identify and understand potential industrial base investment needs
- Identify the requirement for the use of advanced M&Q technology and processes for the concepts being considered.
- Conduct a survey of ManTech program technology concepts that are ongoing, in development, and support the concepts being considered.
    - Identify ongoing ManTech projects and conduct a survey of needs for manufacturing technology assistance
    - Provide recommendations on M&Q technology investments and Title III initiatives based on survey of needs

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- Air Force Technology Development and Transition Strategy Guidebook
- Defense Manufacturing Management Guide for Program Managers, Chapter 8, Technology Development and Investments
- DoDD 4200.15, ManTech
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework

- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Technology Readiness Assessment (TRA) Guide
- Technology Readiness Assessment Guide (GAO-20-48G)

E. DESIGN

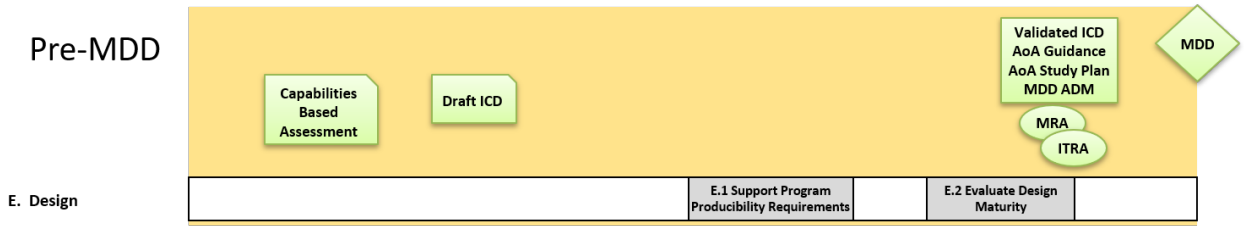


Figure 1-6. Design Manufacturing and Quality Activities

Introduction

DoD SE is a disciplined approach for the specification, design, development, realization, technical management, operation, and retirement of a weapon system. SE is an interdisciplinary and collaborative effort requiring close interaction with many disciplines to include operations, maintenance, logistics, test, production, quality, etc. The practice of SE is composed of 16 processes: 8 technical processes and 8 technical management processes. These 16 processes provide a structured approach to increasing the technical maturity of a system, increasing the likelihood that the capability being developed balances mission performance with cost, schedule, risks, and design considerations. M&Q personnel need to support these activities and processes. For a detailed description of SE processes refer to the DoD Systems Engineering Guidebook at www.ac.cto/erpo.

The lead systems engineer should assess the interdependence and integration of all design considerations and should ensure that all Specialty Engineering (Reliability and Maintainability (R&M), M&Q, Human Systems Integration (HSI), and System Safety) design considerations are addressed at the enterprise level. SE is typically structured as one or more integrated product teams (IPTs) that are collectively responsible for delivering a defined product or process.

As a best practice, M&Q personnel should be integrated into the SE IPT and should support the requirements process, AoA, assessments of costs, trade studies, selection of investment, and inputs to the development of technical performance measures.

One of the major objectives is to evaluate manufacturing feasibility, or to answer the question, "Can it be built?" Producibility is an engineering function directed toward generating a design which is compatible with manufacturing capability and quality processes. It is often considered the most important determinant of product cost, because on both production and sustainment costs.

Proposed materiel solutions should be assessed for manufacturability and producibility to ensure that one or more materiel solutions have the potential to be affordable, effective, and suitable, and can be developed to provide a timely solution to a need at an acceptable level of risk. This presents the first real opportunity to influence systems design and begin planning for production by balancing technology opportunities and current practices against cost, schedule, and performance. User needs should be expressed in terms of quantifiable parameters. The intent is to reduce technical risk, evaluate design concepts, support cost estimates, evaluate manufacturing processes, and refine design requirements.

Quality requirements are integral to design and development efforts as specified in industry best practice standards for quality management systems (ISO 9001, AS9100, etc.). These standards for systems engineering processes emphasize the importance of quality as part of program requirements in early design. The typical processes included in the QMS and included in this document are:

- Design and Development Planning (e.g., Engineering Management, FMECA, Safety)
- Design and Development Inputs/Outputs and Reviews (e.g., Verification and Validation (V&V), Test and Evaluation (T&E) Management, reviews, audits)
- Risk and Configuration Management

DoD acquisition programs may face a high risk of failure at the outset of the design process based on the maturity of the design. Some level of risk associated with new concepts may be unavoidable, historically this risk has been magnified by a misunderstanding of the efforts necessary to mature the concept into a mature product. The government and its contractors must share equal responsibility for this misunderstanding. The contractor's proposal and the government's source selection process provide the most cost-effective opportunity to ensure application of these critical efforts during design maturation.

A mature design in pre-MDD phase should begin to show these characteristics: the design meets requirements and overcomes shortfalls, the design is experiencing minimal changes, and initial testing and experiments indicate performance can be met. However, final design will be determined at Critical Design Review (CDR), much later in the program.

Current "Design Best Practices" include the use of computer-aided design (CAD) and computer-aided manufacturing (CAM).

CAD is the use of computer software to design and document a product's design process. CAD is used to accomplish preliminary design and layouts, design details and calculations, create 3D models, create and release drawings, and interface with analysis, marketing, manufacturing, and end-user personnel.

CAM is the use of software and computer-controlled machinery to automate a manufacturing process. Based on that definition, three components are required for a CAM system to function:

- Software that tells a machine how to make a product by generating toolpaths.
- Machinery that can turn raw material into a finished product.
- Post processing, which converts toolpaths into a language machines can understand.

E.1 Support Program Producibility Requirements

Producibility Engineering and Planning should be directed toward generating a design that is compatible with the current capability of the factory floor. Producibility is a major driver of product affordability because of the effect on both production and sustainment costs. The Producibility Plan should guide the design effort and describe activities that will be accomplished, the responsible organization, and the management controls that will be established to ensure successful accomplishment. Manufacturing and QA managers should consider the need for developing Initial Producibility Plans and requirements.

Manufacturing and Quality Tasks

- Assess the manufacturing producibility and feasibility of the concepts being considered as materiel solutions to ensure that one or more concepts have the potential to be affordable, effective, and suitable, and can be developed to provide a timely solution to a need at an acceptable level of risk. The assessment should include:
    - Evaluation of the contractor approach to design and systems engineering
    - Evaluation of the contractor's use of design tool and software
    - Evaluation of design concepts
    - Identification and determination of costs, cost drivers, and potential risks
    - Identification of M&Q processes needed and requirements
    - Identification of design requirements
    - Identification of technical risks
- Assess use of design analysis tools
    - Fault Tree Analysis (FTA)
    - Failure Mode and Effects Analysis (FMEA)
    - Process Failure Mode and Effects Analysis (PFMEA)
    - Design Failure Mode and Effects Analysis (DFMEA)
- Assess the organizations' ability to identify, manage, and control KCs and CCs
- Conduct additional analysis of the following areas as the concepts mature:

  - Technology maturity
  - Industrial base capability
  - Manufacturability
  - Funding required for maturing the M&Q processes
  - Materials availability
  - Tests and demonstrations for new materials and processes
  - Environmental impacts
  - Anticipated M&Q risks including potential cost and schedule impacts
- Conduct trade studies that consider and incorporate alternative system designs and other technical considerations.

Tools

- ISO 9001 Checklist
- SAE AS9100 Checklist
- SAE AS6500
- DCMA Industrial Capability Assessment Survey Form
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Manufacturing Producibility Assessment Worksheet (PAW)
- Market Research Reporting Template
- CAD/CAM software
- Fault Tree Analysis
- Failure Modes and Effect Analysis
- Process Failure Modes and Effects Analysis
- Design Failure Modes and Effects Analysis
- Preliminary Hazards List
- Pugh Matrix
- TRA Checklist

Resources

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- Quality Management System
- AS6500 Manufacturing Management Program
- AS9103 Variation Management of Key Characteristics
- MIL-STD-1629A Failure Modes Effect and Critical Analysis
- SAE J1739-202101 Potential Failure Mode and Effects Analysis

- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687
- Technology Readiness Assessment (TRA) Guide
- Technology Readiness Assessment Guide (GAO-20-48G)

E.2 Evaluate Design Maturity

M&Q personnel need to support the Design IPT in evaluating design maturity by assuring that top-level performance requirements are defined and trade-offs in design options are assessed based on experimentation.

Manufacturing and Quality Tasks

- Identify the manufacturing industrial base capabilities and the manufacturing technologies required by a materiel solution to evaluate the respective design maturities.
- Identify broad performance requirements of materiel solution approaches that may drive M&Q options.
- Assess the maturity of each materiel solution's design options based on experiments.
- Identify and evaluate materiel solution approaches life cycle and technical requirements.
- Identify and evaluate reasonable technologies that can be available in the timeframe available.
- Support the identification of future design validation and verification activities.

Tools

- DCMA Industrial Capability Assessment Survey Form
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Market Research Reporting Template
- Producibility Assessment Worksheet (PAW)
- Pugh Matrix Template
- TRL Assessment Checklist

Resources

- SAE AS9100, Quality Management Systems – Requirements for Aviation, Space and Defense Organizations
- DoD 5000.60H Assessing Defense Industrial Capabilities
- DoD Market Research Guide
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility System Guidelines, NAVSO P-3687
- Technology Readiness Assessment (TRA) Guide
- Technology Readiness Assessment Guide (GAO-20-48G)

F. COST/FUNDING

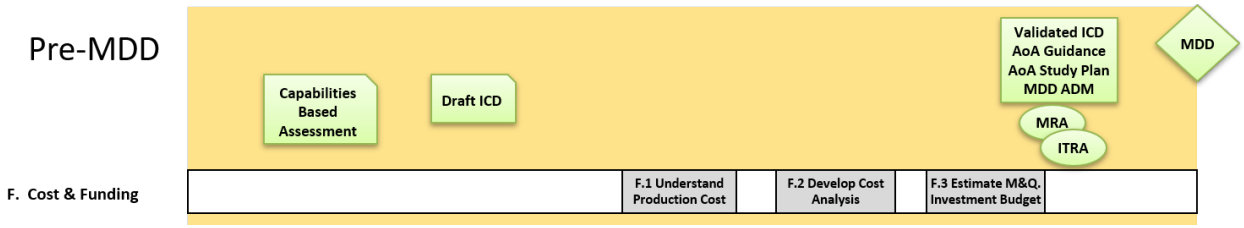


Figure 1-7. Cost and Funding Manufacturing and Quality Activities

Introduction

Services and Agencies develop Program Objective Memorandums (POMs) to identify and request funding to acquire capabilities and perform operations. The POM is part of the Programming phase of the Program, Planning, Budget, and Execution (PPBE) process. The DoD combines the various Service and Agency POM inputs and Budget Estimate Submission (BES) and submits a DoD Budget Request to the Office of Management and Budget (OMB).

DoD efforts at cost estimating and analysis play a critical role in supporting DoD procurement activities to include planning, programming, budgeting, acquisition, and requirements generation. Cost estimating is both a science and an art relying on sound mathematical and analytical skills, critical thinking, communication, and the ability to understand complex functions and processes.

Throughout the acquisition process, systems engineering provides the technical foundation for the acquisition program. In the early stages of an acquisition, systems engineering analysis and products are vital to the ability to assess appropriately the feasibility of addressing user needs, technology needs of potential solutions, and robust estimates of cost, schedule, and risk, all leading to predictable, disciplined acquisition.

The government's objective is to determine the costs to develop, execute, field, and maintain each materiel solution. The effort requires processes and systems that consider manufacturing, quality, and

design functions to achieve a product design that meets cost, schedule, and performance requirements with acceptable risk.

- Cost Capability Analysis (CCA)
- Independent Government Cost Estimate (IGCE)
- Should Cost Estimate (SCE)

Appropriate practices for implementation will include parametric and production cost modeling estimates. Parametric cost modeling requires identification of similar systems, products, components, and manufacturing processes, and other factors. Production cost modeling includes identification of critical characteristics and Key Characteristics (KC) and critical and key manufacturing and test processes; variability reduction; simulations of the manufacturing environment; cost/performance trade studies; manufacturing capability assessments; product and process validation; and key supplier relationships. Depending on the materiel solution, production cost modeling may have limited application in this phase.

Part of the task or role for M&Q is to identify investments needed in the industrial base or infrastructure for each materiel solution. The needed investments may include additional industrial capacity, test equipment, workforce training, special materials handling, transportation, etc.

In addition, investments in processes and systems to assure program affordability, through product quality and manufacturing efficiency, may include for implementation: product improvement initiatives, variability reduction on product and process, manufacturing process control and continuous improvement, key supplier relationships, and investments in manufacturing technology. To that end, ongoing and future ManTech, Title III, etc., program investments need to be considered to achieve the desired performance while controlling or meeting acquisition cost objectives. This is accomplished by developing, maturing, and transitioning advanced manufacturing technologies.

F.1 Understand Production Cost

M&Q personnel need to be able to understand potential production costs and manufacturing cost drivers to develop initial manufacturing cost estimates and targets. This effort requires knowledge of cost models and modeling techniques including analogy, parametric, engineering, and actual costs.

Manufacturing and Quality Tasks

- Evaluate the Cost Analysis and Program Assessment (CAPE) cost estimates for appropriateness and completeness of manufacturing considerations. Cost estimates could use one or more of the following estimating techniques:
    - Analogy: Identifies similar systems for which there is accurate cost and technical data to forecast the cost of the new system

- Parametric: Identifies a statistical (parameter) relationship between historical data and some variable to calculate the cost of the new system
- Engineering: A bottom-up estimate that builds the overall cost estimate by summing up a detailed estimate done at the lower levels of the WBS
- Actual: Uses actual cost data from current systems
- Cost estimates should include:
  - Identification of critical and key/critical product characteristics/features and critical and key/critical manufacturing and test processes
  - Identification of variability reduction needs
  - Simulations of the manufacturing environment
  - Trade studies of cost/performance
  - ESOH and HAZMAT cost impacts
  - Capability assessments of manufacturing and quality, product and process validation, and key supplier relationships
- Independent Cost Estimate (ICE)
- Component Cost Estimate (CCE)
- Component Cost Position (CCP)
- Cost Capability Analysis (CCA)
- Independent Government Cost Estimate (IGCE)
- Should Cost Estimate (SCE)
- Sufficiency Review

Tools

- Analogy and Parametric Estimating Techniques
- Cost Analysis Requirements Description Template (CARD) (*See* CAPE website for tools)
- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan

Resources

- DoD Cost Estimating Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 9, Manufacturing Cost Estimating
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook

- MIL-HDBK-766, Design to Cost
- Parametric Estimating Handbook

F.2 Develop Cost Analysis

M&Q personnel need to support the development of early cost estimates and analysis to include the conduct of sensitivity analysis to define cost drivers and production development strategy (i.e., lab to pilot to factory).

Manufacturing and Quality Tasks

- Identify the applicable guidance for developing M&Q cost estimates
- Identify investments needed in the industrial base or infrastructure for each materiel solution
- Support initial document development of the CARD with the M&Q inputs for the appropriate cost categories (e.g., producibility study costs).
- Identify any M&Q cost implications for materiel solutions.
- Identify M&Q cost drivers of materiel solutions (e.g., proposed materials and process selections that may be inherent).
- Conduct M&Q cost sensitivity analysis where appropriate if possible.
- Identify M&Q workforce and integration cost requirement implications.
- Identify investments needed in the industrial base or infrastructure for each materiel solution.
    - Investments may include additional industrial capacity, test equipment, workforce training, special materials handling, transportation, etc.

Tools

- Cost/Schedule Control System Criteria (widely replaced by Earned Value Management, but could use on a small project)
- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- *See* CAPE website for tools

Resources

- DoD Cost Estimating Guide
- Cost/Schedule Control System Criteria Reference Guide
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook

- Manufacturing Readiness Level (MRL) Deskbook
- *See* CAPE website for guidance

F.3 Estimate Manufacturing and Quality Investment Budget

M&Q personnel need to support the development of program/project budget estimates for manufacturing activities that may need maturing to reach MRL 4 by MS A.

Manufacturing and Quality Tasks

- Estimate investments required for materiel solution approach:
  - Capital equipment (tooling, machines, structures, etc.)
  - Test equipment (specialized, environmental, etc.)
  - Facilities and modifications/expansion (handling, storage, transportation, disposal)
  - Government-furnished equipment (GFE)
- Identify new or high-risk M&Q processes that require investments as part of a manufacturing feasibility assessment to meet concept needs:
  - Assess ongoing ManTech, Title III, etc. program investments
  - Identify future ManTech, Title III, etc. program investments

Tools

- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- *See* CAPE website for tools http://www.cape.osd.mil/

Resources

- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- *See* CAPE website for guidance http://www.cape.osd.mil/

G. MATERIALS MANAGEMENT

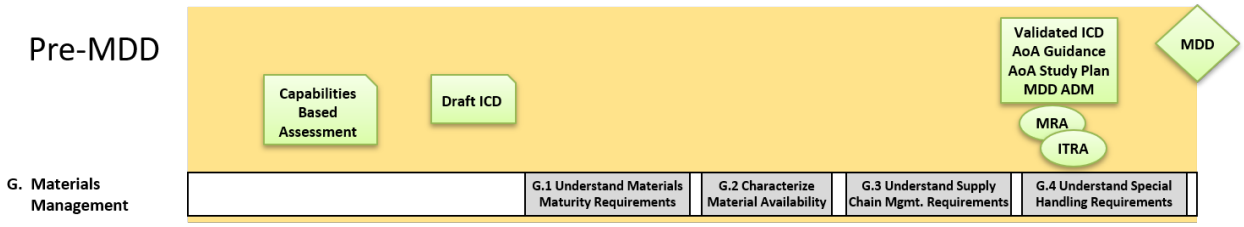


Figure 1-8. Materials Management Manufacturing and Quality Activities

Introduction

Materials management is a core function of supply chain management, including the process for planning and controlling material requirements and material flow through the entire supply chain. Materials management will require assessment of the maturity, the materials availability, the capability and capacity of the proposed supply chain to provide the materials, and the potential need for special handling, government-furnished property (GFP), shelf life, security, storage, environmental, requirements, etc. The process begins with the customer demand signal, and this information flows throughout the supply chain down many tiers: raw materials, fabrication, assembly, test, quality control, distribution, delivery, and acceptance by the customer. Major SCM functions include:

- Material characteristics and maturity
- Material risks
- Supplier management and quality
- Critical materials
- Special handling requirements
- Scale-up requirements / de-mil / shutdown

Materials management is a key focus of M&Q tasks for the concepts being considered for development. It requires assessment of the maturity, the materials availability, the capability and capacity of the proposed supply chain to provide the materials, and the potential need for special handling, government-furnished property (GFP), shelf life, security, storage, environmental, etc. requirements.

The assessment will identify the need for any additional research to mature materials and identify the properties, characteristics, and quality deemed necessary to support the concepts being considered. Material properties, characteristics, and quality will require experiments for validation and assessment for basic manufacturability.

The assessment will also identify materials that are available to support the concepts being considered, as well as the manufacturing, quality, and scale-up risks and issues. It will also identify those materials that are not readily available and will include identification of sources of material (from the NTIB or foreign sources). There are several ways the DoD can address material needs and shortages. One is through the Defense Production Act of 1950 and the implementation of the Defense Priorities and

Allocation System (DPAS) in which the government can designate programs as "high priority" and put them at the front of the contractor's production queue.

The complexity of the DoD supply chain for a weapon system is staggering with a supply chain that often encompasses hundreds of vendors and subcontractors. Adding to the complexity is the fact that on many large weapon system programs the prime contractor is often the integrator, with much of the program content coming from subcontractor, government, and other vendors or suppliers. Thus, managing the supply chain, which includes the materials and the associated schedules, becomes a key and critical management function.

This thread (Materials Management) requires an analysis of the risks associated with materials (including basic/raw materials, components, semi-finished, parts, and sub-assemblies).

G.1 Understand Materials Maturity Requirements

M&Q personnel need to assess and understand material properties for basic manufacturability using experiments. This will form the baseline for advancing the manufacturing readiness level as that material moves forward into acquisition and on into a weapon system.

Manufacturing and Quality Tasks

- Identify materials that require maturation plans to meet the next phase objectives.
- Identify needed material properties, characteristics, and quality for each materiel solution.
    - Identify and document appropriate metrics for evaluating materials against requirements
- Identify additional research and development (R&D) and experiments required for immature materials for validation and assessment of basic manufacturability
- Investigate ongoing programs (DoD, S&T, commercial, government, etc.) to identify materials that address each materiel solution need.
    - Assess materials manufacturing maturity
- Perform volatility assessments for each materiel solution:
    - Potential supply chain sources for critical materials
    - Special handling procedures that were applied in the lab and include in lead time estimates

Tools

- Design for Six Sigma (Tools)
- Design of Experiments Analysis
- Interactive MRL Users Guide (Checklist), Material Management thread
- Lead Time Estimator
- Manufacturing Maturation Plan

- Market Research Reporting Template
- Taguchi Loss Function Analysis

Resources

- Manufacturing Readiness Level (MRL) Deskbook

G.2 Characterize Material Availability

Material characterization refers to the process by which a material's structure and properties are analyzed and measured. It measures how a material will behave or perform. M&Q personnel need to support the identification and characterization of materials, material needs, and material availability to prepare for the introduction of that material on the factory floor.

Manufacturing and Quality Tasks

- Identify the availability of essential raw materials, special alloys, composite materials, and components required to support the concepts being considered.
- Assess material requirements, external dependencies, and availability for materiel solutions.
    - Identify materials that are:
        - Developed in a lab environment, but are not immediately available
        - Readily available within near term (i.e., commodities)
        - Commercially available, but have long lead times
        - Readily available, but have environmental or health concerns
- Assess material scale-up issues for materiel solutions.
- Identify items that are sole or single sourced, fragile source, or available only from sources outside the NTIB.
    - Assess the availability and lead time for alternatives for obtaining such items from within the NTIB
    - Conduct an analysis of any military vulnerability or gaps that could result from the lack of reasonable alternatives
- Assess the effects on the NTIB that result from foreign acquisition of firms in the United States.

Tools

- DCMA Industrial Capability Assessment Survey Form
- Diminishing Manufacturing Sources and Material Sources (DMSMS) Product Life Cycle Assessment (Consult Defense Logistics Agency (DLA))
- Interactive MRL Users Guide (Checklist), Material Management thread
- Lead Time Estimator

- Manufacturing Maturation Plan
- Market Research Reporting Template
- Technology Readiness Level Assessment Checklist

Resources

- DCMA Instruction 3401, Defense Indusial Base Mission Assurance
- DMSMS Guidebook, SD-22
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

G.3 Understand Supply Chain Management Requirements

M&Q personnel need to conduct an initial assessment of the supply chain to understand where the potential sources of supply are, and if there is any competition, or other supply chain risks.

Manufacturing and Quality Tasks

- Conduct an initial assessment of potential supply chain capability and capacity for materiel solution approaches.
- Recommend industry best practices to be followed for management of the materials supply chain for the concepts being considered.
    - Include industry best practices for M&Q to be followed in the supply chain for the concepts being considered
- Recommend M&Q processes or standards for the procurement team to follow to provide a basis for the team to work together and add value.
- Establish threshold and objective requirements for flow down of realistic and attainable requirements for a new concept to the supply chain as appropriate.
    - Identify realistic material estimates (time, material, manpower, etc.) to be provided to the entire supply chain
    - Evaluate the flow down process for gaps throughout the entire supply chain

Tools

- Interactive MRL Users Guide (Checklist), Material Management thread
- Lead Time Estimator
- Manufacturing Maturation Plan
- Supply Chain Management Risk Assessment Checklist

Resources

- DoD 4140.01-R, Supply Chain Materiel Management
- DoD Market Research Guide
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

G.4 Understand Special Handling Requirements

M&Q personnel need to be aware of the need for special handling of material to include government-furnished property (GFP), government-furnished equipment (GFE), hazardous materials, special storage and shelf-life, security, etc.

Manufacturing and Quality Tasks

- Identify the special requirements in the manufacturing processes that will be used to build the materiel solution approaches.
    - Hazardous materials and handling procedures
    - Security requirements
    - Storage and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal
- Identify potential regulatory requirements, handling concerns, transportation, etc., for materiel solution approaches.

Tools

- Cyber Security Assessment
- DMSMS Product Life Cycle Assessment
- Hazardous Material Assessment Template
- Interactive MRL Users Guide (Checklist), for Material Management thread
- ISO 9001, Checklist Section 7.5.5, Preservation (Handling, Storage, Packaging and Delivery)
- ITAR Compliance Checklist
- Lead Time Estimator
- Manufacturing Maturation Plan
- Preliminary Hazard List (PHL) (*See* PHA checklist)
- Shelf Life Calculator for Composite Materials

Resources

- SAE AS9100 Quality Management Systems
- AS9133 Qualification Procedure for Aerospace Standard Products

- ESOH in Acquisition Guide
- ISO 9001, Quality Management Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook

H. PROCESS CAPABILITY AND CONTROL

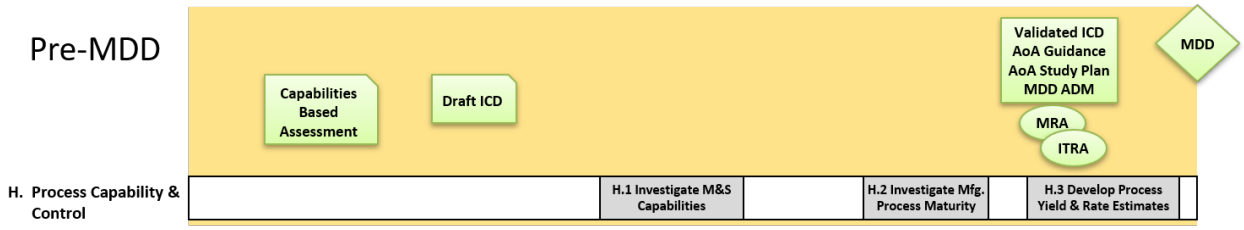


Figure 1-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with "uniform, defect-free product" that has consistent performance and is affordable. Product quality comes from robust product and process design and process control activities including continuous process improvement to identify and remove sources of variation.

Process Capability and Control is a requirement of both SAE AS9100 Quality Management Systems and SAE AS6500 Manufacturing Management Program. It requires a process control plan that describes the actions and activities that will demonstrate process capabilities.

As a best practice, M&Q personnel should analyze process capabilities for each Key Manufacturing Process (KMP) and CMP. The engineering team should use statistical tools to minimize variability and calculate the process capability index (Cpk), if applicable.

For each concept being considered, the M&Q lead should determine the manufacturing process capability. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Critical and key manufacturing processes can also be identified during the assessment and analysis either through M&S or experimentation, such as:

- Capability studies
- Yields and rates
- Process demonstrations

Important definitions include the following:

- Key Characteristics (KC): An attribute or feature whose variation has a significant influence on product fit, form, function, performance, service life, or producibility that requires specific actions for the purpose of controlling variation.
- Key Manufacturing Process (KMP): A process that creates or substantially affects a key characteristic.
- Critical Characteristic (CC): A characteristic whose variation has a significant impact on human safety, or could cause a catastrophic failure resulting in loss of life, permanent disability, or major injury to personnel.

Advances in digital engineering to include modeling and simulation (M&S) along with continual improvements in computer performance have made it possible to perform comprehensive analysis of virtual parts and to test and assess the capability of processes before actual manufacturing begins. The use of solid modeling, finite element analysis, multi-paradigm numerical computing environments, and simulation software analysis tools allows users to simulate different conditions that are likely to occur during manufacturing processes and model the behavior of systems under real-world conditions. An understanding of the capabilities to model products and processes for each of the concepts under consideration can be a valuable discriminator.

The activities managing the concept and program offices must understand the manufacturing feasibility (i.e., manufacturing risks) associated with each potential materiel solution. For example, managers may be under the false impression that identical production facilities will experience identical problems; often this is not the case. Another assumption may be that if a facility has operated smoothly in one location it will operate smoothly again if moved to another location. This often is not the case, even with the same workforce; variability from disassembly, movement, and reassembly will occur. A source of information for these feasibility risks comes from the “lessons learned” data captured by contractors as part of their systems to capture their overall capabilities, knowledge, and best manufacturing practices. Incorporating lessons learned from investigations of similar manufacturing processes maturity into the models and simulations may also increase fidelity of results and characterization of the items being analyzed.

Most companies use M&S and other data analysis tools to help identify, analyze, and remove bottlenecks in the production process, improve yields, reduce costs, and improve quality. By collecting and analyzing the M&Q data, one can get a realistic picture of the entire process. A process has three features: how much variation (spread), where (centering), and shape (normal, skewed, bimodal, etc.). If processes are stable, then the process features, spread, centering, and shape, will remain constant and predictable over time. If the process is unstable, then these features will change, and the product output will become unpredictable. Data and information from similar manufacturing processes, as well as M&S processes, should be used to develop estimates of potential yields and rates of production of each concept under consideration as a discriminator as to which has the greatest potential to meet M&Q requirements.

This thread (Process Capability and Control) requires an analysis of the risk that the manufacturing processes may not be able to reflect the design intent (repeatability and affordability).

H.1 Investigate Modeling and Simulation (Product and Process) Capabilities

M&Q personnel need to support the understanding of needed process capabilities using modeling and simulation techniques.

Manufacturing and Quality Tasks

- Investigate initial product and or process models in development for materiel solution approaches.
- Investigate manufacturing concepts or producibility modeling and simulation needs of materiel solution approaches.
- Identify modeling and simulation tools that make it possible to perform a comprehensive analysis of virtual parts and to assess the capability of processes before actual manufacturing begins.
- Use modeling and simulation software to model the behavior of materiel solutions under simulated "real-world" conditions.
- Establish requirements and data needs for the learning curve (cost improvement curve, or experience curve).

Tools

- SAE AS9100 Checklist
- SAE AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Learning Curve Worksheet
- Manufacturing Maturation Plan
- Plant Modeling and Simulation tools (e.g., FlexSim, SimFactory)
- Process Modeling Tools (e.g., Siemens PLM, Delmia)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins)

Resources

- SAE AS9100, Quality Management System
- SAE AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Simulation Applications
- Modeling and Simulation Guidance for the Acquisition Workforce

H.2 Investigate Manufacturing Process Maturity

M&Q personnel need to be able to assess a materials current process maturity and develop a roadmap for maturing that technology if it should move forward into acquisition.

Manufacturing and Quality Tasks

- Assess feasibility of similar materials and/or similar manufacturing process approaches, and the projected gaps based on the data collected for each concept under consideration for the AoA Study Guidance.
- Conduct a manufacturing feasibility assessment that identifies the M&Q risks incurred for each concept under consideration, which should include:
    - Producibility of the potential design concepts
    - Critical and key manufacturing processes
    - Special tooling development required
    - Demonstration, test, and qualification required for new materials, to include items, parts, and components
    - Alternate design approaches within the individual concepts
    - Lessons learned from similar approaches
    - Anticipated M&Q risks and potential cost and schedule impacts
- Establish plans for identifying critical manufacturing processes and their continuous improvement.

Tools

- SAE AS9100 Checklist
- SAE AS6500 Checklist
- Feasibility Study Checklist
- First Pass Yield Estimates Worksheet
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Studies (Cp and Cpk assessment)
- Producibility Assessment Worksheet (PAW)
- Six Sigma Worksheet

Resources

- SAE AS9100, Quality Management System
- SAE AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook

- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687

H.3 Develop Process Yield and Rate Estimates

M&Q personnel need to be able to investigate a potential material's current or potential process yields and rates and develop estimates of yields and rates that may be required if the material goes past the MDD.

Manufacturing and Quality Tasks

- Identify or estimate the process capability for those critical manufacturing processes.
- Develop and estimate yields and rates of materiel solution approaches.
- Develop other product and process quality metrics, and set goals for production.
- Conduct an M&Q study of existing processes and the need for new processes for each concept under consideration to determine if the yield meets the requirements.
- Identify the sources of variations and plans to address for each concept under consideration.

Tools

- SAE AS9100 Checklist
- Cause and Effect Diagram
- First Pass Yield Estimates Worksheet
- Histograms
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Pareto Analysis
- Process Capability Study Worksheet (Cp and Cpk Assessment)
- Six Sigma Worksheet

Resources

- SAE AS9100 Quality Management System
- SAE AS6500 Manufacturing Management Program
- AS9103 Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

I. QUALITY MANAGEMENT

Figure 1-10. Quality Management Manufacturing and Quality Activities

Introduction

DoD has increased focus on M&Q management during early program phases. Quality is the degree to which material attributes, performance features, and characteristics of a product satisfy a given need. Quality may apply to a product, process, or system and may be physical, sensory, behavioral, temporal, ergonomic, or functional.

Quality management is an integral part of design and development efforts. QMS standards include industry best practices such as ISO 9001, Quality Management Systems–Requirements. SAE AS9100, Quality Management Systems–Requirements for Aviation, Space and Defense Organizations, Product Realization (clause 7) includes typical SE tasks under sub-clause 7.3, Design and Development. The typical SE processes included in the QMS are:

- Design and Development Planning – SE Management, Failure Modes, Effects, and Criticality Analysis (FMECA), System Safety, etc.
- Design and development inputs/outputs – T&E, reviews, and audits
- Design and development review, verification, and validation
- Control of design and development changes – hardware and software configuration management
- Hardware and software configuration management
- Risk, issue, and opportunity management
- Corrective Action System
- Monitoring and measuring equipment calibration records
- Records of training, skills, experience, and qualifications
- Product/service requirements review records
- Record about design and development outputs review
- Record about design and development inputs
- Records of design and development controls
- Records of design and development outputs
- Design and development change records
- Characteristics of product to be produced and service to be provided
- Records about customer property

- Production/service provision change control records
- Record of conformity of product/service with acceptance criteria
- Record of nonconforming outputs
- Monitoring measurement results
- Internal audit program
- Results of internal audits
- Results of the management review
- Results of corrective actions

This thread (Quality) requires an analysis of the risk and management efforts to control quality and foster continuous quality improvement and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Quality Management System (QMS)
- Quality Strategy and Plan
- Product Quality
- Supply Chain Quality
- Quality Risk

I.1 Quality Management Requirements

M&Q personnel should identify the potential requirements for a Quality Management System (QMS) of an identified material based on FAR 46.202 Types of Contract Quality Requirements, and FAR 52.2456-11 Higher-Level Contract Quality Requirements.

M&Q personnel may also consider related clauses to include:

- Inspection of supplies and services clauses, 52.246-2 thru 52.246-9 to ensure appropriate government access, oversight, and protection.
- Warranty for supplies and/or services: 52.246-17 thru 52.246-21 though mainly -18, -19, and -20 depending on what work is being done and what product is being delivered.

Best practice includes contractors operating to either ISO 9001 Quality Management System or SAE AS9100 Quality Management System. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

Manufacturing and Quality Tasks

- Specify the contract quality management requirements to be met by the contractor or government entity as appropriate.
- Evaluate each concept being considered and identify the capability to meet quality management needs.

  - Evaluate each concept being considered and identify the need for focused manufacturing or quality plans (e.g., a program Quality Assurance Plan) to guide the approach
  - Evaluate each concept being considered and identify the need for a stand-alone government manufacturing or quality assurance plan

- Assess the impact of technology and process state of the art on the concepts being considered and the impacts on quality management.
- Identify and understand potential solutions or systems that could address quality management needs.
  - Identify and understand M&Q management lessons learned and best practices among programs and across centers
  - Assess and evaluate quality technologies that could assist on materiel solution programs
- Identify potential solutions or systems to improve low-yield processes and components.
- Establish quality management metrics for each of the concepts being considered
  - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Evaluate the QMS in use for each of the concepts being considered.
  - The QMS should include:
    - Management responsibility
    - Resource management
    - Quality System
    - Contract Review
    - Product Realization
    - Design Control
    - Document Control
    - Purchasing
    - Purchaser-Supplied Product
    - Product Identification and Traceability
    - Process Control
    - Measurement, Analysis, and Improvement (i.e., metrology and calibration)
  - Assess QMS audit records for frequency, compliance, and responsiveness
- Evaluate the contracts and in appropriate agreements with other agencies, e.g., the DCMA to ensure quality and manufacturing requirements are included.
- Ensure that the QMS evaluation of potential contractors and suppliers for each concept being considered includes DCMA input.

Tools

- SAE AS9100, Quality Audit Checklist

- Critical to Customer Assessment
- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Quality Management thread
- ISO 9001, Quality Management Systems, Quality Audit Checklist
- Manufacturing Maturation Plan
- Quality Management Plan (Sample)

Resources

- AFMC Instruction 63-145, Manufacturing and Quality
- SAE AS9100, Quality Management System – Aerospace
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management Systems
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

I.2 Product Quality Requirements

M&Q personnel need to identify the potential product quality requirements of an identified material based on FAR 46.202, Types of Contract Quality Requirements, and FAR 52.246.1, Contractor Inspection Requirements. In addition, the organization needs to identify the process of measuring, examining, testing, or otherwise comparing the product to the requirements for acceptance. FAR 46.291 Production Lot Testing states that the purpose of production lot testing is to validate quality conformance of products before lot acceptance, which usually occurs after acceptance testing.

Manufacturing and Quality Tasks

- Evaluate product quality requirements for each concept being considered:
    - Identify product acceptance methods and determine sampling plan as appropriate
    - Identify product quality metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks
    - Identify the need for focused product quality requirements (i.e., specific product characteristics) to guide the approach
    - Identify the need for government-unique product quality requirements
- Identify and understand potential solutions that could address product quality needs.
    - Assess and evaluate quality technologies (e.g., metrology technologies) that could improve the materiel solution's product quality
    - Identify potential solutions to improve low-yield processes and components for each materiel solution's product quality

- Assess the impact of quality technology and process state of the art on the product quality requirements of the concepts being considered.
- Ensure that the QMS evaluation of potential contractors and suppliers for each concept being considered includes DCMA input.
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements.
- Ensure that measuring and testing devices are calibrated at specified intervals before use and are traceable to national standards.

Tools

- AS9100, Quality Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Quality Management thread
- ISO 9001, Quality Management Systems, Quality Audit Checklist
- Manufacturing Maturation Plan
- Lot Acceptance Testing Calculator
- Quality Management Plan (Sample)

Resources

- AS9100, Quality Management System
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management Systems
- MIL-STD-1916, DoD Test Method Standard
- ANSI Z1.4 Sampling Procedures and Tables for Inspection by Attributes
- ANSI Z1.9 Sampling Procedure and Tables for Inspection by Variables for Percent Nonconforming
- DCMA-INST 302, First Article and Production Lot Testing
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

I.3 Supplier Quality Management Requirements

M&Q personnel need to identify potential sources of supply for an emerging material and identify the proposed supplier quality requirements that should be invoked if the material goes forward.

Manufacturing and Quality Tasks

- Assess the impact of quality technology and process state of the art for the concepts being considered and the impacts on the supply chain (i.e., supplier's) quality management.
- Evaluate each concept being considered and identify supply chain quality management needs.
    - Evaluate each concept being considered and identify the need for focused supplier quality management requirements (e.g., a supplier Quality Assurance Plan) to guide the approach
    - Evaluate each concept being considered and identify the need for a stand-alone government supplier quality plan for the supply chain
- Establish supply chain quality management metrics for each of the concepts being considered for incoming quality inspection to include the identification of inspection and testing requirements including potential use of acceptable quality levels (AQLs).
    - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Identify and understand potential solutions, tools, and techniques that could address supplier quality management requirements.
    - Assess and evaluate quality technologies (i.e., metrology technologies) that could improve the materiel solution's supply chain programs
    - Identify potential solutions (e.g., materials, machines, training) to improve low-yield processes and components and lower variability to meet supplier quality management requirements for each materiel solution
- Ensure that the assessment of potential supplier's quality management (in the lower supply chain) for each concept being considered includes DCMA input.
- Ensure quality and manufacturing requirements are included in contracts of proposed suppliers and in appropriate agreements with other agencies (e.g., DCMA).

Tools

- AS9100, Quality Audit Checklist
- AS9133, Supplier Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Quality Management thread
- ISO 9001, Quality Management Systems, Quality Audit Checklist
- Manufacturing Maturation Plan
- Supplier Quality Questionnaire

Resources

- AS9100, Quality Management System – Aerospace

- AS9133, Supplier Quality Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management Systems
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

J. MANUFACTURING WORKFORCE

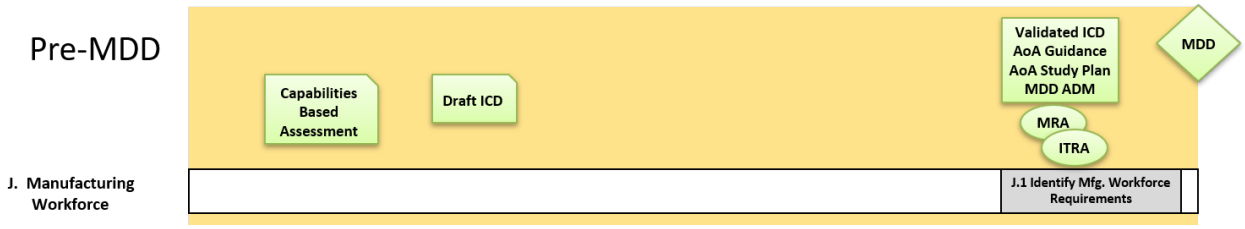


Figure 1-11. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

M&Q workforce requirements, planning, and analysis covers a range of knowledge, skills, and abilities from a competency perspective. Workforce availability is also a concern as companies may face shortfalls in personnel. In addition to specific labor skills (welding, machining, fabrication, assembly, inspection, testing, etc.) associated with production processes, there is a need for M&Q personnel to understand the requirements for fabrication and assembly of countless types of materials.

Manufacturing feasibility and industrial base analyses of the concepts being considered should address the existing skills of the appropriate workforce. The M&Q workforce has been aging in recent decades, especially in many key defense sectors. Established manufacturing capabilities are becoming high risks as skills, facilities, equipment, etc., atrophy. Manufacturers have experienced a moderate to severe shortage of available, qualified production workers and a moderate to severe skills shortage in their overall workforce. They anticipate these shortages to grow worse in the coming years, and workforce shortages and skills deficiencies in production roles are having a significant impact on the ability to expand operations or improve productivity.

This thread (Workforce) outlines the assessment of required personnel skills and availability to support the manufacturing effort.

J.1 Identify Manufacturing Workforce (Engineering and Production) Requirements

M&Q personnel need to support the identification of potential workforce skills, training, and availability requirements based on an identified emerging material and processes.

Manufacturing and Quality Tasks

- Identify new M&Q skills and training requirements for materiel solution approaches to include the need for a Training and Certification Program.
- Identify planned personnel loadings to ensure that adequate numbers of people with the required skills are made available for each candidate materiel solution approach
    - Define a profile of the required workforce
    - Identify workforce requirements, special skills, and training requirements.
    - Identify sources of personnel and their potential availability
    - Plan for the acquisition and training of new personnel
- Review appropriate workforce lessons learned to initiate development of tools and techniques that can be used to establish a better manufacturing workforce strategy.
- Assess new materials and technologies as they evolve and how the M&Q workforce will address processing, testing, and acceptance of these materials.
- Identify potential regulatory requirements and special handling (e.g., hazardous materials, environmental needs, storage requirements, etc.) impacts to the manufacturing workforce by the materiel solution approaches.
- Review and document workforce lessons learned and apply them to development of tools and techniques for a better manufacturing workforce strategy.
- Assess and document impacts of new materials and technologies on the M&Q workforce for each concept, including impacts of processing, testing, and acceptance of these materials and technologies.
- Assess and document potential regulatory requirements and special handling (e.g., hazardous materials, environmental needs, storage requirements, etc.) impacts to the manufacturing workforce for each concept, for the AoA Study Guidance.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Manufacturing Workforce thread
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis

- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRP II)

Resources

- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)

K. FACILITIES

Figure 1-12. Facilities Manufacturing and Quality Activities

Introduction

Facilities management encompasses a variety of professional skills that focus on the design, construction, and management of an installation including plant and equipment. Facilities management includes all permanent and semi-permanent real property required to support a system throughout the system's life cycle. Facility management also includes studies of facility requirements to include: location, environmental and security considerations, and maintenance of property through disposal.

During the Pre-MDD phase, the proposed industrial and manufacturing facilities should be assessed for resources needed by each concept being considered as a materiel solution. Assessment of facility needs for concepts includes real property, factory capacity and storage, special handling and special environmental requirements, storage and handling of hazardous materials, capital equipment, manufacturing processes, tooling, and materiel transportation. Use of new materials and technologies will often require concurrent development and procurement of new capital equipment, test equipment and facilities, and development of new quality assurance procedures and equipment. Use of test ranges and special test facilities should be listed and a notional schedule of when those government assets will be needed. Many government facilities are becoming increasingly obsolete and constantly undergoing consolidation. The M&Q representatives should also identify any requirement for reconstitution or investment in government facilities, labs, ranges, etc. for each concept being considered.

The facility includes the plant, production equipment, and waste handling and storage equipment to be made available to accomplish the production task. In developing the facility plan, both the quantitative and qualitative demands of the product must be considered. The quantitative analysis will determine the size of the processing departments within the facility. This analysis should consider the number of

units to be delivered, and the rate of delivery. For example, the information collected in the analysis will provide a measure of the workstations, plant layout, and the floor space required. The qualitative analysis determines the types of processes that will be required. The contractor then has the option of utilizing currently existing facilities, acquiring new facilities, requesting government-furnished facilities (must be requested in the proposal), or subcontracting a portion of the effort.

Funding profiles for all the aspects of each concept being considered must provide for up front development of capital equipment, manufacturing processes, tooling, and verification that new components can be produced at production rates. A top-level schedule and target costs should be developed. Development for each concept and installation of tooling, test equipment, and facilities are necessary drivers of each concept's costs and development schedule. The overall results of these assessments, estimates, and evaluations should be included in the AoA Study Guidance.

This thread (Facilities) requires an analysis of the capabilities and capacity (Prime, Subcontractor, Supplier, Vendor, and Maintenance Repair) that are key risks in manufacturing.

K.1 Evaluate Special Tooling/Special Test and Inspection Equipment Requirements

M&Q personnel need to support the identification of special tooling (ST), special test equipment (STE), and special inspection equipment (SIE) requirements based on an identified emerging material and processes.

Manufacturing and Quality Tasks

- Identify new capital equipment and tooling required for new technology and material M&Q processes for each concept being considered.
    - Assess new tooling requirements for capability to produce at planned production rates and target unit costs
    - Assess needs for soft tooling vs. hard tooling for facility and funding impacts
    - Assess supplier and sub-tier capabilities and investment incentives
    - Assess the funding requirements and develop appropriate funding profiles
- Evaluate each concept being considered to include alternative designs for ST/STE/SIE:
    - Assess the requirements for ST/STE/SIE
    - Assess the capabilities of ST/STE/SIE to meet needs
- Evaluate each concept being considered to include alternative designs for government-furnished equipment (GFE):
    - Assess the requirements for GFE
    - Assess the capabilities of GFE to meet needs
- Identify requirements for unique or special transportation, handling, and storage equipment to be manufactured for each materiel solution.

- Identify the funding required for capital equipment, M&Q processes, tooling, and test equipment for each concept being considered.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)

Resources

- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)

K.2 Identify Facilities Requirements

M&Q personnel need to support the identification of production facility requirements should the emerging material go forward into the MSA phase. Facility considerations include the capability and capacity to produce an item at potential rates and quantities, at the appropriate quality levels, and in an affordable manner.

Manufacturing and Quality Tasks

- Identify the facilities and capital equipment required by each of the concepts being considered.
- Identify the quantitative and qualitative demands of the each of the concepts being considered.
    - Identify the availability, design, rate, and capacity capabilities of the facilities under consideration (existing, new, or redeveloped)
    - Identify the types of processes required and the resulting impacts on facilities by each of the concepts being considered (e.g., specialized fixtures, test chambers, laboratories, clean rooms, waste storage and disposal, etc.)
    - Identify the unique or special facility requirements for transportation, handling, and storage equipment being manufactured for each materiel solution
- Identify the funding required for facilities and capital equipment for each concept being considered.

Tools

- Bottleneck Analysis (Theory of Constraints)

- Critical Chain Project Management
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRP II)
- Manufacturing Resource Planning (MRPII)
- MRL Assessment using Facilities thread
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)

L. MANUFACTURING MANAGEMENT AND CONTROL

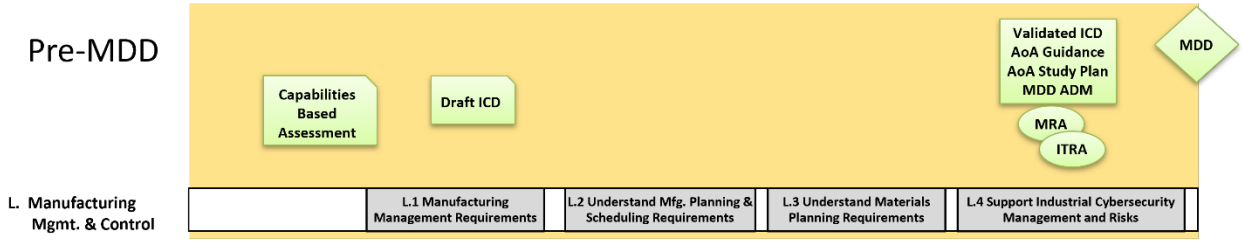


Figure 1-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

Programs with any manufacturing aspects will require a manufacturing management system. The timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risks and issues throughout the program life cycle will only be met by a comprehensive system. Meeting this objective is best accomplished by including best practices and standards (i.e., AS6500, Manufacturing Management Program) in the contracts with industry. MIL-HDBK-896, Manufacturing Management Program Guide, provides a comprehensive description of considerations.

Beginning in this phase, the activities managing the concept (or program office) should begin the planning for manufacturing management and control of the concepts under consideration. This planning will evolve and should be updated during the subsequent acquisition phases. The purpose of manufacturing planning is to identify resources and integrate resources into a structure that provides the capability to achieve production objectives. Manufacturing planning should include:

- Manufacturing requirements in contracts and in appropriate agreements with other agencies (e.g., DCMA)

- Manufacturing assessments to support program milestone decision points and major design reviews
- Manufacturing metrics and reviews at a frequency commensurate with manufacturing risks

DoD Manufacturing Management is concerned with the conversion of raw materials into products based upon a detailed design. This conversion is accomplished through a series of manufacturing procedures and processes. It includes such major functions as manufacturing planning, cost estimating and scheduling; engineering; fabrication and assembly; installation and checkout; demonstration and testing; and product assurance. Manufacturing considerations begin as early as during the Analysis of Alternatives (AoA) in which the manufacturing manager and the PM must be able to understand the "manufacturing feasibility (risks)" are that are associated with each materiel solution.

- Manufacturing strategy and planning
- Manufacturing management system program
- Material management system
- Manufacturing resource planning
- Assess production lines
- Manufacturing strategy and planning
- Manufacturing management system program
- Material management system
- Manufacturing resource planning
- Assess production lines

L.1 Manufacturing Management Requirements

M&Q personnel need to identify the potential need for a Manufacturing Management Program for the emerging requirement.

Manufacturing and Quality Tasks

- Identify the manufacturing management system requirements (i.e., AS6500) to be met by the contractor or government entity during subsequent phases as appropriate in the areas of:
    - Design analysis for manufacturing
    - Manufacturing risk identification
    - Manufacturing planning
    - Manufacturing operations management
- Evaluate each concept being considered and identify the capability to meet manufacturing management needs.
    - Evaluate each concept being considered and identify the need for focused manufacturing or quality plans (e.g., a program Manufacturing Management Plan) to guide the approach

  - Evaluate each concept being considered and identify the need for a stand-alone government manufacturing or quality assurance plan

- Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- Identify and understand potential sources that could address manufacturing management needs.
  - Identify and understand M&Q management lessons learned and best practices among programs and across centers
  - Assess and evaluate manufacturing technologies that could assist on materiel solution programs.
- Establish manufacturing management metrics for each of the concepts being considered
  - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Contact DCMA for input on manufacturing management system evaluation of potential contractor and suppliers for each concept being considered.

Tools

- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRP II)

Resources

- MIL-HDBK-896, Manufacturing Management Program Guide
- AS6500, Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)

L.2 Understand Manufacturing Planning and Scheduling Requirements

M&Q personnel need to support the identification of Manufacturing Resource Planning requirements.

Manufacturing and Quality Tasks

- Initiate planning for each materiel solution approach to include, as a minimum:
  - Description of the M&Q organization
  - Describe the make or buy plan
  - Description and initial identification of resources and M&Q capabilities

  - Identification of M&Q data requirements for facilities, processing, and scheduling

- Evaluate the overall manufacturing feasibility analysis for inputs to planning and scheduling. The analysis should have included:
  - Producibility
  - Critical and key M&Q processes
  - Special tooling requirements
  - Test and demonstration requirements for new materials and processes
  - Alternate design approaches
  - Anticipated M&Q risks and potential cost impacts and identify the needed actions to be incorporated into the initial M&Q plan
- Ensure manufacturing planning addresses transition considerations that may be impacted by:
  - Funding constraints and phasing of money
  - Design considerations, goals, and risks
  - Test and evaluation methods and approaches along with success criteria
  - Production processes, methods, workforce, facilities, equipment, and capabilities
  - Life cycle logistics and sustainment criteria, approach, and goals
  - Management approach to transition risks

Tools

- Assembly Chart
- Interactive MRL Users Guide (Checklist) Manufacturing Management and Control thread
- Line of Balance Assessment
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRP II)
- Operations Process Chart
- Route Sheet
- Work Breakdown Structure

Resources

- SAE AS6500, Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)

L.3 Understand Materials Planning Requirements

M&Q personnel need to support the identification for Material Requirements Planning.

Manufacturing and Quality Tasks

- Assess feasibility and quality of materials to be used for each materiel solution approach.
  - Assess the maturity (technical and characterization) of material sources, essential raw materials, special alloys, composite materials, etc.
  - Understand alternatives to preferred materials for each materiel solution
- Assess all aspects of tasks in materiel availability (*See* Section G.2).
  - Assess the quality, processing, aging, handling, and transit times, etc., as an impact to lead times to include alternative materials
  - Evaluate military vulnerability from source considerations such as quality, fragility, sole source, domestic vs. foreign, etc., for the AoA Study Guidance and MDD processes that could result from the lack of alternatives

Tools

- Bill of Material assessment
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- Make/Buy Decision
- Manufacturing Maturation Plan
- Parts List
- Production Plan (schedule)

Resources

- SAE AS6500, Manufacturing Management Program
- Manufacturing Readiness Level (MRL) Deskbook Manufacturing Resource Planning (MRP II)

L.4 Support Industrial Cybersecurity Management and Risk Assessment

Industrial cybersecurity is concerned with the ability of organizations to share information digitally (government to industry, prime contractor to subs, labs to program offices, etc.). While the sharing of information is critical, it is equally important to do so in a safe and secure environment. Industrial cybersecurity is concerned with the transfer of digital data via Operational Technologies (OT) inside a facility and through the cloud to other organizations and facilities.

NIST standard NIST SP 800-37, "Risk Management Framework for Information Systems and Organizations" defines Operational Technology as:

> "*Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems/devices detect or cause a direct change through the monitoring and/or control of devices,*

processes, and events. Examples include industrial control systems, building management systems, fire control systems, and physical access control mechanisms."

There are three main types of operational technologies of concern:

- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution system (MES) support the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers.
- Enterprise resource planning (ERP) system supports functional management resources within an enterprise, and control process performance.

These data systems are often digital and shared across multiple functions and organizations.

DFARS 252.204-7012 requires contractors to follow NIST SP 800-171 and to:

- Provide adequate security to safeguard covered defense information that resides on or is transiting through a contractor's internal information system or network.
- Report cyber incidents that affect a covered contractor information system or the covered defense information residing therein.
- Submit malicious software discovered and isolated in connection with a reported cyber incident to the DoD Cyber Crime Center.
- Submit media/information as requested to support damage assessment activities.
- Flow down the contract clause in subcontracts for operationally critical support, or for which subcontract performance will involve covered defense information.

Manufacturing, as an industry, is the most targeted industry for cyber-attacks. DoD policy and best business practices require that data be protected from attack. This includes classified data, controlled unclassified data (CUI), personal data, financial data, etc.

This thread (Industrial Cybersecurity) requires an analysis of the risk that the manufacturing environment may not be able to protect digital and other forms of data from cyber risks and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Identification of Cybersecurity Risks
- Cybersecurity Planning and Management (Execution)

M&Q personnel need to identify and manage industrial cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the AAF.

M&Q personnel need to develop and execute industrial cybersecurity planning for system concepts identified and execute the management of those plans. Programs will employ system security engineering methods and practices, including cybersecurity, cyber resilience, and cyber survivability

in design, test, manufacture, and sustainment. Such methods and practices will ensure that systems function as intended, mitigating risks associated with known and exploitable vulnerabilities to provide a level of assurance commensurate with technology, program, system, and mission objectives.

Manufacturing and Quality

- Identify cybersecurity requirements for potential concepts.
- Identify potential OT cybersecurity vulnerabilities of potential manufacturing facilities.

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (DAU)
- Cybersecurity Strategy ADDM Template
- MRL Deskbook and Assessment Criteria
- Interactive MRL Users Guide (Checklist), Cybersecurity thread
- USMC Cybersecurity Management Checklist

Resources

- FAR 52.202.21 Basic Safeguarding of Covered Contractor Information Systems
- DFAR 252.7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.83, Technology and Program Protection
- DoDI 8500.01, Cybersecurity
- DoDI 5000.90, Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoD 5220.22-M, National Industrial Security Program
- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle
- NIST SP 800-171, Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations
- NIST Special Publication 800-82, Guide to Industrial Control Systems (ICS) Security

This page is intentionally blank.

Department of Defense
Manufacturing and Quality Body of Knowledge
(M&Q BoK)

Chapter 2
Materiel Solution Analysis (MSA) Phase

November 2022
Version 1.1

Office of the Under Secretary of Defense
Research and Engineering

Washington, D.C.

The appearance of external hyperlinks does not constitute endorsement by the United States Department of Defense (DoD) of the linked websites, or the information, products, or services contained therein. The DoD does not exercise any editorial, security, or other control over the information you may find at these locations.

Department of Defense Manufacturing and Quality Body of Knowledge (M&Q BoK)

Office of the Under Secretary of Defense for Research and Engineering
Executive Director, Systems Engineering and Architecture
3030 Defense Pentagon
Washington, DC 20301-3030
Email: osd.r-e.comm@mail.mil | Attention: SE&A
https://ac.cto.mil/engineering
Approved for public release. DOPSR Case # 23-S-0359.

Contents

Figures

Introduction: How to Use the M&Q BoK

The Department of Defense (DoD) Manufacturing and Quality (M&Q) Body of Knowledge (BoK) is a compilation of best practices and lessons learned for completing M&Q activities across the DoD system acquisition life cycle. The office of the Executive Director, Systems Engineering and Architecture (ED, SE&A) prepared the BoK and will update the work periodically to reflect current policy, guidance, tools, and best practices. This document does not supersede DoD policy, guidance, or law.

The BoK details M&Q activities throughout the system life cycle but is not intended to be read from end to end. DoD Engineering and Technical Management (ETM) practitioners and managers may refer to the BoK to find information relevant to the phase of the program they are working on. Within a specific phase, the user may focus on the section and tasks that apply (with appropriate tailoring) for the M&Q activities the program is conducting.

The BoK chapters cover recommended M&Q activities and tasks during each acquisition life cycle phase to meet DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework.

The BoK includes 6 chapters:

- Chapter 1: Pre-Materiel Development Decision (Pre-MDD)
- Chapter 2: Materiel Solution Analysis (MSA)
- Chapter 3: Technology Maturation and Risk Reduction (TMRR)
- Chapter 4: Engineering and Manufacturing Development (EMD)
- Chapter 5: Production and Deployment (P&D)
- Chapter 6: Operations and Support (O&S)

Each chapter focuses on the DoDI 5000.02 activities and program documentation required for that phase. Each chapter uses the following format:

- **Introduction:** Discusses the objectives of that phase to allow the user to understand the environment and requirements.
- **Manufacturing and Quality Objectives:** Discusses roles, goals, and objectives of program M&Q during this phase.
- **Threads:** Twelve threads or topic areas include discussions of major M&Q functions based on the "5 Ms" (Manpower, Machines, Materials, Methods, Measurement); Manufacturing Readiness Level (MRL) criteria; and DoD-unique M&Q-related functions not found in industry (i.e., DoD acquisition system, defense contracting system, and surveillance system). The 12 threads are labeled with letters A through L as follows:

  A. DoD Acquisition System
  B. Defense Contracting System
  C. Surveillance System
  D. Technology and Industrial Base

E. Design
F. Cost and Funding
G. Materials Management
H. Process Capability and Control
I. Quality Management
J. Manufacturing Workforce
K. Facilities
L. Manufacturing Management and Control

Each thread includes several **Activities** represented by gray boxes in the corresponding chapter figure (Figure 1). Activities are numbered A.1, A.2, A.3 . . . B.1, B.2, B.3, etc. The BoK includes the following for each activity:

- Activity overview description
- **Tasks** that M&Q personnel could be expected to support or lead.
- **Tools** such as checklists, templates, and samples available to M&Q personnel intended to help them to accomplish these tasks.
- **Resources** including guidance documents, handbooks, manuals, instructions, memos, etc., that provide direction to M&Q personnel for tasks identified in the gray box.

Example: Figure 1 shows Threads, Documents, Activities, and Reviews for the EMD Phase.

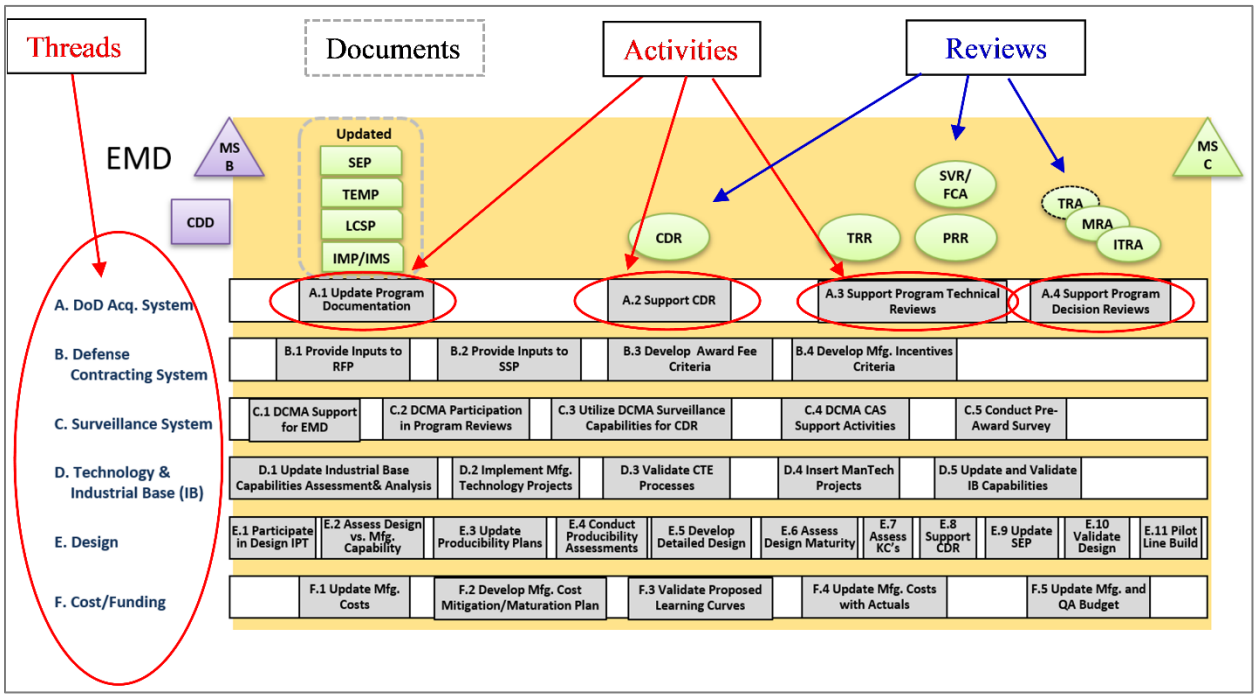
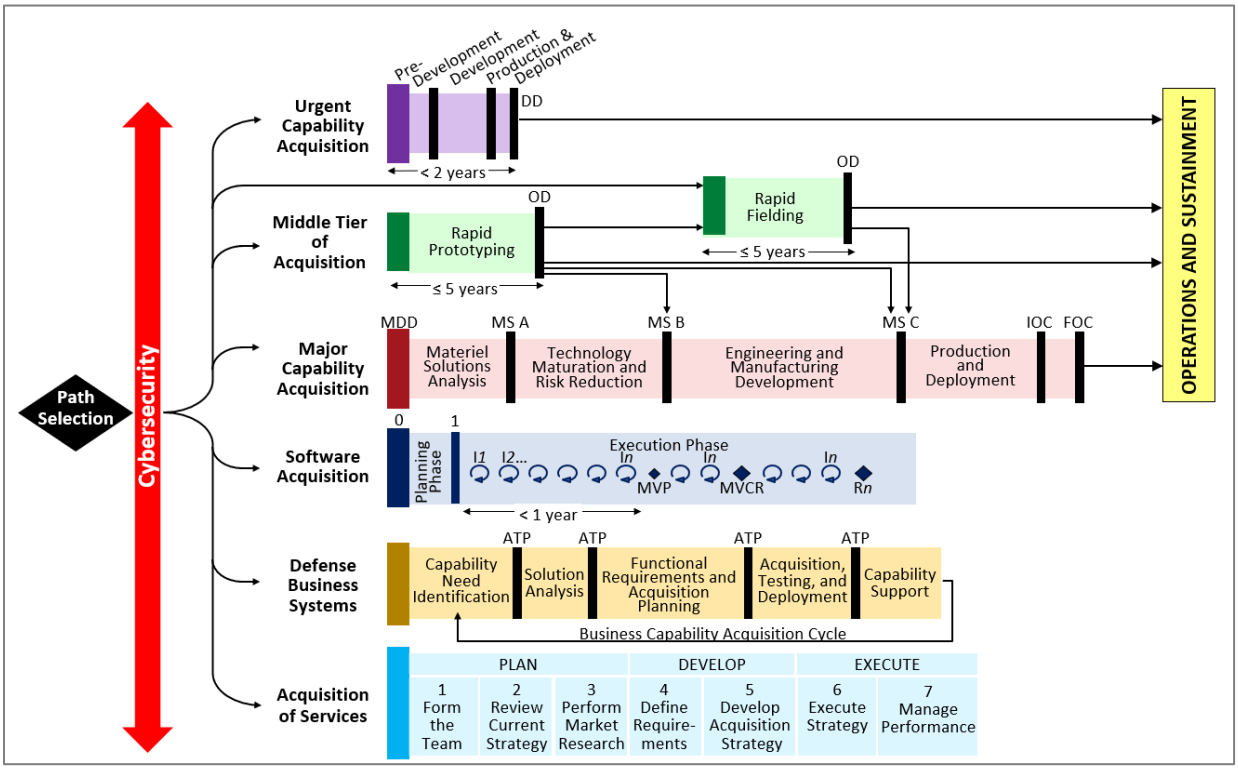


Figure 1. Sample Activity Chart

Adaptive Acquisition Framework (www.aaf.dau.edu)

This BoK follows DoDI 5000.02 and for the most part will describe M&Q activities for the path labeled Major Capability Acquisition (MCA). This path includes a comprehensive and systematic approach for applying M&Q best practices; however, the M&Q BoK best practices are applicable to the alternative AAF pathways as well. AAF pathways are depicted in Figure 2.



Source: DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework, January 23, 2020

Figure 2. Adaptive Acquisition Framework Paths

For example, under the AAF, a program may have an Urgent Capability Acquisition (UCA) and may have less than 2 years to provide a solution to the Warfighter, or the program may be involved in a Middle Tier of Acquisition (MTA) approach focused on rapid prototyping or rapid fielding. If so, users can see how these efforts are aligned with the MCA process in Figure 2 and use those BoK chapters to identify and accomplish required tasks and activities.

In addition to DoDI 5000.02, the following associated policies provide information for the paths:

- DoD Instruction 5000.74, Defense Acquisition of Services
- DoD Instruction 5000.75, Business Systems Requirements and Acquisition
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.85, Major Capability Acquisition

- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation

With any acquisition model, the program office should include M&Q personnel on the technical Integrated Product Team (IPT) and to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

M&Q planning, control, and management activities represent an important and central effort that begins early in the life cycle (Pre-Materiel Development Decision (MDD) and/or Materiel Solution Analysis (MSA) phases) and continues throughout the life of a program though Operations and Support. Although planning is discussed in detail in each chapter, Figure 3 provides key elements of M&Q planning activities in relation to overall program life cycle activities.

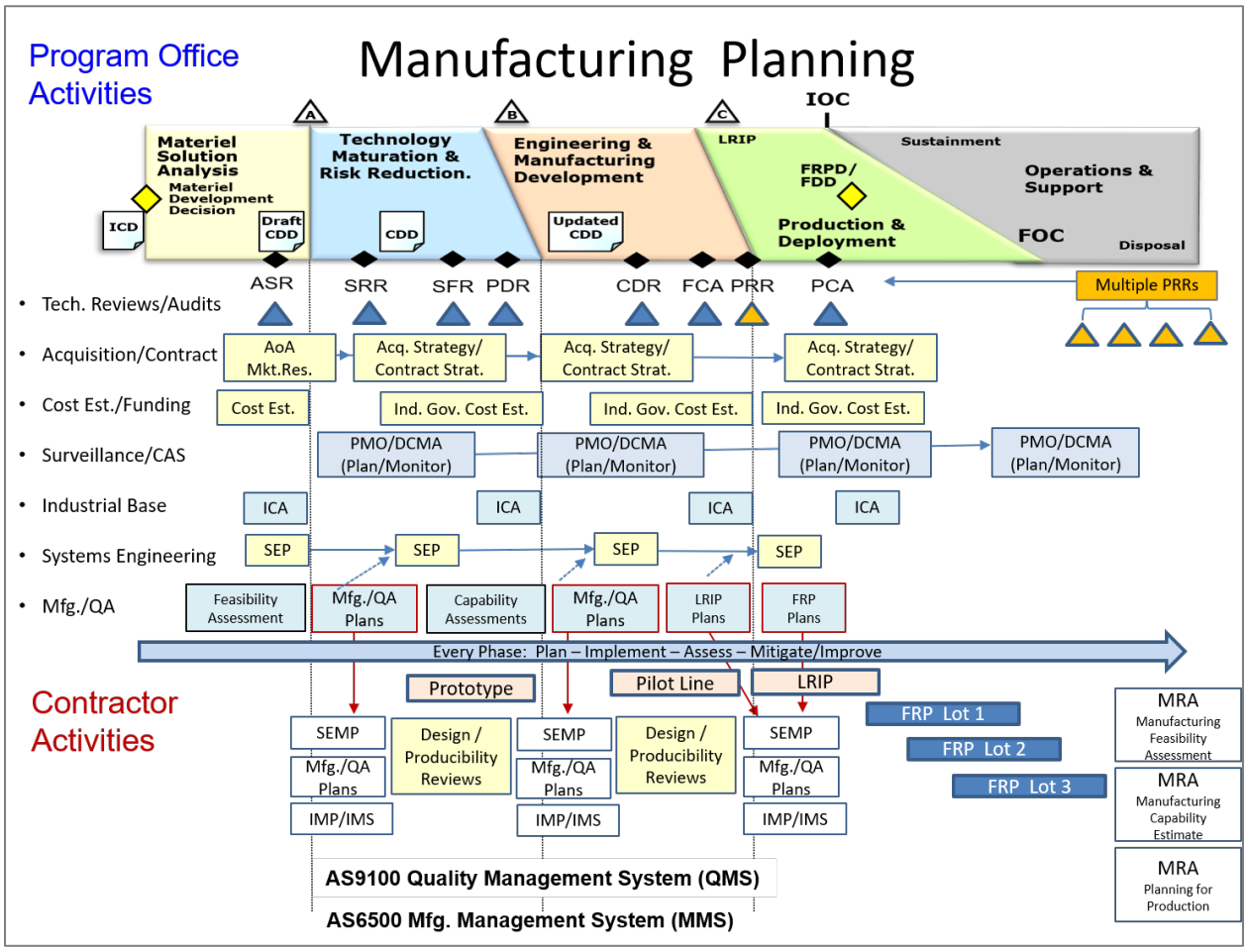


Figure 3. Typical Manufacturing and Quality Planning Activities

Most activities begin with the need to identify requirements, risks, and gaps, followed by planning activities. The top-most planning document is the Acquisition Strategy, and numerous documents feed into the Acquisition Strategy to include the Contracting Strategy and the Systems Engineering Plan (SEP). M&Q strategies should be a component of the SEP. Plans are then evaluated and updated on a recurring basis, usually just before a milestone decision.

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occur. The contractor is responsible for the execution of the program and in planning for success. The government Program Management Office (PMO), along with the Defense Contract Management Agency (DCMA) or other contract surveillance organizations and engineering support activities, is responsible for oversight and management of the acquisition. Risk assessment and mitigation is an ongoing effort that should be conducted throughout the system life cycle. Key references for DoD M&Q planning and management approaches include: MIL-HDBK-896, Manufacturing Management Program Guide; SAE Standard AS6500, Manufacturing Management Program; and Quality Management Systems standards ISO 9100 and/or AS9100. In addition, MRL criteria and assessments are a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

DoD tools and resources are available from many sources. Most should be available through open web-based links, but some may require a ".mil" address or a Common Access Card (CAC), or they may be available only to users in a specific community. Commercial tools and resources should be available to everyone but may require the organization to purchase a user's license/rights (e.g., ISO 9001 Quality Management System industry standard). In many cases, commercial resources and tools have been identified as a best practice. The M&Q BoK lists these tools for reference only; DoD does not necessarily endorse these resources or the publishing organizations. In addition, this document may reference a source for a specific tool (i.e., Pareto Chart), but there may be other widely available sources for this tool or for similar tools.

Sections labeled "Tools and Resources" are provided throughout the document chapters. The following section includes a summary of key references and links by publisher or topic. A more comprehensive list of references is included in Appendix B.

Key Manufacturing and Quality Body of Knowledge References and Resources
Department of Defense (DoD) Issuances, Directives Division https://esd.whs.mil/DD/

- DoD Directive 5000.01, The Defense Acquisition System
- DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.84, Analysis of Alternatives

- DoD Instruction 5000.85, Major Capability Acquisition
- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation
- DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD
- DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD
- DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
- DoD Directive 4400.01E, Defense Production Act Programs
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures

Defense Acquisition University (DAU) www.dau.edu

- DAU Guidebooks and References https://aaf.dau.edu/guidebooks/
- Acquisition Notes (AcqNotes) www.acqnotes.com
- Adaptive Acquisition Framework (AAF) https://aaf.dau.edu
- Analysis of Alternatives (AoA) www.acqnote/acquisitions/analsis-of-alternatives
- Market Research www.acqnotes/acqnote/acquisitions/market-research
- Acquisition Strategy (AS) Process/Guidance https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf
- Systems Engineering Plan (SEP) Outline https://ac.cto.mil/erpo/ (Engineering Guidance tab)
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

Defense Contract Management Agency (DCMA) www.dcma.mil

- DCMA Policies https://www.dcma.mil/Policy/
- DCMA Instructions https://www.dcma.mil/Policy/
- DCMA-INST 204, Manufacturing and Production
- DMCA-INST 205, Program Support
- DMCA-INST 207, Engineering Surveillance
- DMCA-INST 309, Government Contract QA Surveillance Planning
- DCMA-INST 401, Industrial Analysis
- DCMA-INST 3401, Defense Industrial Base Mission Assistance

Defense Federal Acquisition Regulation (DFAR) Supplement https://www.acquisition.gov/dfars

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System

- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS Subpart 242.7200, Contractor Material Management and Accounting

Defense Logistics Agency (DLA) Website www.dla.mil

- DMSMS Guidebook, SD-22 https://www.dsp.dla.mil/Programs/DMSMS
- ASSIST (Database of specifications and standards) https://assist.dla.mil
- ASSIST Quick Search https://quicksearch.dla.mil/qsSearch.aspx
- DoD 4140.01, Supply Chain Materiel Management Regulation www.dla.mil

Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
Manufacturing Readiness Levels (MRLs) www.dodmrl.org

- MRL Assessment Criteria Matrix www.dodmrl.org
- Interactive MRL Users Guide (MRL Assessment Criteria) www.dodmrl.org
- MRL Deskbook www.dodmrl.org
- MIL-HDBK-896, Manufacturing Management Program Guide www.dodmrl.org

National Institute of Standards and Technology (NIST) www.nist.gov

- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST Manufacturing https://www.manufacturing.gov

Office of the Director, Cost Assessment and Program Evaluation (CAPE) www.cape.osd.mil
OSD Manufacturing Technology (ManTech) Program Office https://www.dodmantech.mil
OUSD(R&E) Systems Engineering and Architecture (SE&A) https://ac.cto.mil/engineering
Relevant Government Publications (Available via Web/Internet Search)

- DoD 4245.7-M Manual, Transition from Development to Production, 1985
- NAVSO P-3687, Producibility Systems Guidelines, 1999
- MIL-HDBK-766, Design to Cost
- MIL-HDBK-727, Design Guidance for Producibility, 1984

Standards, Specifications, and Standards Organizations

- ASSIST (Defense Logistics Agency Database of Specifications and standards) https://assist.dla.mil
- ASSIST Quick search https://quicksearch.dla.mil/qsSearch.aspx
- SAE International www.sae.org
- International Organization for Standards (ISO) www.iso.org
- Institute of Electrical and Electronics Engineers (IEEE) www.ieee.org
- *Note:* Many specifications and standards can be accessed at http://everyspec.com/

Technology Readiness Levels (TRLs)

- Technology Readiness Assessment Deskbook www.acqnotes.com
- Technology Readiness Assessment Calculator www.acqnotes.com
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

2. Materiel Solution Analysis (MSA) Phase

The purpose of the Materiel Solution Analysis (MSA) phase is to conduct the analysis and other activities needed to choose the concept for the product that will be acquired. This phase culminates in a risk reduction decision, Milestone A, which is an investment decision to pursue a specific product or design concept and to commit the resources required to mature technology and/or reduce any risks that must be mitigated before decisions committing the resources for development. This phase also is an opportunity for manufacturing and quality (M&Q) to influence chosen system design by balancing requirements against producibility, manufacturability, quality, and affordability.

Figure 2-1 shows the M&Q management activities typical of the MSA phase.

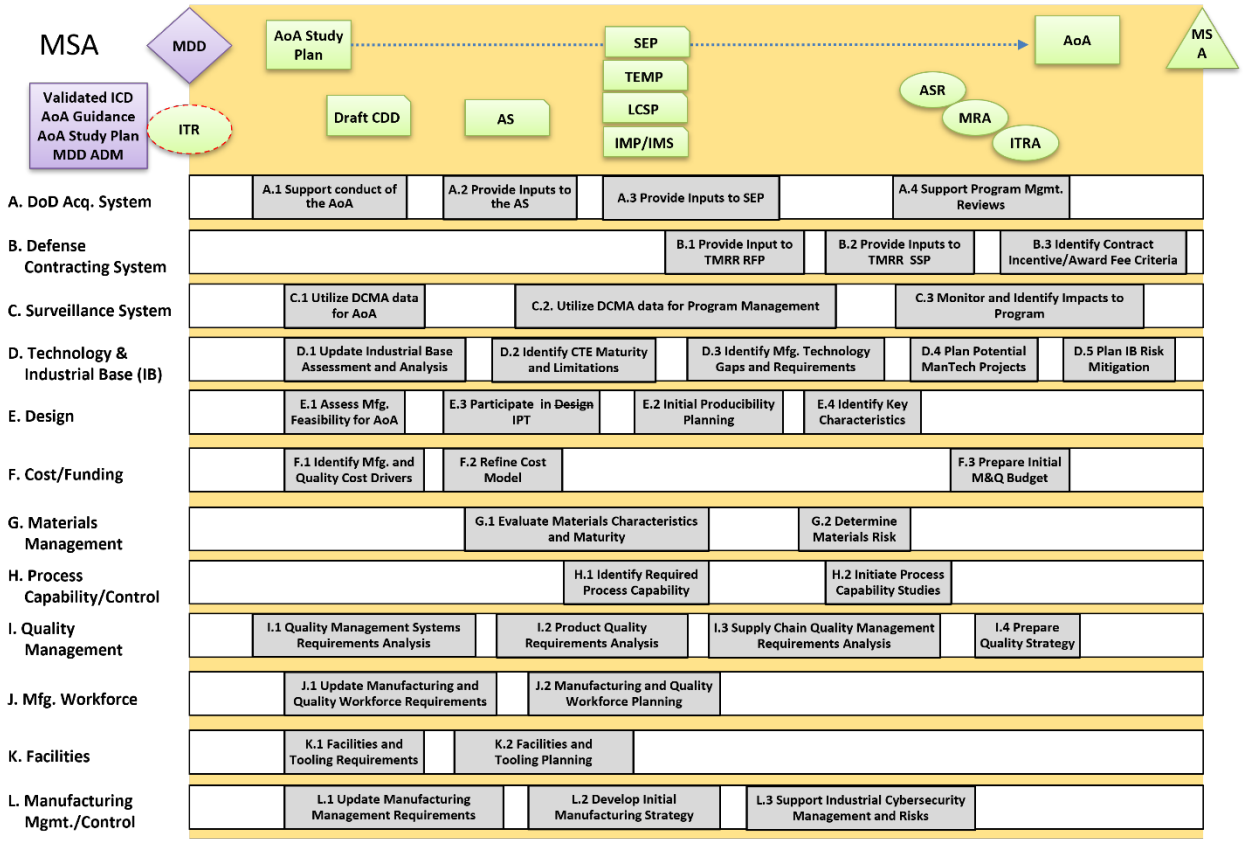


Figure 2-1. MSA Phase Manufacturing and Quality Activities

To support the MSA phase and the Milestone Decision Authority (MDA) decision process, M&Q should perform and/or support activities during the phase including:

- Conduct and complete the Analysis of Alternatives (AoA) with M&Q inputs needed to enable selection of a preferred materiel solution.
- Translate validated Key Performance Parameters (KPPs) and Key System Attributes (KSAs) into Key Characteristics (KCs) for M&Q.

- Conduct M&Q key trades for feasibility and affordability analyses; conduct risk, issue, and opportunity analyses; and plan for mitigations that impact cost, schedule, and performance.
- Develop M&Q goals for any needed development of critical enabling technologies.
- Translate the Initial Capabilities Document (ICD) with M&Q validation and verification analyses results into a draft Capability Development Document (CDD).
- Initiate the Test and Evaluation Master Plan (TEMP), the Systems Engineering Plan (SEP), and the Acquisition Strategy (AS) with inclusion of M&Q requirements.

Phase Description

In conducting and completing the AoA, the various alternative solutions are analyzed for key trades among affordability analyses, risk analyses, and planning for risk mitigations that impact cost, schedule, and performance. It is the role of M&Q to provide inputs to the AoA process with respect to feasibility and industrial base (IB) analyses, performed as part of the AoA Study Guidance, the validated ICD, and the AoA Study Plan, which guide the AoA and MSA phase activities. The analyses focus on identification and analysis of alternatives; measures of effectiveness; key trades between cost and capability; life cycle cost, including sustainment; schedule; concepts of operations; and overall risk. The AoA will include affordability analyses, cost analyses, early systems engineering analyses, threat projections, and market research. Minimum funding required for this phase includes all funding and staffing plans for the AoA and the engineering analysis and planning for the next milestone including the milestone certification requirements.

The AoA will address the M&Q feasibility and technology maturity of the proposed alternatives including the risks, issues, and opportunities associated with varying production rates; IB health and needs; manufacturing technology research; facilities and tooling, special test equipment, and special inspection equipment; manufacturing skill sets; and maturity of new materials and novel processing methods.

Before completion of this phase, the Department of Defense (DoD) Component combat developer will prepare a Concept of Operations/Operational Mode Summary/Mission Profile (CONOPS/OMS/MP) that will include the operational tasks, events, durations, frequency, operating conditions, and environment in which the recommended materiel solution is to perform each mission and each phase of a mission. The Systems Engineering (SE) Integrated Product Team (IPT) uses the outputs of the CONOPS/OMS/MP to identify and validate capability gaps and risks and translate these into system-specific requirements. These KPPs and KSAs are translated by M&Q into identified system, product, and component M&Q KCs. In addition, these outputs are used to provide M&Q inputs to the Acquisition Strategy, TEMP, and SEP, and the Milestone A decision. During the MSA phase, the Component Acquisition Executive (CAE) will select a Program Manager (PM) and establish a program office to complete the necessary actions associated with planning the acquisition program with emphasis on the next phase.

The MSA phase ends when a DoD Component has completed the necessary analysis and the activities necessary to support a decision to proceed to an acquisition phase. The next phase can be Technology Maturation and Risk Reduction (TMRR), Engineering and Manufacturing Development (EMD), or Production and Deployment (P&D), depending on the actions needed to mature the product being acquired. Each of these phases has associated decision points to authorize entry.

A. DOD ACQUISITION SYSTEM

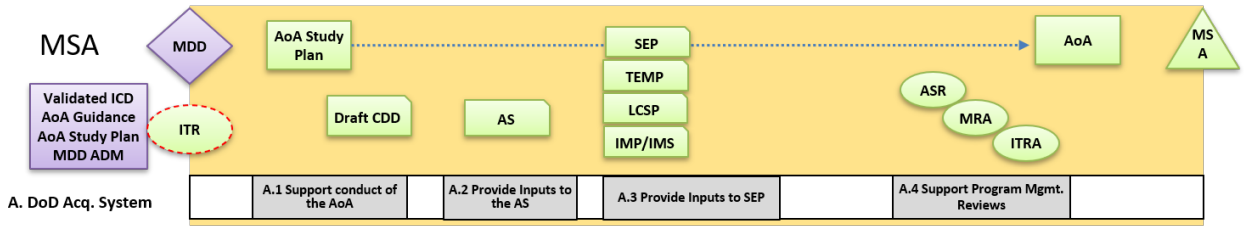


Figure 2-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

The Defense Acquisition System (DAS) is an event-based process. For Major Capability Acquisition, an acquisition program progresses through a series of milestones (five phases), and risk-based reviews in which a Milestone Decision Authority (MDA) determines whether a program will proceed into the next phase. Major Defense Acquisition Programs (MDAPs) and major systems with production requirements should address industrial and manufacturing readiness in the Acquisition Strategy, during milestone reviews, and in program documentation as outlined in this Body of Knowledge (BoK).

During the MSA phase, trade studies are conducted to identify materiel solutions and address gaps in capability based on an AoA. At the close of the AoA, a program office is assigned ownership of the approach. At this point, program management establishes the appropriate IPT structure to support program execution. The IPT conducts systems engineering analysis to support the development of the Acquisition Strategy, the SEP, and the draft CDD. The MSA phase also provides the opportunity to influence system design and plan for production by evaluating technology opportunities and current practices against cost, schedule, and performance. The intent is to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements. The PM will ensure manufacturing, quality, and producibility risks are identified and managed throughout the program life cycle. Assessments of M&Q readiness, risks, and mitigation plans will be developed and documented in the SEP and the Acquisition Strategy.

Analysis of Alternatives

From an M&Q perspective during the AoA, each competing alternative under consideration is analyzed for its impact to industrial and manufacturing capabilities. The analysis uses the IBAs performed previously to determine the likelihood that a proposed materiel solution can be produced using existing

manufacturing capabilities while meeting quality, rate, cost, and schedule requirements. The AoA also identifies new or high-risk manufacturing capability or capacity requirements if they are needed. The AoA should also identify critical technologies and the associated manufacturing process areas in each alternative requiring risk-reduction effort. The results of the analyses are used to quantify the differences between alternatives and select a preferred solution. At the close of the AoA, the program office takes ownership of the approach and conducts additional engineering analyses to support the development of the Acquisition Strategy and the SEP.

Acquisition Strategy

Early systems engineering provides the foundation for the development of the Acquisition Strategy. The strategy is based on engineering analyses, trade studies, and preliminary system functional and performance requirements to meet a capability need. The Acquisition Strategy should address the following program objectives:

- The likely outcome is worth the investment in both resources (real costs) and schedule (opportunity costs).
- The end item meets required performance objectives.
- All risks, issues, and opportunities are identified, managed, and mitigated to an acceptable level.
- The business strategy effectively executes the program.

In addition, an Acquisition Strategy should emphasize and provide incentives for the important aspects of the program. The Acquisition Strategy should include:

- A market analysis and associated acquisition planning.
- An assessment of the IB to support design, development, production, sustainment, or restart of an acquisition program.
- An assessment of manufacturing feasibility to answer the question, “Can it be built?”
- An initial M&Q strategy.

As an integral part of the overall Acquisition Strategy, the initial M&Q strategy should include considerations such as:

- Competition: Competition can be a major contributor to reducing weapon system costs but can also be a major contributor to M&Q complexity and must be carefully planned.
- New manufacturing technologies: If required by the system concept, new manufacturing technologies will require specific plans for development, proofing, and transition of the technology to the eventual producer.
- Production rates and quantities: Rates and quantities play a major role in driving manufacturing cost as they will drive decisions on what production processes to use, types of tooling required, make-buy decisions, etc.

- Materials sourcing: Sources that are sole, single, fragile, or foreign sources, and those domestic sources that are vulnerable to foreign acquisition introduce risks to manufacturing.
- Contracting strategies: Acquisition Strategies and program planning should include M&Q technologies, facilities, investment incentives, risk mitigation efforts, etc.

Other M&Q considerations that should be addressed in the M&Q strategy as part of the Acquisition Strategy:

- How risk areas will be addressed and minimized in the TMRR phase, on the path to full manufacturing capability in the P&D phase.
- How new manufacturing capabilities with a beneficial impact to the program will be addressed.
- The technical or manufacturing risks associated with the program and any critical technologies or manufacturing processes that need to be matured and demonstrated in a manufacturing-relevant environment during the TMRR phase.
- The quality history of the item or system.

Systems Engineering Plan

M&Q input to critical systems engineering processes and functions is essential to ensure that programs deliver capabilities on time and on budget. The effective execution of MSA efforts provides a feasible, producible, and effective solution that satisfies user requirements. The intent is to reduce M&Q risks, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements. Program Managers will prepare a SEP as a management tool to guide the systems engineering activities on the program. The SEP will be submitted for approval for each milestone review, beginning with Milestone A. At each milestone, M&Q will support the Acquisition Strategy and SEP, including input for interdependencies, and overall manufacturing approach to balance system performance, life cycle costs, and risks. The SEP should include:

- Description of the program overall technical approach, including M&Q inputs for key risks, processes, resources, organization, metrics, and design considerations.
- Details of the timing and M&Q criteria for the conduct of technical reviews.
- Details for M&Q planning to provide effective management and control of the progress and the execution of risk mitigation activities.
- Plans for addressing M&Q integration with existing and approved architectures and capabilities.
- Identification of M&Q risks from external dependencies (outside the span of control).
- Guidance on the M&Q details in the program schedule with documentation of the planning.

Finally, the SEP should be included in the Request for Proposals (RFP) with an approved plan or a draft plan as either guidance or a compliance document and will be synchronized with the

Acquisition Strategy. PMs should consider using Systems Engineering Management Plan, DI-SESS-81785A, as a CDRL item.

Program Management Reviews

Management reviews are a major part of the systems engineering process and are conducted by members of the IPT. Reviews serve to confirm:

- Major systems engineering efforts have been conducted and completed.
- The program is ready to proceed to the next major schedule event.

Technical reviews are also an important tool for program management, independent assessors, and subject matter experts including M&Q, to identify and evaluate risks early and throughout the program. If conducted in conjunction with the Materiel Development Decision (MDD), M&Q should support all technical reviews, which should assess the draft ICD, the AoA Study Guidance, and preliminary CONOPS for M&Q analyses of the materiel solution alternatives. Support of the technical reviews will provide detailed M&Q information and understanding of each concept or alternative for:

- Engineering trades.
- Development of a Cost Analysis Requirements Description (CARD).
- Cost drivers, material, and process risks.

The primary review during MSA is the Alternative Systems Review (ASR), which is conducted by the program office prior to the Milestone A decision and entry into TMRR phase. The ASR assesses the preferred materiel solution to ensure it has the potential to be affordable, producible, operationally effective and suitable, and can be developed to provide a timely solution to a need at an acceptable level of risk. The ASR helps ensure that sufficient effort has been given to conducting trade studies that consider and incorporate alternative system designs, M&Q alternatives, and other technical considerations. The technical understanding, assessed at the ASR, is sufficient and rigorous enough to support a valid cost estimate (CARD, or CARD-like Document).

Other reviews that should be conducted include a Manufacturing Readiness Assessment (MRA) and an Independent Technical Risk Assessment (ITRA).

The Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) established policy for the conduct of ITRAs in accordance with 10 USC 2448b. These independent assessments should be conducted in accordance with the current Defense Technical Risk Assessment Methodology (DTRAM). DTRAM focus areas include:

- Mission Capability
- Technology
- System Development and Integration
- Modular Open Systems Approach (MOSA)
- Software

- Security/Cybersecurity
- Manufacturing
- RAM & Sustainment

In general, technical risks are those events or conditions typically emanating from areas such as mission/requirements, technology, engineering, integration, test, software, manufacturing/quality, logistics, and system security/cybersecurity that may prevent a program from meeting cost, schedule, and/or performance objectives.

ITRAs will leverage ongoing program activities whenever practical, e.g., Technology Readiness Assessments (TRA), Manufacturing Readiness Assessments (MRA), and Systems Engineering Technical Reviews. These assessments and activities will inform the ITRA; however, the team will provide an independent assessment of any risks or maturity concerns identified. As such, there may not be a direct correlation between external assessments or measures, such as Technology Readiness Levels, and the ITRA team's assessment.

A.1 Support Conduct of the Analysis of Alternatives

The Analysis of Alternatives (AoA) is an analytical comparison of the operational effectiveness, suitability, and life cycle cost of alternatives that could satisfy user capability needs as identified in the Initial Capabilities Document (ICD). The AoA process is used to better define the trade space across cost, schedule, and performance to support the selection of a solution among alternative solutions. The AoA has three primary products:

- AoA Study Guidance is developed and approved by the Director of Cost Assessment and Program Evaluation (DCAPE) with input from other DoD officials. The Milestone Decision Authority (MDA) must certify in writing to Congress that the Department has completed an AoA consistent with the study guidance developed by DCAPE. The AoA should be updated and performed in each acquisition phase throughout the life cycle of a program to guarantee that the correct materiel solution has been developed, to refine the materiel solution, and to reaffirm the cost-effectiveness of that solution.

- The AoA Study Plan establishes the road map for the conduct of the AoA. M&Q personnel need to be engaged in the assessment of the alternative solutions to assess manufacturing impacts and plan for future implementation.

- The AoA Final Report outlines the AoA process and provides an effectiveness analysis, cost analysis, risk assessment, and conclusions and recommendations.

Manufacturing and Quality Tasks

- Provide analyses of the M&Q requirements and feasibility contained in the draft ICD, the AoA Study Guidance, and the preliminary CONOPS for the AoA.
    - Analyses should verify adequacy, relevance, and completeness
    - Analyses should identify and quantify M&Q risks
- Provide analyses of the M&Q requirements in the AoA Study Plan to include the following:
    - Critical technology elements (CTEs) associated with each proposed alternative, including technology maturity, integration risks, manufacturing feasibility, and technology maturation and demonstration
    - Lifecycle cost estimate and identified methodology including use of models and data, cost sensitivity, and identification of cost drivers and risks
    - Identification of study team and organization; M&Q personnel should be on this team
- Ensure IBAs and market analyses are updated for concepts included in the AoA (conduct if not previously accomplished).
    - IBAs should illustrate the differences between alternatives based on the industrial and manufacturing capabilities and the required resources during the AoA
    - Manufacturing feasibility should answer the question "Can it be built?"
- Ensure assessments of manufacturing feasibility for the AoA preferred concepts are up to date including engineering trade studies, early prototypes, models or data, and the industrial capabilities required to design, develop, manufacture, and maintain each (conduct if not previously accomplished).
    - Identify M&Q risks
        - Include materials, processes, and technology
        - Identify new or high-risk manufacturing processes or capacity requirements
    - Identify manufacturing, quality, materials, and unique requirements that are cost drivers for the AoA
    - Ensure the phase-by-phase requirements for M&Q skills and training are updated for the AoA preferred materiel solutions
    - Ensure the facilities and capital equipment requirements for each AoA preferred concept are updated
    - Ensure that each AoA preferred concept includes and is analyzed for quality management requirements
    - Ensure each AoA preferred concept includes and is analyzed for manufacturing management requirements

Tools

- Acquisition Decision Memorandum (ADM) Template
- Acquisition Strategy (AS) Outline
- Alternative Systems Review Checklist
- Analysis of Alternatives (AoA) Study Plan Template
- AS6500, Manufacturing Management Program Checklist
- AS9100, Quality Management System Checklist
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- DAU Acquisition Notes (AcqNotes)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist)
- ISO 9001, Quality Management System Checklist
- Market Research Reporting Template
- Multi-Attribute Tradespace Exploration (MATE)
- Pugh Matrix Template
- Quality Function Deployment Excel Spreadsheet
- Quality Function Deployment or House of Quality Matrix
- Requirements Traceability Matrix Template
- Requirements Verification Matrix
- Tailoring Worksheet for Materiel Solution Analysis Phase
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- Air Force Analysis of Alternatives (AoA) Guide
- Air Force Analysis of Alternatives (AoA) Handbook
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- DAU Acquisition Notes (AcqNotes)
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoD Market Research Guide
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.73, Cost Analysis Guidance and Procedures

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- ISO 9100, Quality Management Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Pre-MDD Analysis Handbook
- Quality Function Deployment
- Requirements Traceability Matrix Guide
- Technology Readiness Assessment Guidebook
- Technology Readiness Assessment Guide (GAO-20-48G)

A.2 Provide Inputs to the Acquisition Strategy

M&Q personnel need to be actively engaged in the development and update of numerous documents to include:

- Acquisition Strategy (AS)
    - Acquisition Approach
    - Contracting Strategy
    - Market Research
    - Risk Management
    - *Manufacturing Strategy (if developed should go into the Acquisition Strategy)
    - *Quality Strategy (if developed should go into the Acquisition Strategy)
- Systems Engineering Plan (SEP)
    - Manufacturing Plan
    - Quality Plan

Programs will develop a Systems Engineering Plan (SEP) for Milestone Decision Authority (MDA) approval in conjunction with each milestone review and integrated with the Acquisition Strategy. This plan should describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. The SEP should detail the timing, conduct, and success criteria of technical reviews.

Manufacturing and Quality Tasks

- Provide a summary of an updated M&Q IB capability analysis for the Acquisition Strategy, as required by DoDI 5000.02.
    - Provide inputs on the capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
    - Provide inputs on IB capabilities, fragility, gaps, and risks for the Acquisition Strategy (e.g., key technologies, processes, components, etc.)

  - Provide the impacts and interdependencies of this acquisition on the National Technology Industrial Base (NTIB) and the analyses used to make this determination
  - Summarize M&Q impacts, how they will be managed, and the plan for future assessment, including frequency
  - Provide inputs for the government strategy and actions necessary to preserve the IB capabilities (e.g., incentivizing the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)

- Develop and provide a Manufacturing Strategy and a Quality Strategy to address the question "Can it be built?" The strategy should support the Acquisition Strategy development and include considerations of:
  - Competition and contracting strategies
  - New manufacturing technologies
  - Design (feasibility, producibility, KCs, risks, etc.)
  - Materials (characteristics, sourcing, risks, etc.)
  - Process, rates, and quantities (capabilities, control, risks, etc.)
  - Facilities, tooling, and workforce (including government-furnished equipment (GFE), special test equipment (STE), special inspection equipment (SIE), special requirements, etc.)
  - Management (quality, manufacturing, supply chain, risks, etc.)
- Provide M&Q inputs to Acquisition Strategy contracting strategy based on IB capabilities analyses, to support selection of a competitive award, a sole source award, or multiple source development (with down-select for production contract) as the best course of action.
  - Include M&Q metrics to differentiate the value of each contract type such as performance, capacity, functional, economic, etc.
  - Include impacts on IB capabilities and risks that may result from different contract types (firm fixed price (FFP), fixed price incentive fee (FPIF), cost plus fixed fee (CPFF), etc.)
  - Determine prototyping approach for TMRR, either competitive, single, or prototyping of critical subsystems (statutory requirement for Major Defense Acquisition Program (MDAP) Acquisition Strategy, regulatory requirement for all other programs)
- Develop M&Q inputs to the Acquisition Strategy for the source selection approach that establishes and maintains access to competitive suppliers at the system, subsystem, and component level (e.g., requiring a modular open systems approach, alternative sources of supplies or services, etc.).
- Develop M&Q inputs for the Acquisition Strategy that identify and address the sustainment of industrial capabilities, including manufacturing technologies and capabilities, and the maturation required during the TMRR and subsequent phases.
  - Provide M&Q inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes

and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystems, item, and component levels.
    - Provide M&Q inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
        - Domestic alternatives through regeneration of prior capability
        - Creation of new capability for manufacturing products and processes
        - Lifetime buy of items at the subsystem and component levels
- Develop Manufacturing Technology (ManTech) plans for new or high-risk manufacturing capabilities and processes for the Acquisition Strategy that address risks, issues, and opportunities.
    - Specify how this new capability will be demonstrated in a relevant manufacturing environment for the TMRR phase
- Provide M&Q inputs for required technical reviews, production decisions, events, prototypes, and deliveries, including sub-tier subsystem, item, and components, to be included in the Acquisition Strategy based on:
    - Requested inputs from Defense Contract Management Agency (DCMA)
    - Materials availability (lead-time and scale-up) and maturity (characterization)
    - Achievable rates and yields for M&Q
        - Provide methodologies for determining rates and schedules (e.g., Economic Order Quantities, affordability goals, etc.)
    - M&Q maturity
    - Facilities, tooling, and workforce considerations
    - Capital equipment requirements
- Provide M&Q inputs to the Integrated Master Plan (IMP) and Integrated Master Schedule (IMS), based on inputs to the Acquisition Strategy, for required technical reviews, production decisions, events, prototypes, and deliveries, to include:
    - Schedule for any planned use of government-furnished special test equipment, government facilities/ranges, unique tooling, or other similar requirements (specific modeling and simulation (M&S), communications, restricted environment, etc.)
    - Schedule impacts from the requirements for special materials and allotments, and the reasons for them if applicable
    - M&Q internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
- Develop the government M&Q management approach to:
    - M&Q requirements for program plans

  - M&Q contributions to resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - M&Q organization and staffing with leadership positions and necessary skilled manpower
  - M&Q support organization required to meet program projected needs for TMRR and subsequent phases including:
    - Earned Value Management requirements
    - Cost control requirements
    - Data collection, reporting, and management

- Identify the M&Q requirements for the TMRR contractor's Manufacturing Management System (MMS) and Quality Management System (QMS).
  - Specify the standards to be used to promote industry best practices (e.g., Society of Automotive Engineers (SAE) AS6500, International Organization for Standardization (ISO) ISO 9001, SAE AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - If M&Q standards are not specified, develop requirements for a program-specific Manufacturing Management Plan and Quality Management Plan
  - Identify M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- Identify and assess M&Q risks, issues, and opportunities, and associated plans with key risk reduction events specified as inputs for the TMRR Acquisition Strategy and subsequent phases on the path to full capability.
  - Identify risks from the IB, materials, facilities, workforce, interdependencies with other programs, manufacturing technology voids, quality, software, and engineering-related risks, etc.
  - Identify maturation of critical technologies and manufacturing processes to the required level
  - Assess M&Q cost and schedule impacts from these identified risks
- Specify the ongoing requirements for identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program.
- Develop as inputs to the Acquisition Strategy specific and detailed M&Q exit criteria metrics for MSA, TMRR, and subsequent phase decision points.
  - Metrics should include current and projected M&Q maturity of identified critical technologies and manufacturing processes
  - Metrics should also include the planned Manufacturing Readiness Level (MRL) target for system, subsystems, components, and items

- Develop the M&Q support plan for the mandated independent assessment for the Acquisition Strategy.
- Request DCMA inputs on strategies for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.

Tools

- Acquisition Strategy (AS) Outline
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Initial Capabilities Document (ICD) Template
- Interactive MRL Users Guide (Checklist)
- ISO 9001, Quality Management System Checklist
- Manufacturing Maturation Plan
- Pugh Matrix Template
- Quality Function Deployment Excel Spreadsheet
- Requirements Roadmap Worksheet
- SAE AS6500 Manufacturing Management System Checklist
- SAE AS9100 Advanced Quality Management System Checklist

Resources

- Acquisition Plan Preparation Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Capabilities-Based Assessment (CBA) User's Guide
- DCMA Industrial Analysis (DCMA-INST 401)
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- IEEE 15288-2014, Systems and Software Engineering
- ISO 9001: Quality Management Systems
- Manufacturing Readiness Level (MRL) Deskbook

- PL114-328 and subsequent guidance (TBD)
- Pre-Materiel Development Decision Analysis Handbook
- Quality Function Deployment (Reference Books)

A.3 Provide Inputs to the Systems Engineering Plan

M&Q personnel need to be actively engaged in the development and update of numerous documents to include:

- Systems Engineering Plan (SEP)
  - Manufacturing Plan
  - Quality Plan
- Test and Evaluation Master Plan (TEMP)
- Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
- Life Cycle Sustainment Plan (LCSP)
- Capability Development Document (CDD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)

The SEP should describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It should also detail the timing, conduct, and success criteria of technical reviews.

Manufacturing and Quality Tasks

- Update the assessment of manufacturing feasibility for the preferred concept, if not completed; conduct an assessment, for inclusion in the SEP.
- Provide M&Q inputs to the SEP on all IB, design, manufacturing, production, and quality risks and risk reduction and mitigation efforts.
  - Identify critical technologies and M&Q process areas requiring risk reduction and mitigation efforts for the SEP, including the following activities:
    - Initial M&Q approaches for system requirements and system design concepts
    - M&Q trade studies
    - Potential M&Q solutions
  - Identify M&Q risks, issues and opportunities from existing architectures, capabilities, and external dependencies
  - Maintain up-to-date status on all key M&Q inputs to the SEP
- Provide M&Q plans and support to assist in development of the SEP and the program schedule based on the M&Q strategies in the Acquisition Strategy, to include:

  - Inputs on required M&Q products (e.g., assessment, metrics, etc.) for all systems engineering (SE) reviews
  - Inputs on specific and detailed M&Q entry and exit criteria metrics for technical reviews and MSA, TMRR, and subsequent phase decision points
    - Metrics should include current and projected M&Q maturity of identified critical technologies and manufacturing processes
    - Metrics should also include the planned Manufacturing Readiness Level (MRL) target for system, subsystems, components, and items
  - M&Q criteria, metrics, and frequency for SE reviews
  - Planned significant M&Q activities and tools (i.e., modeling and simulations, M&Q assessments, long lead or advanced procurements, prototype builds, production lots/phases, etc.)
  - Specifications for the M&Q organization, billets, and leadership positions
  - Specification of the roles, responsibilities, and organization of the Manufacturing Working Group to support SE
  - M&Q roles and responsibilities within other program IPTs (e.g., Design, Risk Management, Systems Engineering, Test and Evaluation (T&E), Sustainment, Facilities, etc.)
- Provide M&Q requirements, risks, issues, and opportunities (e.g., design, producibility, manufacturing technology, facilities, sustainment, cost, and schedule, etc.), for the SEP to be addressed by all IPTs.
- Identify M&Q inputs on required technical reviews/audits (e.g., Preliminary Design Review, Critical Design Review, Production Readiness Reviews, etc.) to be conducted at the sub-tier level on Configuration Items to be designed and developed by a sub-tier supplier.
- Plan for M&Q activities for the next phase:
  - Summarize key M&Q systems engineering, integration, and verification processes and activities established or modified since the previous phase, including updated
    - Risk and risk mitigation strategies
    - Technical and manufacturing maturity
    - M&Q metrics to support key management focus areas

Tools

- Analysis of Alternatives (AoA) Study Plan Template
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Critical to Customer/Critical to Quality Tree Template
- Interactive MRL Users Guide (Checklist)
- Manufacturing Capability Assessment Worksheet
- Manufacturing Maturation Plan

- Manufacturing Plan, DI-MGMT-81889A
- MDD Development Planning Templates
- MSA Template
- Producibility Assessment Worksheet (PAW)
- Quality Assurance Plan
- Quality Assurance Program Plan, DI-QCIC-81794
- Systems Engineering Management Plan, DI-SESS-81785A
- Systems Engineering Plan (SEP) Outline

Resources

- Air Force Analysis of Alternatives (AoA) Guide
- Air Force Analysis of Alternatives (AoA) Handbook
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- DMMG for PMs, Chapter 1.3 and 2.6 Industrial and Manufacturing Capability Assessments in the Acquisition Lifecycle
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- IEEE 15288-2014, Systems and Software Engineering
- Manufacturing Readiness Level (MRL) Deskbook
- MRL Users Guide
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Guidebook

A.4 Support Program Management Reviews

M&Q personnel should be actively engaged in the organization and execution of numerous formal reviews and audits during this phase to include:

- Alternative System Review (ASR)
- Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)
- Independent Logistics Assessment (ILA)

- Program offices could request an informal review at any time and M&Q managers need to be prepared to support such reviews.

Sources of data used to assess and manage industrial and manufacturing readiness include technical reviews and audits, Program Status Reviews, Pre-Award Surveys, Manufacturing Readiness Assessments, ITRAs, Industrial Capabilities Assessments, trade studies, etc. An important output includes actions to reduce or address any remaining risks.

Manufacturing and Quality Tasks

- Support the conduct of the ASR.
- Support the conduct of an MRA.
- Support the conduct of a TRA.
- Support the conduct of an ITRA.
- Support the conduct of an ILA.
- Perform M&Q analyses of the draft ICD, the AoA Study Guidance, and the preliminary CONOPS of the materiel solution alternatives.
    - Provide detailed M&Q information to promote an understanding of each concept or alternative for:
        - Engineering trades
        - Cost drivers, material, and process risks, issues, and opportunities
        - Development of a CARD
- M&Q provides inputs and analyses to the ASR to support that the preferred materiel solution(s) resulting from the AoA have the best potential to be cost effective, affordable, operationally effective, and suitable, and can be developed to provide a timely solution to the need at an acceptable level of risk. M&Q representatives supporting program IPTs will:
    - Review, evaluate, and update the M&Q producibility assessments for the preferred system concept(s) for adequacy
    - Review, evaluate, and update the comprehensive risk, issue, and opportunity assessment for completeness and adequacy of all M&Q risks and update mitigation plans (develop if not initiated)
        - Complete trade studies or technical demonstrations for manufacturing concept risk reduction
        - Incorporate producibility and manufacturing considerations that could impact program decisions (e.g., critical components, materials and processes, tooling and test equipment development, production testing methods, long lead items, and facilities/personnel/skills requirements)

- Review and evaluate the risks to M&Q associated with the use of a commercial off-the-shelf (COTS)/government off-the-shelf (GOTS)/non-developmental item (NDI) solution versus a new design
- Complete the M&Q input to the initial hazard analysis and/or the system safety analysis for the preferred solution(s)
- Assess the M&Q requirements of the draft CDD to verify that all KCs are traceable to user needs through preliminary system specifications, key assumptions, and constraints back to KPPs and KSAs (from JCIDS)
- Assess the results of the AoA materiel solution(s) to meet M&Q cost, schedule, and performance objectives
- Review, evaluate, and update the comprehensive M&Q plans that address critical items, parts, components, and prototypes to be developed and demonstrated, along with their cost, and critical path drivers
- Provide M&Q inputs on the scope and planning of competitive prototyping of the materiel solution systems, subsystems, and components
- Provide M&Q inputs on the scope, planning, and resources needed for the initial end-item development
- Review Lessons Learned for M&Q drivers of system life cycle cost
- Provide inputs to the CARD that reflect realistic materiel solutions that meet the draft CDD within M&Q IB constraints including workforce estimates
- Review and update M&Q inputs to the SEP and the Acquisition Strategy, if necessary

Tools

- Alternative Systems Review Checklist
- Army Acquisition Logistician's Assessment Checklist v.5
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974,
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist, v3
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Quality Status Report, DI-MGMT-82186
- Technical Readiness Assessment (TRA) Checklist

Resources

- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- DAU AcqNotes website
- Defense Technical Risk Assessment Methodology (DTRAM)

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- Independent Logistics Assessment Guidebook
- Logistics Assessment Guidebook Tool
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

B. DEFENSE CONTRACTING SYSTEM

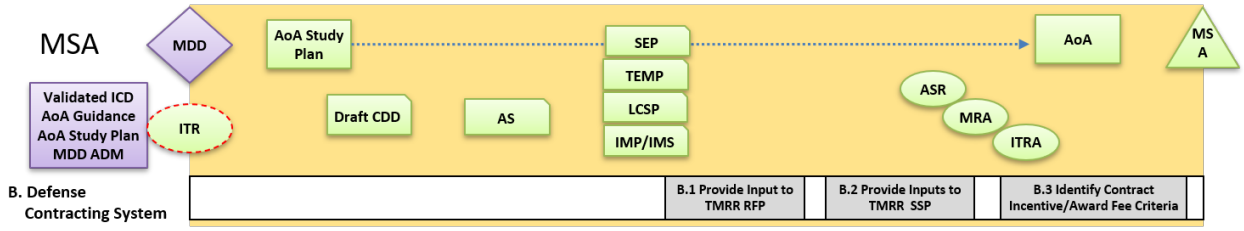


Figure 2-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

M&Q program office personnel will participate in all phases of the development of Technology Maturation and Risk Reduction (TMRR) RFP, Source Selection Plan (SSP), and Award Fee incentive criteria. Many programs do not consider M&Q management requirements until the later stages of the EMD phase and beyond; however, there is a need to manage and control the emerging M&Q risks in the early acquisition phases.

M&Q inputs to the RFP for TMRR should be based on the M&Q inputs to the AoA in order to successfully develop and deliver the preferred solution and to provide a mature product with reduced risks that meet schedule and cost. These inputs will require specifying the use of best practices in manufacturing management and quality management. As part of the RFP, the contractor will be required to identify and to describe their proposed processes, methods, and actions to address manufacturing feasibility, producibility, and M&Q risks associated with the proposed materiel solution. The RFP will require these "ilities," risks, and other requirements to be appropriately documented in Contract Data Requirements List (CDRL), Data Item Description (DID), and other deliverables subject to a specified approval and acceptance process.

Each of the M&Q inputs to the RFP should note appropriate criteria and metrics to be met, included in the SSP, to ensure a fair and equitable source selection. The M&Q criteria and metrics should be coupled with appropriate award fee incentives, with processes and procedures, to reward successful management and execution, including incremental achievements of program goals. The criteria and

metrics should also be used to incentivize domestic manufacturing and technology capability improvements that contribute to performance enhancement, schedule improvement, cost savings, etc.

The early inclusion of M&Q inputs into the RFP, SSP, and other program processes will help guide the future development program success and help minimize risk.

This thread (Defense Contracting System) will focus on the following:

- Market Research
- Contract Strategy
- Source Selection Plan
- Request for Proposal
- M&Q Inputs to the Contract (Sections C, E, L, and M) (refer to MIL-HDBK-245D)
- Contract Evaluation and Award

Appendix D of the BoK provides sample contracting and RFP approaches.

B.1 Provide Input to TMRR Request for Proposal

The RFP is an opportunity to communicate government requirements to the contractor. The RFP should identify the information required in the contractor's proposal and the criteria that will be used to evaluate the proposal, and the relative importance of those criteria. M&Q managers typically support the development of the RFP by identifying M&Q considerations and criteria for inclusion in the RFP and subsequent contract. These considerations need to ensure there is linkage between the ongoing M&Q considerations, warfighter requirements, and the evaluation factors and sub-factors. Evaluation factors often include cost or price, and quality of product or service, which includes technical considerations, past performance, and others.

Prior to developing an RFP, market research is often conducted to collect information and evaluate the market's ability to satisfy the user needs. M&Q personnel should support market research to identify suppliers and assess potential sources, opportunities, and risks to be addressed in the RFP.

Manufacturing and Quality Tasks

- Ensure M&Q personnel are included in the TMRR market research and RFP writing and review teams.
- Support the development of performance specifications for inclusion in the SOW:
    - Support the requirements process and the identification and decomposition of requirements into performance, detail, process, and/or material specifications
- Ensure traceability between requirement or capability and production/quality verification; analyze the M&Q results from the AoA Study Guidance and the AoA as a basis for RFP requirements.

  - Results from other relevant M&Q feasibility and IB studies should be used as additional data for RFP requirements

- Specify appropriate requirements for CDRLs, DIDs to support M&Q processes and the requisite approval process.
  - Include requirements for reporting of manufacturing, quality, and supplier management metrics
- Specify the requirements for best practices for the contractor's Manufacturing Management System (per Section L.1) and Quality Management System (per Section I.1) to be used (e.g., AS6500, ISO 9001, AS9100, etc.).
  - Specify the requirements for the contractors to identify and describe their proposed specific processes, methods, and actions to address manufacturing feasibility, producibility, and M&Q risks associated with the proposed solutions
- If AS6500 is not invoked in the contract(s), the manufacturing management requirements cited in AS6500 should be the basis for specific contractual requirements for a contractor plan. The requirements, at a minimum, should specify that the contractor address:
  - Manufacturing Management System:
    - Documenting how, when, and by whom each requirement of their system is to be accomplished and the authority and responsibility for each
  - Design Analysis for Manufacturing:
    - Conducting producibility analyses
    - Identifying and managing key and critical characteristics in the Technical Data Package (TDP)
    - Implementing Variability Reduction (VR) to reduce part-to-part variation of key and critical characteristics
    - Identifying and managing key and critical manufacturing processes
    - Conducting Process Failure Modes and Effects Analysis (PFMEA) on critical manufacturing processes
  - Manufacturing Risk Identification:
    - Integrating manufacturing risk management activities into the program risk, issue, and opportunity management process, including the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
    - Conducting and documenting manufacturing feasibility assessments for each competing design alternative under consideration
    - Identifying MRL targets and documenting manufacturing risks through the MRL assessments

        - Conducting Pre-Award Survey if applicable
    - Manufacturing Planning:
        - Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing modeling and simulation, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities
    - Manufacturing Operations Management including:
        - Production Scheduling and Control
        - Manufacturing Surveillance
        - Continuous Improvement
        - Process Control Plans
        - Process Capabilities
        - Quality Plans
        - Production Process Verification
        - First Article Inspections and First Article Tests
        - Supplier Management and Quality
- Specify industry best practices for systems engineering to be used (e.g., IEEE 15288, -1, -2, etc.) in the RFP.
    - Include requirements for the contractors to identify and describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specify contractual M&Q requirements for:
    - Conducting M&Q reviews of engineering and software (with frequency of reviews)
    - Providing M&Q information for cost models
    - Implementing a risk, issue, and opportunity management and mitigation program that includes M&Q (including IB risks)
    - Implementing a M&Q variability reduction program
    - Managing materials and subcontractors
    - Using commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and non-developmental items (NDIs)
- Specify M&Q for:
    - Content for Statement of Work (SOW) and contract sections C, E, L, M, and H
    - Metrics to be met as exit criteria for TMRR phase
    - Requirements for cost estimates that include rate, alternate materials, quantity, etc. (including cost-of-quality data, if available).
    - Requirements for identification and description of manufacturing technology capability improvement efforts

  - Requirements for identification and description of producibility efforts
    - Include cost sharing and incentive plans relevant to the solution
  - Requirements for identification and description of contractor cost sharing and incentive initiatives
    - Requirements that encourage acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life cycle costs
    - Requirements that encourage investment in U.S. domestic sources
  - Requirements for facilities, tooling, and test equipment
  - Requirements for workforce (e.g., training, certifications, etc.)
  - Requirements for supply chain management
- Specify the requirement that the contractor support conduct of independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment.

Tools

- AS6500 Manufacturing Management Program Checklist
- AS9100 Quality Management System Checklist
- ISO 9001 Quality Management System Checklist
- DOORS or other Requirements Management Tool
- RFP Template
- DCMA Pre-Award Survey System (PASS)
- SF 1403 DCMA Pre-Award Survey General
- SF 1404 DCMA Pre-Award Survey Technical
- SF 1405 DCMA Pre-Award Survey Production
- SF 1406 DCMA Pre-Award Survey Quality Assurance
- SF1407 DCMA Pre-Award Survey Financial Capability
- Systems Engineering Plan (SEP) Outline

Resources

- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- 10 USC 2366b
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook

- DoD Engineering of Defense Systems Guidebook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- FAR 46-202 Types of Contract Quality Requirements
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management Systems
- SD-15 Performance Specification Guide
- DI-IPSC-81431A/T System Performance Specification Data Item Description
- MIL-STD-961 Defense and Program-Unique Specifications Format and Content
- MIL-HDBK-245D, Handbook for Preparation of Statement of Work
- MIL-HDBK-29612-1A, Guidance for Acquisition of Training Data Products and Services
- AFMC Inst 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-Award Survey Guide
- Pre-Award Survey User's Manual
- Systems Engineering Plan (SEP) Outline

B.2 Provide Input to TMRR Source Selection Plan

The Source Selection Plan (SSP) specifies how the source selection activities will be organized, initiated, and conducted. The SSP serves as the guide for conducting the evaluation and analysis of proposals, and the selection of contractor(s) for the acquisition. The SSP must clearly and succinctly express the Government's minimum needs (evaluation factors) and their relative order of importance. M&Q managers, as members of the technical IPT, should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Support the drafting of the SSP and provide inputs and metrics.
    - Analyze the M&Q results from the AoA Study Guidance and the AoA as a basis for SSP requirements and metrics
    - Results from other relevant M&Q feasibility and IB studies to be used as additional data for SSP requirements and metrics
- Specify the criteria and metrics for evaluating the contractor's use of best practices for Manufacturing Management, Quality Management (e.g., AS6500, ISO 9001, AS9100, etc.), and Systems Engineering management (i.e., IEEE 15288).
    - Specify the criteria and metrics for evaluating the contractor's proposed processes, methods, and actions to address manufacturing feasibility, producibility, and quality risks associated with the proposed solutions

- Support SSP with appropriate criteria and metrics for submission, review, revision, and approval of CDRLs, DIDs, etc., to support M&Q processes.
- Specify M&Q criteria and appropriate metrics to be met for:
    - All milestone and technical reviews
    - M&Q reviews (including frequency of reviews)
    - Cost models and data (include cost-of-quality data)
    - Management processes for key and critical characteristics
    - Risk, issue, and opportunity identification, management, and mitigation program
    - Variability reduction program
    - Materials management process
    - Supply chain management program
    - Facilities, tooling, and test equipment plan
    - Workforce planning
- Specify the criteria and metrics for evaluating the contractor's:
    - Manufacturing and technology capability improvement plans and efforts.
        - Include cost sharing and incentive plans
    - Producibility efforts relevant to the solution.
        - Include cost sharing and incentive plans
    - Planning for IB risk management and mitigation
    - Plan to meet the exit criteria for TMRR phase
    - Strategy for acquisition of modern technology, production equipment, and production systems that increase productivity and reduce life cycle costs
        - Methods to encourage investment in U.S. domestic sources
- Specify the criteria and metrics for contractor support of independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment.

Tools

- AS6500 Manufacturing Management Program Checklist
- AS9100 Quality Management System Checklist
- Quality Management System Checklist
- Source Selection Plan Template (Navy)

Resources

- Air Force Manufacturing Development Guide
- AS6500, Manufacturing Management Program

- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Defense Federal Acquisition Regulation Supplement, Procedures, Guidance and Information, Subpart 215.3 – Source Selection
- IEEE 15288, Systems and Software Engineering
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management Systems
- PL 114-328
- Source Selection Plan Guide

B.3 Identify Contract Incentive/Award Fee Criteria

FAR Subpart 16.4 notes that "incentive contracts are designed to obtain specific acquisition objectives by establishing reasonable and attainable targets that are clearly communicated to the contractor; and include incentive arrangements designed to motivate the contractor to improve or discourage contractor inefficiency and waste."

Contracts should produce measurable performance outcomes that cumulatively contribute to the system Key Performance Parameters (KPPs)/Key System Attributes (KSAs), to their threshold or objective levels. To motivate the contractor to achieve the desired behavior, appropriate contract incentives (including award fee, incentive fee, award term, and cost sharing) need to be developed to promote and facilitate contractor performance.

M&Q managers need to support the development of Award Fee/Incentive Fee criteria in their respective areas. These criteria may focus on manufacturing investments and outcomes, process capability and control, reduction of waste, producibility improvements, etc.

Manufacturing and Quality Tasks

- Develop M&Q entrance and exit criteria for technical reviews and decision points.
    - Specify metrics for partial achievements, incremental awards, penalties for failure to meet contract requirements, and achievement beyond expectations
- Support the development of contract incentives for early delivery of completed, comprehensive, and acceptable M&Q CDRLs, DIDs, and other program documentation to meet the requirements for timely government approval.
    - Specify metrics for partial achievement and penalties for failure to meet contract requirements

- Provide incentives for achievement of M&Q specific thresholds, objectives, and sub-goals with respect to rate, schedule, performance, quality, etc.
    - Specify metrics for partial achievements, incremental awards, and penalties for failure to meet contract requirements
- Specify thresholds for the adoption and effective implementation of industry best practices in M&Q (e.g., AS6500, ISO 9001, AS9100. etc.).
    - Develop program-specific metrics that measure progress
    - Specify incentives for exceeding thresholds
- Specify thresholds and metrics for comprehensive manufacturing, quality, and subcontracting management plans.
    - Develop metrics for a Manufacturing Management Plan that includes identifying KCs and critical manufacturing processes; performing variability reduction activities; performing manufacturing capability assessments; and including a producibility program
    - Develop metrics for a Quality Management Plan that implements an effective Quality Management System, focused on defect prevention
    - Develop metrics for a subcontract management plan that implements a comprehensive supplier management organization, promoting exceptional performance
- Develop M&Q program-specific criteria and metrics that include key trades for and among cost, schedule, and performance, affordability analysis, risk analysis, and risk mitigation.
- Develop M&Q criteria and metrics that incentivize domestic manufacturing capability improvement investments, contributing to enhanced performance, schedule improvement, cost savings, etc. Include as appropriate the following:
    - Continuous Process Improvement (CPI) program or initiatives
    - Cost sharing, risk reduction, cost recovery, etc.
    - Investments in domestic advanced manufacturing equipment and processes

Tools

- AS6500 Manufacturing Management Program Checklist
- AS9100 Quality Management System Checklist
- Award Fee or Incentive Fee Template
- Quality Management System Checklist
- Source Selection Plan Template (Navy)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook

- Award Fee Guide, (Army, Navy or Air Force guidance)
- Defense Production Act Title III (Manufacturing Technology Programs)
- DoDD 4400.01E, Defense Production Act Programs
- ISO 9001:2015, Quality Management Systems
- MIL-HDBK-896, Manufacturing Management Program Guide

C. SURVEILLANCE SYSTEM

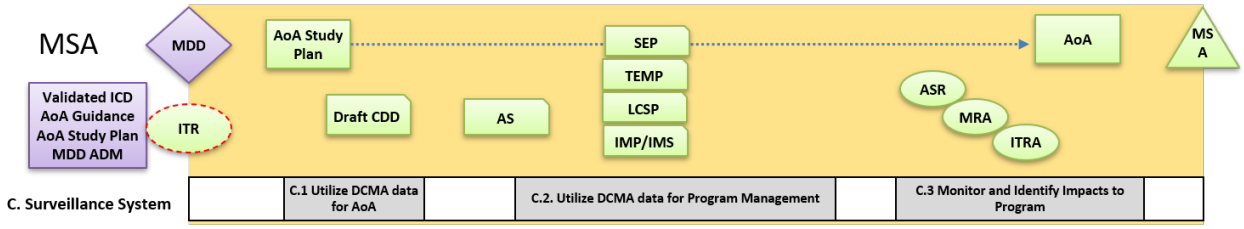


Figure 2-4. Surveillance System Manufacturing and Quality Activities

Introduction

The purpose of contract administration is to ensure the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DoD contractor surveillance activities are required by the FAR/DFAR and by many DoD, Service, and Agency regulations, policies, and guidance documents. DFAR Part 242.2 Contract Administration Services and DFAR Part 242.3, Contract Administration Office Functions, and PGI 242.3 Contract Administration Functions outlines the 70 CAS functions including those requiring M&Q support. M&Q personnel often are called upon to support numerous CAS functions and activities.

Typically, these contractor surveillance activities may be performed under mutual agreement by the program office and DCMA. In many cases the activities may be performed by on-site program office contract administrators, delegated Service contract surveillance offices, or a variety of engineering support activities (e.g., supervisor of ships, development commands). This thread (Surveillance System) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Contract Administration Service (CAS) Functions
- DCMA Support
- DCMA Documentation
- Engineering Support Activity (ESA)
- Monitor and Track Risks
- Participate in Program Reviews

The purpose of contract administration is to ensure the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DFAR subpart 242.3 identifies 71 CAS functions that need to be accomplished and managed. Contractor surveillance is defined by

several FAR and DFAR clauses. Many CAS activities fall under the umbrella of production or quality surveillance activities.

Contractors often depend on their own policies, procedures, processes, plans, controls, and schedules to meet government requirements. Often their plans, procedures, and processes mirror government regulations, directives, instructions, and other documentation that may or may not be contractual.

Government surveillance is often multifunctional, requiring the support of business and technical personnel. Program office, ESA, and DCMA personnel may be required or asked to support surveillance functions at the prime and subcontractor facilities. M&Q managers play an integral and vital role in defining the total scope of contract administration. Program offices can delegate many CAS activities to DCMA as a best practice. Delegations may require a Memorandum of Agreement (MOA) or a Letter of Delegation (LOD). The program office should coordinate with DCMA on required support, provided there is adequate manpower and funding to support the proposed MOA/LOD.

DCMA can provide input into requirements and commitments that enable programs to have current and predictive insight into performance. Access to reliable and accurate data and process information on costs, schedule, and technical performance can assist with objective assessment of supplier plans and the verification of initial and continuing compliance with requirements.

An AoA is an analytical comparison of the operational effectiveness, suitability, and life cycle cost of alternative materiel solutions that satisfy an established capability need identified in an Initial Capabilities Document (ICD). The AoA focuses on identifying and analyzing alternatives, Measures of Effectiveness (MOE), schedule, Concepts of Operations (CONOPS), and overall risk. An AoA also assesses CTEs associated with each proposed materiel solution, including technology maturity, integration risk, manufacturing feasibility, and technology maturation and demonstration needs.

C.1 Use DCMA Data for Analysis of Alternatives

The AoA authority or PM should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. DCMA, using a systematic approach to supplier manufacturing and supply chain evaluation, supply chain improvement initiatives, and best practices, is a valuable resource.

Manufacturing and Quality Tasks

- For manufacturing feasibility assessments of AoA concepts, request information and data input for similar products and manufacturing processes from DCMA in the following areas:
    - Manufacturing maturity
    - Status and readiness of industrial capabilities
    - Current available facilities and equipment

  - Workforce availability and training
  - Quality system processes and results

- Use DCMA M&Q data to analyze the M&Q requirements and feasibility for the AoA.
- Use DCMA M&Q data relevant for emerging technology maturity to develop and provide recommendations/rationale for the AoA preferred concepts.
- Use DCMA data to assist in identifying the manufacturing, quality, and/or supply chain risks for similar products and processes relevant for the AoA.
- Request and use DCMA M&Q data in support of the AoA to include data that supports the following analyses:
  - Manufacturing System Analysis
    - Supplier Surveillance
    - Production Planning and Control System
    - Material Management and Accounting System (MMAS)
  - Manufacturing Program and Product Analysis
    - Development Program-Specific Surveillance
    - Industrial Labor Relations
    - Past Performance
  - Manufacturing Continuous Improvement and Analysis
    - Surveillance of Supplier Continuous Improvement System
    - Supplier Performance Measurement
  - Supply Chain System Analysis
    - Materials Planning
    - Supplier/Sub-tier Qualification/Requirements Decomposition
    - Communication/Systems Integration
    - Continuous Improvement
    - Supplier Performance Measurement System and Surveillance Improvement
    - Data Analysis, Statistics, and Sampling
  - Supply Chain Risk Assessment
    - Risk Realization
    - Program/Platform/Sector Analysis and Modeling
    - Critical Item Risk
    - Capacity/Lead Time Analysis

Tools

- Analysis of Alternatives (AoA) Study Plan Template
- AS6500 Checklist

- AS9100 Checklist
- DCMA Pre-Award Survey
- DCMA Program Support Plan
- Interactive MRL Users Guide (Checklist)
- ISO 9001 Checklist
- SF 1404 Pre-Award Survey – Technical
- SF 1405 Pre-Award Survey – Production
- SF 1406 Pre-Award Survey – Quality

Resources

- Air Force Analysis of Alternatives (AoA) Guide
- Air Force Analysis of Alternatives (AoA) Handbook
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook
- DCMA Industrial Analysis (DCMA-INST 401)
- DCMA Pre-Award Survey Guide
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- ISO 9001:2015, Quality Management Systems

C.2 Use DCMA Data for Program Management

The program office should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. This may require the program office to establish a Memorandum of Agreement (MOA) or a Quality Assurance Letter of Instruction (QALI) with DCMA. DCMA may then use a systematic approach deploying surveillance through the supply chain to evaluate the supply chain and supplier improvement initiatives. At resident and non-resident facilities, DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes.

Manufacturing and Quality Tasks

- Support the development of program documentation, planning, and investments using DCMA information and data with respect to:
    - Manufacturing maturity
    - Industrial capability status and readiness
    - Facilities and equipment availability
    - Workforce availability and training
    - Quality system processes and results

  - Manufacturing and/or supply chain risks

- Support the systems engineering process, trade studies, design, analyses, etc., using DCMA M&Q data from DCMA reports on:
  - Manufacturing and Quality System Analyses
  - Manufacturing and Quality Program and Product Analyses
  - Manufacturing and Quality Continuous Improvement and Analysis
  - Supply Chain System Analysis
  - Supply Chain Risk Assessment
- Recommend manufacturing investment programs required to mature emerging manufacturing technologies and industrial capabilities based in part on DCMA inputs.
- Request DCMA Contract Management Offices support development of M&Q to ensure agreement on contract oversight needs and perspectives with respect to:
  - Product support analysis
  - Software development
  - Counterfeit parts
  - Cybersecurity

Tools

- Army Manufacturing Technology (ManTech) Proposal Rating Template
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist)
- Pugh Matrix template
- Technology Readiness Assessment Checklist
- Technology Readiness Assessment Guide (GAO-20-48G)

Resources

- Counterfeit Parts Prevention Strategy Guide
- DCMA-INST 401, Industrial Analysis
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-325, Technical Reviews
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoD Directive 4200.15, DoD ManTech Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- ManTech Strategic Plan
- Manufacturing Readiness Level (MRL) Deskbook
- Technology Readiness Assessment Guide

C.3 Monitor and Identify Impacts to the Program

Monitoring contractor progress and performance is an ongoing activity. Monitoring begins with an understanding of the contract requirements as specified in the SOO/SOW/PWS. The contractor has the primary responsibility for producing and delivering its supplies or services. The contractor's performance must be monitored daily to ensure that the supply or service delivered conforms to contract requirements. Unsatisfactory performance under a contract may jeopardize a project or may directly affect an activity's ability to perform its mission. Most program offices may not have the manpower or capability to monitor contractor performance closely and thus must depend on DCMA for assistance in this area.

Manufacturing and Quality Tasks

- Monitor and track external environment for potential impacts to M&Q for the program.
    - Environmental impacts to supply chain (legal and natural disasters)
    - Strategic and political changes/risks (domestic and foreign)
    - New laws and regulations (state and federal)
    - Obsolescence impacts
    - New industry or updated standards (e.g., AS6500, IEEE 15288, etc.)
- Monitor and track IB for trends, business startups, technology breakthroughs, etc., for impacts on M&Q.
- Monitor and track economic and business environment developments and impacts on M&Q regarding:
    - Acquisitions
    - Mergers
    - Bankruptcies
    - Market changes/disruptions

Tools

- Hazardous Material Assessment Template
- Interactive MRL Users Guide (Checklist)
- ISO 9001 Checklist Section Preservation (Handling, Storage, Packaging and Delivery)
- Preliminary Hazard List (PHL) See PHA checklist

Resources

- AS9100, Quality Management Systems, SCM Model
- ESOH in Acquisition Guide
- ISO 14001, Environmental Management
- ISO 9001, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook

D. TECHNOLOGY AND INDUSTRIAL BASE

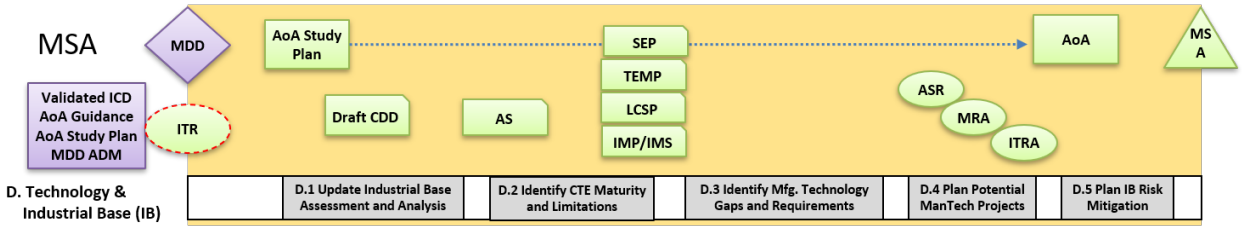


Figure 2-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC 2440 requires the Secretary of Defense to consider the National Technology and Industrial Base (NTIB) in the development and implementation of acquisition plans for each MDAP. The NTIB consists of the people and organizations engaged in national security and dual-use research and development (R&D), production, maintenance, and related activities within the United States, Canada, the United Kingdom, and Australia. All MDAP acquisition planning and plans should consider the following with regard to NTIB:

- Ability to support development and production (rates and quantities)
- Identification of IB risks in the supply chain
- Identification of single points of failure in the supply chain (sole source, foreign source, etc.)
- Support for a resilient supply base for critical defense capabilities
- Support for procurement surges and contractions

This thread (Technology and Industrial Base) requires an analysis of the capabilities of the NTIB to support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal (including environmentally conscious manufacturing). This thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Industrial Base Assessments (IBAs)
- Industrial Base Risks
- Critical Enabling Technologies
- ManTech Projects
- Industrial Base Mitigation Plans

The MSA phase identifies materiel solutions to address gaps in capability based on an AoA. The AoA is performed independent of the Program Management Office and forms the basis for selecting the recommended approaches for materiel solutions. During the AoA, each competing alternative under consideration is analyzed for its impact to industrial and manufacturing capabilities. The results of the analyses are used to quantify the differences between alternatives based on the industrial and manufacturing capabilities and the resources needed.

The IBAs performed previously determine the likelihood that a proposed materiel solution can be produced. The assessments identify relevant sources and potential unique manufacturing capabilities, known gaps, risks, and potential sources, technological developments, market trends, processes, environmental factors, and policies, etc. The IBA focuses on availability, vulnerability, potential obsolescence, and actions necessary to mitigate.

The IBAs identify the high-risk manufacturing areas and highlight the need for investments in manufacturing technology improvements. These gaps must be identified early to reduce acquisition costs by providing the required investments in manufacturing capabilities in time to support production. The DoD ManTech program was created to address the concerns for high-risk manufacturing processes, with the objective of improving performance and reducing cost by developing, maturing, and transitioning advanced manufacturing technologies.

The assessments and analyses also highlight the need to support, maintain, or enhance essential or fragile industrial capabilities. The IBAs identify the IB risks incurred in selecting a design and highlight the need for mitigation of potential product or component obsolescence, supplier fragility, and process economic feasibility.

Note: When industrial capabilities require an investment greater than $10 million and affect more than one defense program or user, or if they support, maintain, or enhance essential or fragile industrial capabilities, the analyses and subsequent decisions must be coordinated within and across the Components in accordance with DoDI 5000.60.

D.1 Update Industrial Base Assessment and Analysis

As a member of the IPT, the program office should update previous IBAs to satisfy the requirements of 10 USC 2440 and DFAR Subpart 207.1.

Manufacturing and Quality Tasks

- M&Q support the update of the IBAs for concepts included in the AoA (conduct if not previously accomplished) by:
    - Ensuring identification of relevant sources including identification of unique manufacturing capabilities that are not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)

  - Determining the likelihood that a proposed materiel solution can be produced using existing manufacturing capabilities while meeting quality, production rate, and cost requirements
  - Ensuring the concept requirements and capabilities assessments are updated to include:
    - Identification of all known gaps, risks, and potential sources for key processes, technologies, and components
    - Identification of all potential and future M&Q needs inclusive of design, development, production, operation, sustainment, and eventual disposal
    - All technological developments, market trends, processes, environmental factors, and policies, etc., that could potentially impact M&Q of the preferred concepts

- Request updated DCMA industrial analysis data to support M&Q inputs to the AoA, including data that supports the following analyses:
  - Industrial Capability Assessments
  - Analytical Products
  - Defense Business and Economic Analyses
  - Acquisition Planning Support

- Ensure the M&Q focus of the IBAs is on the:
  - Capability to cost-effectively design, develop, produce, maintain, support, and restart the program (if necessary)
  - Approach to making production rate and quantity changes that support a response to contingency and support objectives
  - Vulnerability of supply chain (to include sole, single, fragile, foreign sources, foreign acquisition of domestic sources, and cybersecurity)
  - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
  - Potential obsolescence
  - Impact of external dependencies and integration
  - New and unique capabilities and processes
  - Actions necessary to mitigate existing IB gaps/risks and identify when a needed industrial capability could be lost

- Prepare the M&Q inputs to the IBA considerations summary report to summarize the results for inclusion in the Acquisition Strategy:
  - Recommend actions or investments that address risks to cost, schedule, performance, and qualitative considerations
  - Define and recommend how and when the actions would be incorporated into the budget and schedule and, if possible, identify budget offsets

- If the required investment is greater than $10 million and is determined to affect more than one defense program, it must be coordinated within and across the Components per DoDI 5000.60

Tools

- AoA Study Plan Template
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Numerous M&S models available for contractor and government use

Resources

- 10 USC §2440, Technology and Industrial Base Plans
- Air Force AoA Handbook
- DCMA-INST 401, Industrial Analysis
- DFARS 207.105
- DoDD 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Assessments
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook

D.2 Identify Critical Technology Element Maturity and Limitations

The ManTech program focuses on advancing state-of-the-art manufacturing technologies and processes from the research and development environment (laboratory) to the production and shop floor environment. ManTech addresses critical technology elements (CTEs) that are often immature and have process limitations that need to be assessed and plans made to mature the CTE.

Manufacturing and Quality Tasks

- Identify the CTEs and assess the M&Q maturity for the AoA.
  - Include necessary hardware and the associated embedded software maturity
  - Identify mature components, subsystems, M&Q processes, and alternatives for each immature CTE, and specify a plan for increasing the M&Q maturity

- Assess the manufacturing feasibility, and M&Q processes associated with each CTE in the validated ICD and develop a plan to improve and/or maintain maturity.
    - Include integration risk associated with the CTEs in trade studies and development
    - Include CTE interdependencies and associated risks
- Support the ASR, conduct M&Q analyses to document the likelihood that the CTEs will mature to the required level to meet operational effectiveness and suitability with an acceptable level of risk.
- Support the upcoming phase RFP and address M&Q maturation of critical technologies.

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Technology Readiness Assessment

Resources

- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- Early Manufacturing and Quality Engineering Guide
- NAVSO P-3687, Producibility Systems Guidelines
- Technology Readiness Assessment Guidebook
- Technology Readiness Assessment Guide (GAO-20-48G)

D.3 Identify Manufacturing Technology Gaps and Requirements

The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. The manufacturing feasibility assessment should identify high-risk manufacturing process areas that represent technology voids or gaps and may require investments in ManTech or other programs. ManTech program investments should be directed toward areas of greatest need and potential benefit. These investments must be identified early so the manufacturing capabilities will be matured on time to support rate production.

Manufacturing and Quality Tasks

- Conduct M&Q assessments to identify gaps and high risk in manufacturing processes needed for the preferred concept(s).
    - Analyze identified advanced manufacturing capabilities to confirm requirements
    - Analyze the gaps for potential manufacturing technology solutions that mitigate the risks
    - Estimate M&Q cost, schedule, and performance impacts

- Identify potential investments in M&Q technology that address gaps and risks.
- Conduct a survey that includes both DCMA reports and analyses and the ongoing DoD ManTech program projects for potential solutions to manufacturing technology gaps.
    - Request DCMA provide relevant data
    - Request ManTech assistance to identify processes and components
- Identify and develop M&Q assistance requests to DoD and/or component manufacturing technology programs that support:
    - Identification of new manufacturing processes associated with the program and candidate components for the identified processes
    - Identification of low-yield processes and components
    - Development of requests for information from other government agencies, industry, and academia responses to warfighter needs
- Identify recommendations for program and contracting personnel on emerging M&Q technology investments and Defense Production Act Title III initiatives.

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Pugh Matrix
- Technology Roadmap
- TRL Assessment Checklist

Resources

- DoD Systems Engineering Guidebook
- Air Force Technology Development and Transition Strategy Guidebook, Nov 2010
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development, and Investments
- DoD Directive 4200.15, ManTech
- Manufacturing Readiness Level (MRL) Deskbook
- Technology Readiness Assessment (TRA) Guidebook
- Technology Readiness Assessment Guide (Report GAO-20-48G)

D.4 Plan Potential ManTech Projects

Accelerating the flow of technology to the warfighter is one of the top priorities of DoD, Services, and agencies. Technology transition involves the identification and maturation of technologies to the point where they are proven to be mature and ready for insertion into a system or element. As members of

the Technical IPT, M&Q managers need to support the identification of ManTech projects and plan for their insertion into production programs.

Manufacturing and Quality Tasks

- Develop plans for identified gaps and high-risk manufacturing processes that require investments in ManTech or other manufacturing programs.
- Develop a comprehensive plan for each required potential ManTech investment that mitigates M&Q technology gaps for the preferred concept.
    - Determine potential funding sources for ManTech projects (program office, Service, or DoD-wide funding)
- Use both DCMA reports and analyses and ongoing ManTech projects to support planning for potential solutions to M&Q technology gaps.
    - Include relevant DCMA and ManTech program data
    - Request M&Q planning support from DoD and/or component manufacturing technology programs for:
        - Development of new manufacturing processes associated with the program and candidate components for the identified processes
        - Development and maturation of low-yield processes and components
        - Program and contracting personnel supporting manufacturing technology investments and Defense Production Act Title III initiatives
        - Evaluating and maturing emerging manufacturing technology maturity

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Manufacturing Technology Report, DI-MISC-81176A
- TRL Assessment Checklist

Resources

- Air Force Technology Development and Transition Strategy Guidebook
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- DoD Directive 4200.15, ManTech Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Technology Readiness Assessment Guide (Report GAO-20-48G)

D.5 Plan Industrial Base Risk Mitigation

Industrial base risk mitigation activities may be a result of a formal study or analysis or may be a result of routine oversight that identifies a risk or an issue. M&Q managers need to assist in the development and management of risk management strategies and implementation plans.

Manufacturing and Quality Tasks

- Identify all M&Q capability risks that impact the preferred concept.
- Develop a mitigation strategy and plan for each M&Q IB risk.
- Develop an IB capabilities plan with contingencies to identify and mitigate the current and future M&Q capability risks. Plan should identify and mitigate:
    - All M&Q capabilities that should be maintained throughout the life of the program
    - Items projected to go out of production and plan for product or technology obsolescence, lifetime replacement, or regeneration
    - Fragility of unique M&Q capabilities and any facilities or corporations that provide unique services or products
    - The approach to making production rate and quantity changes that support a response to contingency and support objectives
    - Vulnerability of supply chain (to include sole, single, fragile, foreign sources, and foreign acquisition of domestic sources)
    - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
    - Impact of external dependencies and integration
    - New and unique capabilities and processes

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- M&Q Risk Mitigation Plan (no template available)
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Industrial Base Sector Plans (no specific tool)

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions
- DoDI 5000.60, Defense Industrial Assessments
- DoD Systems Engineering Guidebook
- DCMA-INST 401, Industrial Analysis
- MRL Deskbook, Development of a Manufacturing Maturation Plan

E. DESIGN

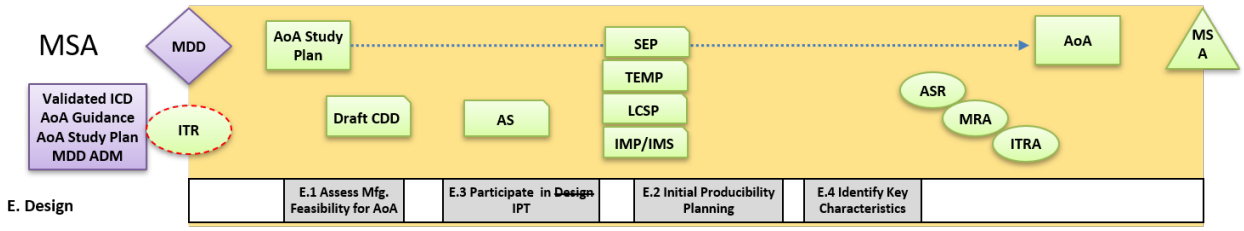


Figure 2-6. Design Manufacturing and Quality Activities

Introduction

The MSA phase presents the first real opportunity to influence system design and begin planning for production by balancing requirements against producibility, manufacturability, and affordability. The AoA team should ensure that a manufacturing feasibility assessment is accomplished as a part of the AoA. The feasibility assessment includes:

- Producibility of the potential design concepts
- Critical manufacturing processes and special tooling development required
- Test and demonstration required for new materials
- Alternate design approaches within the individual concepts
- Anticipated manufacturing risks and potential cost and schedule impacts

The feasibility analyses determine the likelihood that a proposed materiel solution(s) can be produced using existing manufacturing capabilities while meeting quality, production rate, and cost requirements. The feasibility assessments also identify the manufacturing risks incurred and the manufacturing capability gaps in selecting a design. Without these assessments, the PM, once assigned, may find that the program cannot be accomplished within the defined cost and schedule thresholds because of incompatibilities between the system design and the manufacturing capability available to execute it.

At the close of the AoA, a program office is assigned ownership of the approach. At this point, the program management establishes the appropriate IPT structure to support program execution. The IPT structure begins with the Overarching Integrated Product Team (OIPT). Additional IPTs will be designated as needed to support development of the proposed materiel solution(s). The IPTs may eventually include program activities from the macro to the micro (e.g., Systems Engineering; Design; Risk, Issue, and Opportunity Management; Manufacturing and Quality; Configuration Management; Critical Subsystems, components, and items, etc.). Not all IPTs will be present at all phases of development; however, M&Q participation in all program IPTs is essential to program success.

The IPTs conduct systems engineering analyses to support the development of the Acquisition Strategy and the SEP. The MSA phase also provides the opportunity to influence system design and plan for production by evaluating technology opportunities and current practices against cost, schedule, and

performance. The intent is to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements. The PM is responsible for manufacturing, quality, and producibility risk identification and management throughout the program's life cycle. M&Q representatives will plan and conduct assessments of M&Q readiness and risk to be documented in the SEP.

As part of the IPTs, M&Q should conduct analyses that include initial producibility analyses. The IPTs should examine the management of overall requirements and the use of industry best practices, tools, and techniques in development of the established concept. Producibility analyses should include statistical process control, product characterization, modeling and simulations, and lessons learned from similar and/or prior programs.

Systems engineering analyses will also determine the initial KPPs and initial KSAs. User requirements need to be expressed in terms of KPPs and other quantifiable parameters to include:

- System performance requirements to meet mission requirements; and
- The full range of sustainment requirements (materiel availability, production capability, reliability, maintainability, logistics footprint, supportability criteria, etc.) needed to meet system sustainability and affordability over the life cycle.

The KPPs and the KSAs should have threshold values consistent with the requirements specified in the ICD and the performance specified in the preliminary performance specifications. The initial KPPs and KSAs will be documented in the draft CDD. From the initial KPPs and KSAs, M&Q analyses will determine the features of a material, system, subsystem, item, or component whose variation has significant influence on fit, performance, service life, or manufacturability. These features are the KCs, which will be linked to manufacturing processes with associated risks, and should be included as M&Q considerations in the Acquisition Strategy and SEP.

This thread (Design) requires an analysis of the degree to which the identified, evolving, or system design will meet user requirements and the degree to which the design is new and unproven. This thread will focus on the:

- Systems Engineering Plan (SEP)
- Systems Engineering Integrated Product Teams (IPTs)
- Work Breakdown Structure (WBS)
- Technical Reviews and Audits
- Producibility Planning and Assessments
- Key Characteristics
- Design Maturity

E.1 Assess Manufacturing Feasibility for Analysis of Alternatives

As members of the technical Integrated Product Team (IPT), M&Q managers should accomplish manufacturing feasibility assessments of the proposed alternatives identified in the AoA. A feasibility assessment should focus on identifying and reducing production risks of the proposed concepts and evaluating the capability of the factory floor to build to the design. This includes assessing manufacturing readiness and effective integration of industrial capability considerations into the design process. The first consideration is a need to understand the current manufacturing capabilities to see if they match up against the proposed AoA solutions so the program can plan for the enhancements of capabilities where there is a gap between the design and factory floor capabilities.

Manufacturing and Quality Tasks

- Update assessments of manufacturing feasibility for the AoA preferred concepts including the industrial capabilities required to design, develop, manufacture, and maintain each.
    - Update the anticipated M&Q risks for potential cost and schedule impacts
    - Update the producibility and manufacturability assessments for each concept
    - Analyze each AoA concept for manufacturing and producibility gaps and risks including:
        - Critical and unique manufacturing process requirements
        - Alternate design approaches within the concepts
        - Material requirements
        - Supply chain requirements
        - Production rate requirements
        - Facility requirements
        - Special tooling development requirements
        - Test and demonstration requirements for new materials
        - Manufacturing capability obsolescence
        - Manufacturing capability sustainment
- Ensure assessments provide the data required for the initial manufacturing and producibility inputs to KPPs and KSAs

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Manufacturing Producibility Assessment Worksheet (PAW)
- Market Research Reporting Template
- Preliminary Hazards List Developed
- Pugh Matrix

Resources

- DoD Market Research Guide
- CJCSI 5123.01I, JCIDS Instruction
- CJCS JDIDS Manual
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- ESOH in Acquisition Guide
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- Technology Level Assessment Guide (Report GAO-20-48G)

E.2 Participate in Design Integrated Product Teams

Major programs are organized around a core design team, usually composed of 20-50 of the contractor's engineers. This core design team makes 90-95 percent of all critical decisions with most made before production. M&Q should be one of the design team's primary concerns. If the considerations are delegated to secondary teams or not accomplished until late, the program could incur serious problems with cost, schedule, and performance.

Current design best practice includes digital engineering, digital twins, and defining the authoritative source of program data. This includes use of computer-aided design (CAD) and computer-aided manufacturing (CAM).

The PM and technical team need to include M&Q considerations in these early design trade-off decisions. The contractor will follow the government's lead. If the government shows concern for these areas in the development of the design and integration with M&Q, then the contractor receives the message and will show like concern. M&Q personnel must participate with the Design IPT in the development and review of the design and design documentation.

Manufacturing and Quality Tasks

- M&Q IPT participants should review and assess the proposed approach to systems engineering and use of tools and best practices
- M&Q IPT(s) participants provide design inputs and design support to:
    - Develop initial view of system requirements and system design concepts

  - Formulate initial system solutions
  - Develop a system functional definition that incorporates the user needs
  - Perform engineering analyses
  - Conduct initial design trade studies including external dependencies
  - Create a system specification document
  - Develop preliminary system functional and performance requirements
  - Derive and document draft KPPs and KSAs
  - Plan modeling and simulation
  - Identify critical technologies, and conduct a manufacturing maturity assessment of the hardware and embedded software options
  - Identify and assess M&Q risks as part of identification and assessment of system level risks
  - Identify future design validation and verification requirements
- M&Q IPT(s) participants provide inputs and support to:
  - Program management reviews
  - Other program IPTs (e.g., Systems Engineering, Configuration Management, Risk Management, Producibility etc.)
  - The Acquisition Strategy, SEP, draft CDD, and the TEMP in preparation for and participation in the ASR

Tools

- Acquisition Strategy (AS) Outline
- Draft CDD Template
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment
- TEMP Template

Resources

- Acquisition Plan Preparation Guide
- CDD-CPD Writing Guide
- CJCSI 5123.01I, JCIDS Instruction
- CJCS JDIDS Manual
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Systems Engineering Guidebook
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Guide (GAO-20-48G)
- Test and Evaluation Management Guide

E.3 Initial Producibility Planning

Producibility engineering and planning should be directed toward generating a design that is compatible with the current capability of the factory floor. Producibility is a major driver of product affordability because of the effect on both production and sustainment costs. The Producibility Plan should guide the design effort and describe activities that will be accomplished, the responsible organization, and the management controls that will be established to ensure successful accomplishment. M&Q managers should be developing the Initial Producibility Plans to support prototype design efforts with a focus on the realism, completeness, and clarity of the planning accomplished by the contractor.

Manufacturing and Quality Tasks

- Establish a Producibility sub-IPT.
    - Implement a producibility risk management process
    - Identify and deploy producibility design guidelines
    - Identify producibility best practices to be followed
- Analyze potential M&Q process risks and capabilities to determine producibility goals to include:
    - Identification and analysis of state-of-the-art manufacturing and production M&S approaches
    - Critical M&Q processes (yield and rates, if available)
    - Potential cost and schedule impacts
    - Special tooling, testing, and qualification
- Provide producibility planning guidance that emphasizes efficient manufacturing and product design and addresses:
    - Industry best practices, tools, and techniques
    - Design analyses that include:
        - Requirements validation analyses
        - FMEA
        - Trade studies on alternative product and process designs
        - Product complexity analyses
        - Manufacturing process analyses
        - Quality process analyses
        - Design for manufacture and assembly
        - Tolerance analyses
    - Costs, cost drivers, and controls
    - Material characterization and goals
    - KCs

  - Risk and risk mitigation planning
  - Prototypes
  - Learning curve projections
  - Planning for product and process measurements
  - Statistical Process Control (SPC)
  - Data and database management
  - Testing
- Ensure producibility planning is incorporated into the Manufacturing Management Plan.

Tools

- Benchmarking
- CAD/CAM software
- Design Failure Modes and Effects Analysis (DFMEA)
- Design for Manufacture and Assembly (DFMA)
- Design of Experiments (DOE)
- FMEA
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Process Failure Modes and Effects Analysis (PFMEA)
- Producibility Engineering and Planning (PEP) Data Item Description
- Quality Functions Deployment (QFD)
- Six Sigma and Lean

Resources

- DoD Systems Engineering Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS6500, Manufacturing Management Program
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning (PEP)
- Manufacturing Readiness Level (MRL) Deskbook

E.4 Identify Key Characteristics

AS9103 is the industry standard and best practice for the identification and control of Key Characteristics (KCs). The standard requires the producer to maintain documentation of KCs and control the manufacturing processes that directly influence variation of those KCs. KCs should have a Capability Index (Cpk) of 1.33 or greater or as specified by the customer. The concept of identifying KCs is linked to the Pareto principle, which asserts that a small number of features will have the most significant impact on performance. M&Q managers should be involved in the identification and

assessment of KCs early on during the development of the prototype design to see if the design and manufacturing can meet customer requirements and identify risks from not meeting those requirements. Often in the past, companies identified KCs only after experiencing cost problems, in the plant and in the field. Proactive or robust engineering would have contractors identifying KCs early in the design phase.

Manufacturing and Quality Tasks

- Provide M&Q inputs and support to deriving and documenting draft KPPs, KSAs, and Additional Performance Attributes (APA).
- Perform analyses of initial KPPs, KSAs, and APAs to determine the features of a material, system, subsystem, item, or component whose variation has significant influence on fit, performance, service life, or manufacturability and develop initial KCs.
    - Provide analysis and quantification of constraints to form, fit, and function for the preferred concept
    - Provide linkage to M&Q processes and risks
- Provide analyses of draft KPPs, KSAs, and initial determination of KCs as M&Q inputs to program documentation.
- Assess the organizations' ability to identify, manage, and control Key Characteristics (KCs) and Critical Characteristics (CCs).

Tools

- ISO 9001 Checklist
- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Critical to Quality Tree
- FMEA
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- TRL Assessment Checklist

Resources

- ISO 9001 Quality Management Systems – Requirements
- AS9100 Quality Management System
- AS6500, Manufacturing Management Program, Nov 2014
- AS9103, Variation Management of KCs
- DoD Systems Engineering Guidebook

- JCIDS Manual
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- Technology Readiness Assessment Guide (GAO-20-48G)

F. COST/FUNDING

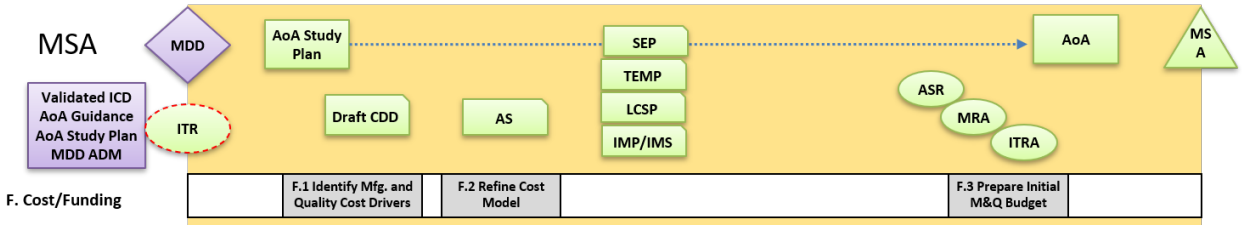


Figure 2-7. Cost and Funding Manufacturing and Quality Activities

Introduction

To identify and prioritize program resources, Services and agencies develop Program Objective Memorandums (POMs). The POM is part of the programming phase of the Planning, Programming Budgeting and Execution (PPBE) process. The DoD combines the various Service and agency POM inputs and Budget Estimate Submission (BES) and submits a DoD Budget Request to the Office of Management and Budget (OMB).

As part of these processes, detailed M&Q cost estimates usually cannot be finalized during the MSA phase, but cost drivers can be identified and initial cost estimates developed based on proposed materials and processes that are inherent in the proposed materiel solution(s).

For example, producibility cost drivers can be identified to estimate required investments in manufacturing technologies. These M&Q cost estimates support development of the total program cost budget. Cost estimates are further used to evaluate affordability (a discriminator) and in establishing initial thresholds for the proposed materiel solution(s). In many cases, the estimates are developed using statistically based cost estimating relationships or analogy with similar systems. The cost estimating team should incorporate M&Q considerations from the AoA and ASR. During MSA, the cost estimates support the evaluation and selection of a preferred system concept for the Milestone A decision.

This thread (Cost/Funding) requires an analysis of the risk that the system development and deployment will not meet the DoD cost and funding goals and will focus on:

- Cost Modeling (Initial Estimates)
- Identification of Cost Drivers
- Assessment of M&Q Costs
- Preparation of M&Q Budgets

- Development of M&Q Cost Mitigation Plans
- Development and Validation of Learning Curves

F.1 Identify Manufacturing and Quality Cost Drivers

M&Q managers need to support the development and update of government cost estimates and the assessment of contractor cost estimates. This responsibility includes identifying manufacturing cost drivers, those costs that have the most impact on cost and affordability.

Manufacturing and Quality Tasks

- Identify manufacturing, quality, materials, and unique or specialized requirements and associated risks that are cost drivers for the AoA and update for the ASR.
    - Include assumptions on process, materials, rate, supplier quality, workforce, special handling, environmental compliance, security, etc., and quantify the cost driver uncertainties
    - Estimate the cost of quality for each concept
    - Estimate the cost of ESOH and HAZMAT requirements and risks
    - Estimate the cost and impact of testing requirements
- Identify producibility cost drivers and associated risks for the AoA and update for the ASR.
    - Estimate impact of producibility opportunities and risks on rates, process, throughput, etc.
    - Estimate cost of implementation for producibility improvements
- Provide updates to the CARD with the M&Q inputs for the ASR.
    - Provide M&Q cost sensitivity analyses updates
- Support cost estimates as appropriate:
    - Independent Cost Estimate (ICE)
    - Component Cost Estimate (CCE)
    - Component Cost Position (CCP)
    - Cost Capability Analysis (CCA)
    - Independent Government Cost Estimate (IGCE)
    - Should Cost Estimate (SCE)
    - Sufficiency Review

Tools

- Cost, Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Design to Cost Estimates

- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- *See* CAPE website for tools

Resources

- CAPE website
- Cost/Schedule Control System Criteria Reference Guide
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoD Systems Engineering Guidebook
- Guidelines for the Preparation and Maintenance of CARD Tables
- Guidelines for the Preparation and Maintenance of the Cost Analysis Requirements Description
- Manufacturing Cost Estimating (*see* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- MIL-HDBK-766, Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook

F.2 Refine Cost Model

A cost estimate is an evaluation and analysis of future costs of hardware, software, and/or services. Cost estimates are derived from models based on historical cost, performance, schedule, and technical data associated with similar items or services. Early in a program that model may be based on analogy when the system is still being defined and created. In reality, even these early models may have some very real data. For example, the warfighter may need a new missile, one that goes faster and farther. Parts of the missile may be new technology and the basis of estimate may need to be analogy, but if the booster is an existing technology and is in production, for that part of the Work Breakdown Structure the program can use actual costs in their modeling.

Manufacturing and Quality Tasks

- Provide M&Q inputs to update cost targets and error bands for proposed materiel solutions for the AoA.
    - Review the assumptions behind these targets
    - Prepare detailed M&Q process charts to ensure the validity behind cost targets
    - Identify and quantify M&Q cost variables
    - Quantify the uncertainties
- Update the cost estimates for the proposed materiel solutions for the AoA including estimates for:

  - KCs and key processes
  - Variability reduction needs
  - Manufacturing environment simulations
  - Cost/performance trade studies
  - M&Q capability requirements
  - Product and process validation requirements
  - Key supplier management
  - Producibility
  - Environmental compliance
  - Manufacturing systems security (physical, cyber, etc.)
- Upon completion of the AoA, develop M&Q inputs to initial cost models for the preferred solution.
  - Verify cost models include all M&Q process variables
  - Provide M&Q inputs to the CARD for the appropriate cost categories
  - Provide initial M&Q inputs (cost models estimates) to the ASR

Tools

- Analogy and Parametric estimating
- Cost Analysis Requirements Description (CARD) (*See* CAPE website for tools)
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Interactive MRL Users Guide (Checklist) for the Cost/Funding thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan

Resources

- CAPE website
- Cost Analysis Requirements Description (CARD) Template (*See* CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- Guidelines for the Preparation and Maintenance of CARD Tables
- Guidelines for the Preparation and Maintenance of the Cost Analysis Requirements Description
- MIL-HDBK-766, Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook
- Parametric Estimating Handbook

F.3 Prepare Initial Manufacturing and Quality Budget

Budget estimates are developed to provide the financial resources needed to improve affordability, reduce risks, mature emerging technologies for insertion, and help resolve several manufacturing-related issues. The budget estimate made near the end of the MSA phase needs to be accurate enough to support the program through TMRR. M&Q managers need to support the review and update of M&Q budgets required to support daily manufacturing and QA and to support maturing technologies and processes.

Manufacturing and Quality Tasks

- Provide M&Q cost estimates for the TMRR budget.
    - Verify that cost estimates include all M&Q cost drivers and risk estimates from the updated cost model
    - Provide updated producibility cost drivers and risk estimates to the budget process
    - Provide quantified M&Q cost driver uncertainties and associated budget impact estimates as inputs to the budget process
    - Provide investment estimates in M&Q technologies, processes, equipment, etc., as inputs to the budget process, to include:
        - Capital equipment (tooling, machines, structures, etc.)
        - Test equipment (specialized, environmental, etc.)
        - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
        - GFE
        - Environmental compliance (processes, facilities, equipment, etc.)
        - Manufacturing systems security (physical, cyber, etc.)
    - Use statistically based cost estimating for comparisons of M&Q aspects of the proposed system with similar systems whose costs are known
- Verify affordability cost estimates are used to establish M&Q initial thresholds.
- Identify potential ManTech investments that mitigate M&Q technology gaps.
    - Identify potential funding sources for ManTech projects (program office, Service, and/or DoD-wide funding)

Tools

- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- Quality Plan
- *See also* CAPE website for tools

Resources

- Cost Analysis Requirements Description (CARD) Template (*See* CAPE website for guidance)
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- Manufacturing Readiness Level (MRL) Deskbook

G. MATERIALS MANAGEMENT

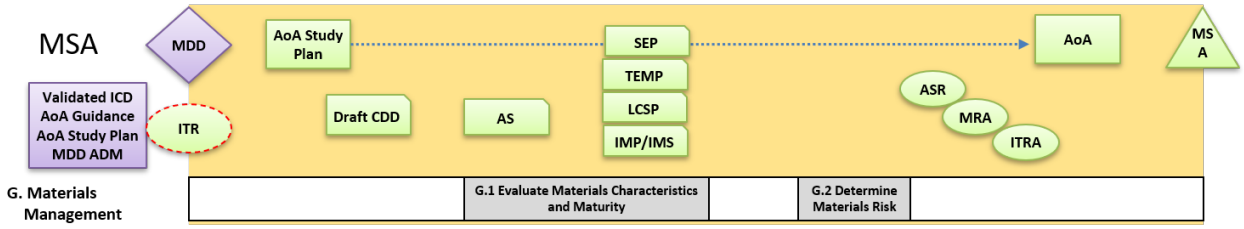


Figure 2-8. Materials Management Manufacturing and Quality Activities

Introduction

Material management is a core function of supply chain management, including the process for planning and controlling material requirements and material flow through the entire supply chain. Material management will require assessment of the maturity, the materials availability, the capability and capacity of the proposed supply chain to provide the materials, and the potential need for special handling, government-furnished property (GFP), shelf life, security, storage, environmental, requirements, etc. The process begins with the customer demand signal, and this information flows throughout the supply chain down many tiers: raw materials, fabrication, assembly, test, quality control, distribution, delivery, and acceptance by the customer. Major SCM functions include:

- Material characteristics and maturity
- Material risks
- Supplier management and quality
- Critical materials
- Special handling requirements
- Scale-up requirements / de-mil / shutdown

One of the major tasks of the MSA phase is to answer the question, "Can it be built?" (i.e., evaluate manufacturing feasibility). This task begins with materials and their capability, maturity, availability, and handling characteristics. In the early MSA phase, the characteristics of each material must be assessed for each concept chosen in the AoA. Many new and emerging materials are identified during the MSA phase, and each carry potential risks. Material capability, maturity, availability, sources, and handling characteristics are key determinates of M&Q risks. Thus, the early MSA phase is a series of trade studies to identify materiel solutions and to address gaps in capability.

Inherent in addressing M&Q risks is an analysis and understanding of the maturity of material properties, characteristics, and quality requirements. This analysis should address scale-up and lead-time requirements, as well as M&Q processes for all materials, especially those that are hazardous or difficult to obtain, process, or handle. Risks from potential counterfeit materials and parts are present at all levels of the supply chain. Additional risks can arise and need to be assessed and understood for materials that are from sole, single, fragile, or foreign sources, and those domestic sources that are vulnerable to foreign acquisition including the entire supply chain.

There are several ways the DoD can address material needs and shortages. One is through the Defense Production Act of 1950 and the implementation of the Defense Priorities and Allocation System (DPAS) in which the government can designate programs as "high priority" and put them at the front of the contractor's production queue. Another is the Defense Industrial Capabilities Handbook, DoD 5000.60H, which identifies alternative actions the government can take when facing material shortages to include:

- Finding foreign sources of supply
- Finding alternative or substitute parts
- Making a lifetime buy to meet all planned future needs
- Maintaining a current capability
- Developing an alternative solution

This thread (Materials Management) requires an analysis of the risks associated with materials (including basic/raw materials, components, semi-finished, parts, and sub-assemblies) and will focus on:

- Material Characteristics and Maturity
- Material Risks
- Supply Chain Management
- Critical Materials
- Special Handling Requirements
- Scale-up Requirements / De-Mil / Shutdown

G.2 Evaluate Material Characteristics and Maturity

Material characterization refers to a process by which a material's structure and properties are probed and measured so that design engineers have a better understanding of how a material performs mechanically. This understanding allows designers to make better material choices, manufacturing to make better process choices on how to form the material, and quality engineers on how to better measure the more important material properties. Material engineers need to be able to make design choices that provide the system with the best performance at the lowest costs. When materials are new or not well characterized (understood), there is greater risk of failure during production or operations.

One of the major goals of material characterization is the maturing of the material so that material characteristics and manufacturability are well understood.

Manufacturing and Quality Tasks

- Update and evaluate material maturity and availability for selected AoA concepts:
  - Determine if the materials have been produced in a laboratory (or more mature) environment
    - Evaluate research and development (R&D) and experiments for validation of material manufacturability
    - Evaluate other ongoing programs for prior use of materials under consideration (DoD, Science and Technology (S&T), commercial, government, etc.)
  - Evaluate material properties, characteristics, and quality requirements for each concept against requirements
  - If new materials emerge or are identified, evaluate needed material properties and characteristics, and quality properties
- Provide M&Q support to evaluation of the realism of projected lead times for materials (including hazardous) that are difficult to obtain or process.
- Assess M&Q requirements for material scale-up of selected AoA concepts.
- Perform M&Q volatility assessments for selected AoA concepts and identify:
  - Potential supply chain sources for critical materials
  - Hazardous materials for each concept
  - Special handling procedures that have been applied
- Determine if all M&Q special handling requirements have been identified.
  - Evaluate all materials for:
    - Potential regulatory requirements
    - Hazardous materials and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal

Tools

- Checklist, Section Preservation (Handling, Storage, Packaging and Delivery)
- Design for Six Sigma
- Design of Experiments Analysis
- DMSMS Product Life Cycle Assessment (consult Defense Logistics Agency website)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center

- Interactive MRL Users Guide (Checklist) for the Materials Management thread
- Manufacturing Maturation Plan
- Rough Cut Capacity Planning
- TRL Assessment Questionnaire

Resources

- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- DMSMS Guidebook, SD-22
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- ESOH in Acquisition Guide
- ISO 9001, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- Technology Readiness Assessment Guidebook
- Technology Readiness Assessment Guide (GAO-20-48G)

G.2 Determine Material Risk

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Material risks and issues can slow or delay a program, can add costs to a program, or can create field failures because of poor material reliability. Material risks could include availability of the material, maturity of the material, or need for special handling and control. Material risks can occur anywhere in the supply chain from the prime contractor all the way down to the lowest level (dirt). M&Q managers need to support the identification and management of material risks and material maturity, especially as suppliers and vendors are brought on board and the prime contractor begins to collect and analyze actual data.

Manufacturing and Quality Tasks

- Assess materials maturity and availability M&Q risks for the AoA preferred solution that are:
    - New or critical materials in development
    - Developed in a lab environment, but are not immediately available
    - Readily available within near term (i.e., commodities)
    - Commercially available (long lead, capacity, etc.)
    - Readily available, but have environmental or health concerns
    - Have long lead times
    - Only available from a single or sole source (domestic or foreign)
    - Available within the NTIB
    - Available only from sources that are outside the NTIB
    - Vulnerable to foreign acquisition of domestic sources

  - Hazardous or difficult to obtain or process
  - Materials that are facing Diminishing Manufacturing Sources and Material Shortages (DMSMS)/Obsolescence
  - Counterfeit parts
- Assess material scale-up M&Q risks for AoA preferred solution.
- Conduct an initial risk assessment of potential supply chain capability and capacity.
  - Include material risks for delivery times, manpower, quality, fragility, availability, etc., for the entire supply chain
  - Evaluate the materials management processes for gaps throughout the entire supply chain
- Assess material capability to meet the threshold and objective requirements.
- Assess military vulnerability or gaps that could result from the lack of reasonable material alternatives.
- Identify all M&Q special handling risks including:
  - Potential regulatory requirements
    - Hazardous materials and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal
- Identify material risks from counterfeit electronic parts and materials (e.g., end items, components, parts, or assemblies).
- Conduct a comprehensive cost/schedule/technical risk assessment in support of the ASR and initiate mitigation plans for each risk.
- Material scale-up M&Q risks for AoA preferred solution have been assessed and documented.
- An initial risk assessment of potential supply chain capability and capacity has been conducted and documents:
  - Material risks for delivery times, manpower, quality, availability, etc., for the entire supply chain
  - The material management processes for gaps throughout the entire supply chain
- Material capability and risks to meeting the threshold and objective requirements have been assessed and documented.
- Military vulnerability or gaps that could result from the lack of reasonable material alternatives have been assessed and documented.
- All M&Q special handling risks have been identified and documented, including potential regulatory requirements for

  - Hazardous materials and handling procedures
  - Security (physical, cyber, etc.)
  - Transportation, storage, and shelf life
  - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
  - Disposal
- Material risks from counterfeit electronic parts and materials (e.g., end items, components, parts, or assemblies) have been identified and documented.
- A comprehensive cost/schedule/technical risk assessment has been conducted in support of the ASR, and mitigation plans for each risk have been documented and provided to the decision maker.

Tools

- Checklist, Section Preservation (Handling, Storage, Packaging and Delivery)
- Design of Experiments Analysis
- Diminishing Manufacturing Sources and Material Shortages (DMSMS) Product Life Cycle Assessment—consult Defense Logistics Agency (DLA)
- Industrial Base Assessment Survey Form (DCMA Industrial Analysis Center)
- Interactive MRL Users Guide (Checklist), Materials Management thread
- Long Lead Times Material Report, DI-PSSS-82201
- Manufacturing Maturation Plan
- Market Research Reporting Template
- Supply Chain Management Risk Assessment Checklist
- TRL Assessment Questionnaire

Resources

- AS9145 Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- DMSMS Guidebook, SD-22
- DoD 4140.01, DoD Supply Chain Materiel Management Regulation
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoD Market Research Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Technology Readiness Assessment Guidebook

H. PROCESS CAPABILITY AND CONTROL

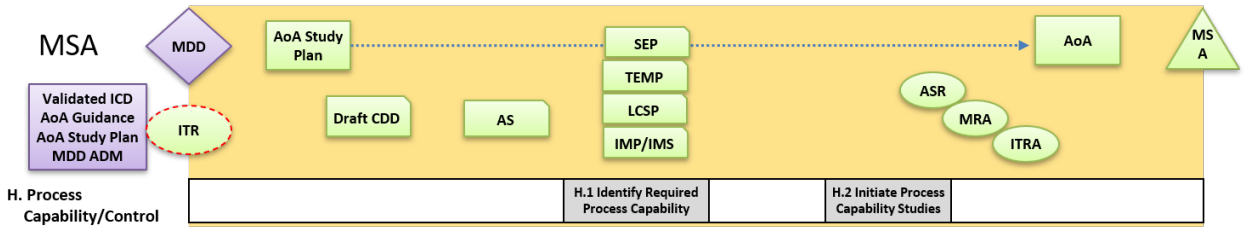


Figure 2-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with uniform, defect-free product that has consistent performance and is affordable. Product quality comes from robust product and process design and process control activities including continuous process improvement to identify and remove sources of variation.

A process is "in control" if it is stable. A stable process does not mean that the contractor is producing only good product, but it means the process is predictable. A capable process is one that is fully capable of producing product within the specification limits. Process capability is usually measured using either a Capability Index (Cp) or a Capability Index centered (Cpk). Process performance is usually measured using either Performance Index (Pp) or a Performance Index centered (Ppk). Contractors should be working to get their processes to be both capable and in control.

The next task is to initiate studies to identify any gaps in M&Q processes. These gaps should include gap in capabilities as a risk and an impact to yields, with time and resources planned to mature these critical capabilities. Manufacturing yields and rates can play a major role in manufacturing cost as they will drive decisions on what processes to use, types of tooling required, quantities to be produced, etc. Studies need to include an analysis of the impact of process capability on KCs, and therefore performance, reliability, and affordability.

Many new technologies and emerging manufacturing processes identified during the MSA phase carry risks. Failure to demonstrate materials and processes may increase the risk that the material or process may not meet the weapon system design, performance, and affordability requirements. When new or high-risk manufacturing capabilities are planned in the Acquisition Strategy, the strategy should specify how this new capability will be demonstrated in a manufacturing environment relevant for the TMRR phase.

This thread (Process Capability and Control) requires an analysis of the risk that the manufacturing processes may not be able to reflect the design intent (repeatability and affordability).

H.1 Identify Required Process Capability

M&Q managers need to be working continuously on production processes to identify where variation has the most impact, reduce variation, and make the process robust to design requirements. Process control studies and other tools can be used to identify upfront and early what the design requirements are, where processes must be made to be capable, and what that capability metric or target should be.

Process capability and control is a requirement of both ISO 9001 and AS9100 quality standards and requires a process control plan, which describes the actions and activities that will demonstrate process capabilities. Process capability clarifies the inherent process variability of a given characteristic or process. Typical process capability measures include Cp/Cpk and Pp/Ppk. A capability study is generally used to assess the ability of a process to meet a drawing or specification requirement. Statistical process control tools are used to determine if a process is in a state of statistical control (predictable). Typical process control tools include the X bar and R charts, among others. For each concept being considered, a determination of the manufacturing processes capability will be completed. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Critical and key manufacturing processes can also be identified during the assessment and analysis either through M&S or experimentation.

Advances in digital engineering including modeling and simulation (M&S), along with continual improvements in computer performance, have made it possible to perform comprehensive analysis of virtual parts and to test and assess the capability of processes before actual manufacturing begins. The use of solid modeling, finite element analysis, multi-paradigm numerical computing environments, and simulation software analysis tools allows users to simulate different conditions that are likely to occur during manufacturing processes and to model the behavior of systems under real-world conditions. An understanding of the capabilities to model products and processes for each of the concepts under consideration can be a valuable discriminator.

M&Q process and control should be a part of any development program and should include an assessment of current required capabilities and potential future capabilities. The first task is to identify the process capability required by the preferred concepts for the AoA. This may be accomplished by an analysis of the preferred concept for process capabilities against industry M&Q standards using manufacturing modeling and simulations.

Note: There is no one standard process capability measurement for all process and product characteristics; however, key and critical characteristics should receive the most focus on development of a standard and on the management of those characteristics during the life of the product.

Important definitions include the following:

- Key Characteristics (KC): An attribute or feature whose variation has a significant influence on product fit, form, function, performance, service life, or producibility that requires specific actions for the purpose of controlling variation.

- Key Manufacturing Process (KMP): A process that creates or substantially affects a key characteristic.
- Critical Characteristic (CC): A characteristic whose variation has a significant impact on human safety, or could cause a catastrophic failure resulting in loss of life, permanent disability, or major injury to personnel.

Manufacturing and Quality Tasks

- Identify anticipated critical manufacturing processes when possible.
- Analyze the current state of process capability for critical M&Q processes for the preferred concept, identify potential gaps, and include the information in the Acquisition Strategy and the SEP.
- Identify and analyze the state-of-the-art manufacturing and production modeling and simulation approaches that support the preferred concept and include the information in the Acquisition Strategy and the SEP.
- Identify M&Q process capability goals and risks for the preferred concept from the manufacturing feasibility assessment, including risks to:
    - Critical M&Q processes
    - Potential cost and schedule impacts
    - Producibility
    - Special tooling
    - Testing and qualification
    - Environmental
    - Management (data, security, etc.)

Tools

- ISO9001 Checklist
- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control Thread
- Manufacturing Maturation Plan
- Plant modeling and simulation tools (FlexSim, SimFactory, etc.)
- Process modeling tools (Siemens PLM, Delmia, etc.)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)

Resources

- MIL-HDBK-896, Manufacturing Management Program Guide
- ISO 9001 Quality Management Systems – Requirements
- AS9100 Quality Management System

- AS6500 Manufacturing Management Program
- AS9103 Variation Management of Key Characteristics
- AS9145 Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- DoD Systems Engineering Guidebook
- Manufacturing Simulation Applications
- Modeling and Simulation Guidance for the Acquisition Workforce
- Manufacturing Readiness Level (MRL) Deskbook

H.2 Initiate Process Capability Studies

A process capability study is a measure of the inherent process variability of a given characteristic. Process capability studies are conducted to assess the ability of a process to meet the contractual specification. Typically, a process capability study follows these steps:

1. Select a candidate for the study.
2. Define the process.
3. Procure resources for the study.
4. Evaluate the measurement system.
5. Prepare a control plan.
6. Select a method for the analysis.
7. Gather and analyze the data.
8. Track down and remove special causes.

Manufacturing and Quality Tasks

- Initiate M&Q process capability studies based on the data from the preferred concept.
    - If no data are available, conduct necessary studies to generate required data
    - Alternatively, use process capabilities of current or similar products to generate the required data
- Analyze the impact of M&Q process capability on KCs that impact performance, reliability, and affordability.
- Analyze M&Q studies of existing processes to determine gaps in manufacturing capabilities as a risk and an impact on yields and rates.
    - Use modeling and simulation tools to perform an analysis of process capability to support yield and rate estimates, before actual manufacturing begins
    - Determine the need for new processes to meet requirements
    - Include time and resources required to mature these critical manufacturing processes
    - Incorporate sources of variations and plans to address the variation
    - Include additional data from existing, proposed, or similar processes from other projects and programs

- Based on analyses, update yield and rate estimates for the Acquisition Strategy and the SEP.

Tools

- ISO 9001 Checklist
- AS9100 Checklist
- AS6500 Checklist
- Cause and Effect Diagram
- Cost of Quality Estimates
- First Pass Yield Estimates Worksheet
- Histograms
- Interactive MRL Users Guide (Checklist), Process Capability and Control Thread
- Manufacturing Maturation Plan
- Pareto Analysis
- Process Capability Studies (Cp and Cpk assessment)
- Statistical Process Control Charts
- Producibility Assessment Worksheet (PAW)
- Six Sigma Worksheet

Resources

- MIL-HDBK-896, Manufacturing Management Program Guide
- ISO 9001 Quality management systems – Requirements
- AS9100 Quality Management System
- AS6500 Manufacturing Management Program
- AS9103 Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- Defense Management Guide for Program Managers, Chapter 7.6.2 Determine Process Capability
- Defense Manufacturing Guide for Program Managers, Chapter 5.5.4 Seven Quality Control Tools
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program
- NAVSO P-3687, Producibility Systems Guidelines

I. QUALITY MANAGEMENT

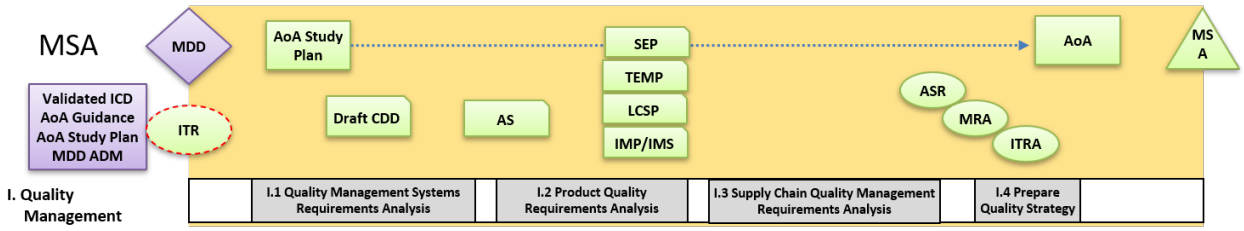


Figure 2-10. Quality Management Manufacturing and Quality Activities

Introduction

Quality management is the set of coordinated activities to direct and control an organization, including the supply chain, regarding quality policy, quality objectives, quality planning, quality assurance, and quality improvement. These activities are performed as part of the QMS, which is that part of the organization's management system that focuses on the results, in relation to the quality objectives, to satisfy the needs, expectations, and requirements. In turn, quality assurance is that part of quality management focused on providing confidence that quality requirements will be fulfilled.

A QMS compliant with industry best practices, ISO 9001 or AS9100, is the foundation for the contractor to deliver a system that meets requirements. The program must evaluate the contractor's QMS to ensure implementation of industry best practices. The program and the contractor should develop a joint government/contractor M&Q plan that specifies:

- Roles, responsibilities, and quality processes
- Tasks, schedules, and outcomes
- Standards, requirements, and metrics
- Joint risk, issue, and opportunity processes and procedures
- Quality tools such as Continuous Process Improvement (CPI)

There are many opportunities during the MSA phase of the acquisition process for M&Q personnel to make a positive impact on program execution. In addition to identifying the intended QMS, M&Q managers need to identify product quality and supply chain quality considerations as a major part of a development program. Quality considerations should be an integral part of the AoA. Therefore, quality requirements, goals, objectives, responsibilities, and authority should be defined and included in quality strategies and plans. The initial Acquisition Strategy will include the approach to quality, quality management, and quality assurance.

This thread (Quality Management) requires an analysis of the risk and management efforts to control quality and foster continuous quality improvement; it will focus on the following sub-threads, tasks, activities, tools, and resources:

- Quality Management System (QMS)

- Quality Strategy and Plan
- Product Quality
- Supply Chain Quality
- Quality Risk

I.1 Quality Management System Requirements Analysis

Quality assurance managers use FAR Part 46 to down-select the appropriate contractual quality requirements. Most DoD programs will require a higher level quality clause. Often contractors will note in their proposal that they will follow a QMS, and it is up to the procuring activity (via DCMA or the ESA) to assess the contractor in its implementation. Best practice has contractors operating to either ISO 9001 Quality Management System or AS9100 Quality Management System. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

M&Q personnel should identify the potential requirements for a QMS of an identified material based on FAR 46.202 Types of Contract Quality Requirements, and FAR 52.2456-11 Higher-Level Contract Quality Requirements.

M&Q personnel may also consider related contract clauses to include:

- Inspection of supplies and services clauses, 52.246-2 through 52.246-9, to ensure appropriate government access, oversight, and protection
- Warranty for supplies and/or services: 52.246-17 through 52.246-21, especially -18, -19, and -20 depending on what work is being done and what product is being delivered.

Manufacturing and Quality Tasks

- Analyze the preferred concepts for quality management system requirements, and document them in the AoA and SEP.
    - The quality management requirements should at a minimum include:
        - Quality management system requirements
        - Management responsibility requirements
        - Resource management requirements
        - Product realization requirements (e.g., risk management, design, and development, purchasing, etc.)
        - Measurement, analysis, and improvement requirements
    - Alternatively, the quality management requirements can be met by adherence to established standards (e.g., AS9100, ISO 9001, etc.)
        - Include M&Q management lessons learned
        - Include industry best practices

- Review, update, and analyze quality management metrics for the preferred concept from the AoA Study Guidance.
    - Verify that the frequency the metrics are reviewed is commensurate with quality risks
- Specify the quality management requirements to be met by the contractor or government entity as appropriate.
    - Provide requirements for quality management responsibilities and personnel within the IPT
    - Provide quality management requirements and metrics
- Contact DCMA for input on QMS evaluation of potential contractor and suppliers for the preferred concept.

Tools

- ISO 9001 Quality Management Systems – Requirements
- ISO 9001, Quality Audit Checklist
- AS9100, Quality Audit Checklist
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Critical to Customer Assessment
- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Quality Management thread
- Manufacturing Maturation Plan
- Quality Management Plan (Sample)
- Quality Management System (QMS), DI-MGMT-82184

Resources

- AFMC Instruction 63-145, Manufacturing and Quality (Draft)
- AS9100, Quality Management System – Aerospace
    - AS9102 First Article Inspection
    - AS9103 Variation Management of Key Characteristics
    - AS9133 Qualification Procedure for Aerospace Parts
    - AS9134 Supply Chain Management Guidelines
    - AS9136 Root Cause Analysis and Problem Solving
    - AS9138 Statistical Process Acceptance
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- ISO 9001, Quality Management Systems
- Manufacturing Readiness Level (MRL) Deskbook

I.2 Product Quality Requirements Analysis

Quality managers must be able to distinguish between a quality assurance (process) and quality control (product). Quality assurance is concerned with how a product is made, and quality control is concerned with how a product turned out. Thus, while the two are certainly interconnected, quality managers need to plan for how they are going to establish product quality requirements in the TMRR phase as the program designs and develops prototypes.

M&Q personnel need to identify the potential product quality requirements of a material based on FAR 46.202, Types of Contract Quality Requirements, and FAR 52.246.1, Contractor Inspection Requirements. In addition, the organization needs to identify the process of measuring, examining, testing, or otherwise comparing the product to the requirements for acceptance. FAR 46.291 Production Lot Testing identifies the purpose of production lot testing is to validate quality conformance of products before lot acceptance, which usually occurs after acceptance testing.

Manufacturing and Quality Tasks

M&Q personnel need to identify and manage product quality requirements:

- Analyze product quality requirements for the AoA preferred concept:
    - Identify product acceptance methods and determine sampling plans as appropriate
    - Incorporate new quality technologies and process state of the art into product quality requirements
    - Analyze the need for unique product quality requirements (i.e., specific product characteristics)
    - Analyze product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Analyze potential solutions and processes that could address product quality needs:
    - Analyze identified quality technologies (i.e., metrology technologies) that could improve product quality
    - Analyze potential solutions or processes to improve the product quality of low-yield processes and components
- Contact DCMA personnel for inputs on potential contractor and supplier quality performance against quality requirements for similar products or processes.
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements.
- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards.

Tools

- AS9100 Quality Audit Checklist

- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Critical to Customer Assessment
- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist) for the Quality Management thread
- ISO 9001, Quality Audit Checklist
- Lot Acceptance Testing Calculator
- Manufacturing Maturation Plan
- Quality Assurance Provisions, DI-SESS-80789A
- Quality Management Plan Samples
- Quality Program Plan, DI-QCIC-81722
- Variability Reduction Plan

Resources

- AS9100, Quality Management System – Aerospace
  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1916 DoD Test Method Standard
- ANSI Z1.4 Sampling Procedures and Tables for Inspection by Attributes
- ANSI Z1.9 Sampling Procedure and Tables for Inspection by Variables for Percent Nonconforming
- DCMA-INST 302 First Article and Production Lot Testing
- DoD Systems Engineering Guide

I.3 Supply Chain Quality Management Requirements Analysis

Major programs require the engagement of the entire supply chain to be successful. Program planning to include the Quality Management Plan, must be delegated down through the supply chain and evaluated on a regular basis for compliance and adequacy. AS9100 and AS9133 define principles that should be called out when qualifying products.

Manufacturing and Quality Tasks

- Analyze the impact of quality technologies and process state-of-the-art for impacts on the quality management of the supply chain.
- Analyze the supply chain quality management requirements for the preferred concept.
    - Analyze the need for focused supplier quality management requirements (e.g., a supplier Quality Assurance Plan)
    - Analyze the need for a stand-alone supplier Quality Management Plan for the supply chain
    - The quality management requirements for the supply chain should at a minimum include:
        - Quality management system requirements
        - Management responsibility requirements
        - Resource management requirements
        - Product realization requirements (e.g., risk management, design, and development, purchasing, etc.)
        - First Article Inspection if required
        - Measurement, analysis, and improvement requirements
    - Quality management requirements for the supply chain can be met by adherence to established quality standards (e.g., AS9100, ISO 9001, etc.)
        - Include M&Q management lessons learned
        - Include industry best practices
    - Analyze and update supply chain quality management metrics for the preferred concept.
- Establish supply chain quality management metrics for each of the concepts being considered for incoming quality inspection, including the identification of acceptable quality levels (AQLs).
    - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Analyze potential solutions, tools, and techniques that could address quality management requirements of the supply chain.
    - Incorporate quality technologies (i.e., metrology technologies) that could improve the supply chain quality programs
    - Incorporate potential solutions (e.g., materials, machines, training, etc.) to improve low-yield processes and components and lower variability to meet supply chain quality requirements
- Contact DCMA personnel for input on the analysis of potential supply chain quality management systems.

- Ensure quality and manufacturing requirements are included in contracts of proposed suppliers and in appropriate agreements with other agencies, e.g., the DCMA.

Tools

- AS9100, Quality Audit Checklist
- AS9133, Qualification Procedure Checklist
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Critical to Customer Assessment
- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Quality Management thread
- ISO 9001, Quality Audit Checklist
- Manufacturing Maturation Plan
- Quality Management Plan
- Supplier Quality Questionnaire
- Variability Reduction Plan

Resources

- AS9100, Quality Management System – Aerospace
    - AS9102 First Article Inspection
    - AS9103 Variation Management of Key Characteristics
    - AS9133 Qualification Procedure for Aerospace Parts
    - AS9134 Supply Chain Management Guidelines
    - AS9136 Root Cause Analysis and Problem Solving
    - AS9138 Statistical Process Acceptance
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Early Manufacturing and Quality Engineering Guide
- ISO 9001 Quality Management Systems
- MIL-STD-1535B Supplier QA
- Manufacturing Readiness Level (MRL) Deskbook

I.4 Prepare Quality Strategy

M&Q managers support the development and updates to the Acquisition Strategy by providing their inputs into the Systems Engineering Plan (SEP). Quality Assurance managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as and AS9100 for implementation requirements. Manufacturing managers can look to industry best

practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and to the success of a program.

Quality management is an integral part of design and development efforts. Quality Management System (QMS) standards include industry best practices such as ISO 9001, Quality Management Systems–Requirements; and AS9100, Quality Management Systems – Requirements for Aviation, Space and Defense Organizations, Product Realization (clause 7). AS9100 clause 7 includes typical systems engineering tasks under sub-clause 7.3, Design and Development. The typical systems engineering processes included in the QMS are:

- Design and Development Planning – SE Management, Failure Modes, Effects, and Criticality Analysis (FMECA), System Safety, etc.
- Design and Development Inputs/Outputs – T&E, Reviews, and Audits
- Design and Development Review, Verification and Validation
- Control of Design and Development Changes – Hardware and Software Configuration Management
- Hardware and Software Configuration Management
- Risk, Issue, and Opportunity Management
- Corrective Action System

Quality assurance and control requirements come from the FAR/DFAR. General industry guidance comes from ISO 9001 and AS9100 quality standards, which require that organizations establish a formal quality policy and submit documentation on internal processes, procedures, and standards. The following are mandatory requirements of ISO 9001:

- Monitoring and measuring equipment calibration records
- Records of training, skills, experience and qualifications
- Product/service requirements review records
- Record about design and development outputs review
- Record about design and development inputs
- Records of design and development controls
- Records of design and development outputs
- Design and development change records
- Characteristics of product to be produced and service to be provided
- Records about customer property
- Production/service provision change control records
- Record of conformity of product/service with acceptance criteria
- Record of nonconforming outputs
- Monitoring measurement results
- Internal audit program
- Results of internal audits

- Results of the management review
- Results of corrective actions

Note: AS9100 standards includes the above.

Manufacturing and Quality Tasks

- Draft a quality management strategy based on the results of the analyses of quality management, product quality, and supply chain quality management requirements, which specifies:
    - Quality management requirements that address:
        - Management responsibility requirements
        - Quality management system requirements
        - Resource management requirements
        - Product realization requirements (e.g., risk management, design, and development, purchasing, etc.)
        - Risks, issues, and opportunities
        - Measurement, analysis, and improvement requirements
    - Alternatively, the quality management requirements met by adherence to established standards (e.g., AS9100, ISO 9001, etc.)
    - Product quality requirements that incorporate new quality technologies and process state of the art, the need for unique product quality requirements, and metrics and the review frequency
    - Supply chain quality management requirements that include:
        - The need for focused supplier quality management requirements
        - A supplier Quality Management Plan
        - Potential standards (e.g., AS9100, ISO 9001, etc.)
        - Metrics
        - Potential solutions, tools, and techniques
    - Planned use of government-furnished quality and testing equipment and assets
    - Establishing appropriate agreements, delegations, and contracts with other agencies, e.g., DCMA
        - Solicit inputs to the quality strategy from on-site government personnel
- Provide the Quality Management Strategy with appropriate language and references for inclusion in the Acquisition Strategy and the SEP.
- Draft an initial program Quality Management Plan for incorporation into the SEP that includes details from the analyses.

Tools

- AS9100 Quality Audit Checklist
- AS9137 Advanced Quality Assurance Procedure (AQAP) Checklist
- AS9145 Requirements for Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP) Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Quality Management thread
- Manufacturing Maturation Plan
- Quality Assurance Program Plan, DI-QCIC-81794
- Quality Audit Checklist
- Quality Management Plan
- Supplier Quality Questionnaire

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102 First Article Inspection
  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
  - AS9137 Advanced Quality Assurance Procedure (AQAP)
  - AS9145 Requirements for Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management Systems

J. MANUFACTURING WORKFORCE

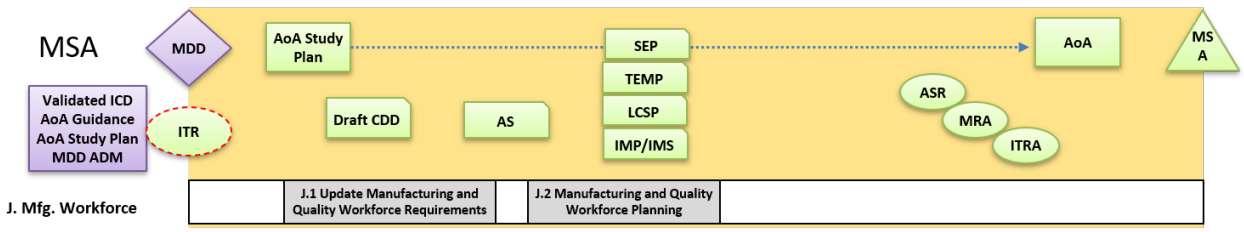


Figure 2-11. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

During the MSA phase, it is essential to update the M&Q workforce requirements and begin planning for future phases. Although highly skilled and trained engineers and artisans may be the workforce used in the laboratory environment, they will not be the workforce used for production. Identification, planning for, and training of the required production workers with required skill sets must begin early. In addition to the production workforce, having a technical staff with education and experience in the relevant areas of engineering and management is key to program success.

As part of the evaluations for the AoA, the processes and planning used by the preferred concepts to determine workforce requirements need to be examined. The preferred concept M&Q processes should be evaluated, as well as a forecast of phase-by-phase requirements for M&Q skills and training.

A staffing plan should be initiated early and include personnel skills, experience and education levels, training, ramp-up, and attrition as part of identifying M&Q skill sets and production workforce requirements. Planning should address risks resulting from shortages of qualified personnel, processes that require certifications, and volatility.

This thread (Workforce) requires the assessment of the required skills and availability in required numbers of personnel to support the manufacturing effort and will focus on:

- Workforce Requirements Identification
- Workforce Planning
- Workforce Risks and Availability

J.1 Update Manufacturing and Quality Workforce Requirements

Manufacturing workforce is one of the 5Ms (manpower, machines, materials, methods, measurement) that needs to be addressed on an ongoing basis, especially early in the MSA phase as alternative solutions are identified, thus uncovering new manufacturing processes and workforce skills. Two major focus areas are:

- Workforce skills availability (are there enough people?)
- Workforce skills capability (do they have the right skills?)

Manufacturing and Quality Tasks

- Evaluate each AoA concept for appropriate industrial workforce standards.
- Evaluate the workforce processes and planning used to determine personnel skills, experience and education levels, training, ramp-up, and attrition for the preferred concepts.
- Evaluate M&Q processes for gaps in workforce skill sets, training, and manpower requirements for each AoA concept to include:
    - Workforce requirements (technical and operational)

  - Processes that require certifications (i.e., special skills)
  - Sources and shortages of qualified personnel based on processes, education, location, precision requirements, etc.
- Update requirements by phase for M&Q skills and training for preferred materiel solutions for the AoA.
  - Identify additional or new skills required
    - Include associated training requirements
  - Determine staffing requirements for skills, experience, certification levels, education levels, ramp-up, and attrition
- Include M&Q workforce requirements in the Acquisition Strategy and the SEP as appropriate.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Workforce thread
- Learning Curve Calculator (Estimator)
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- Defense Manufacturing Guide for Program Managers (DAU website, various chapters)
- Manufacturing Resource Planning (MRP II)
- Manufacturing Readiness Level (MRL) Deskbook

J.2 Manufacturing and Quality Workforce Planning

As the AoA is completed and potential solutions emerge, workforce planning should be assessed and planned for. M&Q managers need to review and update workforce plans. If there are new skills, then the plan should include training and certification if required.

Manufacturing and Quality Tasks

- Initiate M&Q planning, as an input to program management planning, to address M&Q skill sets, production workforce availability requirements, and risks for the TMRR phase.
- Planning should address:
    - Mitigation needs for project ramp-up and workforce attrition
    - Mitigation of critical shortages of qualified personnel based on processes, location, precision requirements, etc.
    - Training and/or certification requirements (e.g., certified welders, skilled machine programmers or operators, etc.)
    - Plans for acquisition and training of new personnel
    - Potential impacts from labor relations, surges, competition, etc.
    - Volatility of demand and impact on workforce requirements
    - Impacts on workforce ability to address processing, testing, and acceptance of new materials and technologies
    - Impacts of regulatory requirements (e.g., special handling, security, HAZMAT, environmental needs, storage requirements, etc.) on the workforce
    - Incorporation of appropriate workforce lessons learned for processes, tools, and techniques for manufacturing workforce strategy
    - Development of M&Q metrics to measure performance
- Document workforce planning as part of the SEP and the Acquisition Strategy.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Workforce thread
- Learning Curve Estimator
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis

- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- Defense Manufacturing Management Guide for Program Managers (various chapters)
- ESOH in Acquisition Guide
- Manufacturing Resource Planning (MRP II)
- Manufacturing Readiness Level (MRL) Deskbook

K. FACILITIES

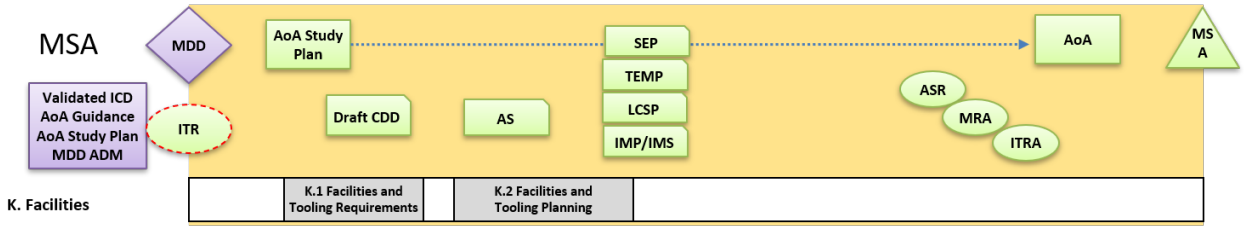


Figure 2-12. Facilities Manufacturing and Quality Activities

Introduction

During the MSA phase, it is essential for the M&Q representatives to update the facility and tooling requirements for the preferred concepts before the AoA and to initiate both a facilities plan and a tooling plan for entry into TMRR and future phases. Based on the preferred concepts, new facilities and tools may be required for new materials, new technologies, and new processes. The decision-making process will also be impacted by production rates, quantities, and capacities by the types of tooling and facilities required. Therefore, facilities and tooling planning should be integral to planning for development, funding, and scheduling.

M&Q planning efforts also define and design the special tooling and test equipment required to execute the effort. Special tooling and test equipment required for a program can be high cost and have a long lead-time to develop and procure. The planning for tooling and test equipment should be initiated during the MSA phase. The planning should include the type of tooling and test equipment to be used, investments, the transition from limited life to rate tools, the need for production and test equipment, and tooling sustainment.

This thread (Facilities) requires an analysis of the capabilities and capacity (prime, subcontractor, supplier, vendor, and maintenance repair) that are key risks in manufacturing. This thread will focus on:

- Facility and Tooling Requirements
- Facility and Tool Planning

K.1 Facilities and Tooling Requirements

Manufacturing facilities and tooling assessment includes an analysis if the capabilities and capacity of the production facilities to develop and build the prototype(s) and prepare for EMD to identify future facility and tooling requirements. Tooling assessment includes special tooling (ST), special test equipment (STE), and special inspection equipment (SIE). Facilities and tooling assessments should include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities.

The facility includes the plant, production equipment, and waste handling and storage equipment to be made available to accomplish the production task. In developing the facility plan, both the quantitative and qualitative demands of the product must be considered. The quantitative analysis will determine the size of the processing departments within the facility. This analysis should consider the number of units to be delivered, and the rate of delivery. For example, the information collected in the analysis will provide a measure of the workstations, plant layout, and the floor space required. The qualitative analysis determines the types of processes that will be required. The contractor then has the option to use currently existing facilities, acquire new facilities, request government-furnished facilities (must be requested in the proposal), or subcontract a portion of the effort.

Manufacturing and Quality Tasks

- Update the M&Q facilities and capital equipment requirements for the AoA preferred concepts.
- Analyze the M&Q quantitative and qualitative facility demands of the preferred concepts for:
    - Availability, design, rate, and capacity capabilities of the facilities under consideration (existing, new, or redeveloped)
    - Types of processes required and the resulting impacts on facilities (e.g., specialized fixtures, test chambers, laboratories, clean rooms, waste storage and disposal, etc.)
    - Unique or special facility requirements for transportation, handling, and storage equipment being manufactured
- Update new M&Q capital equipment, tooling, and Special Test or Inspection Equipment (STE/SIE) requirements for new technology and materials for preferred concepts.
- Update the M&Q assessments of:
    - Tooling requirements for capability to produce at planned production rates and target unit costs
    - Needs for soft tooling versus hard tooling
    - Supplier and sub-tier capabilities, requirements, and investment incentives
    - STE/SIE requirements and capabilities

- Assess M&Q requirements for unique or special transportation, handling, and storage equipment to be manufactured for preferred concepts.
- Update the M&Q funding estimates required for capital equipment, tooling, and test equipment for preferred concepts.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Checklist Section Preservation (Handling, Storage, Packaging, and Delivery)
- Critical Chain Project Management
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 6, Manufacturing Planning
- ISO 9001, Quality Management System
- Manufacturing Resource Planning (MRP II)
- Manufacturing Readiness Level (MRL) Deskbook

K.2 Facilities and Tooling Planning

Once facilities and tooling assessment have been completed and the program has identified future facility and tooling requirements, the program office needs to start planning for the development of these future needs. Facilities and tooling requirements should be planned for at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities.

Facilities management encompasses a variety of professional skills that focus on the design, construction, and management of an installation to include plant and equipment. Life cycle management includes all permanent and semi-permanent real property required to support a system throughout the system life cycle. Facility management includes studies of facility requirements to include location, environmental and security considerations, and maintenance of such property through disposal.

The Facilities and Tooling Plans are subsets of the Manufacturing Strategy, which is in turn a subset of the overall Acquisition Strategy and the SEP.

Manufacturing and Quality Tasks

- Initiate a M&Q Facilities Plan that includes:

  - Requirements for M&Q facilities for development of technologies, prototypes, and subsequent production within required lead times (existing, new, or redeveloped)
  - Addressing the rate and capacity capability requirements on the facilities and needed enhancements for M&Q
  - Mitigation of impacts on facilities from the types of M&Q processes required (e.g., acquisition of specialized fixtures, construction of test chambers, upgrading laboratories and clean rooms, upgrading waste storage and disposal equipment)
  - Addressing unique or specialized M&Q facility requirements for transportation, handling, and storage equipment
  - New facilities to be constructed to mitigate M&Q gaps in current facilities
  - Requirements for M&Q investments and funding with associated schedules
  - Assessment of and mitigation of M&Q environmental and safety factors and impacts
  - Requirements for security of M&Q facilities (physical and cyber)
- Initiate an M&Q Tooling Plan that includes:
  - Tooling requirements to meet production rates, costs, quantities, and schedule
  - Tooling sources, funding, materials impacts, maintenance impacts, etc.
  - Analysis of requirements for soft and/or hard tooling
  - M&Q test equipment including STE, SIE, and GFE
- Derive M&Q funding estimates required for capital equipment, tooling, and test equipment for the preferred concept from the facilities and tooling planning.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 6, Manufacturing Planning
- Manufacturing Resource Planning (MRP II)
- Manufacturing Readiness Level (MRL) Deskbook

L. MANUFACTURING MANAGEMENT AND CONTROL

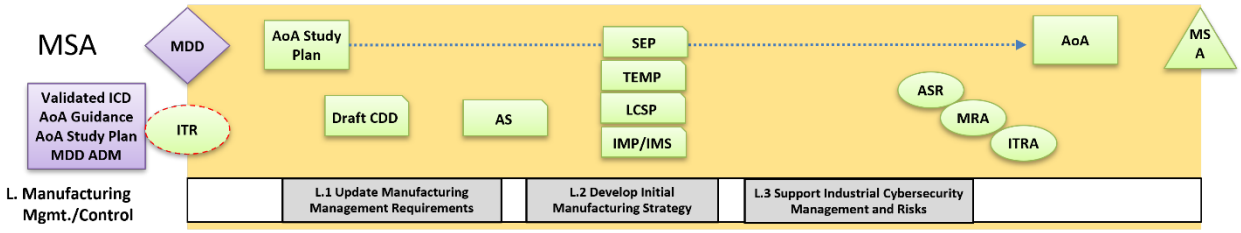


Figure 2-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

Programs with any manufacturing aspects will require a manufacturing management system. Refer to MIL-HDBK-896, Manufacturing Management Program Guide for best practices and definition. The timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risks and issues throughout the program life cycle will be met only by a comprehensive system. Meeting this objective is best accomplished by including best practices and standards (i.e., AS6500, Manufacturing Management Program) in the contracts with industry.

Beginning in MSA, after the preferred concept is determined, the PM and program office develop the Manufacturing Strategy and should begin detailed planning for manufacturing. Before the Materiel Development Decision, the activities managing the concept (or the program office) initiated planning for manufacturing management and control. In this phase, manufacturing management planning should be updated for the AoA. The initial Manufacturing Strategy developed during the MSA phase is a subset of the overall Acquisition Strategy and the SEP. The Manufacturing Strategy should address all aspects of manufacturing management and control from design and materials to processes, workforce, and facilities, to transition to TMRR and subsequent phases. For example, competition considerations are a major contributor to reducing weapon system cost. In addition, if a program will be dual sourced, early planning must consider the strategy required to ensure availability of data and data rights for dual sourcing. New manufacturing technologies may require specific plans for development, proofing, and transition to production. Production rates and quantities can also play a major role in driving manufacturing cost as they influence decisions on processes, tooling, make-buy, etc.

The purpose of manufacturing planning is to identify requirements and resources, to manage risk, issues, and opportunities, and to integrate manufacturing processes into a structure that provides the capability to achieve production objectives. This planning should be updated during the subsequent acquisition phases. Manufacturing planning should include:

- Manufacturing management responsibilities as an integral part of the IPT structure with assignment to specific program office personnel.
- Manufacturing metrics for the program with a specified review cycle of metrics commensurate with risks.

- Manufacturing assessments to identify and quantify risks in support of program milestone decision points and major design reviews.
- Manufacturing requirements and metrics for agreements, delegations, and contracts with other agencies (e.g., DCMA).

The initial Manufacturing Strategy, as an integral part of the Acquisition Strategy and SEP, will guide the future development program and help minimize risk.

This thread (Manufacturing Management and Control) focuses on early manufacturing management requirements and strategy, which will be documented in a manufacturing management plans and programs during later program phases.

L.1 Update Manufacturing Management Requirements

Manufacturing planning is about understanding everything it takes to produce the items required by the contract, on time, on budget, and with the right performance features. It includes considerations of all the "5Ms" (manpower, machines, materials, methods, and measurements), at the prime contractor and throughout the supply chain. During the MSA phase the program office has identified several alternative solutions and M&Q managers need to understand the M&Q impacts of these potential solutions.

Manufacturing and Quality Tasks

- Ensure each AoA preferred concept is analyzed for manufacturing management requirements (to be incorporated into the RFP, per Section B.1):
    - The manufacturing management requirements can be met by adherence to established standards (i.e., AS6500)
    - Alternatively, manufacturing management requirements should at a minimum include:
        - Manufacturing management system requirements
        - Design analysis for manufacturing requirements
        - Manufacturing risk identification requirements
        - Manufacturing planning requirements (e.g., supply chain, materials, cost, workforce)
        - Manufacturing operations management requirements
    - Analyze the impacts of technology and process state of the art on manufacturing management
    - Request DCMA inputs on manufacturing management system evaluations of potential contractors and suppliers for the preferred concept(s).
    - Analyze relevant manufacturing management lessons learned and best practices among programs and across centers

- Review, update, and analyze manufacturing management metrics for the preferred concept from the AoA Study Guidance.
    - Verify the frequency that the metrics are reviewed is commensurate with manufacturing risks
- Specify the manufacturing management requirements to be met by the contractor (in the RFP) or government entity (in the SEP) as appropriate.
    - Provide requirements for manufacturing management responsibilities and personnel within the IPT
    - Provide manufacturing management requirements and metrics
    - Metrics

Tools

- AS6500 Assessment
- Bill of Material Assessment
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control Thread
- Line of Balance Assessment
- Make/Buy Decisions
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII) Assessment
- Materials Requirements Planning (MRP) Assessment
- Systems Engineering Management Plan, DI-SESS-81785A
    - Manufacturing Plan Inputs
    - Manufacturing Plan, DI-MGMT-81889A
    - Quality Plan Inputs
    - Quality Assurance Program Plan, DI-QCIC-81794
- Systems Engineering Plan (SEP)
- Technology Readiness Assessment
- Work Breakdown Structure

Resources

- AFI 63-145, Manufacturing and Quality Management
- AS6500, Manufacturing Management Program
- DoDI 5000.60H, Defense Industrial Capabilities Assessment
- Manufacturing Plan, DI-MGMT-81889A
- MIL-HDBK-896, Manufacturing Management Program Guide
- Systems Engineering Management Plan, DI-SESS-81785A

- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Guide (GAO-20-48G)

L.2 Develop Initial Manufacturing Strategy

A Manufacturing Strategy should be developed as part of the acquisition strategy and often includes considerations such as competition. Manufacturing voids, deficiencies, and dependencies on critical foreign source materials should also be addressed. The producibility of each system design concept should be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and IB goals and thresholds. The AoA identified more than one alternative, and an M&Q Strategy needs to be developed to support the development and production of an affordable program.

Manufacturing and Quality Tasks

- Develop appropriate manufacturing management strategy inputs with references based on the best practices from AS6500 for inclusion in the Acquisition Strategy and the SEP.
- Develop the initial Manufacturing Strategy, as a subset of the Acquisition Strategy, and ensure the Manufacturing Strategy addresses M&Q considerations for:
    - IB Risk Mitigation
    - Enabling/critical technologies and constraints
    - ManTech projects
    - Design and producibility
    - Rate and schedule (includes processes, tooling, make/buy, etc.)
    - Key and critical characteristics
    - Cost, affordability, and budget
    - Materials management, sourcing, and risks (including counterfeit, obsolescence, etc.)
    - Supply chain management, characteristics, and constraints (e.g., sole, single, etc.)
    - Competitive development (e.g., dual source, co-production, etc.)
    - Processes and capability control
    - Workforce planning
    - Facilities, tooling, and test equipment (including GFE and assets)
    - Environmental, safety, and occupational health
    - Cybersecurity to include industrial security
- Ensure that the Manufacturing Strategy also addresses:
    - Manufacturing assessments to support program milestone decision points and major design reviews with appropriate exit criteria
    - Manufacturing metrics for the program with a specified review cycle of metrics commensurate with risks

- Ensure the Manufacturing Strategy (and Acquisition Strategy) includes establishing appropriate agreements, delegations, and contracts with other agencies, e.g., DCMA.
- Draft an initial program Manufacturing Management Plan that addresses each key area of the strategy for incorporation into the SEP that includes details from the analyses. In accordance with AS6500, the plan should address:
    - Manufacturing Management System
    - Design Analysis for Manufacturing
    - Manufacturing Risk Identification (including mitigation)
    - Manufacturing Planning
    - Manufacturing Operations Management

Tools

- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control Thread
- Manufacturing Maturation Plan
- Systems Engineering Management Plan, DI-SESS-81785A
    - Manufacturing Plan, DI-MGMT-81889A
    - Quality Plan Inputs
    - Quality Assurance Program Plan, DI-QCIC-81794
- Systems Engineering Plan (SEP)

Resources

- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- Systems Engineering Plan (SEP) Outline

L.3 Support Industrial Cybersecurity Management and Risk Assessment

Industrial cybersecurity is concerned with the ability of organizations to share information digitally (government to industry, prime contractor to subs, labs to program offices, etc.). While the sharing of information is critical, it is equally important to do so in a safe and secure environment. Industrial cybersecurity is concerned with the transfer of digital data via Operational Technologies (OT) inside a facility and through the cloud to other organizations and facilities.

NIST standard NIST SP 800-37, Risk Management Framework for Information Systems and Organizations defines Operational Technology as:

> *Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems/devices detect or cause a direct change through the monitoring and/or control of devices,*

processes, and events. Examples include industrial control systems, building management systems, fire control systems, and physical access control mechanisms.

There are three main types of operational technologies of concern:

- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution system (MES) to support the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers.
- Enterprise resource planning (ERP) system to support functional management resources and control process performance within an enterprise.

These data systems are often digital and shared across multiple functions and organizations. DFARS 252.204-7012 requires contractors to follow NIST SP 800-171 and to:

- Provide adequate security to safeguard covered defense information that resides on or is transiting through a contractor's internal information system or network.
- Report cyber incidents that affect a covered contractor information system or the covered defense information residing therein.
- Submit malicious software discovered and isolated in connection with a reported cyber incident to the DoD Cyber Crime Center.
- Submit media/information as requested to support damage assessment activities.
- Carry the contract clause into subcontracts for operationally critical support, or for which subcontract performance will involve covered defense information.

Manufacturing, as an industry, is the most targeted industry for cyber attacks. DoD policy and best business practices require that data be protected from attack. This includes classified data, controlled unclassified data (CUI), personal data, financial data, etc.

This thread (Industrial Cybersecurity) requires an analysis of the risk that the manufacturing environment may not be able to protect digital and other forms of data from cyber risks and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Identification of Cybersecurity Risks
- Cybersecurity Planning and Management (Execution)

M&Q personnel need to identify and manage industrial cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the AAF.

M&Q personnel need to develop and execute industrial cybersecurity planning for system concepts identified and execute the management of those plans. Programs will employ system security

engineering methods and practices, including cybersecurity, cyber resilience, and cyber survivability in design, test, manufacture, and sustainment. Such methods and practices will ensure that systems function as intended, mitigating risks associated with known and exploitable vulnerabilities to provide a level of assurance commensurate with technology, program, system, and mission objectives.

Manufacturing and Quality Tasks

- Assess manufacturing operation cybersecurity capabilities and cyber vulnerabilities.
- Assess OT cybersecurity approach and requirements for the preferred materiel solution considered as part of AoA.
- Assess OT cybersecurity risks in the anticipated industrial base.
- Assess cybersecurity risks on measures for manufacturing processes of preferred materiel solutions.
- Assess potential supply chain OT cybersecurity and vulnerability risks.
- Minimize and mitigate cybersecurity risks on OT infrastructure.

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (DAU)
- Cybersecurity Strategy ADDM Template
- Interactive MRL Users Guide (Checklist), Cybersecurity thread
- USMC Cybersecurity Management Checklist

Resources

- FAR 52.202.21 Basic Safeguarding of Covered Contractor Information Systems
- DFAR 252.7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.83 Technology and Program Protection
- DoDI 8500.01 Cybersecurity
- DoDI 5000.90 Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoD 5220.22-M National Industrial Security Program
- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle
- NIST SP 800-171 Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations
- NIST Special Publication 800-82 Guide to Industrial Control Systems (ICS) Security

Department of Defense
Manufacturing and Quality Body of Knowledge
(M&Q BoK)

Chapter 3
Technology Maturation and Risk Reduction (TMRR) Phase

November 2022
Version 1.1

Office of the Under Secretary of Defense
Research and Engineering

Washington, D.C.

The appearance of external hyperlinks does not constitute endorsement by the United States Department of Defense (DoD) of the linked websites, or the information, products, or services contained therein. The DoD does not exercise any editorial, security, or other control over the information you may find at these locations.

Department of Defense Manufacturing and Quality Body of Knowledge (M&Q BoK)

Office of the Under Secretary of Defense for Research and Engineering
Executive Director, Systems Engineering and Architecture
3030 Defense Pentagon
Washington, DC 20301-3030
Email: osd.r-e.comm@mail.mil | Attention: SE&A
https://ac.cto.mil/engineering

Approved for public release. DOPSR Case # 23-S-0359.

Contents

Figures

This page is intentionally blank.

Introduction: How to Use the M&Q BoK

The Department of Defense (DoD) Manufacturing and Quality (M&Q) Body of Knowledge (BoK) is a compilation of best practices and lessons learned for completing M&Q activities across the DoD system acquisition life cycle. The office of the Executive Director, Systems Engineering and Architecture (ED, SE&A) prepared the BoK and will update the work periodically to reflect current policy, guidance, tools, and best practices. This document does not supersede DoD policy, guidance, or law.

The BoK details M&Q activities throughout the system life cycle but is not intended to be read from end to end. DoD Engineering and Technical Management (ETM) practitioners and managers may refer to the BoK to find information relevant to the phase of the program they are working on. Within a specific phase, the user may focus on the section and tasks that apply (with appropriate tailoring) for the M&Q activities the program is conducting.

The BoK chapters cover recommended M&Q activities and tasks during each acquisition life cycle phase to meet DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework.

The BoK includes 6 chapters:

- Chapter 1: Pre-Materiel Development Decision (Pre-MDD)
- Chapter 2: Materiel Solution Analysis (MSA)
- Chapter 3: Technology Maturation and Risk Reduction (TMRR)
- Chapter 4: Engineering and Manufacturing Development (EMD)
- Chapter 5: Production and Deployment (P&D)
- Chapter 6: Operations and Support (O&S)

Each chapter focuses on the DoDI 5000.02 activities and program documentation required for that phase. Each chapter uses the following format:

- **Introduction:** Discusses the objectives of that phase to allow the user to understand the environment and requirements.
- **Manufacturing and Quality Objectives:** Discusses roles, goals, and objectives of program M&Q during this phase.
- **Threads:** Twelve threads or topic areas include discussions of major M&Q functions based on the "5 Ms" (Manpower, Machines, Materials, Methods, Measurement); Manufacturing Readiness Level (MRL) criteria; and DoD-unique M&Q-related functions not found in industry (i.e., DoD acquisition system, defense contracting system, and surveillance system). The 12 threads are labeled with letters A through L as follows:

  A. DoD Acquisition System
  B. Defense Contracting System
  C. Surveillance System
  D. Technology and Industrial Base

E. Design
F. Cost and Funding
G. Materials Management
H. Process Capability and Control
I. Quality Management
J. Manufacturing Workforce
K. Facilities
L. Manufacturing Management and Control

Each thread includes several **Activities** represented by gray boxes in the corresponding chapter figure (Figure 1). Activities are numbered A.1, A.2, A.3 . . . B.1, B.2, B.3, etc. The BoK includes the following for each activity:

- Activity overview description
- **Tasks** that M&Q personnel could be expected to support or lead.
- **Tools** such as checklists, templates, and samples available to M&Q personnel intended to help them to accomplish these tasks.
- **Resources** including guidance documents, handbooks, manuals, instructions, memos, etc., that provide direction to M&Q personnel for tasks identified in the gray box.

Example: Figure 1 shows Threads, Documents, Activities, and Reviews for the EMD Phase.

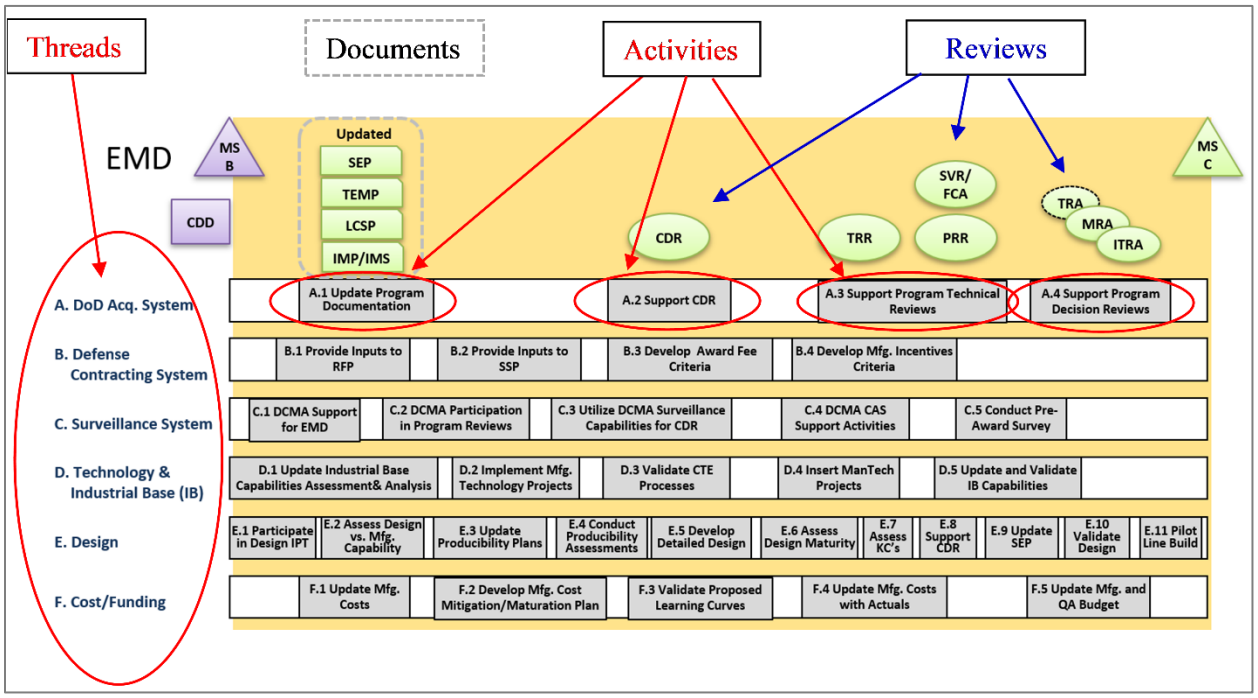
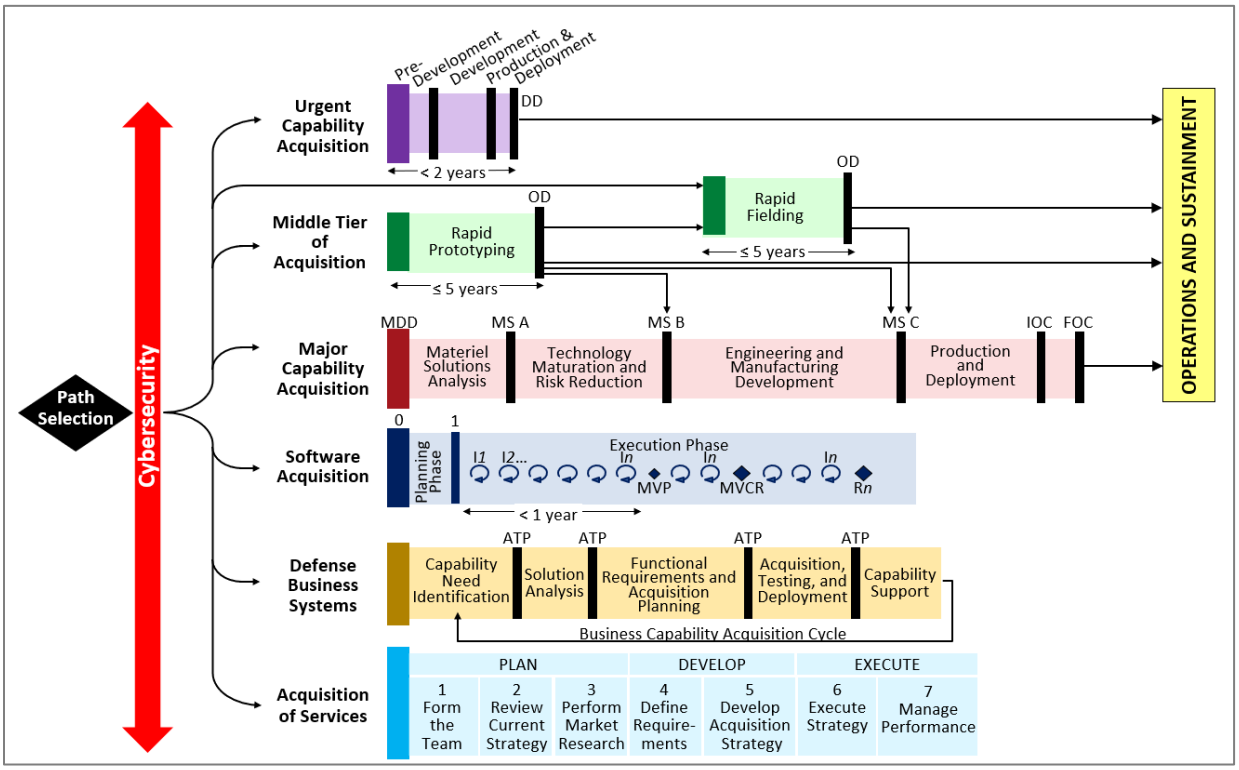


Figure 1. Sample Activity Chart

Adaptive Acquisition Framework (www.aaf.dau.edu)

This BoK follows DoDI 5000.02, Operation of the Adaptive Acquisition Framework (AAF), and for the most part will describe M&Q activities for the path labeled Major Capability Acquisition (MCA). This path includes a comprehensive and systematic approach for applying M&Q best practices; however, the M&Q BoK best practices are applicable to the alternative AAF pathways as well. AAF pathways are depicted in Figure 2.



Source: DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework, January 23, 2020

Figure 2. Adaptive Acquisition Framework Paths

For example, under the AAF, a program may have an Urgent Capability Acquisition (UCA) and may have less than 2 years to provide a solution to the Warfighter, or the program may be involved in a Middle Tier of Acquisition (MTA) approach focused on rapid prototyping or rapid fielding. If so, users can see how these efforts are aligned with the MCA process in Figure 2 and use those BoK chapters to identify and accomplish required tasks and activities.

In addition to DoDI 5000.02, the following associated policies provide information for the paths:

- DoD Instruction 5000.74, Defense Acquisition of Services
- DoD Instruction 5000.75, Business Systems Requirements and Acquisition
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.85, Major Capability Acquisition

- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation

With any acquisition model, the program office should include M&Q personnel on the technical Integrated Product Team (IPT) and to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

M&Q planning, control, and management activities represent an important and central effort that begins early in the life cycle (Pre-Materiel Development Decision (MDD) and/or Materiel Solution Analysis (MSA) phases) and continues throughout the life of a program though Operations and Support. Although planning is discussed in detail in each chapter, Figure 3 provides key elements of M&Q planning activities in relation to overall program life cycle activities.

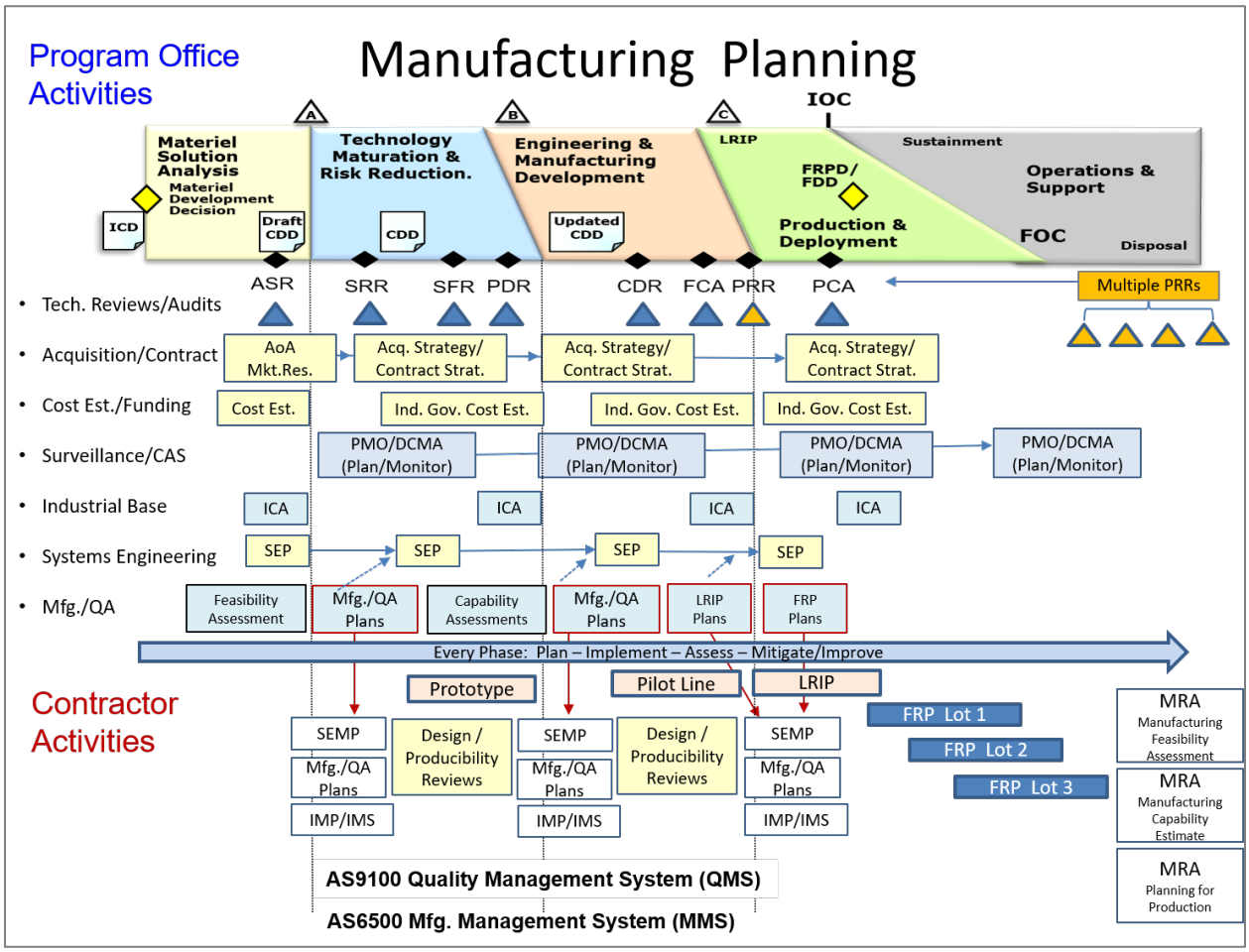


Figure 3. Typical Manufacturing and Quality Planning Activities

Most activities begin with the need to identify requirements, risks, and gaps, followed by planning activities. The top-most planning document is the Acquisition Strategy, and numerous documents feed into the Acquisition Strategy to include the Contracting Strategy and the Systems Engineering Plan (SEP). M&Q strategies should be a component of the SEP. Plans are then evaluated and updated on a recurring basis, usually just before a milestone decision.

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occur. The contractor is responsible for the execution of the program and in planning for success. The government Program Management Office (PMO), along with the Defense Contract Management Agency (DCMA) or other contract surveillance organizations and engineering support activities, is responsible for oversight and management of the acquisition. Risk assessment and mitigation is an ongoing effort that should be conducted throughout the system life cycle. Key references for DoD M&Q planning and management approaches include: MIL-HDBK-896, Manufacturing Management Program Guide; SAE Standard AS6500, Manufacturing Management Program; and Quality Management Systems standards ISO 9100 and/or AS9100. In addition, MRL criteria and assessments are a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

DoD tools and resources are available from many sources. Most should be available through open web-based links, but some may require a ".mil" address or a Common Access Card (CAC), or they may be available only to users in a specific community. Commercial tools and resources should be available to everyone but may require the organization to purchase a user's license/rights (e.g., ISO 9001 Quality Management System industry standard). In many cases, commercial resources and tools have been identified as a best practice. The M&Q BoK lists these tools for reference only; DoD does not necessarily endorse these resources or the publishing organizations. In addition, this document may reference a source for a specific tool (i.e., Pareto Chart), but there may be other widely available sources for this tool or for similar tools.

Sections labeled "Tools and Resources" are provided throughout the document chapters. The following section includes a summary of key references and links by publisher or topic. A more comprehensive list of references is included in Appendix B.

Key Manufacturing and Quality Body of Knowledge References and Resources

Department of Defense (DoD) Issuances, Directives Division https://esd.whs.mil/DD/

- DoD Directive 5000.01, The Defense Acquisition System
- DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- DoD Instruction 5000.81, Urgent Capability Acquisition

- DoD Instruction 5000.84, Analysis of Alternatives
- DoD Instruction 5000.85, Major Capability Acquisition
- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation
- DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD
- DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD
- DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
- DoD Directive 4400.01E, Defense Production Act Programs
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures

Defense Acquisition University (DAU) www.dau.edu

- DAU Guidebooks and References https://aaf.dau.edu/guidebooks/
- Acquisition Notes (AcqNotes) www.acqnotes.com
- Adaptive Acquisition Framework (AAF) https://aaf.dau.edu
- Analysis of Alternatives (AoA) www.acqnote/acquisitions/analsis-of-alternatives
- Market Research www.acqnotes/acqnote/acquisitions/market-research
- Acquisition Strategy (AS) Process/Guidance https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf
- Systems Engineering Plan (SEP) Outline https://ac.cto.mil/erpo/ (Engineering Guidance tab)
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

Defense Contract Management Agency (DCMA) www.dcma.mil

- DCMA Policies https://www.dcma.mil/Policy/
- DCMA Instructions https://www.dcma.mil/Policy/
- DCMA-INST 204, Manufacturing and Production
- DMCA-INST 205, Program Support
- DMCA-INST 207, Engineering Surveillance
- DMCA-INST 309, Government Contract QA Surveillance Planning
- DCMA-INST 401, Industrial Analysis
- DCMA-INST 3401, Defense Industrial Base Mission Assistance

Defense Federal Acquisition Regulation (DFAR) Supplement https://www.acquisition.gov/dfars

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS Subpart 242.7200, Contractor Material Management and Accounting

Defense Logistics Agency (DLA) Website www.dla.mil

- DMSMS Guidebook, SD-22 https://www.dsp.dla.mil/Programs/DMSMS
- ASSIST (Database of specifications and standards) https://assist.dla.mil
- ASSIST Quick search https://quicksearch.dla.mil/qsSearch.aspx
- DoD 4140.01, Supply Chain Materiel Management Regulation www.dla.mil

Federal Acquisition Regulation (FAR) https://www.acquisition.gov/

Manufacturing Readiness Levels (MRLs) www.dodmrl.org

- MRL Assessment Criteria Matrix www.dodmrl.org
- Interactive MRL Users Guide (MRL Assessment Criteria) www.dodmrl.org
- MRL Deskbook www.dodmrl.org
- MIL-HDBK-896, Manufacturing Management Program Guide www.dodmrl.org

National Institute of Standards and Technology (NIST) www.nist.gov

- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST Manufacturing https://www.manufacturing.gov

Office of the Director, Cost Assessment and Program Evaluation (CAPE) www.cape.osd.mil

OSD Manufacturing Technology (ManTech) Program Office https://www.dodmantech.mil

OUSD(R&E) Systems Engineering and Architecture (SE&A) https://ac.cto.mil/engineering

Relevant Government Publications (Available via Web/Internet Search)

- DoD 4245.7-M Manual, Transition from Development to Production, 1985
- NAVSO P-3687, Producibility Systems Guidelines, 1999
- MIL-HDBK-766, Design to Cost
- MIL-HDBK-727, Design Guidance for Producibility, 1984

Standards, Specifications, and Standards Organizations

- ASSIST (Defense Logistics Agency Database of Specifications and standards) https://assist.dla.mil
- ASSIST Quick Search https://quicksearch.dla.mil/qsSearch.aspx
- SAE International www.sae.org
- International Organization for Standards (ISO) www.iso.org
- Institute of Electrical and Electronics Engineers (IEEE) www.ieee.org
- *Note:* Many specifications and standards can be accessed at http://everyspec.com/

Technology Readiness Levels (TRLs)

- Technology Readiness Assessment Deskbook www.acqnotes.com
- Technology Readiness Assessment Calculator www.acqnotes.com
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

3. Technology Maturation and Risk Reduction

Introduction

The purpose of the Technology Maturation and Risk Reduction (TMRR) phase is to reduce technology, engineering, integration, and life cycle cost risk to the point that a decision to contract for Engineering and Manufacturing Development (EMD) can be made with confidence in successful program execution for development, production, and sustainment.

TMRR includes a mix of activities intended to reduce the risks associated with the product to be developed. This includes design and requirements trades, maturation and validation of capability requirements, and finalization of affordability caps. The phase normally includes competing sources conducting technology maturation and risk reduction activities. The phase also includes preliminary design activities, including a Preliminary Design Review (PDR), leading to source selection for the EMD phase.

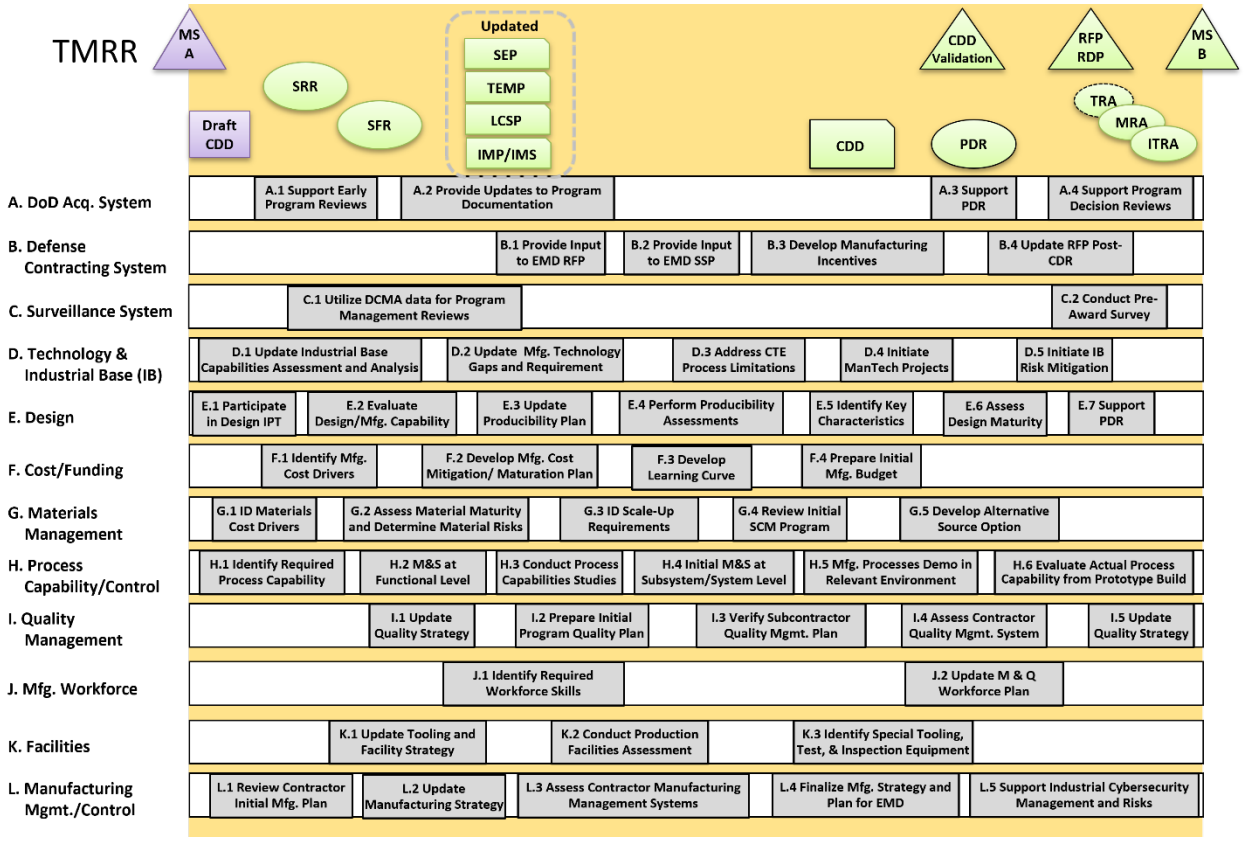


Figure 3-1. TMRR Phase Manufacturing and Quality Activities

The program can exit TMRR when an affordable program or increment of militarily useful capability has been identified, the technology and manufacturing processes for that program or increment have been assessed and demonstrated in a relevant environment and found to be sufficiently mature,

manufacturing risks have been identified and assessed, and a system or increment can be developed for production within a short time frame.

Key program phase reviews and documentation include:

- System Requirements Review (SRR)
- System Functional Review (SFR)
- Program Documentation
    - Acquisition Strategy (AS)
    - Systems Engineering Plan (SEP)
    - Test and Evaluation Master Plan (TEMP)
    - Capability Development Document (CDD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)
- Preliminary Design Review (PDR)
- Manufacturing Readiness Assessment (MRA)
- Independent Technical Risk Assessment (ITRA)
- CDD Validation
- Milestone B (MS B) Decision

Adaptive Acquisition Framework Pathway (Rapid Prototyping)

Under DoDI 5000.02, Operation of the Adaptive Acquisition Pathway, the objective of the Middle Tier of Acquisition (MTA) Rapid Prototyping pathway is to field a prototype to meet defined requirements that can be demonstrated in an operational environment and provide for a residual operational capability within 5 years of the MTA program start date.

Rapid prototyping can be considered an advanced version of TMRR in which the prototype system must be fielded within 5 years, thus the manufacturing processes used to implement the final system configuration must be significantly mature based on acceptable program risk. As a best practice, manufacturing maturity should start at no lower than and MRL 4 and should achieve MRL 7 before demonstrating in an operational environment. Critical manufacturing processes must be matured sufficiently to support fielding.

When a Rapid Prototyping option is chosen, the usual TMRR phase requirements may be truncated and a tailored program initiated. M&Q personnel need to be able to support risk assessments with a Manufacturing Readiness Assessment (MRA) and PRR before entering production.

Manufacturing and Quality Objectives

Manufacturing and quality (M&Q) risks, issues, and opportunities are the most important factors in making the decision to proceed within all phases of development and production. The producibility of

the design and risks are reviewed prior to the EMD phase. The TMRR phase requires assessments of the industrial base (IB) and of the contractor(s) selected.

Programs need to specifically assess the capabilities of the industrial base to understand if the base can support their program. Multiple technology development demonstrations may be required before the operational user and the contractor can substantiate that the solution is feasible, affordable, and supportable; satisfies capability requirements; and has acceptable risks.

By the end of the TMRR phase, M&Q processes will be assessed and demonstrated to the extent needed to verify that risks have been reduced to an acceptable level. Some of the mitigations may involve investments in industrial base capabilities (i.e., Title III) as well as investments in advanced manufacturing capabilities (i.e., ManTech).

Program management is responsible for implementing effective risk, issue, and opportunity management and tracking to include the identification of all known risks, key assumptions, probability of occurrence, consequences of occurrence (in terms of cost, schedule, and performance) if not managed, analysis of risk handling options, decisions about actions to mitigate risk, and execution of those actions. M&Q personnel are responsible for identification, prioritization, and mitigation of M&Q risks and issues. The identification of risks often occurs during the various technical reviews and audits conducted during this phase to include the Independent Technical Risk Assessment (ITRA).

The Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) established policy for the conduct of ITRAs in accordance with 10 USC 2448b. These independent assessments should be conducted in accordance with the Defense Technical Risk Assessment Methodology (DTRAM). DTRAM focus areas include:

- Mission Capability
- Technology
- System Development and Integration
- Modular Open Systems Approach (MOSA)
- Software
- Security/Cybersecurity
- Manufacturing
- RAM and Sustainment

M&Q personnel participation in and support to program design IPTs are critical to success in producing a manufacturable and affordable system with acceptable risks. In TMRR, costs need to be defined and finalized to include identified M&Q cost drivers based on contractor-proposed materials and processes, producibility costs, required investments.

M&Q personnel should analyze the contractor's processes, materials, make/buy processes (hardware and software), and supply chain for capability and completeness, and identification of single points of failure for mitigation. Process capability and control should be an integral part of any development

program and lead to a producible system with effective and efficient manufacturing processes. Workforce skills identification and plans should provide inputs to program planning and should identify the skills required for the scope of the technical effort needed to develop, field, and sustain the system. Also, M&Q personnel should conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases.

During the TMRR phase the contractor will produce prototypes that will be used during tests to validate that the design meets requirements. These prototypes will be built in a relevant manufacturing environment, meaning that there are some elements of production realism present on the manufacturing line. To the extent practicable, M&Q personnel will assess the processes used for prototype build and evaluate the tests and demonstrations to better understand the issues that will need to be resolved during the EMD phase.

Contractors must have an effective combination of people and systems to plan for, monitor, and control M&Q resources. A well-structured manufacturing management system employs the use of industry best practices. A Quality Management System (QMS) compliant with industry best practices is the foundation for the contractor to deliver a system that meets requirements. The contractor should assess its manufacturing management and quality systems against the recognized industry best practices such as AS6500, ISO 9000, AS9100, etc.

The initial M&Q strategies should have been developed during the Materiel Solution Analysis (MSA) phase. During the TMRR phase, an effective joint government/contractor manufacturing strategy and quality strategy are required if the program is to reduce risks and mature and deliver a design for an operationally safe, suitable, and effective weapon system. In addition, the program and the contractor should develop joint government/contractor M&Q plans that execute the strategy for EMD.

A. DOD ACQUISITION SYSTEM

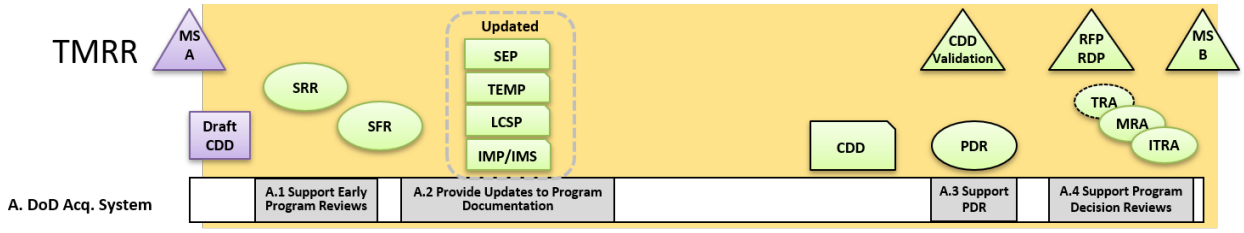


Figure 3-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

The acquisition process includes a series of processes, milestones (five phases), and reviews to determine whether a program will proceed into the next phase. Major Defense Acquisition Programs (MDAPs) and major systems with production requirements should address industrial and

manufacturing readiness in the Acquisition Strategy, during milestone reviews, and in program documentation.

This thread (DoD Acquisition System) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Analysis of Alternatives (AoA)
- User Requirements
- Acquisition Strategy
- Program Documentation
- Program Support
- Milestone Decisions

The TMRR phase objective is to develop designs, demonstrate competitive sources, and prototype designs to reduce technical risk, validate designs and cost estimates, evaluate manufacturing processes, and refine requirements. It focuses on maturing, prototyping, and demonstrating technologies in a relevant environment, resulting in a preferred system concept that achieves acceptable low-risk entry into the EMD phase.

Effective employment of systems engineering will reduce program risk. The program monitors progress with technical reviews to reduce program risk, identify potential management issues in a timely manner, and support key program decisions. M&Q managers should be making significant inputs into these activities and reviews. Early program reviews include the System Requirements Review (SRR) and the System Functional Review (SFR). The SRR helps ensure that the understanding of top-level system requirements is adequate to support further requirements analysis and design activities, and that the system can proceed into initial system design with acceptable risk. The SFR helps ensure that the system under review can proceed into preliminary design with acceptable risk and that all system requirements and functional performance requirements derived from the approved preliminary system specification are defined and are consistent with the program budget, program schedule, risk, and other program and system constraints.

The Acquisition Strategy developed for the Milestone A (MS A) decision should have addressed the following program objectives:

- The program will use industry best practices for manufacturing, quality, and systems engineering management.
- The likely outcome is worth the investment in both resources (real costs) and schedule (opportunity costs).
- The end item meets required performance objectives.
- All risks, issues, and opportunities are identified, managed, and mitigated to an acceptable level.
- The business strategy effectively executes the program.

In the TMRR phase, the updated Acquisition Strategy describes the overall approach to acquiring the capability to include the program schedule, risks, funding, and the business strategy.

The pre-Milestone A initial M&Q strategies, as an integral part of the Acquisition Strategy, should include considerations of:

- Competition
- New manufacturing technologies
- Production rates and quantities
- Materials sourcing
- Contracting strategies

For TMRR, the updated M&Q strategies are a subset of the program Acquisition Strategy and will include these same considerations. Competition is a major contributor to reducing weapon system cost. If the program will be dual sourced, the early planning must consider the strategy required to ensure availability of capability and data and data rights for dual sourcing. New manufacturing technologies, if required by the system concept, will require specific plans for development, proofing, and transition of the technology to the eventual producer. This effort will necessitate close coordination with the Service manufacturing technology (ManTech) organization to ensure compatibility of the technology development schedule with the system development schedule. Production rates and quantities also play a major role in driving manufacturing cost as they will drive decisions on what production processes to use, types of tooling required, make-buy decisions, etc.

The Acquisition Strategy provides a master schedule for research, development, test, and production. M&Q considerations for the strategy should include establishing feasibility, assessing risks, identifying capable manufacturers and suppliers, manufacturing technology maturation, capabilities of the industrial base, availability of critical materials, and the transition from development to production. The Acquisition Strategy and the included M&Q strategies summarize how the industrial and manufacturing risk will be addressed in the TMRR phase to ensure that manufacturing maturity is appropriate to enter EMD, particularly for new or high-risk manufacturing endeavors.

The SEP implements the technical development and engineering aspects of the Acquisition Strategy. The Pre-Milestone A SEP requires updates based on contract award to reflect any changes due to the contractor's technical approach and details not available prior to contract award. Effective employment of systems engineering with competitive prototyping, as applied through the SEP, and monitored with meaningful technical reviews, will reduce program risk, identify potential management issues in a timely manner, and support key program decisions. M&Q managers should be making significant inputs into these documents and activities. In addition, M&Q personnel should provide an M&Q capability assessment update for the SEP during TMRR. They should assess M&Q risks for each competing prototype during TMRR and verify risks have been reduced to an acceptable level. Individual risks should be identified and integrated into a cumulative assessment of the production, manufacturing, and quality risks, issues, and opportunities.

As the program matures, it is important to mature the requisite manufacturing requirements and processes needed to build prototypes and production items. The SEP ensures this by providing, updating, and planning for:

- Conducting producibility analyses with consideration of the life cycle costs of proposed manufacturing, assembly, and test processes.
- Significant activities (i.e., manufacturing assessments, long-lead or advanced procurements, prototype builds, production lots/phases, and Production Readiness Review (PRR) indicated on program schedule).
- Industrial, manufacturing, production, engineering, software, firmware, and quality risks and issues, and reduction efforts, as well as opportunities.
- M&Q organization, billets, and Production, Quality, and Manufacturing (PQM) Key Leadership Positions (KLPs).
- M&Q Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics).
- Planned activities for the next phase.

Additional considerations for the Acquisition Strategy and the SEP, based on assessments of the contractor's cybersecurity plans, are M&Q inputs for cybersecurity that include technical risks, processes, industrial control systems, M&Q resources and organizations, and design considerations. The updated program M&Q strategies also should include appropriate agreements, delegations, and contracts with other agencies (e.g., Defense Contract Management Agency (DCMA), Defense Logistics Agency (DLA), etc.).

Outputs of the SRR, SFR, and PDR will create the need for substantive updates and changes to the SEP. This phase normally includes competitive sources conducting TMRR activities and preliminary design activities up to and including a PDR in advance of source selection for the EMD phase. A final revision and re-submission will be required for approval before the Development Request for Proposal Release Decision (RFP RD) and Milestone B.

The role of M&Q in the TMRR phase is to influence the design. This is critical because of the impact of design decisions on Life Cycle Cost (LCC). Studies have shown that by the time a PDR is held approximately 80 percent of the program's LCC is determined, even though only a small percentage of the program's cumulative costs have been expended (source: DoD O&S Cost Management Guidebook, Figure 4). TMRR is also the time when a program or contractor has the most opportunity to impact life cycle cost savings.

The PDR is a technical assessment establishing the allocated baseline to ensure that the system under review has a reasonable expectation of being judged operationally effective and suitable and has a reasonable expectation of satisfying the requirements within the currently allocated budget and schedule. A successful PDR includes an assessment of the producibility of the design and an assessment of manufacturing costs and risks.

During this phase and timed to support CDD validation (or its equivalent), M&Q will provide support to the Program Manager's conduct of systems engineering trade-off analyses showing how cost and capability vary as a function of the major design parameters. The analyses will support the assessment of refined Key Performance Parameters (KPPs) and Key System Attributes (KSAs) in the CDD. Capability requirements proposed in the CDD (or equivalent requirements document) should be consistent with program affordability goals.

In support of program decision reviews, Development RFP RD, and Milestone B, M&Q will have conducted additional requirements analyses and demonstrations including requirements decomposition and allocation, definition of internal and external interfaces, design activities, and prototypes and process demonstrations that led to a PDR. Milestone B requires final demonstration that all sources of risk have been mitigated to support a commitment to design for production. This includes technology, engineering, integration, manufacturing, sustainment, and cost risks. In addition, pursuant to the NDAA for FY 2017, Sec. 807, before any decision to grant Milestone B approval for the program (pursuant to section 2366b), M&Q personnel are required to identify manufacturing processes that have not been successfully demonstrated in a relevant environment.

Other reviews that should be conducted include an MRA and an Independent Technical Risk Assessment (ITRA).

10 USC 2448b requires that ITRAs be conducted in support of milestone and production decisions for MDAPs. ITRAs will be conducted for all MDAPs before Milestone A, Milestone B, and Milestone C approval and before a Full-Rate Production decision.

In general, technical risks are those events or conditions typically emanating from areas such as mission/requirements, technology, engineering, integration, test, software, manufacturing/quality, logistics, and system security/cybersecurity that may prevent a program from meeting cost, schedule, and/or performance objectives.

ITRAs will leverage ongoing program activities whenever practical, e.g., Technology Readiness Assessments (TRAs), MRAs, and Systems Engineering Technical Reviews. These assessments and activities will inform the ITRA; however, the team will provide an independent assessment of any risks or maturity concerns identified. As such, there may not be a direct correlation between external assessments or measures, such as Technology Readiness Levels (TRLs), and the ITRA team's assessment.

A.1 Support Early Technical Reviews

M&Q personnel should be engaged in the organization and execution of numerous formal reviews and audits during this phase.

Program offices could request an informal review at any time, and M&Q managers need to be prepared to support such reviews.

Sources of data used to assess and manage industrial and manufacturing readiness include technical reviews and audits, program status reviews, pre-award surveys, MRAs, ITRAs, Industrial Capabilities Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

Manufacturing and Quality Tasks

- Provide M&Q support to various Technical Reviews to include:
    - System Requirements Review (SRR)
    - System Functional Review (SFR)
    - Preliminary Design Review (PDR)
    - Manufacturing Readiness Assessment (MRA)
    - Independent Technical Risk Assessment (ITRA)
    - Technical Readiness Assessments (TRAs)
    - Independent Logistics Assessment (ILA)
- Support to the program's overall risk, issue, and opportunity management processes (e.g., industrial base, manufacturing technology gaps, quality, software, and engineering-related risks and issues, etc.).
- Identify program workforce requirements for program organization, billets, and PQM Key Leadership Positions.
- Identify M&Q program requirements (e.g., AS6500, ISO 9000, AS9100, IEEE 15288, etc.) to program management to be used in assessing the contractor's plans to meet program cost, schedule, and performance requirements throughout the product life cycle (*See* I.1 and L.1).
    - Ensure the program and contractor have a joint understanding of the system M&Q requirements and performance that are:
        - Consistent with the preferred materiel solution
        - Consistent with M&Q budget, schedule, risk, user, and other specific constraints
        - Feasible given available manufacturing technologies for the preferred system solution
        - Adequate and consider the maturity of interdependent system elements
        - Bidirectional with traceability to the set of source documents (e.g., Key Characteristics (KC) to KPPs)
        - Verifiable with defined and agreed-upon methods
        - Consistent with program's objectives (with manageable risk
- Technical reviews should address the following areas:
    - Provide M&Q requirements that are sufficiently detailed and understood that enable M&Q functional definitions and functional decompositions
    - Assess M&Q feasibility of the contractor(s)' proposed (traceable to the AoA results):
        - External interface requirements
        - Alternative and/or competitive architectural concepts

- Operational and life cycle sustainment requirements

- Provide M&Q requirements in support of:
  - Human safety and health
  - Hazardous materials (HAZMAT) management and pollution prevention
  - Environmental management (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security (physical and cyber) for both hardware and software
  - KPPs and KCs
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
  - Supportability and sustainment
  - Use of commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and government-furnished equipment (GFE) (including diminishing manufacturing sources)
  - Parts, materials, and processes
- Provide M&Q analyses of requirements that could impact manufacturing feasibility for:
  - System human systems integration/interface requirements
  - System safety requirements
  - System command, control, communication, computer, and intelligence (C4I) requirements
  - System security requirements (e.g., communications, cyber, program protection, anti-tamper, etc.)
  - KPPs (e.g., mandatory, and other)
  - Interoperability requirements
  - Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) requirements
  - Product assurance
  - Specialized manufacturing requirements (extreme complexity, multiple or very tight tolerances, precision assembly, handling of fragile components, etc.)
- Assess and analyze the completeness and adequacy of M&Q requirements for:
  - Contractor's plans for processes and metrics included in the System Engineering Management Plan (SEMP)
  - Contractor's budget and schedule plans including identification of cost and schedule drivers (with impacts on the critical path)
  - Contractor's software development strategy and development plans (to include functionality, adequacy, testing, etc.)
  - Technology maturation plans
  - Developmental Test and Evaluation (DT&E) approaches

        - Development, qualification, and acceptance testing approaches including consideration for non-developmental items (NDI), COTS, and reuse items
        - Modeling and Simulation plans to include design, production, processes, costing, etc.
    - Provide M&Q strategies input to:
        - The joint program/contractor risk, issue, and opportunity management system including hazards, technologies, sources of supply, etc., and mitigating courses of action
        - The joint program/contractor configuration management system
        - The joint program/contractor Integrated Master Plan/Integrated Master Schedule
        - The Cost Analysis Requirements Description (CARD) for M&Q should-cost inputs (*See* F.1)

- Provide M&Q analyses and support to the program and systems engineering functions by:
    - Conducting manufacturing feasibility analyses including cost and schedule
    - Providing M&Q requirements mapped to the hardware and software functional baseline
    - Providing traceability of M&Q requirements to the draft Capability Development Document (CDD)
    - Providing results of Industrial Base Assessments
    - Conducting assessments of risks, issues, and opportunities and associated mitigation planning
    - M&Q inputs to the program PDR planning to include sustainment and life cycle planning
    - Providing analysis of the contractor's SEMP
    - Providing inputs to the detailed plan and schedule with inputs on sufficient resources to continue design and development (i.e., Integrated Master Plan (IMP) and Integrated Master Schedule (IMS)
    - Providing results of assessments of contractor(s) and supply chain capability to mature the proposed design(s) within the program overall cost, schedule, and performance goals (*See* E.2)
    - Providing results of M&Q design producibility analyses (*See* E.2)
    - Conducting analyses of materials availability, maturity, and characterization (*See* G.2)
    - Conducting assessments and providing estimates of process maturity and capability for manufacturing and production processes (*See* H.1)
    - Assessing contractor initial Manufacturing Plans for workforce requirements, skills, capabilities, training, and certifications (including for prototypes and system development) (*See* J.1)
    - Providing analyses of the contractor's tooling and facilities strategies (*See* K.1)
    - Assessing the contractor's Manufacturing Management System and plans (*See* L.1)

Tools

- Army Acquisition Logistician's Assessment Checklist

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Independent Technical Risk Assessments (ITRAs) Execution Guidance
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide Checklist
- ISO 9001 Quality Management System Checklist
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Preliminary Design Review (PDR) Checklist
- Risk Assessment Tool
- System Functional Review (SFR) Checklist
- System Requirements Review (SRR) Checklist
- Systems Engineering Plan (SEP) Outline
- Technical Readiness Assessments (TRAs) Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits, specifically 12.5.3 System Requirements Review (SRR), 12.5.4 and System Functional Review (SFR)
- Defense Technical Risk Assessment Methodology (DTRAM)
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoD 5000.60-H, DoD Handbook: Assessing Defense Industrial Capabilities
- DoD HCI Style Guide, Human Computer Interaction (HCI)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.84, Analysis of Alternatives
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Guide to Environment, Safety, and Occupational Health (ESOH) in the Systems Engineering Plan (SEP)
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs

- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Independent Logistics Assessment Guidebook
- ISO 9001:2015, Quality Management System
- Logistics Assessment Guidebook Tool
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-1472, DoD Design Criteria Standard: Human Engineering
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- NIST 800-171, Controls for Controlled Unclassified information
- Systems Engineering Plan (SEP) Outline
- Systems Engineering Plan Preparation Guide
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

A.2 Provide Manufacturing and Quality Updates to Program Documentation

M&Q personnel need to be actively engaged in the development and update of numerous documents to include:

- **Acquisition Strategy (AS)**
  - Manufacturing Strategy
  - Quality Strategy
- **Systems Engineering Plan (SEP)**
  - Manufacturing Plan
  - Quality Plan
- Test and Evaluation Master Plan (TEMP)
- Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
- Life Cycle Sustainment Plan (LCSP)
- Capability Development Document (CDD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)

Per DoDI 5000.88, programs are required to develop a Systems Engineering Plan (SEP) for Milestone Decision Authority (MDA) approval in conjunction with each milestone review and integrated with the Acquisition Strategy. The SEP must describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It must detail the timing, conduct, and success criteria of technical reviews.

Manufacturing and Quality Tasks

- Update the Manufacturing Strategy and Quality Strategies based on the results, action items, and resolutions pertaining to M&Q requirements and concerns from the SRR and the SFR, to address development and considerations of:
    - Competition and contracting strategies
    - Management (quality, manufacturing, supply chain, risks, etc.)
    - Design (feasibility, producibility, KCs, risks, etc.)
    - New manufacturing technologies
    - Modular Open Systems Approach (MOSA)
    - Intellectual Property rights (including deliverables and associated license rights over the entire product life cycle)
    - Materials (characteristics, sourcing, risks, etc.)
    - Cyber threat protection measures (*See* L.2)
    - Integrated Product Support Plan
    - Process, rates, and quantities (capabilities, control, risks, etc.) (*See* H.1)
    - Facilities, Tooling, and Workforce (including GFE/GFI, STE/SIE, special requirements, etc.)
- Provide M&Q support for the development of Quality Strategies with detailed M&Q requirements for:
    - Rates, quantities, and schedule (including reference to Economic Order Quantity and the affordability targets)
    - Manufacturing maturity and progress against M&Q goals required for each technical review (SRRs, PDRs, Critical Design Reviews (CDRs), and at other appropriate reviews)
    - Human safety and health
        - Hazardous materials management and pollution prevention
    - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
    - Security parameters (physical and cyber) for both hardware and software
    - KPPs (i.e., KCs)
    - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
    - Supportability and sustainment
    - Use of priorities, allocations, and allotments, and justification
    - Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
    - Parts, materials, and processes (PM&P)
- Update the Manufacturing Strategy and Quality Strategy to address the sustainment of industrial capabilities (including manufacturing technologies and capabilities) and the maturation required during the EMD and subsequent phases.

  - Provide M&Q inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystem, item, and component levels.
  - Provide M&Q inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
    - Domestic alternatives through regeneration of prior capability
    - Creation of new capability for manufacturing products and processes
    - Lifetime buy of items at the subsystems, and component levels

- Incorporate planning for new or high-risk manufacturing capabilities and processes Manufacturing Technology (ManTech) in the Manufacturing Strategy that addresses risks, issues, and opportunities in the EMD phase. (*See* D.2)
  - If this new manufacturing capability can be demonstrated in TMRR phase in a relevant manufacturing environment, specify this demonstration in the plans
  - Include insertion of the new manufacturing capability in planning for EMD
- Initiate the M&Q Industrial Base (IB) capability analyses updates for inclusion in the Acquisition Strategy and the RFP to include inputs on:
  - IB capabilities, fragility, gaps, and risks for the Acquisition Strategy (e.g., key technologies and key and critical processes, parts, components, etc.)
  - Capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Impacts and interdependencies of this acquisition on the National Technology Industrial Base (NTIB) and the analyses used to make this determination
    - Include how they will be managed
    - Include plans for future assessments, including frequency
  - Government strategy and actions necessary to preserve the IB capabilities (e.g., incentives for the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)
- Provide M&Q inputs to Acquisition Strategy for a contracting strategy that supports selection of the best course of action through either a competitive award, a sole source award, or multiple source development to include:
  - M&Q metrics to differentiate the value of each contract type to include performance, capability, capacity, affordability, etc.
  - Impacts and risks, issues, and opportunities that may result from different contract types (Firm Fixed Price (FFP), Fixed Price Incentive Fee (FPIF), Cost Plus Fixed Fee (CPFF), etc.)

  - Prototyping approach for EMD, either competitive, single, or prototyping of critical subsystems (statutory requirement for MDAP AS, regulatory requirement for all other programs)
  - Potential production approach for EMD and subsequent phases

- Update M&Q inputs to the Acquisition Strategy for EMD with a source selection approach that establishes and maintains access to competitive suppliers at the system, subsystem, and component level (e.g., requiring a modular open systems approach, alternative sources of supplies or services, etc.).
- Provide updated M&Q requirements as inputs for required technical reviews, production decisions, events, prototypes, and deliveries, including sub-tier subsystem, item, and components, to be included in the Acquisition Strategy based on:
  - Reports and data from DCMA
  - Analyses materials availability (lead-time and scale-up) and maturity (characterization)
  - Contractor data on rates and yields for M&Q
  - Analyses of M&Q maturity and projections
  - Reports on facilities, tooling, and workforce utilization
  - Updated capital equipment requirements
- Provide updated M&Q inputs and plans to the IMP/IMS including:
  - Schedule for any planned use of government-furnished special test equipment (STE), government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.).
  - Schedule impacts from the requirements for special materials and allotments, and the reasons for them if applicable
  - M&Q internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
  - Inputs on reviews down to the sub-tier level (including PDR, CDR, PRR, etc.), documentation inputs (e.g., draft CDD, TEMP, AS, SEP, PDR, etc.), production events, and deliveries
- Update the government Manufacturing Management and Quality Management approach for EMD to include: (*See* I.1 and L.2)
  - Changes in M&Q requirements
  - M&Q resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to M&Q organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
  - Changes to M&Q support organization required to meet program projected needs for EMD and subsequent phases including:
    - Earned Value Management requirements

  - Cost control requirements
  - Data collection, reporting, and management

- Update the M&Q requirements for the EMD contractor's Manufacturing Management System (MMS) and Quality Management System (QMS).
  - Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - If M&Q standards are not specified, develop requirements for program specific manufacturing management plan and quality management plan.
  - Identify M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- Update requirements for identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program.
  - Ensure a joint M&Q comprehensive Risk, Issue, and Opportunity Management Process that can identify, and tracking risks and associated mitigation plans is in place
- Analyze identified M&Q risks, issues, and opportunities, and associated mitigation plans for adequacy and completeness, and potential impacts on EMD and subsequent phases to include:
  - Risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule
  - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
  - Required maturation of critical technologies and manufacturing processes to the appropriate level
  - M&Q cost and schedule impacts
- Update M&Q exit criteria metrics for TMRR and subsequent phase decision points.
  - Metrics should include current and projected M&Q maturity of identified critical technologies and manufacturing processes
  - Metrics should also include the planned Manufacturing Readiness Level (MRL) targets for system, subsystems, components, and items
- Update the M&Q support plan for an assessment of manufacturing readiness and the mandated independent assessment.
- Ensure other agencies are providing inputs on strategies (e.g., DCMA, Defense Logistics Agency (DLA), etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.
- Ensure M&Q updated inputs to the SEP and TEMP include the following:

- M&Q updates and impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
- Planned significant activities indicated on the updated EMD program schedule
  - Manufacturing assessments
  - Long-lead or advanced procurements
  - Prototype builds
  - Projected lots or phases
  - Production Readiness Review
- Updated inputs to the program Risk, Issue, and Opportunity Management process and plans that include:
  - Industrial risks
  - Manufacturing risks
  - Quality risks
  - Engineering risks
  - Software risks
  - Production risks
  - Risk reduction and mitigation efforts
- Updated Program Manufacturing Management Plan addressing software development and reuse.
- Updated M&Q inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
  - Compliance with Defense Federal Acquisition Regulation Supplement (DFARS), Program Protection Plan (PPP), International Trafficking in Arms Regulation (ITAR), etc.
  - Management of Controlled Unclassified Information
  - Technical approaches to cybersecurity and related M&Q security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
- Updated Program Manufacturing Management Plan addressing each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management
- Updated inputs on the M&Q organization, billets and key assignments including

        - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
    - Updated M&Q planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
    - Updated M&Q inputs to the configuration managed IMP/IMS including critical path

Tools

- Acquisition Strategy Outline
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- CDD Template
- ISO 9001, Quality Management System Checklist
- Interactive MRL Users Guide Checklist
- Life Cycle Sustainment Plan
- Manufacturing Maturation Plan
- Technology Readiness Level (TRL) Assessment Checklist
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Integrated Master Plan/Integrated Master Schedule use MS Project
- Risk Management Plan Template
- Systems Engineering Plan Outline
    - Manufacturing Management Plan
    - Quality Assurance Management Plan
- TEMP Outline

Resources

- Acquisition Strategy Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- CDD Writing Guide
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting

- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities subpart 207.106 (S-70) of the Defense Federal Acquisition Regulation Supplement
- DoDD 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89 Test and Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- ISO 9001:2015, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- NIST 800-171, June 2015, Controls for Controlled Unclassified Information
- RFP Proposal Evaluation Guide
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide

A.3 Support Preliminary Design Review

M&Q personnel should be actively engaged in the organization and execution of the Preliminary Design Review (PDR) during this phase. The PDR is an assessment that establishes the Allocated Baseline of the system and is used to ensure that the system has a reasonable expectation of meeting the current requirements within the given cost and schedule. The completion of the PDR should provide:

- An established system allocated baseline
- An updated risk assessment for the EMD phase
- An updated CARD based on the allocated baseline
- An updated program schedule including system and software critical path drivers
- An approved Life Cycle Sustainment Plan

Manufacturing and Quality Tasks

- Ensure all M&Q system-level requirements, base-lined at the SRR and the SFR have been correctly decomposed or directly allocated to the appropriate subsystem, item, or component.
- Provide M&Q system, subsystem, item, and component requirements and inputs for the verification and validation entry/exit criteria required for the PDR process.
- Provide M&Q support to system (product), subsystem, item, and component design trades to finalize system requirements and configuration.
- Provide an M&Q assessment of the preliminary system-level design and margins for producibility and costs within the production budget.
- Assess all system (product), subsystem, item, and component physical and functional interfaces and architecture for M&Q feasibility and producibility (e.g., inspectability, manufacturability, etc.)
    - Include analyses of prototypes
- Assess the design for M&Q constraints and ensure they have been captured and incorporated into the allocated requirements.
- Provide M&Q support for the analyses to identify all preliminary key and critical M&Q processes and characteristics to show traceability to system-level requirements and technical performance measures (e.g., KPPs, KSAs, TPMs) using Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA) and similar analyses for design (DFMEA) and process (PFMEA).
    - Ensure all the preliminary key and critical M&Q processes are defined and traceable to Critical Safety Items (CSI)and/or Critical Application Items (CAIs)
    - Identify initial process capability indexes for key and critical manufacturing processes
    - Analyze the contractor's identified major/critical sub-tier suppliers for their impact on or responsibility for KCs (and therefore KPPs/KSAs)
- Assess the preliminary system design for impacts on requirements to M&Q design, processes, and procedures, including:
    - Incomplete specifications of subsystem, items, and components (i.e., TBDs)
    - Change to subsystem, items, and components from re-design based on testing deficiencies or failures
    - Results and data from building and testing prototypes
    - Incorporation of Parts, Materials, and Processes allocated requirements
    - Requirements for computer system Hardware Configuration Items (HWCIs)
    - Analyses of mass properties including growth
    - MOSA requirements
    - Tooling design, testing, and schedule (including special tooling and test equipment)
    - Security physical and cyber (e.g., processes, industrial control systems, anti-tamper requirements, manufacturing resources and organization, etc.)

  - Requirements for processes and procedures to control and mitigate EMI
  - Human Machine Interface requirements
  - ESOH requirements
  - System safety requirements
  - HAZMAT and environmental controls (e.g., handling, contamination, pollution control, disposal, etc.)
  - Supportability and maintainability requirements

- Provide an assessment of requirements for M&Q data and data storage including:
  - Analyses and post processing
  - Availability, integrity, and maintainability
  - Communications and processing capacity
  - User integrity
- Provide M&Q analyses of the Software Development Plan for physical architectures, firmware integration, and physical interfaces that impact M&Q processes, procedures, and schedule.
- Provide an assessment of long-lead materials and production requirements (e.g., components, facilities, equipment, etc.).
- Provide an updated analysis of M&Q inputs to the TEMP include the following:
  - M&Q updates and impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Planned significant activities indicated on the updated EMD program schedule (e.g., manufacturing assessments, long-lead or advanced procurements, prototype builds, projected lots, or phases, PRRs, etc.)
  - Updated inputs to the program Risk, Issue, and Opportunity Management System and plans including industrial, manufacturing and production, quality, engineering, software (firmware), and risk reduction and/or mitigation efforts
  - Results of prototype builds, demonstrations, and tests and associated data
  - Updated M&Q inputs from the contractor's management of defense information and Cyber Incident Reporting, compliance with DFARS, PPP, ITAR, etc.
  - Updated planning for M&Q tests and assessments to be conducted, facilities and test equipment to be used, metrics to be tracked, progress against goals, thresholds, and objectives, etc.
- Provide an updated assessment and analysis of the M&Q processes and metrics included in the contractor's SEMP for completeness, adequacy, and alignment with those processes and metrics included in the program SEP, including:
  - Integration of any lower-level technical reviews and audits such as SFRs, PDRs, CDRs, Physical Configuration Audits (PCAs), Functional Configuration Audits (FCAs), and/or PRRs

  - Identified risks and issues to be incorporated into mitigation and/or action plans
  - Contractor's plan to CDR

- Provide an updated assessment of program and contractor M&Q workforce plans and requirements for adequacy and completeness including:
  - Skills, capabilities, training, and certifications
  - M&Q human resources (staffing and staffing plans)
  - Potential changes to organization and KLPs

- Update the M&Q strategies to include plans for: (*See* A.1, I.5, and L.4)
  - Manufacturing maturity and progress against M&Q goals required for each technical review (SRRs, PDRs, CDRs, and at other appropriate reviews)
    - Definition and characterization of all M&Q processes
    - Manufacturing technology ongoing and future projects (ManTech)
    - Rates, yields, quantities, and schedule (including reference to Economic Order Quantity and the affordability targets)
  - KPPs (i.e., KCs)
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
  - Continued M&Q IB analyses on:
    - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical processes, parts, components, etc.)
    - IB capabilities to design, develop, produce, support, and restart the acquisition program, if appropriate
    - Impacts and interdependencies of this acquisition program to the NTIB
    - Government strategy and actions necessary to preserve the IB
  - Use of priorities, allocations, and allotments, and justification
  - Meeting IMP/IMS with acceptable risk for schedule and budget
  - Impacts and changes, requiring updates to the program's Configuration Items (i.e., GFE, GOTS, etc.) and contractor's supply chain (including COTS)
  - Impacts and changes, requiring updates to program critical items and Critical Safety Items
  - Support of the failure reporting and corrective action system (FRACAS)
  - Updates and changes to the program Variability Reduction Plans
  - Support and inputs to the Life Cycle Sustainment Plans (LCSP)including Diminishing Manufacturing Sources Materials Sources (DMSMS), PM&P, and counterfeit parts
  - Human safety and health
  - Hazardous materials management and pollution prevention

  - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security parameters (physical and cyber) for both hardware and software
  - Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
  - Products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
    - Domestic alternatives through regeneration of prior capability
    - Creation of new capability for manufacturing products and processes
    - Lifetime buy of items at the subsystems, and component levels

- Update the plans for a comprehensive joint M&Q Risk, Issue, and Opportunity Management Process for EMD that has the capacity to identify, monitor, and track risks and associated mitigation plans, including plans for:
  - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software, and engineering related risks and issues
  - Required maturation of critical technologies and manufacturing processes to the appropriate level
  - M&Q cost and schedule impacts
- Provide M&Q support for the analyses of demonstrations conducted in a production relevant environment to include verification of:
  - Prototypes (e.g., subsystems, items, and components)
  - Manufacturing processes with yield and rate data collected
  - Special Handling procedures
  - Workforce skills
  - Prototype tooling
  - Special test equipment/special inspection equipment (STE/SIE)
  - Acceptance test procedures
  - Modeling and Simulations (M&S)
  - Material maturity
  - Cost models
  - KCs
  - Producibility efforts
  - Manufacturing technology solutions
- Conduct an assessment and an analysis of program manufacturing maturity against the MRL criteria.

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist

- Manufacturing Maturation Plan
- Preliminary Design Review Checklist

Resources

- AS6500, Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89 Test and Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1521B, Jun 1985 (retired)
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Preliminary Design Review (PDR) Procedure
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)

A.4 Support Program Decision Reviews

M&Q assurance managers should support the Milestone B decision by providing insight into various M&Q considerations. The goal of Milestone B is to determine if a program has met all its Exit Criteria and is mature enough to move into EMD. Often it is the maturity of the emerging technologies and manufacturing processes that determines the path forward. Manufacturing and quality assurance (QA) managers need to assess and demonstrate manufacturing processes to the extent needed to verify that risk have been reduced to an acceptable level. Risk reduction prototypes will be developed if those prototypes will materially reduce EMD development risks to an acceptable cost.

Manufacturing and Quality Tasks

- Provide M&Q inputs and updates, for both the Development RFP RD and Milestone B Decision following post-PDR assessment results, the following statutory and regulatory program required updates to:
  - The Acquisition Strategy
    - Acquisition Approach
    - Business Strategy
    - Contracting Strategy (type and termination liability)
    - Cooperative Opportunities (if necessary)
    - General Equipment Valuation
    - Industrial Base Considerations
    - Intellectual Property Considerations
    - Market Research (for Development RFP RD)
    - Modular Open Systems Approach
    - Multiyear Procurement
    - Risk, Issue, and Opportunity Management Process
    - Small Business Innovation Research/Small Business Technology Transfer (for RFP DP)
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives
  - Bandwidth Requirements Review
  - Capability Development Document
  - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - Life Cycle Sustainment Plan (LCSP)
  - Low-Rate Initial Production (LRIP) Quantity
  - PESHE and NEPA Compliance Schedule
  - Program Protection Plan (PPP)
  - Request for Proposal (RFP)
  - Should Cost Target
  - Spectrum Supportability Risk Assessment
  - Systems Engineering Plan (SEP)
  - Technology Readiness Assessment (TRA)
  - Test and Evaluation Master Plan (TEMP)
- Provide PDR documentation of conducted demonstrations in a production relevant environment of M&Q maturity (including risks and mitigation) with status of:

  - Prototypes (e.g., subsystems, items, and components)
  - Manufacturing processes with yield and rate data collected
  - Special Handling procedures
  - Workforce skills
  - Prototype tooling
  - Special Test Equipment/Special Inspection Equipment (STE/SIE)
  - Acceptance test procedures
  - Modeling and Simulations (M&S)
  - Material maturity
  - Cost models
  - KCs
  - Producibility efforts
  - Manufacturing technology solutions
- Provide results of an MRL assessment and analyses that was conducted for PDR.

Tools

- Acquisition Decision Memorandum (ADM) Milestone B Template
- Independent Technical Risk Assessment Checklist
- Integrated Master Plan/Schedule
- Interactive MRL Users Guide Checklist
- Life Cycle Sustainment Plan
- Manufacturing Maturation Plan
- Market Research using Pugh Template
- Navy PEO Milestone B Review Checklist
- Technology Readiness Assessment (TRA)
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Master Plan
- Transition to Production Assessment

Resources

- Affordability Analysis Tools
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- DoD Market Research Guide
- DoDI 4245.7-M, Transition from Development to Production
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Life Cycle Sustainment Plan (*See* Product Support Manager Guide)
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Technology Readiness Assessment (TRA) Deskbook
- Test and Evaluation Management Guide

B. DEFENSE CONTRACTING SYSTEM

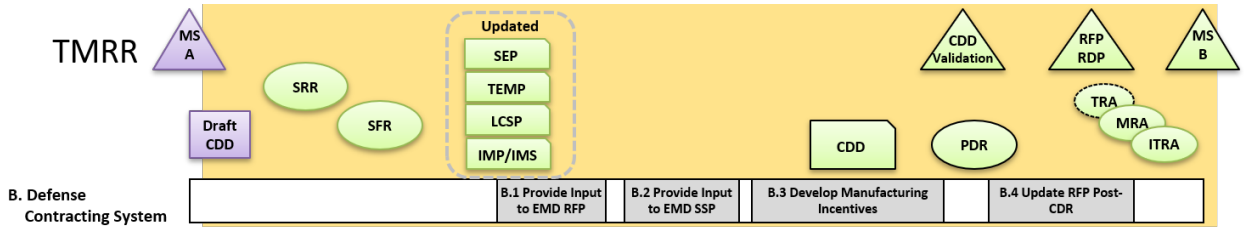


Figure 3-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

DoD contracting requirements are governed by the Federal Acquisition Regulation (FAR)/DFAR and by DoD, Service and Agency regulations, policies, and guidance documents.

The contract is the vehicle used to establish the formal relationship between the government and a prime contractor. Government business processes include the business strategy or Acquisition Strategy, contracting approach, contracting strategies, contract language, and financial strategies. M&Q personnel often are called upon to support various contracting functions and activities.

This thread (Defense Contracting System) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Market Research
- Contract Strategy
- Source Selection Plan
- Request for Proposal
- M&Q Inputs to the Contract (Section C, E, L and M) (refer to MIL-HDBK-245E)
- Contract Evaluation and Award

The contracting process is a partnership between the contracting office and program personnel. Contracting molds and shapes the procurement process and is responsible for contract award and administration. However, a cohesive effort between the contracts and program management including the participation of both contractual and technical subject matter experts is essential to managing and completing the steps in this phase of the contracting process.

In preparation for the RFP, Market Research is a pre-solicitation activity that involves the identification of the market or market of interest, the sources of market information, the collection of market information, and the evaluation of the market's ability to satisfy the user needs. M&Q personnel need to support market research to identify suppliers and evaluate potential sources and opportunities to assess the associated risks. Once market research has been completed, requirements may be defined in the form of Performance Work Statements, Statements of Work, or Statements of Objectives.

The RFP is the primary opportunity to make inputs to the EMD contract and is based on M&Q risks, issues, and opportunities discovered during TMRR. Typical areas to be included in the proposal include industry best practices for manufacturing management, quality management, and systems engineering. Other areas such as design and producibility, trade studies, M&Q technology investments, competition, materials (availability, counterfeit, and/or long-lead), data management, quality processes (capability studies), M&Q reporting and control, etc., should be addressed by M&Q. This list and other details should be addressed in the Statement of Work (SOW) and/or the Statement of Objectives (SOO).

As part of implementing industry best practices and meeting regulatory requirements, certain M&Q requirements need to be incorporated into the EMD RFP. For example, when the system under development meets the definitions in FAR 46.203 (Criteria for Use of Contract Quality Requirements, for Complexity and/or Criticality), FAR 46.202-4 requires supplier compliance with higher-level quality standards that should be addressed in the RFP. This may also require on-site government quality personnel to perform source inspections.

Other program requirements, often neglected during the contracting process, for M&Q input include:

- Direction for use of COTS items, GOTS items, and NDIs.
- Determination of need to develop and maintain a FMECA
- Determination of intellectual property and data rights, maintenance, ownership, and access for later phases.
- Direction for incorporation of manufacturing safety into System Safety Analyses.
- Determination of specialized system requirements, such as Flight Operations, Space Operations, etc.
- Determination of appropriate M&Q physical and cybersecurity requirements (e.g., data, information, control systems and networks, supply chain, etc.)
- Direction for inclusion of DCMA in an appropriate role to support the program

M&Q personnel should be making early and significant inputs into EMD RFP documents and activities to ensure M&Q risks, issues, and opportunities will be considered. Having determined and provided the early and significant requirements for EMD, the M&Q objective for the source selection plan is to develop criteria that ensure selection of the proposal that represents the best value to the government. The criteria for source selection should be realistic and address all the above areas, especially industry best practices.

Award fees can provide increased interaction of program and contractor M&Q management and provide the program with increased visibility into the contractor's best practices for manufacturing, quality, and supply chain processes and procedures. Award fees in the contract should be based on contractor performance to industry M&Q best practices and reward specific accomplishments such as:

- Producibility improvements
- Materials characterization in production relevant environment
- Manufacturing cost reduction efforts
- Manufacturing maturation plan risks burned down
- Variation and variability reduction
- Manufacturing process definition and characterization
- Progress in achieving the targeted Manufacturing Readiness Level
- Progress in maturation and demonstration of KCs (i.e., meeting KPPs/KSAs)
- Progress in achieving specific yield and rate goals
- Progress in meeting the EMD exit criteria

Incentives in the contract should be consistent with the Acquisition Strategy and tied to goals for exceeding contract requirements and program expectations. M&Q incentives in contracts are designed to obtain specific M&Q objectives by establishing reasonable and attainable criteria that can meet the goals or targets. These criteria must be clearly communicated to the contractor; and include appropriate incentive arrangements that will motivate contractor efforts that might not otherwise be emphasized and discourage contractor inefficiency and waste.

Important M&Q management goals and expectations to be exceeded in contract incentives include:

  - Cost (e.g., cost reductions, should costs, life cycle costs)
  - Schedule (e.g., expedited development or delivery, early delivery, on-time delivery, etc.)
  - Technical (e.g., quality, cycle-time reduction, product improvement, etc.)
  - Management commitment
  - Producibility processes
  - Risk, Issue, and Opportunity Management processes
  - Commercial best practices

The success of an enterprise's M&Q system is related to the commitment of the enterprise to the quality and producibility elements presented in the contract and the ability of the successful contractor to implement them effectively.

The learning curve (cost improvement curve, or experience curve) is a well-known approach to modeling many effects, such as the effect of quantity on cost. Generally, people and organizations learn to do things more efficiently when performing repetitive tasks. Learning curves are used as a measurement of progress in processes and procedures. Learning curves show that as the number of units produced doubles, the unit cost decreases in a predictable pattern. This technique continues as an industry standard today both in commercial and government applications. M&Q should be developing the appropriate learning curves for the system and the plans for data collection to support further development.

Before the RFP RD, but after M&Q analyses of the PDR, the M&Q inputs provided to the RFP should be reviewed, including:

- Overall affordability
- Competition strategy and incentive structure
- Provisions for small business utilization
- Source selection criteria
- M&Q trades
- Capability requirements
- Security requirements
- Should Cost goals
- Risk, issue, and opportunity management
- M&Q schedule

B.1 Provide Input to EMD Request for Proposal

The Request for Proposal (RFP) is an opportunity to communicate to the contractor the government's requirements for a specific proposal. The RFP should identify the information required in the contractor's proposal and the criteria that will be used to evaluate the proposal and the relative importance of those criteria. Manufacturing and QA managers typically support the development of the RFP by identifying M&Q considerations and criteria for inclusion in the RFP and subsequent contract. These considerations need to ensure that there is linkage between the M&Q consideration and the warfighter requirements and evaluation factors and sub-factors. Evaluation factors often include cost or price, and quality of product or service, which includes technical, past performance and others.

Manufacturing and Quality Tasks

- Ensure M&Q personnel are included in the EMD Request for Proposals (RFP) writing and review teams.
- Support the development of performance specifications:
    - Support the requirements process and the identification and flow down of requirements into performance, detail, process, or material specifications
    - Ensure traceability between requirement or capability and production/quality verification
    - Ensure identification or development of rigorous verification methods for incorporation for all requirements.
    - Ensure incorporation of rigorous, statistically based acceptance requirements including for Qualification (including Design Verification), First Article, and Conformance inspections.
- Specify the requirements for best practices for the contractor's Manufacturing Management System (MMS) (per Section L.2) and Quality Management System (QMS) (per Section I.1 and per FAR 52.246-11, Higher-Level Contract Quality Requirement) to be used (e.g., AS6500, ISO 9000, AS9100, etc.).
    - Specify the requirements for the contractors to identify and to describe their proposed specific processes, methods, and actions to address manufacturing feasibility, producibility, and M&Q risks associated with the proposed system
    - Specify a requirement for on-site government quality personnel will have access to perform management system audits
    - Specify a requirement for on-site government quality personnel to have access to perform source inspections and data monitoring
- If AS6500 is not invoked in the contract(s), the manufacturing management requirements cited in AS6500 should be the basis for specific contractual requirements for a contractor plan. The requirements, at a minimum, should specify that the contractor addresses:
    - Manufacturing Management System:
        - Documenting how, when, and by whom each requirement of their system is to be accomplished and define the authority and responsibility for each.
    - Design Analysis for Manufacturing:
        - Conducting producibility analyses
        - Identifying and managing key and critical characteristics in the Technical Data Package (TDP)
        - Implementing Variability Reduction (VR) to reduce part to part variation of key and critical characteristics
        - Identifying and managing key and critical manufacturing processes
        - Conducting FMEA on critical manufacturing processes (PFMEA)

- Manufacturing Risk Identification:
  - Integrating manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
  - Conducting and documenting manufacturing feasibility assessments for a competing design alternative
  - Identifying MRL targets and documenting manufacturing risks through the MRL assessments
  - Conduct Pre-award Survey
  - Conduct Post-award Orientation Conference
- Manufacturing Planning:
  - Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing modeling and simulation, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities.
- Manufacturing Operations Management including:
  - Production Scheduling and Control
  - Manufacturing Surveillance
  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - Production Process Verification
  - First Article Inspections and First Article Tests
  - Supplier Management and Quality

- If ISO 9000 or AS9100 is not invoked in the contract(s), the quality management requirements cited in the standards should be the basis for specific contractual requirements for a contractor plan. The requirements, at a minimum, should specify that the contractor addresses:
  - Quality Management Leadership
    - Leadership and Commitment
    - Policy
    - Organizational Roles, Responsibilities, and Authorities
  - Quality Planning
    - Actions to Address Risks and Opportunities
    - Quality Objectives and Planning
    - Planning of Changes

- Quality Support
  - Resources
  - Competence
  - Awareness
  - Communication
  - Documented Information
- Operation
  - Operational Planning and Control
  - Requirements for Products and Services
  - Design and Development of Products and Services
  - Control of Externally Provided Processes, Products, and Services
  - Production and Service Provision
  - Release of Products and Services
  - Control of Non-conforming Outputs
- Quality Performance
  - Monitoring, Measurement, Analyses, and Evaluation
  - Internal Audit
- Quality Improvement
  - Nonconformity and Corrective Actions
  - Continual Improvement

- Analyze the TMRR M&Q output as a basis for RFP EMD requirements and inputs to include the following areas:
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, feasibility, and manufacturability studies and analyses
  - Tooling, facility, and workforce analyses
  - Prototype demonstrations and development tests
  - Materials analyses
  - Make/buy processes and analyses
  - Costs and budget analyses
  - Market research and analyses
  - Modeling and simulations analyses
  - Process Capability Studies
  - Environmental studies and risks (PESHE)
  - M&Q processes and data
  - Work measurement/learning curve analyses
  - Industrial Base studies

- Specify appropriate requirements for M&Q Contract data Requirements List (CDRL), Data Item Description (DID), etc. to support M&Q processes, include the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.)
    - Specify a requirement for on-site government QA personnel will have access to perform source inspection of the plan (include on-site government Quality personnel in contractual distribution of the program Quality Plan (ref. I.1))
- Specify industry M&Q best practices for Systems Engineering to be used (e.g., IEEE 15288, -1, -2, etc.) in the EMD RFP.
    - Include requirements for the contractors to identify and to describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specify contractual M&Q requirements for:
    - Content for SOW, SOO, and contract sections C, L, M, and H
    - Conducting M&Q reviews of engineering and software (with frequency of reviews)
    - Intellectual property and government technical/manufacturing data rights, maintenance, ownership, and access
    - Identification and description of producibility efforts including cost sharing and incentive plans relevant to the solution
    - Plans for facilities, tooling, test equipment, workforce (e.g., training, certifications, etc.), and supply chain management
    - Plans for material availability including make/buy, long-lead, sources, and risks (sole, single, foreign, fragile, and critical)
    - Utilizing analyses of failure mode effects and criticality (e.g., FTA, FMECA, DFMEA, PFMEA) from the system level down to the component level (i.e., throughout the supply chain)
    - Definition and traceability of CSI and/or CAIs to all preliminary key and critical M&Q processes
    - Conducting analyses of manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
    - Providing M&Q information for costs, cost models, and cost estimates that include rate, alternate materials, quantity, etc. (including Cost of Quality data)
    - Plans for establishing and meeting EMD required process capability (Cpk) goals
    - Identification and description of manufacturing technology capability improvements
    - Encouraging investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
    - Implementing (or continuing) a joint risk, issue, and opportunity management and mitigation program that includes M&Q (including industrial base risks)

  - Implementing (or continuing) an M&Q variability reduction program
  - Appropriate cyber threat protection measures including
    - Safeguarding M&Q information, designed-in system protection, supply chain risks, hardware, and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security
    - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
    - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
    - Compliance with NIST 800-82 Guide to Industrial Control Systems Security
  - Managing materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
  - Utilizing COTS, GOTS, GFE, and NDIs
  - Metrics to be met as exit criteria for EMD phase
- Provide M&Q inputs and support to specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specify the requirement that the contractor support and/or conduct as required M&Q:
  - Technical reviews and audits including CDR, TRR, PRR, PCA, FCA, etc.
  - MRL assessments with trained personnel utilizing the MRL criteria
  - Independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment
  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
  - Joint risk, issue, and opportunity management meetings to manage mitigation activities

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- IG5315.204-5(b), Section L Guide and Template
- IG5315.204-5(c), Section M Guide and Template

- ISO 9001, Quality Management System Checklist
- DOORS or other Requirements Management Tool
- DCMA Pre-award Survey System (PASS)
- SF 1403 DCMA Pre-award Survey General
- SF 1404 DCMA Pre-award Survey Technical
- SF 1405 DCMA Pre-award Survey Production
- SF 1406 DCMA Pre-award Survey Quality Assurance
- SF1407 DCMA Pre-award Survey Financial Capability
- DCMA Post-award Orientation Conference (FAR 42.502)
- DCMA Post-award Orientation Conference Record (DD1484)

Resources

- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.228-7001, Ground and Flight Risk
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- SD-15 Performance Specification Guide

- DI-IPSC-81431A/T System Performance Specification Data Item Description
- MIL-STD-961 Defense and Program-Unique Specifications Format and Content
- MIL-HDBK-245E, Preparation of Statement of Work
- MIL-STD-882, Rev. E, System Safety
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- AFMC Inst 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-award Survey Guide
- Pre-award Survey User's Manual
- DCMA Post-award Orientation Conference Record (DD1484)

B.2 Provide Input to EMD Source Selection Plan

The Source Selection Plan (SSP) is a key document that specifies how the source selection activities will be organized, initiated, and conducted. The SSP serves as the guide for conducting the evaluation and analysis of proposals, and the selection of contractor(s) for the acquisition. SSP must clearly and succinctly express the Government's minimum needs (evaluation factors) and their relative order of importance. Manufacturing and QA managers, as members of the technical IPT, should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Ensure that M&Q personnel are included in the EMD Source Selection Plan (SSP) writing and review team.
- Specify in the SSP metrics and scoring for application of M&Q industry best practices for the contractor's Manufacturing Management System and Quality Management System (e.g., AS6500, ISO 9000, AS9100, etc.).
    - Plan should include metrics and scoring for preferred specific processes, methods, and actions to address manufacturing feasibility, producibility, and M&Q risks associated with the proposed system
    - Plan should include metrics and scoring for accommodation of on-site government quality personnel to complete required management and quality audits and data collection
- If manufacturing management industry best practice requirements (i.e., AS6500) are not invoked in the contract(s), the requirements cited in AS6500 should be the basis for specific SSP metrics and scoring. Specify metrics that, at a minimum, include the contractor plans, processes, and procedures for:
    - Documenting how, when, and by whom each requirement of their manufacturing management system is to be accomplished and defining the authority and responsibility for each.

  - Conducting producibility design analyses
  - Identification and management of key and critical characteristics in the TDP
  - Implementation of VR to reduce part to part variation of key and critical characteristics
  - Identification and management of key and critical manufacturing processes
  - Conducting Process FMEA on critical manufacturing processes
  - Integration of manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
  - Conducting and documenting manufacturing feasibility assessments for any competing design alternative
  - Identification of MRL targets and documenting manufacturing risks through the MRL assessments
  - Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing modeling and simulation, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities
  - Production Scheduling and Control
  - Manufacturing Surveillance
  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - Production Process Verification
  - First Article Inspections and First Article Tests
  - Supplier Management and Quality

- If ISO 9000 or AS9100 quality management industry best practices are not invoked in the contract(s), the requirements cited in the standards should be the basis for specific SSP metrics and scoring. Specify metrics that, at a minimum, include the contractor plans, processes, and procedures for:

  - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
  - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management
  - Quality support with resources, competence, awareness, communication, and documented information
  - Operation including operational planning and control, products and services requirements, and design and development
  - Control of externally provided processes, products, and services
  - Production and service provision
  - Release of products and services
  - Control of non-conforming outputs

  - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
  - Quality improvement including nonconformities and corrective actions, and continual improvement

- Specify metrics and scoring that at a minimum address the contractor(s) plans, processes, and procedures utilizing analyses of TMRR M&Q outputs for the following:
  - Risk, issue, and opportunity management
  - Design producibility, feasibility, and manufacturability
  - Tooling, facility, and workforce
  - Prototype demonstrations and development tests
  - Materials management
  - Make/buy management
  - Costs and budgets
  - Modeling and simulations
  - Process capability management
  - Hazardous materials, environmental and safety management
  - M&Q process and data management
  - Work measurement/learning curve management
  - Industrial security
  - Supply chain management
- Specify metrics and scoring that ranks contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing M&Q CDRLs, DIDs, etc., including the requisite approval processes.
- Specify in the SSP metrics and scoring for application of M&Q industry best practices for the contractor's Systems Engineering management (e.g., IEEE 15288, -1, -2, etc.).
  - Include metrics and scoring for the contractors proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specify M&Q metrics and scoring on timeliness, completeness, accuracy, and alignment (corrective actions, if required) for:
  - Meeting each SOW, SOO requirements, and requirements for contract sections C, L, M, and H
  - Planning of M&Q reviews of engineering and software (with frequency of reviews)
  - Planning and processes for Intellectual Property management and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Planning and processes for producibility (including cost sharing and incentive plans relevant to the solution)

- Plans for facilities, tooling, test equipment, workforce (e.g., training, certifications, etc.), and supply chain management
- Planning and processes for materials including make/buy, long-lead, sources, and risks (sole, single, foreign, fragile, and critical)
- Plans for utilizing failure mode effects and criticality analyses (e.g., FMECA, DFMEA, PFMEA) from the system level down to the component level (i.e., throughout the supply chain)
- Planning and processes for management of CSIs and/or CAIs, and all preliminary key and critical M&Q processes
- Planning and processes for manufacturing system safety analyses
- Planning and processes for providing M&Q information for costs, cost models, and cost estimates that include rate, alternate materials, quantity, etc. (including Cost of Quality data)
- Plans for establishing and processes for meeting EMD required process capability (Cpk) goals
- Planning for manufacturing technology capability improvements
- Plans for investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- Plans for implementing (or continuing) a joint risk, issue, and opportunity management and mitigation program that includes M&Q (including industrial base risks)
- Plans for implementing (or continuing) an M&Q variability reduction program
- Planning and processes for cyber-threat protection measures including:
  - Safeguarding M&Q information including supply chain risks
  - Designed-in system protection, hardware, and software manufacturing network assurance (including suppliers), anti-tamper, and security-related activities such as physical security and industrial security
  - Anti-counterfeit practices
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
- Planning and processes for utilization of COTS, GOTS, GFE, NDI items

- Specify metrics and scoring that ranks contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing specialized system requirements, such as Flight Operations, Space Operations, etc.

- Specify M&Q metrics and scoring on timeliness, completeness, accuracy, and alignment (corrective actions, if required) for contractor planning and processes to support and/or conduct as required M&Q:
    - Technical reviews and audits including CDR, TRR, PRR, PCA, FCA, etc.
    - MRL assessments with trained personnel utilizing the MRL criteria
    - Independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment
    - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
    - Joint risk, issue, and opportunity management meetings to manage mitigation activities

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System Checklist
- Source Selection Plan Template, USMC

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems – Requirements for Aviation, Space, and Defense Organizations
- DoD Systems Engineering Guidebook
- DAU AcqNotes
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.228-7001, Ground and Flight Risk
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoD Source Selection Procedures Memo
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs

- ISO 9001, Quality Management System
- ISO 9001:2015, Quality Management System
- MIL-HDBK 245E, Preparation of Statement of Work
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-882, Rev. E, System Safety
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- Source Selection Plan Guide, IG5315.303

B.3 Develop Manufacturing Incentives

FAR Subpart 16.4 notes that "incentive contracts are designed to obtain specific acquisition objectives by establishing reasonable and attainable targets that are clearly communicated to the contractor; and include incentive arrangements designed to motivate the contractor to improve or discourage contractor inefficiency and waste."

Contracts should produce measurable performance outcomes that cumulatively contribute to the system KPPs/KSAs, to their threshold or objective levels. To motivate the contractor to achieve the desired behavior, appropriate contract incentives (including award fee, incentive fee, award term, and cost sharing) need to be developed to promote and facilitate contractor performance.

M&Q managers need to support the development of Award Fee/Incentive Fee criteria in their areas. These criteria may focus on manufacturing investments and outcomes, process capability and control, reduction of waste, producibility improvements, etc.

Manufacturing and Quality Tasks

- Develop and provide M&Q input to the contract in the form of Award or Incentive Fee Criteria, appropriate to the contract type and consistent with the Acquisition Strategy, that specify program goals and address the necessary M&Q (including supply chain) cost, schedule, and performance improvements (to include progress against goals, partial progress, recovery, and penalty) in the areas of:
    - M&Q CDRLs, DIDs, etc. (e.g., timely submission and approval)
    - Compliance with cyber-threat protection and industrial security requirements (e.g., PPP, DFARS 252.204-7012, NIST 800-82, etc.)
    - M&Q Industrial Base risk mitigations to schedule goals (#/%, milestones)
    - Manufacturing readiness progress (MRL assessments) against targets
    - Assessments of lower tier supply chain for manufacturing readiness and maturity in advance of the System maturity targets (#/%)
    - M&Q risk and issues mitigations complete (schedule/#)

- Manufacturing and producibility projects planned and implemented (#/%)
- Progress of M&Q learning curves (% to goals) including rates, yields, variability, process times, re-work, and repair, etc.
- M&Q systems operations (production line, tooling, equipment, ManTech insertion, etc.) performance to goals (schedule/ %)
- Key and critical manufacturing process capability improvements and variability reduction (i.e., C_{pk} improvements on key and critical processes beyond contract)
- Key Characteristics maturation and management to goals (% to goal and schedule progress)
- Technical Performance Measures (TPMs) (% progress to schedule)
- Manufacturing processes and advanced manufacturing capability improvement, and implementation (#/% to goals)
- Materials characterization schedule improvements in additional environments beyond contract requirements (time)
- Management of CSIs and CAIs to requirements
- Process Capability improvement (Cpk value to goals)
- Quality improvement projects planned and completed (#/% to goals)
- Quality improvement positive trends (acceleration of improvements %)
- Exceeding quality improvement goals
- Variation and Variability reduction efforts (yields/rates/trends)
- Manufacturing improvement projects implemented (#/% to goals)
- Parts and materials management against appropriate M&Q goals (e.g., availability, capacity, sourcing, standardization, etc.) (#/%)
- Facilities and equipment utilization (% to plan)
- Workforce development and management to plan (e.g., hiring, training, and reductions) (#/% to plan)
- Testing completion to schedule (% successfully completed) and testing improvements and positive trends (%)
- Testing and demonstration beyond contract requirements (include test reductions)
- Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
- Manufacturing Plan progress against completion (cost and schedule)
- Manufacturing cost (Δ$), cost reduction (%/$), and cost avoidance
- Cost sharing when goals are not met must also be specified.
- Improvements in schedule (e.g., increased slack time, expedited development, early delivery, or just-in-time implementation, etc.)
- Quality Management System compliance to best practices and/or contract requirements (# to standard)
- Quality Plan progress against completion (cost and schedule)
- Quality costs and cost reduction (including cost of quality) (schedule/#/%)
- M&Q safety system requirements (% compliance)

- System Engineering management compliance to best practices for M&Q technical processes, technical management processes, and essential specialty engineering (# to standard)
- Performance to IMP/IMS (schedule)
- Progress toward meeting LRIP exit criteria
- Predictive and pro-active maintenance and modernization of facilities, tooling, and equipment (including GFE)
- Investments in modern manufacturing methods, software, and equipment including ManTech and other investments (cost share %)
- Qualification and investments in additional sources within the U.S. IB ($)

Tools

- Award Fee/Incentive Fee Plan
- Aware Fee Template, USAF

Resources

- Air Force Award Fee Guide
- Army Award Fee Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations,
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- DAU AcqNotes
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoD Guidance on Using Incentive Contracts, Mar 2016
- DoD/NASA Incentive Contracting Guide
- FAR Subpart 16.4 Incentive Contracts
- ISO 9001:2015, Quality Management System
- Navy Award Fee Guide
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)

B.4 Update Request for Proposal Post-PDR

The RFP should be updated to identify the information required in the contractor's proposal for the next acquisition phase and the criteria that will be used to evaluate the proposal and the relative importance of those criteria. Manufacturing and QA managers typically support the development of the RFP by identifying M&Q considerations and criteria for inclusion in the RFP and subsequent contract. These considerations need to ensure that there is linkage between the M&Q consideration and the warfighter requirements and evaluation factors and sub-factors. Evaluation factors often include cost or price, and quality of product or service, which includes technical, past performance and others.

Manufacturing and Quality Tasks

- Update M&Q inputs to the RFP based on post-PDR assessment results (*See* A.3) and updates made to the following (*see* A.4):
    - The Acquisition Strategy
        - Acquisition Approach
        - Business Strategy
        - Contracting Strategy (type and termination liability)
        - Cooperative Opportunities (if necessary)
        - General Equipment Valuation
        - Industrial Base Considerations
        - Intellectual Property Considerations
        - Market Research (for RFP RD)
        - Modular Open Systems Approach
        - Multiyear Procurement
        - Risk, Issue, and Opportunity Management Process
        - Small Business Innovation Research/Small Business Technology Transfer (for RFP RD)
    - Acquisition Program Baseline
    - Affordability Analysis
    - Analysis of Alternatives
    - Bandwidth Requirements Review
    - Capability Development Document
    - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
    - Exit Criteria
    - Item Unique Identification Implementation Plan
    - Life Cycle Sustainment Plan (LCSP)
    - Low-Rate Initial Production (LRIP) Quantity
    - PESHE and NEPA Compliance Schedule
    - Program Protection Plan (PPP)

- Should Cost Targets
- Spectrum Supportability Risk Assessment
- Systems Engineering Plan (SEP)
- Technology Readiness Assessment (TRA)
- Test and Evaluation Master Plan (TEMP)

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System Checklist
- Section L Guide and Template, IG5315.204-5(b)
- Section M Guide and Template, IG5315.204-5(c)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)

C. SURVEILLANCE SYSTEM

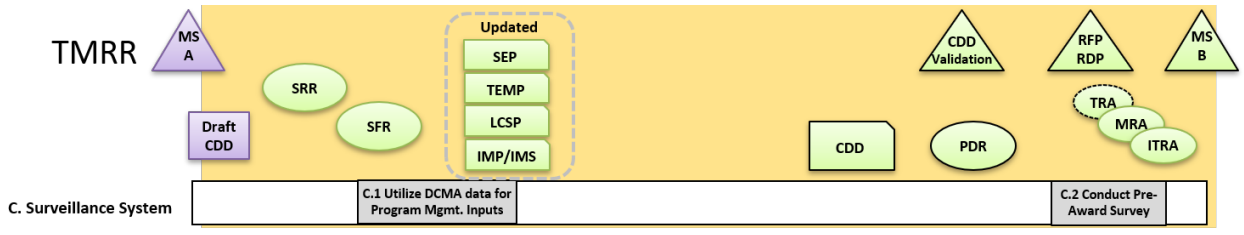


Figure 3-4. Surveillance System Manufacturing and Quality Activities

Introduction

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DoD contractor surveillance requirements and activities are required by the FAR/DFAR and by many DoD, Service, and Agency regulations, policies, and guidance documents. DFAR Part 242.2 Contract Administration Services and DFAR Part 242.3, Contract Administration Office Functions, and PGI 242.3 Contract Administration Functions outline the 70 Contract Administration Service (CAS) functions and the many that may require M&Q support. M&Q personnel often are called upon to support CAS functions and activities.

Often these activities may be performed under mutual agreement by the program office and DCMA. In many cases these contractor surveillance activities may be performed by on-site engineering support activity, program office contract administrators, delegated Service contract surveillance offices or a variety of engineering support activities (i.e. supervisor of shipbuilding (SUPSHIP), development command field activities). This thread (Surveillance System) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Contract Administration Service (CAS) Functions
- Engineering Support Activity (ESA)
- DCMA Support
- DCMA Documentation
- Monitor and Track Risks
- Participate in Program Reviews

Contractors often depend on their own policies, procedures, processes, plans, controls, and schedules to meet government requirements. Their processes often mirror government regulations, directives, instructions, and other documentation that may or may not be contractual.

Government surveillance is often multifunctional requiring the support of business and technical personnel. Personnel from the program office as well as from DCMA may be required or asked to support surveillance functions at the prime and subcontractor facilities. M&Q managers play an integral and vital role in defining the total scope of contract administration.

Program offices may delegate many CAS activities to DCMA as a best practice. This may require a Memorandum of Agreement (MOA) or a Letter of Delegation (LOD). The program office should coordinate with DCMA on required support, provided there is adequate manpower and funding to support the proposed MOA/LOD.

The Program Manager should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. This may require the program office to establish an MOA or a Quality Assurance Letter of Delegation (QALI) with DCMA. DCMA may then, based on manpower availability and funding, utilize a systematic approach

deploying surveillance through the supply chain to evaluate the supply chain and supplier improvement initiatives. At resident and non-resident facilities DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes. Most contractors will have implemented a higher-level quality management process in accordance with AS9100 or ISO 9001 as a best practice. Some contractors, but not all, may have implemented a manufacturing management process in accordance with AS6500. Regardless of what management processes the contractor has implemented, DCMA personnel should have access to that data and should be reviewing it on a continuous basis.

Effective M&Q management is required if the contractor is to deliver an operationally safe, suitable, and effective system. The Quality Management System (QMS) assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The QMS serves as the control function within the systems engineering process, requiring control over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. The QMS also requires monitoring and measuring of processes and products to ensure they conform to requirements.

DCMA provides access to reliable and accurate QMS data and process information on costs, schedule, and technical performance and can assist with objective assessment of supplier plans and the verification of initial and continuing compliance with requirements. The ability to continually analyze risks and identify risk-adjusted solutions to sustain a reliable, technologically superior, efficient, cost-effective, and resilient defense industrial base mitigates overall program risk.

M&Q should provide information, data, plans for the requirement to obtain DCMA analyses, supporting information, and recommendations as inputs to the program management and technical reviews.

A pre-award survey is one tool DCMA personnel can use to focus on virtually every facet of the contractor's business operation from technical capability to financial stability, from QA to plant safety. DCMA conducts nearly all pre-award surveys required by government buying activities. M&Q should provide recommendations and inputs to program management for the pre-award survey requirements to be addressed by DCMA.

The process begins with a program request for a survey and concludes with a program decision based on a recommendation by a DCMA Contract Management Office (CMO) survey team. A pre-award survey can focus on virtually every facet of the contractor's business operation from technical capability to financial stability, from QA to plant safety. In a sense, the survey process is the contractor's opportunity to provide evidence (i.e., Plan of Performance) that they can successfully fulfill the terms of the contract.

A Post-award Orientation Conference is one tool DCMA or the DoD engineering support activity personnel can use to achieve a clear and mutual understanding of all contractual requirements and identify and resolve potential problems.

C.1 Utilize DCMA data for Program Management Reviews

During the TMRR phase, M&Q personnel should be actively engaged in the organization and execution of numerous formal reviews and audits during this phase to include:

- System Requirements Review (SRR)
- System Functional Review (SFR)
- Preliminary Design Review (PDR)
- Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)

Program offices could request an informal review at any time and M&Q managers need to be prepared to support such reviews and Manufacturing and QA managers as a member of the Technical IPT need to support these reviews and audits. DCMA personnel need to support these reviews if delegated CAS activities by the program office.

Manufacturing and Quality Tasks

- M&Q requests DCMA support and participation in program reviews (e.g., IPRs, IPT meetings, etc.), including government only, to provide data on:
    - Contractor operations (technical, performance and financial)
    - Supply chain operations (technical, performance and financial)
    - Program goals and metrics
- M&Q managers should be a member of the Technical IPT that supports the following reviews and audits:
    - System Requirements Review (SRR)
    - System Functional Review (SFR)
    - Preliminary Design Review (PDR)
    - Manufacturing Readiness Assessments (MRAs)
    - Technical Readiness Assessments (TRAs)
    - Independent Technical Risk Assessments (ITRAs)
- Request and utilize the DCMA information and data in the following areas:
    - Assessments of M&Q feasibility
    - Contractor(s) capability to meet M&Q requirements for:
        - Manufacturing Management System best practices (i.e., AS6500)
        - Quality Management System best practices (e.g., AS9100, ISO 9000, etc.)
        - Risk, Issues, and Opportunities Management System capabilities
        - Human safety and health
        - Environmental and HAZMAT management (pollution prevention)

  - Security (physical and cyber) for both hardware and software (e.g., communications, cyber, program protection, anti-tamper, etc.)
  - Management of KCs
  - Management of data and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
  - Supportability and sustainment
  - Use of COTS, GOTS, NDIs, and GFE (including diminishing manufacturing sources)
  - Management of parts, materials, and processes (PMP)
  - Configuration Management System capabilities
  - Specialized manufacturing requirements (extreme complexity, multiple or very tight tolerances, EMI protection, precision assembly, handling of fragile components and Electrostatic Discharge protection, etc.)
  - Process capabilities and manufacturing operations
  - Modeling and Simulation tools and capabilities
  - Testing processes, equipment, and facilities capabilities
  - Earned Value Management System capabilities
  - Cost, Scheduling, and Control System capabilities
  - Systems Engineering Management capabilities (i.e., IEEE 15288)
  - Performance to plans and schedules (IMP/IMS)

- Request and utilize the DCMA information and data in the following areas:
  - Analyses and results of contractor(s) and supply chain capabilities
  - Analyses and results of industrial base capability studies
  - Recommendations from assessments of contractor(s) supply chain capability, if available
  - Analyses of contractor(s)' capability to procure, mature, and characterize materials
  - Analyses and recommendations for contractor(s)' producibility and continuous improvement processes
  - Recommendations for the contractor(s) tooling and equipment strategies
  - Recommendations for the M&Q Plans, the TEMP, and the IMP/IMS
  - Analyses and recommendations for the contractor's SEMP
  - Recommendations for the contractor(s) workforce requirements, skills, capabilities, training, and certifications
  - Analyses of contractor(s) manufacturing and production process verifications and Process Capabilities (Cpks)
  - Analyses and recommendations for the contractor(s) Quality Management System and processes

- Develop recommendations for manufacturing investment programs that mature emerging manufacturing technologies and industrial capabilities based in part on DCMA data inputs.

Tools

- DCMA provides inputs to the following documents, go/no-go (either is or is not included)
- Independent Technical Risk Assessments (ITRAs) Execution Guidance
- Integrated Master Plan/Schedule (IMP/IMS)
- Interactive MRL Users Guide (Checklist), 2018
- Manufacturing Maturation Plan
- Manufacturing Readiness Assessment (MRA) Checklist
- Preliminary Design Review (PDR) Checklist
- System Functional Review (SFR) Checklist
- System Requirements Review (SRR) Checklist
- Systems Engineering Plan (SEP)
- Technology Readiness Assessment (TRA) Checklist
- Test and Evaluation Master Plan (TEMP)

Resources

- DCMA-209, Pre-award Surveys
- DCMA-INST-1201, Corrective Action
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-323, Data Collection and Analysis
- DCMA-INST-325, Technical Reviews
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Assessment (MRA) Deskbook
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

C.2 Conduct Pre-Award Survey and Post-Award Orientation Conference

Pre-Award Survey

A Pre-award Survey may be required per FAR 9.106 and is an evaluation of a prospective contractor's capability to perform under the terms of a proposed contract. It typically requires an on-site visit to the prospective contractor's facility and could be an assessment of their technical, production, quality, and financial capabilities. Manufacturing and QA managers need to support assessments at the contractors'

facilities and should involve the support by DCMA personnel stationed at the facility. DMCA personnel can conduct the following pre-award surveys:

- SF 1404 Pre-award Survey – Technical
- SF 1405 Pre-award Survey – Production
- SF 1406 Pre-award Survey – Quality Assurance
- SF 1407 Pre-award Survey – Financial Capability
- SF 1408 Pre-award Survey – Technical Contractor Accounting System

Manufacturing and Quality Tasks

- Develop M&Q requirements for DCMA pre-award surveys requests.
- Provide M&Q recommendations and inputs to program management for the pre-award type survey requirements (e.g., formal general purpose, formal on-site with solicitation requirements, or short form).
    - Identify M&Q management systems (MMS/QMS) specific contract clauses and work statements within the acquisition planning documents
    - Identify MMS/QMS risk areas during pre-award and post-award conferences, and follow-on assessments
- Ensure the following factors are included in the pre-award surveys of the contractor and key and critical suppliers:
    - Technical capability
    - Production capability
    - Quality assurance
    - Financial capability
    - Risk identification
    - Supply chain management
    - Finance and accounting
    - Government property control
    - Transportation and packaging
    - Security, physical and cyber
    - Plant safety
    - HAZMAT/environmental/energy/regulatory compliance
    - Flight, space, and/or operations, and safety
    - Software capability
    - Technical documentation
    - Configuration management
- Review DCMA audit results for M&Q impacts and make recommendations to the source selection personnel, the Procurement Contracting Officer (PCO), the program Systems Engineer, and the Program Manager.

Tools

- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- SF 1404, Pre-Award Survey – Technical
- SF 1405, Pre-Award Survey – Production
- SF 1406, Pre-Award Survey – Quality Assurance
- SF 1407, Pre-Award Survey – Financial Capability

Resources

- DCMA Pre-Award Survey Guide
- DCMA-209, Pre-Award Surveys
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- Manufacturing Readiness Level (MRL) Deskbook

Post-Award Orientation Conference

A Post-Award Orientation Conference may be performed as prescribed in FAR 42.5. A post-award orientation aids both Government and contractor personnel to achieve a clear understanding of all contract requirements and to identify and resolve potential problems. However, it is not a substitute for the contractor's full understanding of the work requirements at the time the contractor submits the offer. Nor should the orientation be used to alter the final agreement arrived at in any negotiations leading to contract award. M&Q managers need to support DCMA in this assessment at the contractors' facilities.

- Ensure M&Q personnel provide inputs for the request to DCMA to conduct a Post-Award Orientation Conference. All aspects of the contract are subject to discussion with emphasis in the areas of:
    - Compliance to appropriate industry best practices (e.g., AS6500, AS9100, etc.)
    - Technical Performance including TPMs, CIs, CSIs, KCs, and critical characteristics
    - Design
    - Manufacturing capabilities and capacities
    - Quality assurance including processes and procedures compliance to best practices
    - EVMS processes, procedures, and data
    - Government Property management and control (e.g., GFE, GFP, etc.)
    - Transportation, storage, and packaging processes and controls
    - Security (physical, cyber, and industrial)
    - System Safety
    - Plant safety, materials handling, hazardous waste disposal, etc.

- Environmental and Energy compliance with applicable policies and statutes
- Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
- Configuration management processes and procedures
- Software surveillance
- Test planning, test equipment, and test results

Tools

- DCMA Post-Award Orientation Conference Checklist

Resources

- FAR Part 42.5, and DFARS, 242.5
- Multiple DCMA standards, documents, and procedures
- DCMA Post-Award Orientation Conference Checklist

D. TECHNOLOGY AND INDUSTRIAL BASE

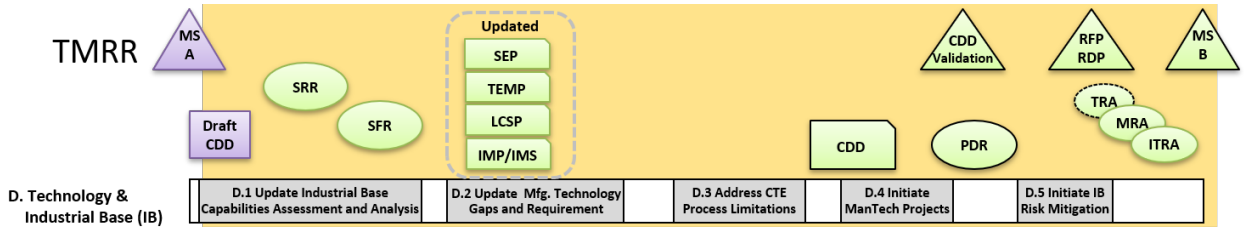


Figure 3-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC 2440 requires the Secretary of Defense to consider the National Technology Industrial Base (NTIB) in the development and implementation of acquisition plans for each MDAP. The NTIB consists of the people and organizations engaged in national security and dual-use research and development (R&D), production, maintenance, and related activities within the United States, Canada, the United Kingdom, and Australia. Acquisition planning and plans shall include considerations of the NTIB for all MDAPs. These considerations should include:

- The ability to support development and production (rates and quantities)
- The identification of IB risks in the supply chain
- The identification of single points of failure in the supply chain (sole source, foreign source, etc.)
- Support for a resilient supply base for critical defense capabilities
- Support for procurement surges and contractions

This thread (Technology and IB) requires an analysis of the capabilities of the national technology and industrial base to support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal (including environmentally conscious manufacturing). This thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Industrial Base Assessments (IBAs)
- Industrial Base Risks
- Critical Enabling Technologies
- ManTech Projects
- Industrial Base Mitigation Plans

TMRR phase IB considerations should include a thorough evaluation of the IB to understand how the IB capability and availability will impact the program. DoD Directives (DoDD) and Public Law requires each major program to conduct assessments of the IB throughout the acquisition cycle. The phase assessments help determine the capabilities of the IB to develop, produce, maintain, and support all defense acquisition programs. The program will document the source availability, producibility, supportability, and maintainability risks and technology needs associated with the materials and components needed.

The update of earlier phase assessments will serve as a baseline as the design evolves. It will document the manufacturing capabilities required for the Acquisition Strategy and facilitate the updates of M&Q inputs to the Systems Engineering Plan (SEP) and Request for Proposal (RFP) documents. The IB topic areas that should be assessed include:

- Industrial base sources relevant to the program, the contractor, and the contractor's supply chain
- M&Q processes and techniques
- Design producibility risks, issues, and opportunities
- Cyber risks and vulnerabilities to M&Q information and data
- Impacts of materials (e.g., critical, long-lead, etc.)
- Supply disruption risks, issues, and program impacts from critical and strategic materials
- Availability and capability of production machinery, equipment, and tooling

IB analysis is a continuing process that gathers program specific information and provides feedback throughout the program life cycle. Earlier IB analyses require updating for the following:

- Development requirements and planned production rates
- Industrial capabilities risks, issues, and opportunities (e.g., single points of failure, fragile suppliers, sole and single sources, etc.)
- Resilience of critical defense industrial base capabilities
- Procurement surges and contractions

Much of the technology that will be incorporated into the system is matured during phase for inclusion or insertion. M&Q should be working closely with the design engineers to evaluate the maturity and feasibility of each new system technology. New system technologies are prone to producibility issues that make them high risk and these technologies may require new manufacturing technologies. Manufacturing technology gaps should be addressed with plans and budget for development, initiation, and insertion points identified along with cost, schedule, and performance impacts. Contractor agreements to utilize completed or successful manufacturing technology projects are essential.

While all new or innovative technologies need to be monitored, certain technologies will be critical to the success of the program these critical technologies deserve special considerations. If a system depends on specific technologies to meet operational thresholds in development, production, operation, and sustainment, and if the technology or its application is either new or novel, then that technology is considered a critical or enabling technology. These Critical Technology Elements should have been identified and evaluated in the MSA phase for maturity of the technology, in preparation for a formal Technology Readiness Assessment (TRA).

Additionally, CTEs were identified in the previous phase and assessed for feasibility, affordability, and supportability and for M&Q maturity. Plans to increase maturity were incorporated into the draft CDD, AS, SEP, and the RFP for the MSA phase. For TMRR, the identified M&Q process areas and process limitations requiring risk mitigation will be updated, including the hardware and the associated embedded software maturity and the cybersecurity risks and vulnerabilities to software and firmware. Implementation of risk reduction efforts in these areas should be initiated in this phase.

Technology risks that are critical to the success of the program are candidates for new Manufacturing Technology (ManTech) projects. However, these types of projects will have their own risks, costs, and schedule impacts that must be factored into the program. The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. The ManTech program impacts all phases of acquisition. It aids in achieving reduced acquisition and total ownership costs by developing, maturing, and transitioning key manufacturing technologies in support of new system technologies. Plans from the previous provide the basis for investments and should be initiated in this phase to find and implement affordable, low-risk solutions.

During TMRR phase program management is responsible for incorporating industrial base analyses, to include capacity and capability considerations, into acquisition planning and execution. Having documented industrial base considerations in the Acquisition Strategy and identified industrial capability problems, the program should initiate an IB mitigation plan that addresses current and future M&Q risks. The plan should address M&Q capabilities that should be maintained throughout program life cycle; mitigate obsolescence, business fragility, supply chain vulnerability, material availability; and address impacts of external dependencies, new and unique capabilities, military vulnerabilities, and rate and quantity changes.

In addition, public law requires major defense acquisition programs to conduct an analysis of the capabilities of the national technology and industrial base to develop, produce, maintain, and support the program, including consideration of the following factors related to foreign dependency:

- The availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment for the sustained production of systems fully capable of meeting the performance objectives established for those systems; the uninterrupted maintenance and repair of such systems; and the sustained operation of such systems.
- The identification of major systems and items available only from sources outside the national technology and industrial base.
- The availability of alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base; and an analysis of any military vulnerability that could result from the lack of reasonable alternatives.
- The effects on the national technology and industrial base that result from foreign acquisition of firms in the United States.

During TMRR, management of industrial base and technology considerations to reduce technology, engineering, integration, and life cycle risks must be an integral part of program management and are key to the success of the program through development, production, and sustainment.

D.1 Update Industrial Base Assessment and Analyses

M&Q personnel as members of the Integrated Product Team (IPT) should update previous Industrial Base Assessments to satisfy the requirements of 10 USC 2440 and DFAR Subpart 207.1.

Manufacturing and Quality Tasks

- Update the analyses of Industrial Base Considerations (from previous phase or conduct if not previously accomplished) of the national technology and industrial base to develop, produce, maintain, and support the program, including foreign dependency. The updated analyses will consider the following:
    - Identification of relevant sources including identification of:
        - Unique manufacturing capabilities
        - Capabilities not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
        - Major systems and items available only from sources outside the national technology and industrial base
        - Alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base

- Vulnerabilities of and effect on the supply chain including sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
- Capability of the materiel solution to be produced using existing manufacturing capabilities and capacities while meeting quality, production rate and cost requirements.
- Capability of the IB to protect digitized program and system information including system definition, design, and test, contracting, and competitive prototyping.
- Capability to cost effectively design, develop, produce, maintain, and support the program, including:
  - Tooling
  - Production test equipment
  - Operation of systems
  - Maintenance and sustainment of systems
- Capability to make production rate and quantity changes that support a response to contingency and support objectives (surges and contractions)
- Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
- Potential obsolescence of components, parts, and materials
- Impacts of external dependencies and integration
- New and unique capabilities and processes
- Assessed requirements and capabilities, which include:
  - Identified sources for key technologies, components, and processes, including known gaps and risks
  - Identified needs including design, development, production, operation, and sustainment, and eventual disposal
  - All technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact the program
- Updated DCMA industrial analysis data and reports to include:
  - Industrial Capability Assessments
  - Appropriate Analytical Products
  - Defense Business and Economic Analysis
  - Acquisition Planning Support

- Prepare the updated Industrial Base Considerations summary report for inclusion in the Acquisition Strategy and appropriate updates to the SEP:
  - Include recommended actions or investments that address risks to cost, schedule, performance, and qualitative considerations that define and recommend how and when the actions would be incorporated into the budget and schedule and, if possible, identify budget offsets

- Note: If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components and approved by the Under Secretary of Defense for Acquisition, Technology, And Logistics per DoDI 5000.60.

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide Checklist, 2018 for Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- 10 USC 2440, Technology, and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology, and Industrial Base
- 10 USC 2503, Analysis of the Technology, and Industrial Base
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

D.2 Update Manufacturing Technology Gaps and Requirements

The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. The manufacturing feasibility assessment should identify high risk manufacturing process areas that represent technology voids or gaps and may require investments in ManTech or other programs. ManTech program investments should be directed toward areas of greatest need and potential benefit. These investments must be identified early so that these manufacturing capabilities will be matured on time to support rate production.

Manufacturing and Quality Tasks

- Update assessments and analyses of emerging technologies to determine capability of current manufacturing technology, processes, and infrastructure to support system development.

  - Analyze the need (determine gaps) for new manufacturing technologies, processes, and infrastructure
  - Identify required risk mitigation efforts with cost and schedule impacts
- Perform manufacturing technology trade studies that includes an assessment of how new and emerging technology might impact product design requirements, affordability, and manufacturing capabilities.
- Update the assessment of identified high risk manufacturing process areas necessary for the program that require investments in ManTech programs.
  - Estimate cost, schedule, and performance impacts
- Update current ManTech project plans with survey data from ongoing ManTech projects and DCMA reports and analyses for solutions to manufacturing technology gaps.
  - Request DCMA provide up-to-date data
  - Update the comprehensive plan for each required ManTech investment
    - Ensure DoD/Service ManTech membership in appropriate IPT
    - Request information from other government agencies, industry, and academia responses to needs

Tools

- Interactive MRL Users Guide Checklist, Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet (PAWs)
- Pugh Matrix
- Technology Readiness Assessment

Resources

- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687 Producibility Systems Guidelines,
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Technology Transition Managers Guide

D.3 Address Critical Technology Element Process Limitations

The ManTech program focuses on advancing state-of-the-art manufacturing technologies and processes from the research and development environment (laboratory) to the production and shop floor environment. ManTech addresses Critical Technology Elements (CTEs) that are often immature and have process limitations that need to be assessed and plans made to mature the CTE.

Manufacturing and Quality Tasks

- Update and assess the identified CTEs for feasibility, affordability, and supportability and for M&Q maturity.
    - Identify mature alternative components or subsystems for each immature CTE
    - Develop plans for increasing CTE M&Q maturity and mitigating associated risks:
        - Update plans to improve and/or maintain maturity from the draft CDD, AS, and SEP (if available)
        - If manufacturing processes need to be updated or developed, plan and budget for the effort to mitigate manufacturing risk
        - Include integration risks associated with the updated CTEs from trade studies
        - Include updates for CTE interdependencies and associated risks
- Update the identified M&Q process areas and process limitations requiring risk mitigation
    - Include necessary hardware and the associated embedded software maturity
    - Include cybersecurity risks and vulnerabilities (software and firmware)
- Support the Technology Readiness Assessments that benchmark technology risks.
    - Determine the degree of M&Q risks in development
    - Conduct in depth analyses of the M&Q risks associated with the design as needed
    - Develop plans for recommended M&Q risk mitigations to be conducted
    - Implement plans to improve CTE M&Q maturity
- Support the identification of the required Technology Readiness Levels (TRLs) to be achieved for each CTE at each systems engineering milestone (e.g., Systems Requirements Review (SRR), Test Readiness Review (TRR), etc.).

Tools

- Independent Technical Risk Assessment Checklist/DTRAM
- Interactive MRL Users Guide Checklist, for Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Technology Readiness Assessment
- TRL Calculator

Resources

- Defense Acquisition Program Support Methodology
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.4 Initiate ManTech Projects

Accelerating the flow of technology to the warfighter is one of the top priorities of DoD, services, and agencies. Technology transition involves the maturation of technologies to the point where they are proven to be mature and ready of insertion into a system or element. Manufacturing and QA managers as members of the Technical IPT need to support the analysis of maturity and the insertion of technologies into production programs.

Manufacturing and Quality Tasks

- Review Service ManTech portfolios for projects with potential application to program gaps to:
    - Determine if the program/contractor should participate in the project
    - Determine if the program/contractor should support bridging of the project to the next phase
    - Determine how the results of the project can be implemented in the program
- Review current Title III, IBAS, and other government investment program portfolios for projects with potential application to program gaps.
- Update program ManTech plan and submit proposals for funding based on Service portfolio reviews, which should include:
    - Identified high-risk manufacturing process areas that require investments in state-of-the-art manufacturing technology
    - Identification of manufacturing technology development efforts to be funded by the program or other alternative sources
    - Justification of benefit to industry, industry sector, or other DoD systems
    - Determination if required manufacture technology efforts will be completed in time to support program needs
    - Relevant data from DCMA and other sources to support plan

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, Technology and Industrial Base thread
- Manufacturing Maturation Plan
- TRL Assessment Checklist

Resources

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development, and Investments
- Defense Production Act, Title III
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDD 4200.15, ManTech Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Service ManTech guidance, e.g., Air Force Technology and Transition Strategy Guidebook,
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.5 Initiate Industrial Base Risk Mitigation

Industrial base risk mitigation activities may be a result of a formal study or analysis or may be a result of routine oversight that identifies a risk or an issue. Manufacturing and QA managers need to assist in the development and management of risk management strategies and implementation plans.

Manufacturing and Quality Tasks

- Initiate mitigation plans that address current and future M&Q Industrial Base risks. Plans should:
    - Address all M&Q capabilities required that should be maintained throughout the life of the program
    - Mitigate product or technology obsolescence, lifetime replacement, or regeneration of items projected to go out of production
    - Mitigate business fragility of any facilities or corporations that provide unique services or products or unique M&Q capabilities
    - Address the approach to making production rate and quantity changes that support a response to contingency and support requirements including surges

- Mitigate the vulnerability of the supply chain (to include sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources)
- Address the availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment (required to include the availability of alternatives for obtaining such items from within the NTIB)
- Address the impacts of external dependencies and integration
- Address the risks introduced by new and unique capabilities and processes

Tools

- Interactive MRL Users Guide Checklist, Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions, Apr 1996
- Manufacturing Readiness Level (MRL) Deskbook, Chapter 5.2 Development of a Manufacturing Maturation Plan
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

E. DESIGN

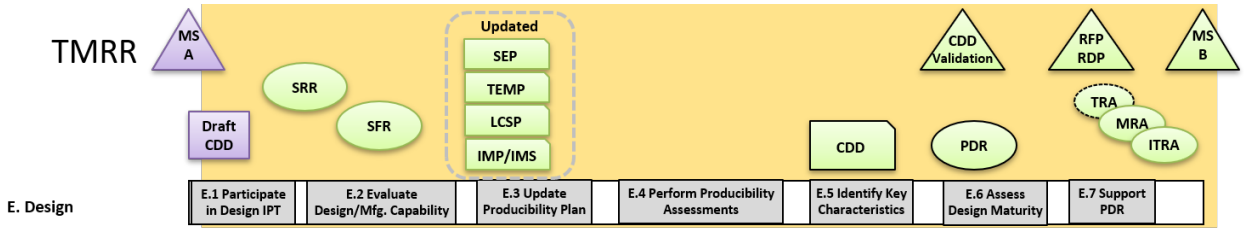


Figure 3-6. Design Manufacturing and Quality Activities

Introduction

DoD Systems Engineering (SE) is a disciplined approach for the specification, design, development, realization, technical management, operation, and retirement of a weapon system. SE is an interdisciplinary and collaborative effort requiring close interaction with other disciplines to include operations, maintenance, logistics, test, production, quality, etc. SE accomplishes these activities by focusing on eight technical processes and eight technical management processes. M&Q personnel need

to support these SE activities. For a detailed description of SE processes refer to the DoD Systems Engineering Guidebook at www.ac.cto/erpo.

This thread (Design) requires an analysis of the degree to which the identified, evolving or system design will meet user requirements and the degree to which the design is new and unproven. will focus on the following sub-threads, tasks, activities, tools, and resources:

- Systems Engineering Plan (SEP)
- Systems Engineering Integrated Product Teams (IPTs)
- Work Breakdown Structure (WBS)
- Technical Reviews and Audits
- Producibility Planning and Assessments
- Key Characteristics
- Design Maturity

M&Q personnel participation in and support to Program Design IPTs are critical to success in developing a producible and affordable system with acceptable risks. M&Q industry best practices are integral to design and development efforts in both Manufacturing Management System (MMS) and Quality Management System (QMS) requirements (e.g., AS6500, ISO 9001, AS9100, etc.). The program should integrate M&Q into the product design and development process and engage M&Q expertise as early as possible. Analyses of design alternatives through trade studies, producibility analyses, and manufacturing feasibility based on program requirements need to be conducted with results incorporated into the design. To accomplish program objectives, these need to be performed throughout the supply chain (e.g., failure mode analyses, Key Characteristics (KC), quality capabilities, test processes, etc.), enabling appropriate visibility and accountability through collection, recording, and communication of technical and programmatic data to all levels.

During the TMRR phase, the M&Q capabilities should be assessed for each competing design under consideration. The assessments should baseline needed industrial, manufacturing, and quality capabilities and identify required investments. While it is not expected that contractors have a complete factory and supply chain established at this point, program understanding of key and critical M&Q processes, scale-up efforts, and supply chain risks and issues is critical. This understanding for TMRR phase should include:

- Manufacturing processes and techniques not currently available
- Design producibility risks, issues, and opportunities
- Probability of meeting milestones
- Potential impacts of critical, strategic, and long-lead materials including disruptions
- M&Q equipment and tooling availability
- Cost models and goals realism
- Estimates for support of management reviews

- Analyses and rationale for M&Q feasibility, cost, and schedule trade-offs of alternative approaches
- Anticipated M&Q processes testing and demonstration efforts

Producibility criteria should reflect a blending of general criteria and specific criteria applicable to the system being developed. Producibility analyses will be effective if the design engineers understand and apply the producibility design criteria. Producibility is more than a design engineering function requiring M&Q engineer participation to generate a design that is compatible with the M&Q capabilities of the contractors. Producibility is the most important determinant of product cost, due to the impacts on EMD, Production and Deployment (P&D), and Operations and Support (O&S) costs. Ignoring producibility may lock the acquisition program into design solutions that can only be accomplished at unnecessarily high costs and/or designs that can entail substantial technical, cost and schedule risk. The TMRR contract should have required that the contractor develop, execute, and maintain a Producibility Plan and criteria to guide the design and development efforts. The plan should describe specifically what activities will be accomplished in each phase, the responsible organization, and the management controls that will be established to ensure successful accomplishment. M&Q should review the plan with a focus on the completeness, clarity, adequacy, and realism of the planning accomplished by the contractor. Results of these analyses will support the development of specific contractual provisions for the EMD phase.

DoD policy on major system acquisitions makes producibility risk considerations a requirement in the Acquisition Program Baseline (APB) prior to the start of technology development. Producibility assessments should be an integral part of the on-going systems engineering process. Design processes should have included producibility assessments as part of the design decisions, however producibility is not limited to design.

Effective measurement is critical to accuracy producibility assessments. Measurement is a tool for evaluating the effectiveness of producibility performance and for determining the degree to which improvements need to be made to ensure that future products are producible. Producibility assessments are conducted on system, subsystem, item, and component levels. M&Q processes must be monitored and controlled with measurements, to ensure repeatable and consistent production of accurate, high-quality products. Process variability results in product variability, and product variability, when outside of design limits, means unacceptable quality. As a rule, reducing process variability improves product quality and, therefore, producibility.

In general, to assess program producibility, the organization must evaluate producibility on a product-by-product basis. Analysis of producibility on a per product basis allows the organization to better understand the strengths and weaknesses of the system, so that enhancements can be identified.

Other producibility considerations include:

- Minimizing costs and schedule while maximizing performance
- Infrastructure – cyber-security, software tools, design guides, training, and policies

- Trade studies for design principles, reducing part counts, using of common parts, ease of assembly, simplicity of fabrication, safety, etc.

Key and critical product characteristics and features are the output of key and critical M&Q processes. Consequently, to achieve program goals it is important for the contractor to identify and control these characteristics early in the system design and development effort.

According to AS9100D, KCs (Key Characteristics) are defined as an attribute or feature whose variation have a significant effect on product fit, form, function, performance, service life or producibility, that require specific actions for the purpose of controlling variation. A critical characteristic is defined by AS6500 as a characteristic that is likely, if defective, to create or increase a hazard to human safety, or to result in failure of a system to perform a required function. Additionally, AS6500 defines a critical manufacturing process as a process that creates or affects a key or critical characteristic. KCs and critical characteristics and the associated manufacturing processes may be produced or accomplished at a sub-tier supplier. By the end of the TMRR phase, the contractor and the program office should have a top-level understanding of KCs. Products perform better when there is less variation on the key and critical characteristics.

Based on design and manufacturing feasibility and capability analyses, producibility assessments, and KC identification process, M&Q will assess design maturity in accordance with industry best practices. It must be economically feasible to manufacture a quality product at a specified rate and to deliver end items capable of achieving the performance and reliability inherent in the design. A strong emphasis early in the design phase on:

- Configuration control
- Key and critical characteristics processes
- Risk, issue, and opportunity management
- M&Q capabilities, feasibility, and producibility, contribute to reduce the time and cost required for successful transition to production

Design maturity occurs when a product design meets the requirements, as well as cost, schedule, and performance targets. It is a best practice to achieve design completion at the system-level CDR in the EMD phase. Consequently, design completion should include a ramp-up during TMRR to meet Preliminary Design Review exit criteria.

The PDR is a technical assessment establishing the physically allocated baseline and the functional baseline to ensure that the system under review has a reasonable expectation of being judged operationally effective and suitable and has a reasonable expectation of satisfying the requirements within the currently allocated budget and schedule. A successful PDR should include an assessment of the producibility of the design and an assessment of manufacturing costs and risks.

M&Q is responsible for inputs, per industry best practices, to many aspects of a PDR. M&Q inputs include:

- Entry/exit criteria for the preliminary PDR process
- Results of MRL assessments
- Reviews, analyses, assessments, and contractor deliverables that support sufficient maturity of the allocated baseline
- Results of the assessments establishing the system functional baseline
- Inputs and documentation to the technical planning process
- Manufacturing Plans and Quality Plans
- Inputs to the program risk, issue, and opportunity assessment process for identification and mitigation of M&Q cost, schedule, and technical risks
- Inputs to the program life cycle cost estimates

E.1 Participate in Design Integrated Product Team

Major programs are organized around core design team, usually comprised of 20-50 of the contractor's best engineers. This core design team makes 90-95% of all critical decisions with most design decision made prior to production. If M&Q are not one of their primary concerns, then these considerations will be delegated to secondary teams or not accomplished until late in the program causing serious problems with cost, schedule, and performance.

The PM and Technical team need to ask M&Q questions and ask them often. The contractor will follow the government's lead. If the government shows concern for these areas in the development of the design and integration with M&Q, then the contractor receives the message and will show like concern. Manufacturing and quality personnel must participate with the Design IPT in the development and review of the design and design documentation.

Manufacturing and Quality Tasks

- Ensure adherence to M&Q design best practices (e.g., AS6500, AS9100, ISO 9001, etc.).
- Provide M&Q requirements based on analyses of system requirements and design concepts.
    - Identify capabilities and constraints based on the system specifications
    - Establish the required M&Q capabilities baseline
    - Identify M&Q affordability cost drivers and impact on schedule and performance
- Provide input to design trade studies (i.e., functional and performance requirements) that include criteria concerning:
    - KPPs, KSAs, APAs, and evolving KCs
    - Manufacturing process capabilities, limitations, and concerns
    - Software and firmware development and re-use
    - Safety, handling, storage, and disposal considerations and restrictions

  - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
  - Manufacturing costs, materials, special tooling, and test equipment
  - Cost-effective and affordable designs to achieve performance and schedule while minimizing cost
  - Manufacturing capacity, workforce, and schedule impacts
- Participate in the design producibility process provides:
  - Identification products and processes that would benefit from producibility analyses (i.e., Design for Manufacturing (DFM)/Design for Assembly (DFA)
  - Monitoring and reporting on producibility process activities with respect to risks, issues, and opportunities
  - Integration of producibility with other design activities including software and firmware development and re-use
  - Participation in producibility design trade studies to include process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
  - Identification of innovative manufacturing technology opportunities
- Provide monitoring, reviewing, analyses, and reporting on multiple analyses as part of the FMECA process (e.g., DFMEA, PFMEA).
- Provide inputs into the Design and Development planning process to include:
  - Planning inputs that establish, implement, and maintain appropriate processes to manage key and critical subsystems, components, and items including process controls for KCs
  - Requirements for design, production process verification, test, inspection, verification, and product acceptance (statistical techniques)
  - Inputs for monitoring and managing the development process through frequency, data, and metrics for design reviews
  - Criteria for M&Q evaluation of design outputs (product)
  - Requirements for M&Q verification, validation, and change control
- Provide M&Q impacts and interdependencies of design activities to other functional areas or activities (e.g., engineering, producibility, costs, safety, manpower, schedule, etc.).
- Perform assessments and identification of M&Q risks, issues, and opportunities (e.g., technology, manufacturing, cybersecurity, software development, and sustainment) including mitigation.
- Provide M&Q support to program reviews (e.g., PMRs, SRR, SFR, and PDR).
- Provide M&Q support to the program level TRA and MRL assessment (as required).
- Provide M&Q support to the specified program configuration control process for the design.
- Evaluate the design for the impacts on M&Q requirements with respect to GFE (e.g., subsystems, components, test ranges, facilities, etc.).

- Provide M&Q inputs to program documentation (e.g., SEP, TEMP, AS, CDD, etc.)
    - Include inputs and support for CDD validation efforts
    - Include inputs for manufacturing plan updates (including design changes, investments, etc.)
- Provide support to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.)
- Provide M&Q input in support of congressionally mandated assessments and reports.
    - Inputs on M&Q risks associated with the program
    - Inputs on M&Q processes that need to be matured.

Tools

- Acquisition Plan Preparation Guide template
- Capability Development Document (CDD) template
- Design for Manufacturing and Assembly (DFMA)
- Interactive MRL Users Guide Checklist for the Design thread
- Life Cycle Sustainment Plan template
- Manufacturing Maturation Plan
- Preliminary Design Review (PDR) Checklist
- Systems Engineering Plan (SEP) Outline
- System Functional Review (SFR) Checklist
- System Requirements Review (SRR) Checklist
- Test and Evaluation Master Plan (TEMP) template
- Technology Readiness Assessment (TRA) Checklist

Resources

- 10 USC 144B, Sec 2366 and 2448
- Acquisition Strategy Guide, DSMC
- AS 9103, Variation Management of Key Characteristics
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- CDD-CPD Writing Guide, Feb 2015
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs

- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management Program
- LCSP memo, Sep 2011, and DAG Chapter 4-3.1
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment (TRA) Deskbook
- TEMP Guide, and DAG Chapter 8-4.1

E.2 Evaluate Design and Manufacturing Capability

M&Q managers as members of the technical Integrated Product Team (IPT) should accomplish an assessment of the design and the capability of the factory floor to build to the design. This includes assessing manufacturing readiness and effective integration of industrial capability considerations into the design process. The first consideration is a need to understand the current manufacturing capabilities to see if they match up against the design requirements so that the program can plan for the enhancements of capabilities where there is a gap between the design and factory floor capabilities.

Current "Design Best Practices" include the use of Computer-aided Design (CAD) and Computer-aided Manufacturing (CAM).

CAD (Computer Aided Design) is the use of computer software to design and document a product's design process. CAD is used to accomplish preliminary design and layouts, design details, and calculations, creating 3-D models, creating and releasing drawings, and interfacing with analysis, marketing, manufacturing, and end-user personnel.

Computer-aided manufacturing (CAM) is the use of software and computer-controlled machinery to automate a manufacturing process. Based on that definition, you need three components for a CAM system to function:

- Software that tells a machine how to make a product by generating toolpaths.
- Machinery that can turn raw material into a finished product.
- Post Processing converts toolpaths into a language machines can understand.

Manufacturing and Quality Tasks

- Assess the organization's approach to systems engineering and use of best practices to solve design and manufacturing problems
- Perform an M&Q Design IPT participants assessments of the contractor(s) and supply chain capability to mature the proposed design(s) within the program overall cost, schedule, and performance goals.
    - Identify risks, issues, opportunities, and mitigation plans

  - Include competing technologies, prototypes, etc.
  - Include capabilities with respect to environmental and hazardous processes
- Conduct analyses to:
  - Determine shortfalls (risks) to the required baseline M&Q capability and mitigation required
  - Identify M&Q processes and techniques that require development (including for special and hazardous)
  - Identify materials, producibility, equipment, and schedule risks, issues, and opportunities (including availability, hazardous, and long-lead)
  - Develop M&Q inputs to production unit cost and schedule (realism) estimates
  - Provide M&Q comparisons of competing and/or alternative approaches
  - Provide M&Q recommendations for anticipated M&Q process testing and demonstration efforts for each competing and alternative approach
  - Identify required M&Q capability investments (e.g., ManTech, GFE, facilities, capital equipment, tooling, test equipment, and processes, Modeling and Simulation (M&S), etc.)

Tools

- Independent Technical Risk Assessment (ITRA) Checklist
- Interactive MRL Users Guide Checklist, Design thread
- Manufacturing Maturation Plan
- Quality System Audit

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

E.3 Update Producibility Plan

Producibility Engineering and Planning should be directed toward generating a design that is compatible with the current capability of the factory floor. Producibility is a major driver of product affordability because of the effect on both production and sustainment costs. The Producibility Plan

should guide the design effort and describe activities that will be accomplished, the responsible organization, and the management controls that will be established to ensure successful accomplishment. M&Q managers should be updating the Producibility Plans with a focus on the realism, completeness and clarity of the planning accomplished by the contractor.

Manufacturing and Quality Tasks

- Review and analyze the contractor(s) plans for specific processes, methods, and actions to address manufacturing feasibility, producibility, and M&Q risks associated with the proposed solutions.
    - Include schedule, responsibilities, and management controls
    - Review the plan for purpose, realism, completeness, and clarity
    - Identify interdependencies and integration factors
    - Identify risks, issues, and opportunities
    - Identify manufacturing technology requirements
    - Include technology insertion opportunities
- Ensure plan describes how the design engineers apply the producibility design criteria.
    - If a competitive approach is used, describe how each competing design will be evaluated from a producibility standpoint
- Update identified and potential M&Q process risks, issues, and capabilities to include:
    - Validated and updated producibility goals and metrics
    - Updated Modeling and Simulation (software) approaches (manufacturing and production)
    - Critical M&Q processes (yield, rates, and variability, if available)
    - Impacts to cost, schedule, and performance
    - Facilities, tooling, testing, and qualification
- Merge the identified contractor and government M&Q risks, issues, and opportunities into a consolidated government/contractor program plan and process.
- Ensure producibility planning for design includes M&Q considerations for and/or address the following:
    - Security (physical and cyber)
    - System safety and HAZMAT management criteria
    - Interdependencies and integration
    - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
    - Benchmarking
    - Costing
    - Data management systems
    - Design for Manufacture/Assembly
    - Design of Experiments (DOE)
    - Failure Modes and Effects Analysis (FMEA)

        - Design Failure Modes and Effects Analysis (DFMEA)
        - System Failure Modes and Effects Analysis (SFMEA)
        - Process Failure Modes and Effects Analysis (PFMEA)
    - Prototyping approaches
    - Design for Six Sigma
    - Tools (Quality Functions Deployment (QFD), Root Cause Analyses, Statistical Process Control (SPC), Tolerance Analyses, etc.)

Tools

- Interactive MRL Users Guide Checklist, Design thread
- Manufacturing Maturation Plan
- Producibility Engineering and Planning (PEP) Data Item Description

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- MIL-STD-882E, DoD Standard Practice: System Safety
- NAVSO P-3687, Producibility System Guidelines
- Producibility System Guidelines, Missile Defense Agency

E.4 Perform Producibility Assessments

DoD policy on makes producibility considerations a requirement for MDAPs. DODD 5000.01 states that the PM shall "reduce manufacturing risk and demonstrate producibility" prior to FRP.

Producibility engineering and producibility assessments should be a part of the ongoing systems engineering process. Producibility is directly connected to the complexity of a system. As complexity increases, so does the acquisition cost. Therefore, producibility programs are necessary as a management means for ensuring that the cost increases associated with the growing complexity of systems are minimized. Producibility analysis accomplished by the PMO must be performed by a team of specialists assembled from the program office: and supporting organizations. Manufacturing and QA managers are key to the successful implementation of a producibility program.

Manufacturing and Quality Tasks

- Perform and/or support producibility assessments as a member of the Design IPT utilizing approved contractual documentation (CDRLs, DIDs, etc.) and other programmatic information and data including the following factors in the assessments:
    - Planned producibility goals and metrics
    - Management responsibilities and controls
    - Design analyses (between and among competitive designs)
    - Cost and schedule
    - Key Characteristics
    - Interdependencies and integration
    - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
    - Risks, issues, and opportunities
    - Manufacturing technology requirements (including innovative and advanced)
    - Technology insertion opportunities
    - Review of goals, realism, completeness, and clarity
    - Implementation of industry best practices, tools, and techniques
    - System safety design and HAZMAT management criteria
    - Security (physical and cyber)
    - Facilities, tooling, testing, and qualification
    - Government-furnished equipment (GFE), etc.
- Utilize producibility tools, techniques, procedures, and associated metrics that include:
    - State-of-the-art Modeling and Simulation software
    - Failure Modes and Effects Analyses (FMEA)
        - Fault Tree Analysis (FTA)
        - DFMEA
        - SFMEA
        - PFMEA
    - Design for Manufacture and Assembly (DFMA)
    - Design of Experiments (DOE)
    - Design for Six Sigma
    - Quality Function Deployment (QFD)
    - Benchmarking
    - Design guides
    - Interdependencies and integration analyses
    - Tolerance analyses
    - Requirements validation analyses
    - Trade studies on alternative product and process designs
    - Product complexity analyses

  - Safety analyses
  - Manufacturing process analyses
  - Quality and quality process analyses
  - Costs, cost drivers, and controls analyses
  - Materials characterization and availability
  - Prototyping of component, item, subsystem, competitive, etc.
  - Learning curve goals and projections
  - Product and process measurements utilizing Statistical Process Control (SPC)
  - Data and database management
  - Testing
- Provide M&Q support to design producibility analyses including:
  - Process capabilities
  - Manufacturing costs
  - Tooling and test equipment
  - Materials availability and characterization
  - Manufacturing capacity and capability
  - Workforce availability and training
  - Schedule impacts
  - M&Q cybersecurity (including all digital communications and connectivity for design, facilities, equipment, etc.)
  - System safety and vulnerability

Tools

- Design of Experiments (DOE)
- CAD/CAM software
- Interactive MRL Users Guide Checklist, for the Design thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Quality Function Deployment (QFD) method
- Taguchi Loss Function Sheet
- Trade Studies

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide

- MIL-STD-882E, DoD Standard Practice: System Safety
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering Standard Practice Manual, U.S. Army Belvoir R&D Center
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)

E.5 Identify Key Characteristics

AS9103 is the industry best practice of the identification and control of Key Characteristics (KCs) and requires the producer to maintain documentation of KCs and control those manufacturing processes that directly influence variation of those KCs. Key Characteristics should be capable and have a Cpk of 1.33 or greater or as specified by the customer. The concept of identifying key characteristics is linked to the Pareto principle, which asserts that a small number of features will have the most significant impact on performance. M&Q managers should be involved in the identification and assessment of Key Characteristics to see if they meet customer requirements and identify risks from not meeting those requirements. Often in the past companies identified Key Characteristics only after experiencing cost problems, in the plant and in the field. Proactive or robust engineering would have contractors identifying Key Characteristics early in the design phase.

Manufacturing and Quality Tasks

- Provide monitoring, evaluation, and analyses from multiple FMEA activities (e.g., FMECA DFMEA, PFMEA, etc.) for the derivation of KCs, critical characteristics, and Critical Safety Items (CSIs), where possible.
    - Provide M&Q support to the System Safety Assessment (SAR) to assist in CSI identification with supporting rationale
- Guide and ensure identification, derivation, and justification of KCs and critical characteristics from identified KPPs, KSAs, and APAs (including all mandatory KPPs).
    - Update initial M&Q draft KPPs, KSAs, and APAs, and associated CTEs
    - Provide M&Q inputs on development and management processes to establish, implement, and maintain management of key and critical subsystems, components, items, and software including process controls for KCs
        - Provide inputs on development and management processes to be evaluated
        - Include identification of M&Q processes to be matured
        - Specify, as applicable, specific actions to be taken (e.g., mitigation, investments, etc.)
    - Develop a preliminary list, which includes where produced or accomplished and a rationale for inclusion (*see* G.6), of:
        - Key Characteristics

    - Critical characteristics
    - Critical Application Items (CAIs) (e.g., systems, subsystems, software, materials, components, etc.)
    - Key M&Q processes
    - Critical Safety Items (CSIs)
- Provide outputs of and updates to key and critical characteristic identification, derivation, justification, and management processes to the SEP, AS, CDD validation process, RFP development process, TRA, MRL assessment, and PDR entry/exit criteria development process.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide Checklist, for the Design thread
- Manufacturing Maturation Plan
- MRL Matrix
    - Critical to Quality Tree
    - Failure Mode and Effects Analysis
    - Process Capability Analysis Worksheet
    - Producibility Assessment Checklist
    - Technology Readiness Level (TRL) Assessment Checklist

Resources

- AS9100, Quality Management System
- AS6500, Manufacturing Management Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI5000.02, Operation of the Adaptive Acquisition Framework
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- JCIDS Manual
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-882E, DoD Standard Practice: System Safety
- NAVSO P-3687, Producibility System Guidelines
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

E.6 Assess Design Maturity

The Preliminary Design Review (PDR) is conducted at the end of the TMRR phase to assess prototype(s) technical progress, adequacy, and risks to cost, schedule and performance for moving that configuration forward into Engineering and Manufacturing Development.

After PDR, the design should be maturing to the point that the review can assess the allocated design documentation in subsystem product specifications for each configuration item in the system and that all functions have been allocated thus providing the Milestone Decision Authority enough evidence to move the program forward. M&Q managers as a part of the technical IPT should support assessments of design maturity.

Manufacturing and Quality Tasks

- Assess design maturity for the following in accordance with industry best practices (e.g., AS6500, AS9100, etc.) and readiness for the PDR (per IEEE 15288) based on design and manufacturing feasibility and capability analyses, producibility assessments, and KC identification process:
    - Update prior or conduct M&Q assessments of capability and feasibility based on contracted system concept(s).
        - Assess lower-level performance requirements to determine sufficiency to proceed to preliminary design
        - Assess completeness of product data required for component manufacturing
    - Update the producibility and manufacturability assessments for gaps and risks including:
        - Critical and unique manufacturing process requirements including software
        - Alternate design approaches within the concepts
        - Material requirements
        - Supply chain requirements
        - Production rate and yield requirements
        - Facility requirements
        - Special tooling development requirements
        - Test and demonstration requirements for new materials
        - System safety and HAZMAT management
        - Economic feasibility

    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment
  - Assess adequacy and robustness of the contractor configuration control processes with respect to design, engineering, software changes
  - Assess updates and status of key and critical characteristic processes
    - Assess M&Q engineering and management activities for adequacy and completeness (e.g., documentation, drawings, data collection and management, etc.)
    - Assess for adequacy and completeness of M&Q inputs on mandatory KPPs
  - Provide inputs and plans for M&Q risks, issues, and opportunities to the government/contractor Risk, Issue, and Opportunity Management Process:
    - Update and status known
    - Identify and develop plans for new
    - Evaluate adequacy and completeness of mitigation activities
  - Provide M&Q inputs for product level engineering/design requirements definition and support the validation activities.
  - Assess and validate product requirements and features as well enough defined to support PDR
  - Identify M&Q components of Technical Performance Measures (TPMs) to support tracking of design maturity
  - Assess and validate if product data essential for system/subsystem prototyping is ready for release
  - Assess completion status of physical and functional interface definitions for the product (system)
  - Assess and validate prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software
  - Assess percentage completion of subsystem design (with schedule for completion) and component and item maturity (percentage in current production) for PDR

Tools

- Design for Six Sigma
- Independent Technical Risk Assessment Checklist
- Manufacturing Maturation Plan
- MRL Assessment Checklist, Design thread

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- Defense Technical Risk Assessment Methodology (DTRAM)

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- JCIDS Manual
- MIL-STD-882E DoD Standard Practice: System Safety
- NDAA for FY 2017, Public Law 114-328
- Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs

E.7 Support Preliminary Design Review

M&Q personnel should be actively engaged in the organization and execution of the Preliminary Design Review (DR) during this phase. The PDR is an assessment that establishes the Allocated Baseline of the system and is used to ensure that the system has a reasonable expectation of meeting the current requirements within the given cost and schedule. The completion of the PDR should provide:

- An established system allocated baseline
- An updated risk assessment for the EMD phase
- An updated CARD based on the allocated baseline
- An updated program schedule including system and software critical path drivers
- An approved Life Cycle Sustainment Plan

Manufacturing and Quality Tasks

- Provide M&Q inputs to the entry criteria for the preliminary PDR process per industry best practices (i.e., IEEE 15288) including:
    - Acceptability criteria for technical review outputs
    - Preparatory actions for the specific program
    - Inputs to allocated baseline and budget
    - Review of lower-level subsystem PDRs
- Provide M&Q inputs to the exit criteria for the PDR process per industry best practices (i.e., IEEE 15288) that include addressing:
    - Adequacy, accuracy, and completeness of required M&Q PDR criteria
    - Closure of M&Q action items with appropriate corrective action plans
    - Risk and issue mitigation and opportunity planning
    - Adequacy of the allocated and functional baselines
- Support the PDR to ensure, by inputs provided from results of an MRL assessment(s), that the manufacturing system will meet expectations for effectiveness and suitability (quality) within the allocated budget and schedule includes:
    - Manufacturing equipment, tooling, and software (including ManTech)

  - Processes, process control, and process capabilities (C_{pk}s)
    - Include initial data analyses
  - Interfaces and interface requirements
  - Materials management (including hazardous)
  - Workforce (personnel, skill sets, training, etc.)
  - Supply chain (includes industrial base alternatives)
  - Facilities (including GFE)
- Provide M&Q design inputs for reviews, analyses, assessments, and contractor deliverables that support sufficient maturity of the allocated baseline per contractual requirements to conduct a PDR including:
  - Analyses of system-level performance, producibility, growth allocations, and traceability
  - Design trade studies to the lowest level
  - Software development and re-use
  - Allocation of interoperability performance requirements
  - Preliminary long-lead production requirements
  - Requirements for parts, materials, and processes incorporated in the preliminary design including risks, issues, and opportunities (e.g., obsolescence; fragile, sole, single, foreign sources, hazardous, etc.)
  - M&Q control processes and procedures (e.g., Electromagnetic Interference, hazardous, environmental, etc.)
  - Meeting the Mandatory KPPs and system performance/functional KPPs and KSAs (including supply chain)
  - Key Characteristics and key processes management
    - Include critical characteristics and critical processes (including Critical Technologies List of CTEs with CSIs and CAIs included) analyses (*See* E.5 and G.6)
  - DT&E requirements
  - System safety requirements
  - Environmental Safety, Occupational Health (ESOH) requirements and preliminary hazards list
  - Manufacturing security and access (physical and cyber)
  - Quality assurance requirements (including tolerances/design margin analyses for a robust design)
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
- Provide the M&Q inputs to the assessment establishing the system functional baseline, including inputs for:

  - Preliminary designs of hardware, software, and procedures including interfaces is complete, satisfies all requirements in the system functional baseline and is under Configuration Management without any major To Be Determined (TBD) or open items
  - System, segment, subsystem, and component-level interfaces
  - M&Q aspects of C4I equipment, interfaces, processes, and procedures across segments, subsystems, and components
  - Implication of the threat scenario to M&Q processes and environments (traceable to all segments, subsystems, and components)
  - M&Q data collected to date, including test data, on the subsystems, items, and components for the preliminary design
    - Data should be traceable to requirements via specifications and verification cross-reference matrix (from SFR)
    - Data should support bidirectional traceability between functional and allocated baselines

- Provide the M&Q inputs and documentation to the technical planning process to include:
  - M&Q analyses of the Supplier(s) SEMP to determine adequacy and alignment with the M&Q provisions in the SEP
  - M&Q analyses of lower-level PDRs to identify risks and issues and determination of actions required
  - A review of the Manufacturing Management and Quality Management plans in the SEMP and the SEP for adequacy to meet proposed EMD requirements
    - Include requirements for sub-tier SE reviews and audits such as PDR, CDR, PRR, etc.
  - The assessment of design maturity for the M&Q components of TPMs for the technical planning process
  - Manufacturing Management Plan and Quality Management Plan approaches to support program Validation and Verification (V&V) processes as part of design, development, test, data acquisition, etc.
  - M&Q inputs to the HAZMAT management and pollution prevention processes and procedures
  - Inputs on adequacy of facilities chosen to perform design verification (includes facilities, equipment, GFE, etc.)
  - Status of ongoing system producibility and trade studies
  - Identification of long-lead materials and supply chain elements (including multi-sourcing of items, parts, and components)
  - Inputs to the requirements for software development plans
    - Coordination, scheduling, and availability of assets (e.g., facilities, labs, equipment, etc.) for test and integration

    - Hardware/software interfaces and integration
    - Data storage, handling, and security (physical and cyber)
    - Built-in test and performance

- Review M&Q plans for completeness and adequacy to include
    - Analyses, demonstrations, and prototypes to confirm the design/development approach in a relevant environment
    - Trade studies that address COTS, re-use, and other related issues
    - A draft Bill of Materials for the system
    - An updated IMP and IMS that includes all major phases with acceptable risks and executable budget
    - Use of computer modeling, design tools, and test and integration labs
    - Identification, definition, and characterization of critical manufacturing processes, metrics, and the management process
    - A failure reporting and corrective action system (FRACAS) process
    - Inputs to the TEMP components and items, facilities, equipment, fixtures, and interfaces
    - Capability to meet rate and schedule
- Provide M&Q support to the Life Cycle Sustainment Plan.
- Provide inputs to the program risk, issue, and opportunity assessment process for identification and mitigation of M&Q cost, schedule, and technical risks.
- Provide inputs to the program life cycle cost estimates for M&Q.

Tools

- Interactive MRL Users Guide Checklist, Design thread
- Manufacturing Maturation Plan
- Preliminary Design Review Checklist

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-882E, DoD Standard Practice: System Safety

F. COST/FUNDING

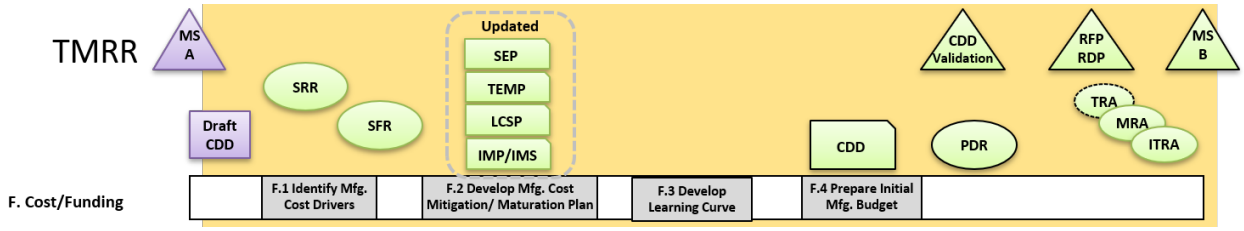


Figure 3-7. Cost and Funding Manufacturing and Quality Activities

Introduction

Services and Agencies develop Program Objective Memorandums (POMs) to identify and request resources (money) to acquire capabilities and perform operations. The POM is part of the Programming phase of the Program, Planning, Budget, and Execution (PPBE) process. The DoD combines the various Service and Agency POM inputs and Budget Estimate Submission (BES) and submits a DoD Budget Request to the Office of Management and Budget (OMB).

DoD efforts at cost estimating and analysis play a critical role in supporting DoD procurement activities to include planning, programming, budgeting, acquisition, and requirements generation. Cost estimating is both a science and an art relying on sound mathematical and analytical skills, critical thinking, communication, and the ability to understand complex functions and processes.

This thread (Cost and Funding) requires an analysis of the risk that the system development and deployment will not meet the DoD cost and funding goals. The thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Cost Modeling (Initial Estimates)
- Identification of Cost Drivers
- Assessment of M&Q Costs
- Preparation of M&Q Budgets
- Development of M&Q Cost Mitigation Plans
- Development and Validation of Learning Curves

Detailed manufacturing cost estimates could not be developed during the Materiel Solution Analysis phase, but cost drivers should have been identified based on proposed materials and process selections that were inherent in the proposed materiel solutions. In addition, producibility cost could be assessed and investments in manufacturing technologies could be estimated. In TMRR, costs need to be defined and finalized.

The DoD typically requires objective cost estimates and analysis on programs. The type of cost estimate is a function of the program category, events, and type. Cost estimates include:

- Independent Cost Estimate (ICE)

- Component Cost Estimate (CCE)
- Component Cost Position (CCP)
- Cost Capability Analysis (CCA)
- Independent Government Cost Estimate (IGCE)
- Should Cost Estimate (SCE)
- Sufficiency Review

Cost estimates should be used to evaluate affordability and establish initial program cost thresholds. In most cases, the estimates in MSA were developed using statistically based cost estimating relationships or by comparison of the proposed systems with similar systems whose costs are known. The cost estimates will be used as the initial basis for concept costs in the TMRR phase.

M&Q cost estimating is a process used to predict life cycle manufacturing costs based upon the capabilities and processes to produce and support the components of a system. M&Q specialists within the program predict system costs using the results of trade studies and probable process yields. M&Q should-cost inputs should be provided to the Cost Analysis Requirements Document (CARD) to update it for consistency with the approved system specification.

Within any program there will be certain systems, subsystems, items, and components the cost of which will dramatically impact the overall system cost; these are the cost drivers. Any analysis of M&Q risks and producibility issues will identify a cost driver. M&Q focuses on producibility planning and risk and issue mitigation for identification and reduction of cost drivers. Areas that are ripe for discovering and eliminating manufacturing cost drivers include the following areas:

- Emerging technologies
- Industrial base
- Design/producibility
- Funding for maturing the M&Q processes
- Materials availability and environmental impacts
- Supply chain management
- Process capability and control
- M&Q management/supplier quality management
- Workforce
- Facilities, capital equipment, tooling, and test equipment

A concerted effort should be initiated to reduce identified drivers and the overall costs wherever possible. There are cost tools that can be used within the program that can help identify and achieve overall cost reductions.

A should-cost review uses an integrated team to conduct coordinated, in-depth cost analyses of a contractor's plans and ongoing efforts. The purpose of the review is to identify inefficient and uneconomical contractor practices, to quantify the impact of these practices on system cost, and to use

the findings to develop a realistic price objective. The approved cost reduction efforts or initiatives are used to incentivize contractor performance toward achievement of the new should-cost target. The should-cost analysis is intended to not only evaluate proposed contractor costs, but to then track and monitor those costs and to identify further savings opportunities that will lead to further cost reductions.

Will-cost estimates should be verified by an office that is external to and independent of the program office. Additionally, it is DOD policy that programs actively manage the budget baseline using the current will-cost estimates for all acquisition, budget, and program execution decisions (e.g., source-selection, contract negotiations, major reviews, etc.). The programs budget baseline is based on a will-cost estimate and is sometimes referred to as the Independent Cost Estimate (ICE) or verified Program Office Estimate. This estimate is historical in nature and aims to provide sufficient funds to execute the program under normal conditions (average program risks). This will-cost estimate is used to support the budget and ensures sufficient funding.

Program Managers will employ Earned Value Management (EVM). The purpose of EVM is to ensure sound planning and resourcing of all tasks required for contract performance. EVM provides a disciplined, structured, objective, and quantitative method to integrate technical work scope, cost, and schedule objectives into a single cohesive contract baseline plan called a Performance Measurement Baseline for tracking contract performance.

M&Q personnel must analyze contractor data to develop, update, and support plans for mitigation and/or maturation of cost drivers.

As the program matures the manufacturing budget will become more refined and accurate. During the TMRR phase, as the design matures, the contractor and the program should be able to create budgets based upon specific design characteristics and knowledge of the M&Q capabilities and processes that will be used to produce the system. The budget should include:

- M&Q cost reduction initiatives.
- Accurate costs based on analyses and assessments of cost data against cost targets and trends.
- M&Q funding estimates for emerging requirements including investment opportunities and investment roadmaps
- Budgeting for M&Q initiatives and manufacturing technology investment programs.

When budgeting for M&Q, interaction with the contractor will enable the program to understand the significant cost impacts experienced by the contractor. Interaction increases the program’s understanding of the contractor's M&Q operations and M&Q costs, as well as the factors that can impact M&Q operations.

F.1 Identify Manufacturing Cost Drivers

M&Q managers need to support to development and update of government cost estimates and the assessment of contractor cost estimates. This includes the identification of manufacturing cost drivers, those costs that have the most impact on cost and affordability.

Manufacturing and Quality Tasks

- Support cost estimates as appropriate:
  - Independent Cost Estimate (ICE)
  - Component Cost Estimate (CCE)
  - Component Cost Position (CCP)
  - Cost Capability Analysis (CCA)
  - Independent Government Cost Estimate (IGCE)
  - Should Cost Estimate (SCE)
  - Sufficiency Review
- Analyze and update M&Q should-cost inputs and provide these to the Cost Analysis Requirements Document (CARD) update for consistency with the approved system specification and budget for the SRR.
  - Include updates to the will-cost model based on industry best practices
  - Include updates to M&Q cost sensitivity analyses
- Analyze and update M&Q cost drivers from manufacturing, quality, materials, and unique or specialized requirements and associated risks and issues for the SRR.
  - Include contractor descriptions and plans for processes, materials, rates, supplier quality, workforce, special handling, environmental compliance, security (physical and cyber), etc.
  - Include identified subsystems, parts, items, and components
  - Include “should-cost” analyses
  - Quantify the cost driver uncertainties
  - Update the estimate for the cost of quality
  - Update the estimate for the cost and impact of testing
- Analyze and update the contractor producibility planning for cost drivers and associated risks for the SRR to include:
  - Emerging technologies
  - Design producibility
  - Cost reduction and avoidance
  - Manufacturing processes
  - Materials availability

  - Compliance with ESOH, NEPA, NEPA Compliance Schedule, System Safety, HAZMAT program, Pollution Prevention, and PESHE Supply chain
  - Process capability and control
  - Quality and supplier quality
  - Workforce training
  - Security, required special handling, cyber protection
  - Facilities, capital equipment, tooling, and test equipment
- Analyze the contractor initial M&Q risk assessment for mitigation plan costs and drivers within budget and schedule for the SRR.
  - Include risks from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
- Analyze the contractor M&Q cost planning for realistic and appropriate allocation of cost drivers for the SRR.
- Update M&Q cost estimates for predicted life cycle costs of the evolving design for consistency with program affordability constraints for the SRR.
- Analyze and update M&Q cost estimates and budget for prototype demos and validations contributing to cost drivers for the SRR.
- Ensure M&Q cost should-cost estimates (inputs) to the CARD are consistent with the allocated baseline for the PDR.
  - Include M&Q cost sensitivity analyses validation
- Update M&Q cost drivers from manufacturing, quality, materials, and unique or specialized requirements and associated risks, issues, and opportunities for the MRL assessment and the PDR including:
  - Contractor processes, materials, rates, supplier quality, workforce, special handling, environmental compliance, security (physical and cyber), etc.
  - Subsystems, parts, items, and components
  - Quantified cost drivers
  - Cost of quality estimates
  - Estimates for the cost of testing
- Validate the contractor producibility cost drivers and associated risks, issues, and mitigation plans for the MRL assessment and the PDR including SRR producibility planning areas above.
- Update status of contractor M&Q risks and issues mitigation costs and drivers (budget and schedule) for the MRL assessment and the PDR.
  - Include risks and issues from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
  - Cost, schedule, and technical risks are identified, and mitigation plans are in place

- Validate the contractor M&Q costs and cost planning for realism and allocation of cost drivers for the MRL assessment and the PDR.
- Update M&Q cost estimates for predicted life cycle costs for the MRL assessment and the PDR.
- Validate M&Q cost estimates and budget for prototype actual costs and validation costs for cost drivers for the MRL assessment and the PDR.
- Update M&Q hardware estimates for quantity, effort (costs), and schedule for the MRL assessment and the PDR.
- Update M&Q inputs to the system cost model and budget including allocations to lower system element levels, tracking against targets, and the production cost model for the MRL assessment and the PDR.

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Design to Cost Estimates
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- *See* CAPE website for tools

Resources

- CARD website and process
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Should-Cost and Affordability Memo

F.2 Develop Manufacturing Cost Mitigation/Maturation Plan

Affordability is always a concern for the DoD. M&Q managers need to support the development and implementation of cost mitigation plans. Cost mitigation plans are often focus on manufacturing cost drivers and continuous improvement opportunities. Since the program is in TMRR, costs are still evolving as the design evolves and as testing proves out the design. Manufacturing processes are also evolving and thus need a strong focus on maturing proposed manufacturing processes.

Manufacturing and Quality Tasks

- Develop cost reduction (i.e., mitigation) plans utilizing the outputs (SRR/SFR) from the should-cost and will-cost analyses:
    - Conduct a coordinated, in-depth should-cost review on the contractor(s) planning and ongoing efforts against best practices
    - Incorporate identified cost drivers
    - Conduct will-cost analyses on the results
    - Plans include tracking and monitoring costs to identify further savings opportunities and reductions
    - Plans address M&Q cost risks and issues mitigation plans
    - Plans include completion of major cost and performance trades, and risk and issue reduction efforts to support the CDD Validation Decision prior to PDR
- Provide M&Q inputs and support to the Independent Cost Estimate (ICE) or verified Program Office Estimate:
    - Provide validated M&Q capability requirements
    - Provide M&Q inputs on required funding for the FYDP
    - Verify M&Q compliance with affordability goals for production and sustainment
- Analyze the contractor M&Q Earned Value Management (EVM) plan to include the critical path documentation.
- Update the cost model to include cost targets and include:
    - Design/Producibility analyses considerations and results
    - M&Q costs
        - New M&Q processes implementation
        - Materials availability and maturity
        - Environmental management and disposal impacts
        - Process capability and throughput (setup, yield, scrap, rework, Work in Progress)
        - Quality (including supplier quality) issues
        - Workforce issues
        - Facilities costs
        - Security, required special handling, cyber protection

        - Special Tooling and Test Equipment
        - Equipment availability, capacity, and constraints
        - New Technologies analyses and impacts
    - Support of Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs.)
- Update the M&Q cost models to support mitigation/maturation planning to include the capability for the models to support:
    - Design trades to assess the cost impacts of specific design changes
    - Alternative production processes or process improvements
- Incorporation of the current estimates and actual (if available) manufacturing costs into the cost estimates
- Plan for EMD, production, developmental and operational test, and life cycle sustainment of proposed products.
    - The CDD Validation Decision process
- Develop cost maturation and mitigation plans to support independent evaluations (MRL assessments)
    - Manufacturing Maturation Plan incorporates and document the costs associated for maturing manufacturing capability that does not meet required maturity levels

Tools

- Cost Analysis Requirements Description (CARD) (*See* CAPE website for tools)
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Interactive MRL Users Guide Checklist, for the Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- Parametric, Engineering and Actual estimating

Resources

- 10 USC Sec. 2334 Independent Cost Estimation and Cost Analysis
- Cost Analysis Requirements Description (CARD) Template (*See* CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition

- JCIDS Manual
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

F.3 Develop Learning Curve

Manufacturing cost estimates may include learning curves. During the TMRR phase the initial manufacturing cost estimate will be based on the prototype design-build activities. These estimates may be based upon a limited number of unite and there may not yet be detailed manufacturing standards for the proposed operations to be performed. At this time, the contractor should be developing learning curves for manufacturing processes that will be carried forward into EMD. Then these learning curves can be assessed and adjusted, as the design matures and as manufacturing processes are realized.

Manufacturing and Quality Tasks

- Define appropriate learning curves for the system and subsystems to include initiation and reporting requirements.
    - Include the basis for the slope (quantity and schedule) for the learning curves
- Define requirements for the baseline data and data collection to include:
    - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
    - Labor efficiency
    - Improvements in methods, equipment, tools, automation
    - Standardization and common processes
    - Design changes (producibility/manufacturability)
- Plan for collection of data to support learning curves development that includes the following factors and improvements, at a minimum:
    - Workforce learning, worker, and supervisor
    - Process, line, and workstation
    - Machinery, equipment, and tooling
    - Design producibility changes
    - Work methods and processes
    - Planning and scheduling processes
    - Lot and batch sizing and optimization (just-in-time)
    - Engineering and test activities and changes
    - Quality inspections/tests sampling requirements
    - Inventory, storage, re-work, and scrap levels
    - Operation sequencing and synchronization

- Pre-Planned Product Improvement program and processes

Tools

- Interactive MRL Users Guide Checklist, Cost thread
- Learning Curve Worksheet
- Manufacturing Maturation Plan

Resources

- Application of Learning Curve Theory to Systems Acquisition, Defense Acquisition University (DAU) Teaching Note, Feb 2011
- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8 Learning Curve

F.4 Prepare Initial Manufacturing Budget

Budget estimates are developed to provide the financial resources to needed to improve affordability, reduce risks, mature emerging technologies for insertion and to help resolve manufacturing related issues. The budget estimate made near the end of the TMRR phase needs to be accurate enough to support the program through EMD. Manufacturing and QA managers need to support the review and update of M&Q budgets required to support daily manufacturing and quality activities and to support maturing technologies and processes.

Manufacturing and Quality Tasks

- Update the M&Q cost estimates from MSA to validate and update the TMRR budget to include fact-of-life changes.
  - Verify that cost estimates include all M&Q cost drivers and risk estimates from the updated cost model
  - Verify M&Q quantification of cost driver uncertainties and associated budget impact estimates as inputs to the budget process
  - Verify the producibility costs (cost drivers and risks) are included in budget process
  - Update investment estimates in M&Q technologies, processes, equipment, etc. (including ManTech) as inputs to the budget process to include:
    - Capital equipment (tooling, machines, structures, etc.)
    - Test equipment (specialized, environmental, etc.)
    - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
    - GFE
    - Environmental compliance (processes, facilities, equipment, etc.)
    - Manufacturing systems security (physical, cyber, etc.)

  - Update cost estimating (should-cost and will-cost) with contractor data on M&Q aspects of the proposed system (include similar systems whose costs are known)
  - Validate established M&Q targets (from initial thresholds) affordability cost estimates (should-cost and will-cost) for TMRR based on contractor data
  - Update identified ManTech investments to mitigate M&Q technology gaps in TMRR for implementation
    - Contact and coordinate with potential funding sources for ManTech projects (program office, Service, and/or DoD-wide funding)
  - Provide analyses of the adequacy, reasonableness, and necessity of contractor-proposed manufacturing labor hours and material costs and determine the adequacy of the manufacturing budget for TMRR

- Identify and manage M&Q risks and issues identified in the SRR and the SFR with approved TMRR budget for mitigation plans to achieve PDR entrance criteria including:
  - Technology
  - Industrial Base
  - Design
  - Cost and Funding
  - Materials
  - Process and Capability Control
  - Quality Management
  - Manufacturing Workforce
  - Facilities
  - Manufacturing Management
- Analyze the M&Q TMRR budget sufficiency for the capability to produce a prototype system or subsystem in a production relevant environment prior to Milestone B.
  - Assess each TMRR prototype requirements (system or subsystem) for M&Q process needs, risks and issues, and affordability analyses with budget impacts.
- Evaluate the ongoing manufacturing technology investments (ManTech programs) for sufficiency to meet program objectives (e.g., EMD, P&D, and O&S).
  - Include sponsored initiatives in the program budget and from other sources
- Monitor the execution of the TMRR program and evaluate for impacts to recommend appropriate changes to the M&Q budget.
  - Assess the affordability and executability of the manufacturing processes
  - Recommend quality and manufacturing cost reduction initiatives
  - Analyze the quality, manufacturing, and production cost data (if available) down to the component level against cost targets, and identify trends
  - Identify quality and manufacturing emerging issues

  - Identify manufacturing investment opportunities and develop investment roadmaps to further the manufacturing development efforts

- Identify budget resources to support an MRL assessment and a TRA prior to PDR.
- Develop M&Q budget inputs for EMD.
  - Ensure program management includes required support by M&Q to program processes and technical and programmatic reviews for:
    - Producibility
    - Key Characteristics
    - Manufacturing Risks
    - Material and supply chain management
    - Manufacturing Technology
    - Manufacturing Surveillance and Audits
    - Manufacturing Security (physical and cyber)
    - GFE
    - Continuous improvement
    - Process control and capability
    - First article inspection and test
  - Provide an assessment of requirements for manufacturing processes, risks and issues, and affordability analyses with budget impacts
  - Perform analyses of proposed manufacturing labor hours and material costs for adequacy, reasonableness, and necessity for a budget estimate
    - Utilize data from contractor reported manufacturing labor hours and material costs, if available
  - Perform analyses of proposed M&Q cost reduction initiatives and incentives for a budget estimate
  - Analyze M&Q EMD cost estimates and supporting TMRR performance data to develop appropriate budget requests that include:
    - Monitoring and managing Key Characteristics (includes critical characteristics, and all KPPs)
    - Assessment of identified trends
    - Emerging quality and manufacturing initiatives
    - Cost/funding estimates and recommendations on emerging requirements
    - Investment opportunities with associated roadmaps
  - Provide M&Q EMD phase budget inputs that include comprehensive M&Q planning for EMD, production, developmental and operational test, life cycle sustainment, and disposal of proposed products including:

  - Investments for quality and test (e.g., training, equipment, personnel, process improvement, etc.)
  - Quantities and rates through Low-Rate Initial Production (LRIP), Production, and Sustainment
  - Materials (e.g., obsolescence, long-lead purchase, storage and handling, transportation, etc.)
  - Capital equipment requirements (e.g., production equipment, facilities, etc.)
  - Facilities (e.g., production, storage, handling, waste disposal, etc.)
  - Risk and issue identification and mitigation
  - Technology investment programs including emerging quality and manufacturing initiatives
  - Manufacturing workforce (e.g., availability, training, etc.)
  - Manufacturing processes (e.g., existing, and new, scale-up, modifications, process capability and control, corrective actions, etc.)
  - Manufacturing management and control
  - Manufacturing Security (physical and cyber)
  - Resources to support contractor, sub-tier, and supplier MRL assessments prior to CDR and PRR.
  - Resources to support an MRL assessment and a TRA prior to Milestone C
  - Demonstration of pilot line capability and readiness to begin LRIP
- Completed M&Q risks and issue identification, and all risks are understood for the Milestone B Decision with approved EMD budget for mitigation plans to achieve CDR and LRIP entrance criteria including:
  - Technology
  - Industrial Base
  - Design
  - Cost and Funding
  - Materials
  - Process and Capability Control
  - Quality Management
  - Manufacturing Workforce
  - Facilities
  - Manufacturing Management

Tools

- Interactive MRL Users Guide Checklist, for the Cost thread
- Manufacturing Maturation Plan
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- AS6500, Manufacturing Management Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

G. MATERIALS MANAGEMENT

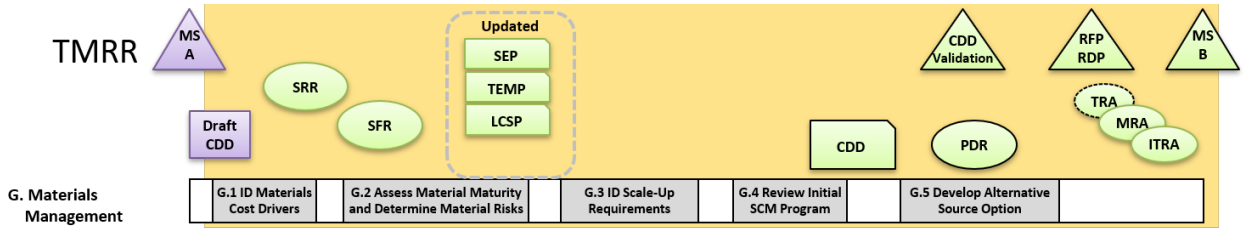


Figure 3-8. Materials Management Manufacturing and Quality Activities

Introduction

Materials Management is a core function of supply chain management including the process for planning and controlling material requirements and material flow for industrial and other organizations. Materials management will require assessment of the maturity, the materials availability, the capability and capacity of the proposed supply chain to provide the materials, and the potential need for special handling, government-furnished property (GFP), shelf life, security, storage, and environmental requirements. The process begins with the customer (demand signal), and this information flows throughout the supply chain, down several tiers, from raw materials, to fabrication, assembly, test, quality control, distribution and to the customer.

This thread (Materials Management) requires an analysis of the risks associated with materials (including basic/raw materials, components, semi-finished, parts, and sub-assemblies).

Material cost like manufacturing cost is estimated early in the program and turns to actual cost when production begins. As the program matures and the design becomes stable the estimates become more actual costs. Material cost drivers can vary from the cost of the material itself to the cost of the material and processing it into an end item. Selecting the most producible materials for their capability, maturity, availability, and handling characteristics during the TMRR phase will reduce costs and benefit program on cost and schedule.

Based on contractor data, M&Q personnel must assess all materials for all M&Q risks, issues, and opportunities. This begins with an update of the evaluation of material maturity and availability from the previous phase including an assessment of the validity and maturity of emerging materials. Material availability should consider lead times with associated impacts to schedule, budget, and critical path, etc. The assessment should also include analyses for fluctuations, rarity, availability, capacity, regulatory issues, ITAR, anti-tamper, and military vulnerability. The contractor may have proposed alternate materials that will require the same rigorous assessment for properties, characteristics, and quality requirements applicable to this system. There may be other opportunities for alternate materials that address known risks and issues that should be included. Finally, M&Q risks, issues, and opportunities based on potential materials obsolescence and lack of availability based on the business climate (e.g., business failures, market changes, political, etc.) should be incorporated for the SRR and the SFR, and updates for the PDR.

During the TMRR phase, while it is not expected that contractors would have a complete factory and supply chain established, key knowledge must be obtained to determine requirements for EMD scale-up efforts, and the resulting supply chain issues. Scale up for EMD considerations should include:

- Manufacturing processes and techniques not currently available
- Probability of meeting delivery dates
- Potential impacts from critical and long-lead time materials
- Facility, equipment, tooling availability (acquisition and/or scheduling)
- Trade-offs among M&Q materials alternatives
- Anticipated in-process testing and demonstration
- Methods for conserving critical and strategic materials and mitigating supply disruption risks and associated impacts
- Transportation and security including ITAR considerations

TMRR presents the first opportunity to assess the contractor's Supply Chain Management (SCM) program. Ideally, the contractor chosen adheres to industry M&Q best practices for manufacturing management, quality management, systems engineering, sourcing, and configuration management (CM) with strong contracts and supplier interactions including processes, plans, scheduling, variability reduction, and lead times with associated impact on the critical path. If not, it can be extremely difficult to effectively manage a program's supply chain.

Alternate source options are a technique for risk mitigation due to material availability risks. If availability of materials or components, subsystems or systems is at risk, qualifying an alternative source may be a viable solution. Having an alternate source will mitigate issues with diminishing manufacturing sources and material shortages (DMSMS).

There are ways the DoD can address material needs and shortages. One is through the Defense Production Act of 1950 and the implementation of the Defense Priorities and Allocation System (DPAS) in which the government can designate programs as "high priority" and put them at the front

of the contractor's production queue. Another is the Defense Industrial Capabilities Handbook, DOD 5000.60H, which identifies alternative actions the government can take when facing material shortages to include:

- Finding foreign sources of supply
- Finding alternative or substitute parts
- Making a Lifetime buy to meet all planned future needs
- Maintaining a current capability
- Developing an Alternative solution

M&Q should analyze the contractor Critical Supplier's List (hardware and software) for completeness and identification of single points of failure for potential mitigation in EMD phase.

G.1 Identify Materials Cost Drivers

Production costs are driven by product complexity (design), rate of production and total numbers produced. Direct labor and direct material cost often make up a large portion of product costs and must be assessed. Material cost drivers could include long-lead items, items that require special handling, storage, or treatment. Some materials are just more expensive (titanium vs steel), and other materials are harder to work with or have low yield rates. Manufacturing and quality managers need to pay special attention to materials that are cost drivers and manage those as these cost drivers make themselves known during the development of prototypes in the TMRR phase.

Manufacturing and Quality Tasks

- Based on manufacturing, quality, and unique or specialized requirements, specifications, and tolerances, and associated risks and issues; analyze and update M&Q materials cost drivers for the SRR.
    - Include contractor descriptions and plans for materials, materials processes, rates, and quantities (including lot buys), supplier quality, special handling and training, environmental compliance and training, materials security (physical and cyber), etc.
    - Include as materials identified subsystems, parts, items, and components (supply chain commodities)
    - Include materials "should-cost" analyses
    - Quantify the materials cost driver uncertainties
    - Include cost drivers from methods used to conserve critical and strategic materials
    - Include cost drivers for mitigation of supply disruptions
    - Cost for implementing ESOH, NEPA, NEPA Compliance Schedule, System Safety, HAZMAT program, pollution prevention, and PESHE
    - Update the estimate for the cost of quality
    - Update the estimate for the cost and impact of materials testing

- Analyze and update the contractor planning (producibility) with respect to materials cost drivers and associated risks (*See* G.2) for the SRR to include:
    - Emerging materials
    - Materials design requirements
    - Price stability, cost reduction and avoidance
    - Materials processes
    - Materials availability
    - Environmental factors and compliance
    - Supply chain
    - Processes and quality
    - Security, required special handling, cyber protection
    - Facilities, capital equipment, tooling, and test equipment
- Update materials cost drivers based on manufacturing, quality, and unique or specialized requirements, specifications, and tolerances, and associated risks and issues for the MRL assessment and the PDR including:
    - Contractor materials and materials processes used
    - Materials rates and quantities obtained
    - Supplier quality levels, special handling, environmental compliance reported
    - Materials security (physical and cyber) required, etc.
    - Utilized supply chain commodities (subsystems, parts, items, and components)
    - Quantified cost drivers with continuing uncertainties
    - Cost of quality reported
    - cost of completed and projected materials testing
- Validate the contractor materials cost drivers and associated materials risks, issues, and mitigation plans for the MRL assessment and the PDR including SRR materials planning areas above.

Tools

- Cost, Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment

Resources

- Cost/Schedule Control System Criteria
- Defense Technical Risk Assessment Methodology (DTRAM)

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Cost Estimating (*See* the Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Producibility Systems Guidelines, NAVSO P-3687

G.2 Assess Materials Maturity and Determine Materials Risk

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Material risks and issues can slow or delay a program, can add additional costs to a program, or can create field failures because of poor material reliability. Material risks could include availability of the material, maturity of the material, or need for special handling and control. Material risks can occur anywhere in the supply chain from the prime contractor all the way down to the lowest level (raw materials). Manufacturing and QA managers need to support the identification and management of material risks and material maturity especially as suppliers and vendors are brought on board and the prime contractor begins to collect and analyze actual data.

Manufacturing and Quality Tasks

- Analyze and update the contractor planning (producibility) with respect to M&Q maturity of materials (risks, issues, and the associated cost drivers in G.1) for the SRR and the SFR to include:
    - Emerging materials
    - Materials design requirements
    - Cost reduction and avoidance
    - Materials processes
    - Materials availability and lead times
    - Environmental factors and compliance
    - Supply chain
    - Processes and quality
    - Security, required special handling, physical and cyber protection
    - Facilities, capital equipment, tooling, and test equipment
- Based on contractor data, assess all materials for M&Q risks and issues:
    - Update evaluation of material maturity and availability from the AoA process:
        - Assess validity and maturity of emerging (from Research and development and experiments in MSA) for manufacturability

  - Update the M&Q evaluation of lead times including:
    - Impacts to schedule, budget, and critical path, etc.
    - Analyses for fluctuations, rarity, availability, capacity, regulatory issues, ITAR, Anti-Tamper, etc.
  - Evaluate maturity of other materials (contractor proposed) for properties, characteristics, and quality requirements for application in this system
  - Evaluate military vulnerability or gaps that could result from the lack of reasonable materials alternatives
  - Identify opportunities for alternative materials (to mitigate known risks and issues)
- Assess and identify M&Q risks, issues, and opportunities based on potential materials obsolescence and lack of availability based on the business climate (e.g., business failures, market changes, political, etc.) for the SRR and the SFR, and update for the PDR.
  - Include availability from single or sole sources (domestic or foreign), within the NTIB, only from sources that are outside the NTIB, vulnerable to foreign acquisition
  - Assess business climate for disruptive conditions (e.g., natural disasters, strikes, etc.)
  - Develop mitigation for known risks to critical and strategic materials
  - Assess availability issues to be addressed for prototype builds
  - Initiate government mitigation plans as appropriate as specified in the program SEP
  - Monitor contractor mitigation processes and plans as specified in the contractor SEMP in alignment with the program SEP
- Analyze and Assess the contractor's make/buy process for adequacy and completeness to include:
  - Contractor's make/buy processes for key and/or critical subsystems, items, parts, and components to include volatility
  - Contractor's supply chain (including other divisions) make/buy processes for vendors to meet quality requirements, schedule, and cost targets
  - Identification of and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
  - Identify hazardous and special handling/storage/environmental compliance procedures, risks, and issues to include:
    - Potential regulatory requirements
    - HAZMAT and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal

  - Assess the characterization of materials (maturity) and degree of M&Q risks applicable to the system under development.
  - Determine if materials have been manufactured or produced in a relevant environment (e.g., a factory, a similar application/program, as part of a prototype, etc.)
  - Assess and characterize all GFE, GFF, GFM, GFP
    - Methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials
  - Analyze government and contractor maturation efforts to mitigate material (existing and new) production risks

- Complete M&Q materials planning for EMD including preliminary specifications and material properties characterization. This should address:
  - Verification of materials maturity through technology demonstration subsystems, items, and components (articles)
  - Availability risks, issues, and opportunities
  - Long-lead items
  - Future DMSMS/Obsolescence risks, issues, and opportunities
  - Future Counterfeit Parts

Tools

- DMSMS Product Life Cycle Assessment (Consult DLA)
- Independent Technical Risk Assessment Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide Checklist, Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Supply Chain Management Risk Assessment Checklist
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- TRL Assessment Questionnaire

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- Defense Technical Risk Assessment Methodology (DTRAM)
- DMSMS Guidebook, SD-22
- DoD 4140.1-R, Supply Chain Management Regulation
- DoD 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.84, Analysis of Alternatives

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems 4140.01, DoD Supply Chain Materiel Management Regulation
- IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

G.3 Identify Scale-Up Requirements

As a program moves through the TMRR phase and develops prototype(s), M&Q managers are forced to deal with issues and concerns relating to producing the prototype and to scaling up. The back shop that is often used to develop a prototype and is not a Pilot Line and does not have the same manufacturing concerns that one has when preparing to go into limited production. The entire factory floor including the 5Ms (manpower, machines, materials, methods, and measurement) must be capable of responding to the requirements imposed by scaling up and manufacturing and quality managers need to be able to help identify scale-up requirements and risks.

Manufacturing and Quality Tasks

- Conduct assessments of materials producibility (manufacturing processes and techniques), and availability to meet future program requirements (scale-up for prototypes, pilot line, LRIP, and FRP) and determine materials risks, issues, and opportunities.
    - Consider new materials (to the industry, to the program, to the suppliers)
    - Consider source criticality and fragility (e.g., sole, or single sources, foreign sources, domestic foreign owned, etc.)
    - Consider lead times from suppliers where availability is not proven
    - Consider volume rates that are higher or lower than typical
    - Consider obsolescence due to product improvements and market/technology changes
    - Consider regulatory requirements and impacts (e.g., US law, ITAR, environmental, REACH concerns, etc.)
- Develop M&Q plans to address scale-up risks, issues, and opportunities. Plans may include:
    - Manufacturing processes and techniques not currently available
    - Probability of meeting delivery dates
    - Addressing potential impacts from critical and long-lead time materials
    - Addressing production equipment availability (acquisition and/or scheduling)

- Impact analyses to support trade-offs among M&Q materials alternatives
- Recommendations for anticipated in-process testing and demonstration
- Methods for conserving critical and strategic materials and mitigating supply disruption risks and associated impacts
- Issues associated with materials transportation and security including ITAR considerations

Tools

- Interactive MRL Users Guide Checklist, Materials thread
- ManTech Strategic Plan
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet

Resources

- Air Force Technology Development and Transition Strategy Guidebook
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Readiness Level (MRL) Users Guide
- Producibility Systems Guidelines, NAVSO P-3687
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

G.4 Review Initial Supply Chain Management Program

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then Supply Chain Management (SCM) becomes a pivotal task. Often program problems originate in the supply chain, but do not manifest themselves until the component is integrated into the system. Program offices and contractors often have efforts to identify and manage problems at the first tier, but do not do well below that level. Manufacturing and QA managers need to routinely review and assess contractors supply chain and procurement activities and efforts.

Manufacturing and Quality Tasks

- Assess the contractor's Supply Chain Management (SCM) program for veracity and adherence to industry M&Q best practices to include:
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)

  - Manufacturing management standards (e.g., AS6500, MIL-HDBK-896, IEEE 15288, etc.)
  - Configuration management,
  - Sourcing processes
  - Development of strategic partnerships with vendors and suppliers
  - Sub-contract management
    - Monitoring sub-tier compliance to contract M&Q requirements
    - Sub-tier supplier processes (e.g., configuration management, parts management, counterfeit parts management, electro-static discharge program, etc.)
    - Collaboration of information (especially quality and forecasting data)
  - Procurement processes (schedule, quantity, packaging, kitting, identification, quality)
  - Variability reduction
  - Logistics and inventory management
    - Order Fulfillment (schedule, kitting, identification)
    - Warehouse Management (storage, schedule, kitting, packaging, environmental, security)
    - Transportation Management (methods, special handling, packaging, environment, identification)
    - Vendor Managed Inventory (schedule, quantity, packaging, kitting, identification, quality)
  - A robust risk, issue, and opportunity management process for integration of risks, criticality, obsolescence, sourcing

- Assess the contractor M&Q processes for compliance with or adherence to Company policy, process, and contracts, utilizing DCMA support (if available).
  - Contract Management with evidence of strong contracts and supplier interaction process with plans and schedule to reduce variability and lead times and associated impact on the critical path
  - Assess supply chain interdependencies with regards to other programs
  - Strategic Sourcing to minimize risks, criticality, and obsolescence
  - Supplier qualification, approval, and monitoring processes to include
    - Suppliers with known risks
    - Supplier parts usage and sources (i.e., GIDEP prohibited)
  - Requirements and data flow processes (two-way)
    - Program milestones and metrics (consistent with the IMS)
    - Demand Planning consistent with the IMS
    - Quality, safety, technical, and inspection requirements
    - Key and critical characteristics

  - Management of suppliers and sub-tier materials manufacturing processes and procedures, especially suppliers performing key and/or critical materials manufacturing processes impacting Key Characteristics (KCs)
  - Make or buy decision analysis processes
  - DMSMS management processes
  - Material waiver process (should only be utilized in limited circumstances)
  - Requirements for use of industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
  - Requirements for first article/qualification unit(s) (i.e., AS 9103)
  - Vendor survey requirements
  - Identification of Sub-tier supplier processes for embedded software and firmware risks, issues, and opportunities management including requirements:
    - For conducting Software Acceptance Test (SAT)/ Software Formal Qualification Testing (SFQT)
    - For performing surveillance of this activity
- Initiate SCM planning for EMD, production, developmental and operational test, and life cycle sustainment.

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Materials thread
- Manufacturing Maturation Plan
- Supply Chain Assessment

Resources

- AS 9133, Qualification Procedure for Aerospace Standard Parts
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Readiness Level (MRL) Users Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

G.5 Develop Alternate Source Options

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole source, single source and foreign sources of supply come with risks. In addition, suppliers come and go in the marketplace. One day there might have four sources of supply and the next one or none. Diminishing Manufacturing Sources and Obsolescence is a very real problem on DoD programs, even programs that are pushing the state of the art may have components that are aging. One way to mitigate those risks and to increase competition (reduce cost) is to identify critical sources and develop alternative sources of supply. But this is not a quick or a cheap fix as the new supplier will need to go through a qualification program and prove that they have the capability to produce one, the capacity to produce all that is needed and the financial stability to be able to perform for the entire contract period of performance.

Manufacturing and Quality Tasks

- Provide analyses of the program materials (system, subsystem, items, and components) for M&Q sourcing strategies to address:
    - Qualification planning
    - Contingencies for capacity, economic/political impacts, disaster impacts, etc.)
    - Dual source competition (include GFE)
    - Readily available materials that have environmental or health concerns
    - Single, sole, foreign, foreign-owned domestic, etc. vulnerability mitigation
    - Materials only available outside the NTIB
    - Quality, schedule, transportation, fulfillment, etc. requirements
    - Hazardous, difficult to obtain, or process materials
- Analyze and validate material maturity through demonstration of subsystems, items, and components in a relevant environment
    - Validate material properties have been characterized
    - Verify material specifications in place
- Based on M&Q analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, develop recommendations for alternate sources and options.
- Initiate planning to address DMSMS including:
    - Development of recommended options or mitigation plans
    - Analyses of materials, sources, and issues from the GIDEP database relevant to the program
- Perform analyses (e.g., FTA, FMECA, DFMEA, PFMEA, etc.) to identify KCs, critical characteristics, and key M&Q processes (*See* E.5 and E.7)
    - Include Critical Technologies list of CTEs with CSIs and CAIs

  - Include sub-tier supplier subsystems, items, and components
  - Include software and firmware configuration items
  - Develop a preliminary list, which includes where produced or accomplished and associated rationale for inclusion, of:
    - Key Characteristics
    - Critical characteristics
    - Critical Application Items (CAIs) (e.g., systems, subsystems, software, materials, components, etc.)
    - Key M&Q processes
    - Critical Safety Items (CSIs)
- Analyze and validate that the contractor Critical Supplier's List (hardware and software) is up to date.
  - Include contractor materials planning and management process (*See* L.3)
  - Include risks and issues management process (*See* G.2)

Tools

- FMECA, DFMEA, PFMEA templates
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet (PAW)
- Supply Chain Assessment
- Technology Readiness Assessment Checklist
- TRL Calculator

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- AS9133, Qualification Procedure for Aerospace Standard Parts
- Defense Acquisition Guide, Chapter 4
- Defense Acquisition Program Support Methodology
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.4.5.5 Failure Mode and Effects Analysis (FMEA)
- Defense Technical Risk Assessment Methodology (DTRAM)
- FAR Part 46, Quality Assurance
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Integrated Product Support (IPS) Element Guide, Chapter 2.1.1.3 FMECA, Apr 2017

- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NAVSO P-3687, Producibility Systems Guidelines
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

H. PROCESS CAPABILITY/CONTROL

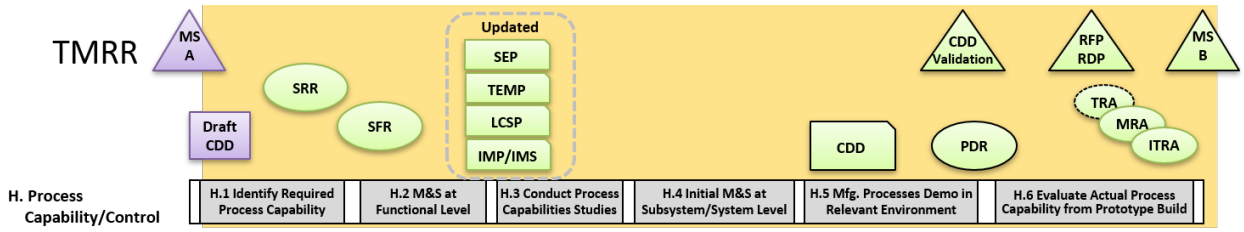


Figure 3-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with a uniform, defect free product that provides consistent performance and is affordable. Product quality comes from robust product and process design and process control activities to include continuous process improvement to identify and remove sources of variation.

Process capability and control is a requirement of the AS6500 Manufacturing Management Program standard, and both ISO 9001 and AS9100 quality standards. These standards require a process control plan to describe activities to demonstrate process capabilities. Process capability clarifies the inherent variability of a given process. Typical measures include process capability and process capability index (Cp/Cpk) and process performance (Pp/Ppk); X bar and R charts; control charts; and other statistical analysis tools. A capability study generally assesses the ability of a process to meet drawing and specification requirements. These Statistical Process Control (SPC) tools measure whether a process is stable (predictable). This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Cp/Cpk and Pp/Ppk are typical process control measures to determine the manufacturing process capability of each concept being considered. Critical and key manufacturing processes to be placed under SPC can also be identified through M&S or experimentation. Advances in digital engineering to include modeling and simulation (M&S) along with continual improvements in computer performance have made it possible to perform

comprehensive analysis of virtual parts and to assess the capability of processes before actual manufacturing begins. The use of solid modeling, finite element analysis, multi-paradigm numerical computing environments, and simulation software analysis tools allows users to simulate different conditions that are likely to occur during manufacturing processes and to model the behavior of systems under real-world conditions. An understanding of the capabilities to model products and processes for each of the concepts under consideration can be a valuable discriminator.

This thread (Process Capability and Control) requires an analysis of the risk that the manufacturing processes may not be able to reflect the design intent (repeatability and affordability) of key characteristics. The thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Modeling and Simulation (M&S) of Processes
- Process Capability Studies
- Process Yields and Rates
- Process Demonstrations

M&Q process capability and control should be a part of any development program. A process is “in control” if it is stable. A stable process does not mean that the contractor is producing only good product; it means that the process is predictable. A capable process is one that is producing conforming product. Process capability is usually measured using either a Capability Ratio (Cp) or a Capability Index (Cpk). Contractors should be working to get their processes to be both capable and in control. Note: There is no one standard process capability measurement for all process and product characteristics; however, key and critical characteristics should receive the most focus on development of a standard and on the management of those characteristics during the life of the product.

M&Q engineering efforts should lead to a producible and testable system with the objective of achieving effective and efficient manufacturing processes with the necessary process controls to satisfy requirements with consistent, repeatable products while minimizing manufacturing costs. During the MSA phase, required process capabilities were identified for critical M&Q processes with the associated risks. In TMRR, process capability data collection begins and continues into EMD.

In preparation for SRR and SFR, prior identified M&Q process capabilities should be refined and updated based on data collected and the contractor’s plans, processes, and procedures to identify the process capabilities required for the system. During the development process, additional studies at the system, subsystem, item, and component levels will be conducted to define the appropriate level of process capability and control. A thorough knowledge of a contractor’s and supply chain's process capabilities is critical to developing a successful system. Process capabilities and data must be understood, measured, controlled, and documented, and process capability information must be up to date.

Program M&Q personnel should understand the state-of-the-art and industry best practices in manufacturing and production Modeling and Simulation (M&S) tools and or products. In TMRR, the contractor will have proposed use of certain M&S M&Q tools that must be verified for adequacy, applicability, and consistency with other system models. Additionally, M&Q must understand the contractor's plans and processes for maturing and validating their M&Ss as high-fidelity representations of the M&Q systems and systems performance and capability based on actual program data.

During the TMRR phase the contractor will produce prototypes that will be used during tests to ensure they will meet the customers' requirements. These prototypes will be built in a relevant manufacturing environment, meaning that there are elements of production realism present on the manufacturing line. To the extent practicable, the processes used for prototype build should be evaluated to better understand the difficulties and risks that will need to be overcome during the EMD phase. In preparation for PDR and EMD transition, manufacturing processes, products, and prototypes demonstrated and assessed in a relevant environment results are incorporated into the appropriate M&Ss. These assessments and demonstrations should provide an understanding of the contractor's M&S tools and provide the basis for program manufacturing planning, resource loading, and facilities management, etc. for future phases.

H.1 Identify Required Process Capability

One of the goals of manufacturing is to have a uniform, defect-free product. To achieve that goal, the production processes must be capable, that is the outcome of the production process is a product that meets spec. M&Q managers need to be working continuously on production processes to identify where variation has the most impact, reduce variation and make the process robust to design requirements. Process control studies and other tools can be used to identify upfront and early what the design requirements are and where processes must be made to be capable and in control, and what that capability metrics, goals, or targets should be established.

Manufacturing and Quality Tasks

- Update the analyses of the current state and gaps in process capability within industry for M&Q processes appropriate to the system, subsystems, items, and components.
- Update or identify M&Q process capability risks, issues, and opportunities for the SRR and the SFR from the manufacturing feasibility and other prior assessments including risks to:
    - Key Characteristics
    - M&Q processes (new equipment and technology)
    - Potential cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - Testing and qualification

  - Environmental, transportation, storage, etc.
  - Data management (collection, storage, cybersecurity, etc.)
- Assess, estimate, and manage process maturity and capability for processes with insufficient data utilizing information from similar subsystems, items, and components that are currently or have been previously manufactured.
- Develop targeted process capability (Cp/Cpk) and process performance (Pp/Ppk) metrics.
- Analyze if planned manufacturing and production processes can produce units (subsystems, items, and components) in quantities to the contract specifications and schedule.
  - Determine if the contract requires the contractor provide estimated and actual yield rates by source and/or facility for materials, components, items, and subsystems.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guide
- DoD Systems Engineering Guidebook
- Capability-Based Assessment (CBA) Handbook
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.2 Modeling and Simulation at Functional Level

The DoD uses modeling and simulation (M&S) to deliver new or enhanced capability better, faster, and cheaper. M&S can be used to understand manufacturing processes and their capability and capacity to produce compliant products. Early M&S studies based on at the functional level can reduce the risks associated with prototype development. Manufacturing and QA managers need to support M&S for manufacturing systems and processes throughout the TMRR phase.

Manufacturing and Quality Tasks

- Update analyses of the state of the art and industry best practices in manufacturing and production modeling and simulation tools and or products (i.e., software) that support the functional analyses of the system.
- Assess and analyze the contractor-proposed modeling and simulation tools and plan for adequacy and sufficiency for system M&Q, process capability, control, and maturation.
    - Include analyses of capability to provide inputs to manufacturing planning, resource loading, and facilities management
    - Include analyses of contractor usage of tools against industry standards for potential improvements and to determine functional constraints

Tools

- AS9100 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)
- Process Modeling Tools (/Siemens PLM, Delmia, etc.)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- System Capabilities Analytic Process (SCAP)

Resources

- Defense Technical Risk Assessment Methodology (DTRAM)
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- Modeling and Simulation Guidance for the Acquisition Workforce, Oct 2008
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.3 Conduct Process Capabilities Studies

A process capability study is a measure of the inherent process variability of a given characteristic. Process capability studies are conducted to assess the ability of a process to meet the contractual specification. Typically, a process capability study follows these steps:

1. Select a candidate for the study.
2. Define the process.
3. Procure resources for the study.
4. Evaluate the measurement system.
5. Prepare a control plan.
6. Select a method for the analysis.
7. Gather and analyze the data.
8. Track down and remove special causes.

Manufacturing and Quality Tasks

- Utilizing results of the SRR/SFR, update M&Q process capability risks, issues, and opportunities for the Acquisition Strategy, the SEP, the TEMP, and the CDD including:
    - Key Characteristics
    - M&Q processes (new equipment and technology)
    - Potential cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - Testing and qualification
    - Environmental, transportation, storage, etc.
    - Data management (collection, storage, cybersecurity, etc.)
- Conduct process capability and variability studies and analyses on:
    - Similar subsystems, items, and components that are currently or have been previously manufactured utilizing previous estimates
    - Current subsystems, items, and components manufacturing and production processes and equipment
    - Incorporate data collected from contractor yield rates for subsystem, item, component, and prototype builds
- Identify required process capability and variability studies and analyses for planned subsystems, items, and components manufacturing and production processes and equipment for the Acquisition Strategy, the SEP, and the PDR.
- Determine process capability requirements for pilot line and production.
    - Identify C_{pk} goals for each key manufacturing process

Tools

- AS9100 Checklist
- AS6500 Checklist
- Cause and Effect Diagram
- Cost of Quality Estimates

- First Pass Yield Estimates Worksheet
- Histograms
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Pareto Analysis
- Process Capability Studies (C_p and C_{pk} assessment)
- Producibility Assessment Worksheet (PAWs)
- Six Sigma Worksheet

Resources

- AS9100 Quality Management System
- ISO 9001 Quality Management System
- AS6500 Manufacturing Management Program
- AS9103 Variation Management of Key Characteristics
- DoD Systems Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.4 Modeling and Simulation (M&S) at Subsystem/System Level

During the TMRR phase, programs often build prototypes and Modeling and Simulation (M&S) can help to reduce risks associated with prototype development. M&S needs to move beyond the functional level to the sub-system and system level. As each level of design matures and is build, the integration and testing becomes more complex and complete. M&S of manufacturing and QA processes needs to enable Manufacturing and QA managers need to analyze manufacturing systems and processes early and develop maturation plans to get these processes into a steady state.

Manufacturing and Quality Tasks

- Assess contractor Modeling and Simulation (M&S) tools prior to product and/or process implementation for the capability to model the proposed design concept(s) for the PDR process. Tools should include:
    - Capability to evaluate the proposed design and manufacturing concepts to meet M&Q objectives
    - Capability to estimate outputs of design performance
    - Outputs for updating cost models (*See* F.2)
    - Identification of potential M&Q bottlenecks or constraints
    - Confirmation of planned M&Q cycle times achievability
    - Impacts of M&Q process variability
    - Capability to model the factory floor, process flows, assembly lines, yields/ throughput, cycle times, etc.
    - Capability to estimate required quantities of tooling, personnel, and inventory
    - Sufficient complexity to represent and support the complexity of the product being manufactured
- Assess the M&Q aspects of the contractor and/or government prototype environment (i.e., system simulation/integration lab) to validate M&S emulation of subsystems, components, and items, including:
    - A mix of mature hardware, prototypes, and models and simulations
    - Integration and interdependencies
    - Identification of constraints
    - Performance
    - Status of contractor M&S of the "to be" system or subsystem
- Provide M&Q recommendations to the contractor for innovative M&S capabilities (factory simulations) that go beyond basic capabilities and will allow the manufacturing engineer to address:
    - Sustainable manufacturing goals (energy, water, and other resource usage)
    - Monitor and optimize maintenance and calibration requirements
    - Supply chain collaboration for product design, quality, and scheduling
    - Manufacturing execution and execution systems networked to machines, test, and measurement devices, robotics, and process planning

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, Process Capability and Control thread
- Manufacturing Maturation Plan
- Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)

- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)

Resources

- AS6500, Manufacturing Management Program
- Defense Technical Risk Assessment Methodology (DTRAM)
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- Modeling and Simulation Guidance for the Acquisition Workforce
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.5 Manufacturing Processes Demonstration in Relevant Environment

A relevant environment is an environment that moves beyond the lab and onto a shop floor with some production realism present. That is, manpower, materials, machines, methods, measurement systems, facilities and tooling should be identified and utilized in at least a limited fashion. This environment requires the contractor to demonstrate their ability to meet cost, schedule, and performance objectives. The demonstration must provide the program with confidence that program targets are achievable.

Manufacturing and Quality Tasks

- Based on government/contractor IPT interactions, define, and document the appropriate M&Q production relevant environment(s) to be used for process demonstrations and prototypes.
- Assess demonstrations of manufacturing processes in an environment with shop floor production realism present (e.g., actual production facilities, manufacturing personnel, using production tooling, processes, materials) incorporating factors such as:
    - Minimum reliance on laboratory resources
    - Environmental conditions (i.e., temperature, humidity, air quality)
    - Equipment (i.e., accuracy, calibration, age and condition, suitability, capacity, reliability)
    - Workforce (i.e., training, skills, and certifications)
    - Human factors (i.e., noise, vibrations, ergonomics)
    - Ability to meet the cost, schedule, and performance requirements of the EMD phase
- Evaluate demonstrations to determine environmental factors impacting the manufacturing of subsystems, items, and components.
    - Include ambient temperature, humidity, noise, vibrations, personnel skills levels, materials specifications, etc.

- Evaluate process demonstrations and production of prototypes for mitigation of M&Q risks.
- Evaluate and analyze yields and rates from process demonstrations and production of components and items for prototype builds.
    - Utilize results as inputs to improvement plans
- Collect data from process demonstrations and production of components and items for prototype builds to support verification, validation, and authentication of M&S processes.
- Develop a comprehensive plan for EMD to demonstrate M&Q processes in a production representative environment by CDR and on a pilot line to support the Milestone C decision process.
    - Include all M&Q risks
- Assess manufacturing readiness by conducting an MRL assessment to support PDR and the Milestone B decision process (See A.3)
    - Support the Technology Readiness Assessment, if conducted
    - Support identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment

Tools

- AS9100 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Management System
- ISO 9001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.6 Evaluate Actual Process Capability from Prototype Builds

Prototype builds offer an opportunity to evaluate process capability on the preliminary design and preliminary production environment. At this point there is still design work to accomplish, but some of the design and some of the manufacturing processes are stable enough to assess against future work.

Manufacturing and Quality Tasks

- Based on analyses and evaluations of M&S models, process demonstrations, production of components and items, and prototype builds, summarize, define, and finalize M&Q processes, process capabilities, and limitations for EMD Acquisition Strategy and SEP planning.
    - Refine process capability requirements for the EMD phase.
    - Develop plans to transition from production relevant environment with some shop floor realism present to the production representative environment with as much production realism as possible prior to CDR
    - Update models and simulations for use in EMD with actual data to increase fidelity and confidence that the model and prototypes realistically represent the final product

Tools

- AS9100 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Studies (C_p and C_{pk} assessments)
- Producibility Assessment Worksheet (PAW)

Resources

- AS9100, Quality Management System
- ISO 9001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- Defense Technical Risk Assessment Methodology (DTRAM)
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy

- Process Capability Control and Improvement Requirements – Process Control Plan Reference Guide, Picatinny Arsenal
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

I. QUALITY MANAGEMENT

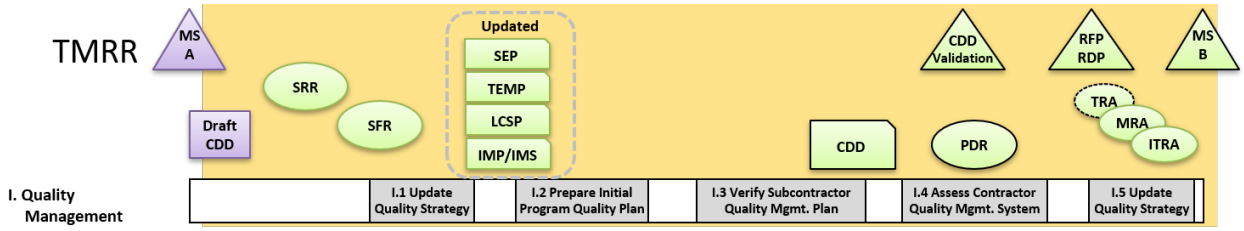


Figure 3-10. Quality Management Manufacturing and Quality Activities

Introduction

Quality is the degree to which material attributes, performance features, and characteristics of a product satisfy a given need. Quality may apply to a product, process, or system and may be physical, sensory, behavioral, temporal, ergonomic, or functional.

Quality management is an integral part of design and development efforts. QMS standards include industry best practices such as ISO 9001, Quality Management Systems–Requirements. AS9100, Quality Management Systems–Requirements for Aviation, Space and Defense Organizations, Product Realization (clause 7) includes typical systems engineering tasks under sub-clause 7.3, Design and Development. The typical systems engineering processes included in the QMS are:

- Design and Development Planning – SE Management, Failure Modes, Effects, and Criticality Analysis (FMECA), System Safety, etc.
- Design and Development Inputs/Outputs – T&E, Reviews, and Audits.
- Design and Development Review, Verification and Validation.
- Control of Design and Development Changes – hardware and software Configuration Management.
- Hardware and Software Configuration Management.
- Risk, Issue, and Opportunity Management.
- Corrective Action System.

The requirements for Quality Assurance and Control come from the FAR/DFAR and general industry guidance comes from ISO 9001 and AS9100 quality standards. These standards requires that organizations establish a formal quality policy and must submit documentation on its internal processes, procedures, and standards. The following are mandatory requirements of ISO 9001:

- Monitoring and measuring equipment calibration records

- Records of training, skills, experience and qualifications
- Product/service requirements review records
- Record about design and development outputs review
- Record about design and development inputs
- Records of design and development controls
- Records of design and development outputs
- Design and development changes records
- Characteristics of product to be produced and service to be provided
- Records about customer property
- Production/service provision change control records
- Record of conformity of product/service with acceptance criteria
- Record of nonconforming outputs
- Monitoring measurement results
- Internal audit program
- Results of internal audits
- Results of the management review
- Results of corrective actions

Note: AS9100 standards includes all of the above, and more.

An effective quality strategy and contractor Quality Management System (QMS) are required if the program is to deliver operationally safe, suitable, and effective weapon systems. The initial quality strategy should have been developed during the MSA phase. The QMS assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The quality strategy serves as the basis for the management and control function within the program systems engineering process and should be continuously updated in each phase. The strategy requires basic controls over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. It also requires monitoring and measuring of processes and products (including embedded software and firmware) to ensure they conform to requirements. Quality strategy development must begin during the earliest stages of system development and must continue throughout the program life cycle.

A QMS compliant with industry best practices, ISO 9000 or AS9100, is the foundation for the contractor to deliver a system that meets requirements. The program must evaluate the contractor's QMS to ensure implementation of industry best practices. The program and the contractor should develop a joint government/contractor M&Q plan that specifies:

- Roles, responsibilities, and quality processes
- Tasks, schedules, and outcomes
- Standards, requirements, and metrics
- Joint risk, issue, and opportunity processes and procedures

- Quality tools such as Continuous Process Improvement (CPI)

Everything a contractor does will be related to the quality of its products or services, a contractor's QMS should be the basis for integrating all other management systems within an enterprise. The program must assess the contractor QMS to ensure that the contractor has an effective QMS and an effective subcontractor quality management system and plan. M&Q personnel must ensure that all M&Q systems are working toward the same goals and are not creating conflicting or dysfunctional results. It is important for the program to convey to the contractor the requirement and importance of quality throughout supply chain and effective supply chain management, as quality deficiencies often occur in the lower tiers. The contractor, in addition to having list of qualified vendors, should have visibility into their subcontractors' planned suppliers with the same requirements.

Effective quality management activities are important for identifying and reducing process-related risks. If not managed and mitigated, these risks may start a chain of events leading to undesirable outcomes such as defects discovered later in production or testing, not meeting requirements, degraded mission effectiveness, overruns, shortages, etc. The later these risks are identified, the greater the cost of corrective action and the greater the delays in schedule.

Quality will permeate all levels of a company only if certain important factors are present in the contractor’s QMS:

- Corporate strategic vision, objectives, policies, and procedures with a commitment to quality in-house and in the supply chain
- Communication of organizational direction and values regarding quality
- Structures and resources for full implementation of the QMS
- Commitment to continuous processes improvement
- Goals, objectives, and metrics throughout the organization for customer satisfaction
- Management accountability

This thread (Quality Management) requires an analysis of the risk and management efforts to control quality, and foster continuous quality improvement.

At the conclusion of TMRR phase, post PDR evaluation, the program quality strategy should be updated for entry into EMD based on TMRR results, assessment of the contractor and subcontractor QMSs, and the revised program quality plans for EMD.

I.1 Update Quality Strategy

M&Q managers support the development and updates to the Acquisition Strategy by providing their inputs into the Systems Engineering Plan (SEP). quality managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best

practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and to the success of a program.

Manufacturing and Quality Tasks

- Update and revise the draft Program Quality Strategy in the Acquisition Strategy and the SEP based on the contractor's QMS and strategies to include:
    - The contractor's quality strategy should address compliance to established standards (e.g., AS9100, ISO 9000, etc.)
    - Alternatively, the contractor's quality strategy requirements should address:
        - Management responsibility requirements
        - Quality management system requirements
        - Resource management requirements
        - Product Realization requirements (e.g., risk management, design, and development, purchasing, etc.)
        - Risks, issues, and opportunities
        - Measurement, analysis, and improvement requirements
- Verify that the Program Quality Strategy:
    - Incorporates new quality technologies and processes (state of the art), unique product quality requirements, metrics, and the review frequency.
    - Includes compliance with FAR 52.2456-11, Higher-Level Contract Quality Requirements.
    - M&Q personnel may also consider related clauses to include:
        - Inspection of supplies and services clauses, 52.246-2 thru 52.246-9 to ensure appropriate government access, oversight, and protection.
        - Warranty for supplies and/or services: 52.246-17 thru 52.246-21 though mainly -18, -19, & -20 depending on what work is being done and what product is being delivered.
    - Encompasses the quality aspects of contractor compliance to industry best manufacturing practices (i.e., AS6500).
        - Management, measurement, and control of key and critical characteristics and processes
    - Addresses use of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
    - Encompasses supply chain quality management requirements that include:
        - Need for focused supplier quality management requirements
        - Contractor supplier quality management plan
        - Supply chain best practices and standards (e.g., AS9100, ISO 9000, etc.)

        - Metrics and review frequency
        - Solutions, tools, techniques, and procedures
        - Use of government furnished quality and testing equipment and assets
    - Establishes appropriate agreements, delegations, and contracts with other agencies, e.g., DCMA, throughout the supply chain
    - Addresses software and firmware development quality assurance and configuration management.

Tools

- Acquisition Strategy Template
- AS9100 Audit Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Quality thread
- ISO 9001 QMS Audit Checklist
- Manufacturing Maturation Plan

Resources

- AFMC Instruction 63-145, Manufacturing and Quality
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
    - AS9102 First Article Inspection
    - AS9103 Variation Management of Key Characteristics
    - AS9133 Qualification Procedure for Aerospace Parts
    - AS9134 Supply Chain Management Guidelines
    - AS9136 Root Cause Analysis and Problem Solving
    - AS9138 Statistical Process Acceptance
- DAG Chapter 14.3.1.3.6 Quality Plans
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- FAR 52.246-11
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

I.2 Prepare Initial Program Quality Plan

A **Systems Engineering Plan (SEP)** is required for Milestone Decision Authority (MDA) approval in conjunction with each Milestone review and integrated with the **Acquisition Strategy**. This plan shall describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It shall also detail the timing, conduct, and success criteria of technical reviews.

M&Q personnel need to be actively engaged in the development and update of the SEP to include the Initial Quality Plan.

Manufacturing and Quality Tasks

- Evaluate the contractor's QMS for processes and procedures that are in alignment with industry best practices (e.g., AS9100, ISO 9000, etc.) to include elements such as:
    - Effective policies and procedures that encourage adherence to the quality system
    - Organizations with defined authorities and responsibilities
    - Objectives to drive people, processes, and the system
    - Methods to analyze and resolve quality problems
    - Product and process metrics that reflect desired outcomes
    - Interacting processes to transform inputs into outputs
    - Records as evidence of what happened
- Based on MSA documentation, evaluate Contractor's proposed quality plan for previously determined product quality requirements, metrics, frequency of metrics reviews, and M&Q risks, issues, and opportunities, and update accordingly.
    - Include software development quality requirements
    - Include impacts of safety processes and procedures
    - Include Contactor's planned supply chain
    - Include DCMA inputs on Contractor and supply chain quality performance against quality requirements for similar products or processes
- Evaluate Contractor-proposed or planned solutions, capabilities, equipment, and processes that address product quality requirements in the form of:
- Quality technologies (i.e., metrology technologies) that could improve product quality (e.g., new quality technologies, state of the art, etc.)
    - Proposed or planned solutions or processes to improve low-yield processes and components product quality
- Develop a joint government/contractor M&Q plan based upon the evaluations of contractor's and supplier's QMSs and proposed plans that specifies:

  - Roles, responsibilities, and quality processes for government and contractor quality management including:
    - Role and participation of DCMA (contractor and supply chain)
    - Key Characteristics management
    - Acceptance test procedures including software
    - In-process and final inspections
    - Statistical process controls and management
    - Quality improvement plans
    - Certification requirements (e.g., flight safety, man-ratings, etc.)
    - Issues and dispositions (i.e., material review boards and processes)
    - Continuous process improvement
    - Software quality assurance
    - Data storage, management, and security (physical and cyber)
    - Use of COTS items, GOTS items, and NDIs
    - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
    - Audits and verifications
  - Tasks, schedules, and outcomes
  - Standards and requirements to be followed (e.g., industry product standards, MIL-STDs, etc.)
  - Joint risk, issue, and opportunity processes including supply chain quality capabilities and risk, issue, and opportunity identification processes
  - Quality processes, roles, and responsibilities identified for:
    - Key Characteristics management
    - Acceptance test procedures including software
    - In-process and final inspections
    - Statistical process controls and management
    - Quality improvement plans
  - Quality workforce qualifications and training requirements
  - Quality tooling and equipment requirements
  - Quality targets, metrics, incentives, and process capabilities (C_{pk}s)
  - Quality failures identification and analyses processes
  - Software requirements
  - Requirements for tracking quality costs
  - New quality technology identification and introduction processes to include transformative processes

- Update the joint government/contractor risk, issue, and opportunity process to ensure inclusion of updated M&Q process capability risks, issues, and opportunities from the SRR and the SFR (*see* H.1) including:

- Key Characteristics
- M&Q processes (new equipment and technology)
- Potential cost and schedule impacts
- Producibility
- Tooling and facilities
- Testing and qualification
- Environmental, transportation, storage, etc.
- Data management (collection, storage, cybersecurity, etc.)
- Process maturity and capabilities
- Yields, rates, and quantities

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Quality thread
- Manufacturing Maturation Plan
- Quality Management Plan Template
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102 First Article Inspection
  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Specified Industry and Military Standards
- Systems Engineering Plan (SEP) Outline

I.3 Verify Subcontractor Quality Management

Major programs require the engagement of the entire supply chain to be successful. Thus, program planning, to include the Quality Management Plan, must be delegated down through the supply chain, and evaluated on a regular basis for compliance and adequacy.

Manufacturing and Quality Tasks

- Verify that the contractor supplier management system requires subcontractor QMS processes and procedures that are in alignment with industry best practices (e.g., AS9100, ISO 9000, etc.) to include elements such as:
    - Management responsibility requirements
    - Quality management system requirements
    - Resource management requirements
    - Product Realization requirements (e.g., risk management, design, and development, purchasing, etc.)
    - First Article Inspection if required
    - Risks, issues, and opportunities
    - Measurement, analysis, and improvement requirements
- Establish supply chain quality management metrics for each of the concepts being considered for incoming quality inspection to include the identification of acceptable quality levels (AQLs)
    - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Analyze the contractor's supplier management system capability to perform the anticipated design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including:
    - Effectiveness of prime and subcontractor communication and interaction processes to include:
        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Quality data exchange processes
        - Integration of risk, issue, and opportunity management
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions, communication, and end user feedback
        - Specification and production of prototypes
    - Key Characteristics management
    - Supplier risk, issue, and opportunity management processes for quality, technical, schedule, material, facility, scale-up, financial impacts, etc.

  - Make/buy processes for supplier quality performance and impacts
  - Approval/removal and qualification processes for suppliers, which includes period re-assessment
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials (*See* AS5553 and AS6174)
  - Identification of major and critical suppliers, and suppliers performing Critical Manufacturing Processes
  - Supplier development program that focuses on and measures continuous improvement
  - Effective metrics to monitor, evaluate, verify, improve processes, and prevent defects
- Analyze the contractor's supplier management system and quality management plan for:
  - Management of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
    - Request DMCA assistance in analyses and verifications
  - Roles, responsibilities, and quality processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Software and firmware quality and integration into the program Software Quality Assurance Plan (SQAP), Software Development Plan (SDP), and Software Configuration Management Plan (SCMP)
  - Acceptance tests (prototypes, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP
- Verify the contract and the subcontractor management plan includes right of access for both the contractor and the government to supplier facilities and documentation, where applicable.

Tools

- AS9100, Audit Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Supplier QA Questionnaire

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102 First Article Inspection

  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

I.4 Assess Contractor Quality Management System

Quality managers use FAR Part 46 to identify the appropriate contractual quality requirements based on complexity and criticality of the item being procured. Most DoD programs will require a higher-level quality clause. Both ISO 9001 and AS9100 satisfy the requirements for a higher-level quality management system (QMS). Often contractors will note in their proposal that they will follow one of the two QMS's identified above, and it is up to the procuring activity to assess the contractor and their implementation to see if it does in fact satisfy their requirements and will result is conforming product. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

Organizations need to identify the process of measuring, examining, testing, or otherwise comparing the product to the requirements for acceptance. FAR 46.291 Production Lot Testing identifies the purpose of production lot testing is to validate quality conformance of products prior to lot acceptance, which usually occurs after acceptance testing.

Manufacturing and Quality Tasks

- Evaluate the QMSs in use for the following:
  - Management responsibility
  - Resource management
  - Quality System
  - Contract Review
  - Product Realization
  - Design Control
  - Document Control
  - Purchasing
  - Purchaser-Supplied Product

  - Product Identification and Traceability
  - Process Control
  - Measurement, Analysis, and Improvement (metrology and calibration)

- Assess the contractor's corporate strategic vision, objectives, policies, and procedures for alignment to the contracted program needs and industry best practices (e.g., AS9100, ISO 9000, etc.) for quality both in-house and in suppliers' facilities to include:
  - Established quality policy, at the highest level in the company, based on industry best practices, which commits to continuously improving processes and exceeding customer expectations
  - Organizational direction and values regarding quality are communicated throughout the supply chain
  - Management provides structures and resources supporting full implementation of the quality management system
  - Management solicits quantitative and qualitative feedback on the effectiveness and efficiency of quality management system and takes actions based on that feedback
  - Procedures for internal reviewing of the quality management system periodically with goals and objectives throughout the organization, customer satisfaction, and continuous improvement
  - Procedures independent reporting channels for quality functions and audits
  - Management accountability with emphasis on quality results and customer satisfaction
- M&Q personnel need to identify and manage product quality requirements:
  - Identify product acceptance methods and determine sampling plans as appropriate.
  - Incorporate and mature new quality technologies and process state of the art into product quality requirements.
  - Identify and manage product quality requirements on prototype items (i.e., specific product characteristics).
  - Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks.
- Conduct a functional audit of the contractor's QMS including assessment of:
  - Quality processes, product quality, and supply chain quality including:
    - Role and participation of DCMA (contractor and supply chain)
    - Key Characteristics management
    - Acceptance testing including software
    - In-process and final inspection functionality
    - Statistical process controls, rates, and yields (and management of same)
    - Quality improvement plan execution
    - Certification process (e.g., flight safety, man-ratings, etc.)
    - Continuous process improvement results

        - Software quality assurance results
        - Data storage, management, and security (physical and cyber)
        - Management of safety, environmental, transportation, storage, etc.
        - Use of COTS items, GOTS items, and NDIs
        - GFE/GFP management (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
        - Audits and verifications results
    - Incorporate results and reports from contractor's developmental testing for CTEs, KPPs, KSAs, and Key Characteristics and integration into the QMS.
    - Results and reports from the contractor's QMS Failure Reporting, Analysis and Corrective Action System for sufficiency and adequacy including results of dispositions (i.e., material review boards and processes)
    - QMS impacts on tasks, costs, schedules, and outcomes
    - QMS compliance to standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
    - Integration with the Risk, Issue, and Opportunity Management processes
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements.
- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards.
- Request DCMA support to assess veracity of contractor QMS for inclusion and integration of subsystems, items, and components and inclusion in the initial TEMP including:
    - Assessment of the contractor's progress in generating or updating the TEMP
    - Verification of the TEMP addressing requirements to conduct a Physical Configuration Audits (PCAs) and Functional Configuration Audits (FCAs) on designated subsystems, items, components, and software/firmware
    - Verification of Software testing, to include Software Acceptance Test (SAT)/Software Formal Qualification Testing (SFQT) is addressed in the TEMP

Tools

- AS9100, Audit Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Lot Acceptance Testing Calculator

Resources

- AS9100, Quality Management System – Aerospace

  - AS9102 First Article Inspection
  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1916 DoD Test Method Standard, Apr 1996,
- ANSI Z1.4 Sampling Procedures and Tables for Inspection by Attributes
- ANSI Z1.9 Sampling Procedure and Tables for Inspection by Variables for Percent Nonconforming
- DCMA-INST 302 First Article and Production Lot Testing
- DoD Systems Engineering Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

I.5 Update Quality Strategy

M&Q managers support the development and updates to the Acquisition Strategy by providing their inputs into the Systems Engineering Plan (SEP). Quality managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and to the success of a program.

Manufacturing and Quality Tasks

- Update and revise the initial Program Quality Management Strategy from the Acquisition Strategy and the SEP:
  - Incorporate changes based the results of the assessment of the contractor's QMS
  - Update all quality factors from tasks accomplished in I.1 through I.4
- Initiate quality planning for EMD, production, developmental and operational test, and life cycle sustainment.

Tools

- Acquisition Strategy Template

- Interactive MRL Users Guide Checklist, for the Quality thread
- Manufacturing Maturation Plan
- MRL Assessment Checklist, Quality thread

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102 First Article Inspection
  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

J. MANUFACTURING WORKFORCE

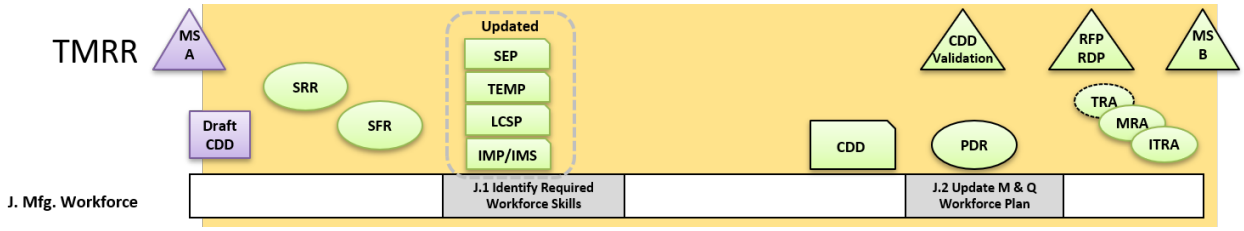


Figure 3-11. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

Manufacturing feasibility and industrial base analysis of concepts considered by the TMRR program team should address the existing skills of the appropriate workforce. This thread (Manufacturing Workforce) outlines activities and tasks to assess required skills (capability) and availability (workforce capacity) to support the manufacturing effort.

A comprehensive assessment of contractor manufacturing plans for prototype and system development is necessary to understand the requirements workforce skills, capabilities, training, and certifications.

Workforce skills identification and plans provide quantitative inputs to program planning. Workforce planning should align the skills required to the scope of the technical effort required to develop, field, and sustain the system.

To determine the scope of the M&Q workforce plan to develop, field, and sustain the system, the following should be included:

- Work Breakdown Structure for the technical activities and tasks (including the Bill of Materials)
- Contractor's make/buy plans
- Contractor's M&Q plans, process, and procedures
- Identified risks, issues, and opportunities
- Integrated Master Plan for all technical activities and tasks
- Time-phased sequence of the technical efforts (Integrated Master Schedule)
- Other resources (support equipment, tools, facilities, training, etc.

Based on contractor M&Q planning, execution, and results of the system development and prototypes efforts, update the program M&Q workforce plans for required skills, capabilities, training, and certifications for EMD.

J.1 Identify Required Workforce Skills

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on a regular and on-going basis, especially early in the development of the prototypes as new manufacturing processes and workforce skills are emerging. Two major focus areas are:

- Workforce Skills availability (are there enough people)
- Workforce Skills capability (do they have the right skills)

Manufacturing and Quality Tasks

- Assess contractor initial Manufacturing Plans for prototypes and system development to identify workforce requirements for skills, capabilities, training, and certifications, including:
    - Contractor's make/buy processes for factors that determine the outsourcing of workforce skills
    - Scale-up of materials, subsystems, items, and components for TMRR
    - Contractor's labor market (availability, stability, capabilities, training, etc.)
    - Potential ManTech changes, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
    - Potential facilities changes (e.g., location, improvements and expansion, lay-out changes, etc.)

  - Materials handling (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
  - Environmental, safety, and health
  - Manufacturing machinery and equipment (e.g., programming and operation, maintenance, calibration, and repair, etc.)
  - Facilities and tooling (e.g., operation and maintenance, safety, security, cleanliness, acoustics, Heating, Ventilation, Air Conditioning (HVAC), and environmental controls, etc.)
  - Quality (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- Review contractor's processes for impacts on the workforce:
  - Identify impacts on personnel, training, etc.
  - Identify risk, issues, and opportunities concerning the workforce
  - Include M&Q requirements on workforce environmental, safety, and health

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Workforce thread
- Learning Curve Calculator
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management System
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II) software

- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

J.2 Update Manufacturing and Quality Workforce Plan

As the prototype is being developed and built, Manufacturing and QA managers need to review and update workforce plans. If there are new skills, then the plan should include training and certification if required.

Manufacturing and Quality Tasks

- Based on contractor M&Q planning, execution, and results of the system development and prototypes efforts, update M&Q plans for required workforce skills, capabilities, training, and certifications for EMD planning, update the Acquisition Strategy and as input for PDR and other decision reviews. Updates include:
    - Workforce skills requirements based on contractor's make/buy decisions for internal and/or outsourcing of workforce skills
    - Contractor's labor market impacts on availability, stability, capabilities, and training to meet M&Q workforce requirements
    - Scale-up of materials, subsystems, items, and components
    - Materials handling requirements changes (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
    - Environmental, safety, and health requirements changes
    - Manufacturing machinery and equipment improvements and changes (e.g., programming and operation, maintenance, calibration, and repair, etc.)
    - ManTech demonstrations, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
    - Facility's re-locations, and changes (e.g., location, improvements and expansion, lay-out changes, etc.)
    - Tooling improvements and changes (e.g., operation and maintenance, safety, security, cleanliness, acoustics, HVAC, and environmental controls, etc.)
    - Quality requirements changes and additions (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- Assess contractor M&Q workforce management and plans for EMD to include:
    - Synchronization with the SEP, the IMP/IMS, and the Subcontractor Management Plan
    - Consistency with the contractor's Manufacturing Plan
    - Staffing rate requirements for pilot line and initial production
    - Workforce skills availability (i.e., number of trained capable workers)
    - Workforce stability (e.g., labor force age, turn-over rate, labor force sustainability, etc.)

  - Special skills certification and training requirements
- Analyze TMRR planned versus actual staffing rates, training, turn-over, etc.
- Assess M&Q workforce and environmental, safety, and health requirements in current guidance, regulations, and laws for impact.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Workforce thread
- Learning Curve Calculator
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

K. FACILITIES

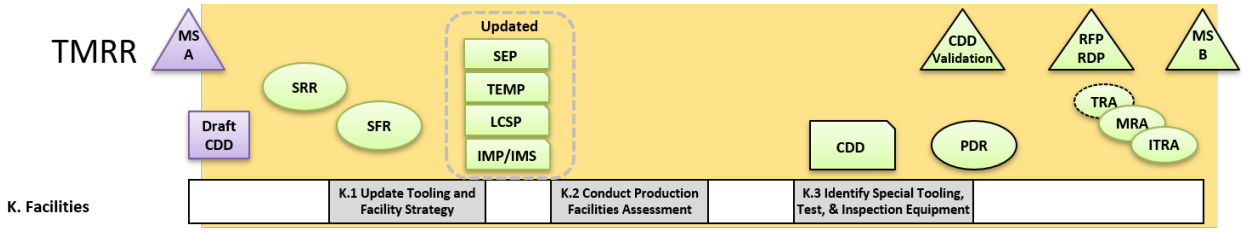


Figure 3-12. Facilities Manufacturing and Quality Activities

Introduction

Facilities management encompasses a variety of professional skills that focus on the design, construction, management, of an installation to include plant and equipment. Life cycle management includes all permanent and semi-permanent real property required to support a system throughout the systems life cycle. Facility management includes studies of facility requirements to include location, environmental and security considerations, and maintenance of such property through disposal.

The facility includes the plant, production equipment, and waste handling and storage equipment to be made available to accomplish the production task. In developing the facility plan, both the quantitative and qualitative demands of the product must be considered. The quantitative analysis will determine the size of the processing departments within the facility. This analysis should consider the number of units to be delivered, and the rate of delivery. For example, the information collected in the analysis will provide a measure of the workstations, plant layout, and the floor space required. The qualitative analysis determines the types of processes that will be required. The contractor then has the option of utilizing currently existing facilities, acquiring new facilities, requesting government-furnished facilities (must be requested in the proposal), or subcontracting a portion of the effort.

This thread (Facilities) requires an analysis of the capabilities and capacity (Prime, Subcontractor, Supplier, Vendor, and Maintenance Repair) that are key risks in manufacturing and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Facility/Tooling Strategy
- Facility Planning and Assessment
- Tooling Planning and Assessment

During the TMRR phase, M&Q personnel should update the facility and tooling strategies and plans developed for the concept during MSA, and conduct assessments of proposed production facilities, and update and finalize the tooling plan for EMD and future phases.

Based on the concept, new facilities and tools may be required for new materials, new technologies, and new processes. Programs and the contractor(s) need to address and plan for the capability and capacity to develop, produce, maintain, and support the program. Included in this are considerations

of the availability of essential tooling, facilities, and production and test equipment for the sustained production of systems capable of meeting the performance objectives, as well as sustained operations, maintenance, and repair. Capacity is normally constrained by physical facilities, available equipment, tooling and/or test equipment. The portion of this capacity utilized is determined by the demand on the plant for current and known future workload. Final validation of M&Q plans must be accomplished prior to PDR and prior to entry into EMD.

M&Q personnel should conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases. These assessments should include subcontractors and key suppliers identified in the contractor's manufacturing management plan. Assessments of the contractor's manufacturing management plans should include tooling and facilities plans with utilization, and any relocation/consolidation considerations, schedules, and requirements for manufacturing maturity. These assessments should be conducted on-site and can be included as part of the MRL assessment. The results of these assessments should identify, and document risks, issues, and opportunities arising from facility and tooling shortfalls and document the required planning for mitigation.

Prior to PDR and entry into EMD, the program tooling plan, which includes specialized tooling and test equipment is finalized. This requires that all facilities, tooling, and test equipment has been appropriately identified from assessments conducted as required by the FAR Section 2.101.

The lack of attention to facilities, tooling, and test equipment will increase risk and can be a major factor in cost overruns and schedule delays. Facilities, tooling, and test equipment is a common production risk that can affect cost, schedule, and performance if the program is not proactive in managing it.

K.1 Update Tooling and Facility Strategy

Facilities and Tooling (special tooling, special test equipment and special inspection equipment) is often a significant cost and schedule driver. The B1 program for example had over $1B in tooling, and the lead times for facility and tooling development can be years. Often one risk reduction strategy is to begin development of facilities and long-lead tooling well in advance of the contract for the next phase. During TMRR Manufacturing and QA managers need to be considering what their strategy is for reducing risk in the implementation of a facility and tooling program.

Manufacturing and Quality Tasks

- Update the Manufacturing Strategy (tooling and facilities plans from the MSA Acquisition Strategy and SEP) for tooling and facilities to include:
    - Design, fabrication, and control of tooling and test equipment
    - Mix of "soft" and "hard" tooling
    - Availability
    - Surge capability to meet rates and/or fluctuating demand

  - Procurement of commercial or existing tooling,
  - Identification of any unique tooling required to support production
  - Planning for M&Q ManTech initiatives for new tools
  - Specific material specifications that require peculiar production facilities or special handling
  - M&Q environmental and safety factors
  - Security requirements for M&Q facilities (physical and cyber)
- Initiate planning for construction, fabrication, test, and demonstration of required new or modified facilities or tools.
- Update the planning for Special Test Equipment (STE) and Special Inspection Equipment (SIE) based on prototyping results (e.g., acquisition of specialized fixtures, construction of test chambers, upgrading laboratories and clean rooms, upgrading waste storage and disposal equipment, etc.).
- Update planning for new manufacturing tooling and facilities required for new technologies.
- Update M&Q tooling and facilities plans based on the availability, storage, and handling requirements of essential raw materials, special alloys, composite materials, components, tooling, and production test.
- Update plans for mitigation of identified tooling and facility shortfalls and risk areas associated with the proposed facility.
- Initiate M&Q planning for EMD tooling and facilities.

Tools

- Acquisition Strategy Template
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Strategy (no template available)

Resources

- AS6500, Manufacturing Management Program
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

K.2 Conduct Production Facilities Assessments

Manufacturing facilities assessment includes an analysis if the capabilities and capacity of the production facilities to develop and build the prototype(s) and prepare for EMD. Facilities assessments should include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur.

Manufacturing and Quality Tasks

- Conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases, including prime/subcontractors and key suppliers identified in the contractor's manufacturing management plan for the program.
- Assess the contractor's manufacturing management plans for tooling and facilities including plans, utilization, and any relocation/consolidation, program schedules, and manufacturing maturity requirements for adequacy, compliance, and impact to the contract to include:
    - Identification new to the contractor materials, technologies, manufacturing methods that require new M&Q processes requiring additional facilities, equipment, and tools
    - Review of the technical data package to identify specific material specifications that require unique production facilities
    - Assessment of current utilization for proposed manufacturing facilities
        - Assess adequacy of contractor identified facility, manufacturing equipment, test, and quality assurance equipment
        - Review contractor capabilities required for special handling, material storage, ultra-clean work environments, material, and part handling, storage, and transportation, etc.
    - Planned relocation and/or consolidation of production facilities, tooling, and production lines impacts to schedule and costs
    - Impacts to schedule and costs from planned changes to increase manufacturing maturity (i.e., manufacturing technology)
    - M&Q environmental and safety factors
    - Security requirements for M&Q facilities (physical and cyber)
    - Request DCMA data and assistance for these efforts
- Conduct on-site capability assessments of contractor's current and proposed manufacturing facilities (including critical and prototype suppliers) for:
    - Adequacy of contractor-identified facility and layout, tooling, manufacturing equipment, test, and quality assurance equipment
    - Contractor capabilities required for special handling, material storage, ultra-clean work environments, material, and part handling, storage, and transportation, etc.
    - Adequacy for prototype builds
    - Program unique production facility and tooling requirements
    - M&Q environmental and safety factors

  - Security requirements for M&Q facilities (physical and cyber)
  - Request DCMA data and assistance for these efforts
- Identify production facility and tooling shortfalls and risks, issues, and opportunities associated with the proposed facility (include current and subsequent phases).
  - Include data from the prototype builds into overall facility risks, issues, and opportunities process
  - Identify capacity constraints
  - Request DCMA data and assistance for these efforts

Tools

- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Facilities thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- DCMA-INST-204 Manufacturing and Production
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

K.3 Identify Special Tooling, Test, and Inspection Equipment

The Department of Defense often permits contractors to acquire Special Tooling, Special Test Equipment, and Special Inspection Equipment (ST/STE/SIE) as government-furnished property to be used in the development or manufacturing of a product. Special tooling can include jigs, dies, fixtures, molds, patterns, taps, and gauges that are of a specialized nature intended for the development or production of specific DoD products. Special test equipment can be single or multi-purpose test units based to accomplish special purpose testing in the performance of a DoD contract. Special inspection equipment can be single or multi-purpose equipment used in the inspection and acceptance of DoD products.

Manufacturing and Quality Tasks

- For EMD and subsequent phases, finalize the Tooling Plan (developed in MSA) for specialized tooling whose use is limited to the development or production of supplies or parts or to the performance of functions for the program including jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items including foundations and similar improvements necessary.
- For EMD and subsequent phases, finalize the Tooling Plan for single or multipurpose integrated specialized test equipment (STE/SIE) that is engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items or assemblies of equipment including inter-connected or interdependent, and foundations and similar improvements necessary.
- Assess contractor demonstrations of Prototype tooling and STE/SIE in production relevant environment for functionality and sufficiency.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- DCMA Manufacturing Systems Risk Assessment Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Material Requirements Planning
- Plant Design and Facility Layout Software Evaluation Tools
- Rough Cut Capacity Planning Spreadsheet

Resources

- AS6500, Manufacturing Management System
- DCMA-INST-204 Manufacturing and Production
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 4275.5, Acquisition and Management of Industrial Resources
- DoDI 5000.88, Engineering of Defense Systems
- FAR Part 2, §2.101 Definitions
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

L. MANUFACTURING MANAGEMENT/CONTROL

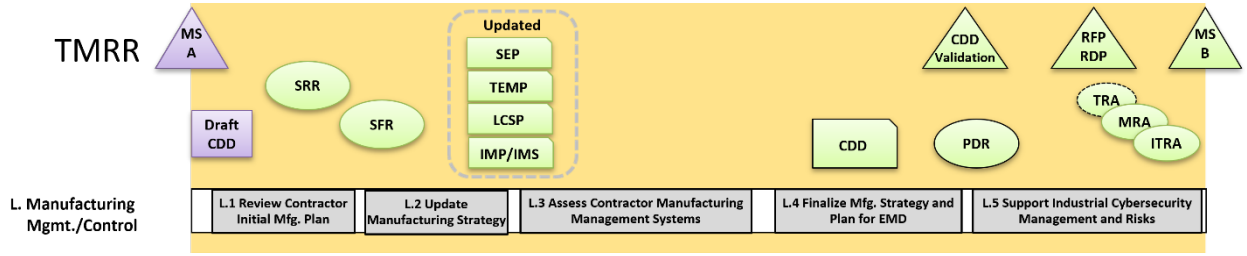


Figure 3-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

DoD Manufacturing Management is concerned with the conversion of raw materials into products based upon a detailed design. This conversion is accomplished through a series of manufacturing procedures and processes. It includes such major functions as manufacturing planning, cost estimating and scheduling; engineering; fabrication and assembly; installation and checkout; demonstration and testing; and product assurance. Manufacturing considerations begin as early as during the Analysis of Alternatives (AoA) in which the manufacturing manager and the PM must be able to understand the "manufacturing feasibility (risks)" are that are associated with each materiel solution.

Programs with any manufacturing aspects will require a manufacturing management system. The timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risks and issues throughout the program life cycle will only be met by a comprehensive system. Meeting this objective is best accomplished by including best practices and standards (i.e., AS6500, Manufacturing Management Program) in the contracts with industry.

Beginning in this phase, the activities managing the concept (or program office) should begin the planning for manufacturing management and control of the concepts under consideration. This planning will be evolving and should be updated during the subsequent acquisition phases. The purpose of manufacturing planning is the identification of resources and integration into a structure that provides the capability to achieve production objectives. Manufacturing planning should include:

- Manufacturing requirements in contracts and in appropriate agreements with other agencies (e.g., DCMA)
- Manufacturing assessments to support program Milestone decision points and major design reviews
- Manufacturing metrics and reviews at a frequency commensurate with manufacturing risks

This thread (Acquisition) requires an analysis of the orchestration of all elements needed to translate the design into an integrated and fielded system (meeting Program goals for affordability and availability) and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Manufacturing Strategy and Planning
- Manufacturing Management System Program
- Material Management System
- Manufacturing Resource Planning
- Assess Production Lines

The initial program M&Q strategy should have been developed as part of the program's Acquisition Strategy in MSA phase. The M&Q strategy is a major aspect of the master schedule for development, test, production, fielding, modification, postproduction management, and other activities essential for program success. Now that there is a contractor responsible for technology maturation and risk reduction, the M&Q strategy will require updating. This requires an assessment of the contractor's manufacturing plans for adequacy and alignment with the Acquisition Strategy.

Manufacturing resources consist of facilities, materials, machines, manpower, methods, measurement systems, and capital that are used to convert or transform raw materials and component parts into end products. Contractors must have an effective combination of people and systems to plan for, monitor, and control these manufacturing resources. A well-structured manufacturing management system employs the use of industry best practices. A program technical team to include manufacturing and quality practitioners should assess the contractor's manufacturing management and quality systems against recognized industry best practices such as AS6500, ISO 9000, AS9100, etc.

In addition, the government requires contractors to implement cyber threat protection measures and manufacturing control systems that include safeguarding M&Q information, designed-in system protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security to comply with the following:

- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST, Cybersecurity Framework

In preparation for PDR, the Request for Proposal Release Decision Point (RFP DP), and Milestone B, the program's M&Q Management Strategies and Plans should be updated. The knowledge gained from the results of TMRR assessments, prototypes, demonstrations, and accomplishments, risk, issue, and opportunity plans and on-going mitigations, etc., should be utilized for the updates. These

comprehensive strategies and plans will provide the basis for program M&Q management in the EMD phase.

L.1 Review Contractor Initial Manufacturing Plan

Manufacturing planning is about understanding everything it takes to produce the items required by the contract, on time, on budget, and with the right performance features. It includes considerations of all the 5Ms (manpower, machines, materials, methods, and measurements), at the prime contractor and throughout the supply chain. During the TMRR phase, there may be many new manufacturing requirements (5Ms) that will require development and maturing.

Manufacturing and Quality Tasks

- Compare, contrast, and assess the contractor's Manufacturing Plan for agreement with the program's overall Acquisition Strategy and the program's Manufacturing Strategy for TMRR and future phases, to include:
    - Consistency with program IB risk and issue mitigation plans
    - Development and incorporation of enabling/critical technologies (and constraints)
    - Requirements and schedules for incorporating manufacturing development projects (ManTech)
    - Design feasibility, methodology, and producibility
    - Planned rates and schedules (includes processes, tooling, make/buy, etc.)
    - Management of key and critical characteristics
    - Costs, schedule, budgets, and affordability requirements
    - Management of materials, including lead-times, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
    - Management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
    - Processes for managing the schedule, including contingencies, variances, and risks
    - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
    - Processes and process capability control requirements
    - Workforce capabilities, training, certifications, availability, etc.
    - Facilities, tooling, and test equipment (including GFE and assets) requirements
    - Environmental, security, and safety requirements
- Assess the contractor's Manufacturing Plan for appropriate cyber threat protection measures including safeguarding M&Q information, designed-in system protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper, and security-related activities such as physical security and industrial security.

  - Verify that the contractor and subcontractors can comply with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Verify periodic assessments are conducted to understand the risk to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems
  - Verify contractor's Industrial Control Systems (ICS) are included in plans for cyber threat protection measures to be applied to M&Q systems

- Assess the contractor's Manufacturing Plan for proposed processes, methods, actions, and metrics that address M&Q capability improvement, feasibility, producibility, and risks, issues, and opportunities.
  - Review plan for a scheduled review cycle of the above commensurate with the risks and issues
- Assess the contractor's Risk, Issue, and Opportunity Management System and planning for this contractual TMRR phase (may be part of the SEP).
  - Verify the contractor has included in their plan a requirement for a joint government/contractor program risk and issue registers
- Assess the contractor's Configuration Management Plan for control and management of M&Q data for the program's TMRR phase contract.
- Assess the contractor's M&Q safety analyses processes and procedures for compliance to required program standards (i.e., MIL-STD-882) and integration into the Manufacturing Management System.
- Evaluate the contractor's proposed processes and methods for submission, review, revision, and process for obtaining approval of CDRLs, DIDs, etc. to support M&Q processes for consistency with program plans and procedures.
- Evaluate the contractor's proposed processes and methods for providing M&Q data and support to:
  - Milestone and technical reviews
  - M&Q reviews (with frequency of reviews)
  - Cost models and data (including Cost of Quality)
  - Key characteristic management process
  - Risk, issue, and opportunity identification, management, and mitigation system
  - Variability reduction processes
  - Materials management processes
  - Supply chain management system
  - Facilities, tooling, and test equipment planning
  - Workforce planning

- Assess the contractor's Manufacturing Plan for M&Q TMRR phase goals/exit criteria.
- Assess the contractor's strategy and plans for acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life cycle costs including methods to encourage investment in U.S. domestic sources.
- Assess contractor's capability to comply with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Manufacturing Management/Control thread
- Learning Curve Calculator
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Material Management and Accounting System (MMAS) audit
- Material Requirements Planning (MRP)
- Risk, Issues and Opportunities assessment
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Program
- DAG, Chapter 3-4 3.18, Producibility, Quality and Manufacturing Readiness
- Defense Technical Risk Assessment Methodology (DTRAM)
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.72 Contractor Material Management and Accounting System
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs

- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-882E DoD Standard Practice: System Safety
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Preparation Guide

L.2 Update Manufacturing Strategy

A manufacturing strategy is developed as part of the program Acquisition Strategy and often includes considerations such as competition. Manufacturing voids, deficiencies, and dependencies on critical foreign source materials should also be addressed. The producibility of each system design concept shall be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and industrial base goals and thresholds.

Manufacturing and Quality Tasks

- From the assessment of the contractor's Manufacturing Strategy and plans, update the program Manufacturing Strategy (and the Acquisition Strategy) and plans (and the SEP) for TMRR and future phases to include:
    - Incorporation of industry and government M&Q best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896, etc.)
    - Compliance with policy directives and regulations
    - Requirements for the EMD Acquisition Strategy and RFP
    - Program plans for IB risk and issue mitigation (government plans) complementary to contractor plans
    - The joint Risk, Issue, and Opportunity Management plans
    - Development and incorporation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
    - Development and incorporation of system required technologies (and constraints)
    - Requirements and schedules for manufacturing development projects (ManTech)
    - Management of Intellectual Property
    - Design feasibility, methodology, and producibility initiatives
    - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
    - Management of key and critical characteristics
    - Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path

  - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
  - Management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
  - Processes for managing the schedule, including contingencies, variances, and risks
  - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Processes and process capability control requirements
  - Workforce needs, capabilities, training, certifications, availability, etc.
  - Facilities, tooling, and test equipment (including GFE and assets) requirements
  - Acceptance testing (including incorporation in the IMP/IMS)
  - Environmental, security, and safety requirements
- Based on assessments of the contractor's Manufacturing System and plans for cyber threat protection measures, update the SEP technical approaches for cybersecurity and related program security
  - Include technical risk, processes, industrial control systems, resources, organization, metrics, and design considerations
  - Provide M&Q input to the Program Protection Plan (PPP) for considerations of contractor level of compliance, risks, and issues
    - Validate that the updated Program Manufacturing Strategy (and Acquisition Strategy) includes appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA), Defense Logistics Agency (DLA), etc.)
    - For the SEP, update the Program Manufacturing Management Plan to address each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
      - Manufacturing Management System
      - Design Analysis for Manufacturing
      - Manufacturing Risk Identification (including mitigation)
      - Manufacturing Planning
      - Manufacturing Operations Management
- Identify requirements for Integrated Product Support for the program and update the Program Manufacturing Strategy accordingly (if required).

Tools

- Acquisition Strategy Template
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Manufacturing Management/Control thread
- Manufacturing Maturation Plan

Resources

- Acquisition Plan Preparation Guide
- AS6500, Manufacturing Management System
- Defense Technical Risk Assessment Methodology (DTRAM)
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82 Guide to Industrial Control Systems Security
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Service-specific policies and regulations (i.e., AFI 63-145)

L.3 Assess Contractor Manufacturing Management System

The Department of Defense was instrumental in the development of AS6500 Manufacturing Management Program. This document is a replacement for the old MIL-STD-1528A Manufacturing Management Program. AS6500 outlines the requirements for a Manufacturing Management System (MMS) to include design and producibility analysis, the identification of key characteristics and use of process controls, manufacturing feasibility and other manufacturing risks assessments, supply chain management, technology development manufacturing cost, modeling, and simulation, etc. Manufacturing and QA managers need to be well versed in AS6500 to be able to assess a contractor's MMS.

Manufacturing and Quality Tasks

- Assess the contractor's Manufacturing Management system capability to perform the design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including (*see* I.3) for:
    - Effectiveness of program and contractor communication and interaction processes to include:
        - Cost, schedule, and performance requirements and timely notification of changes

        - Manufacturing data management processes (to include responses, status, and reports for cost, schedule, and performance actuals)
        - Integration of risk, issue, and opportunity management processes
        - Failures, corrective, and preventative actions, communication processes
        - Specification and production of prototypes
    - Design analyses incorporating producibility and manufacturing feasibility
    - Failure mode analyses processes
    - Key Characteristics management processes
    - Risk, issue, and opportunity management processes (to include quality, technical, schedule, material, facility, scale-up, financial impacts, etc.)
    - Make/buy processes (to include performance and impacts)
    - Processes and procedures for prevention and/or detection of counterfeit parts and materials
    - Development program that focuses on and measures continuous improvement
    - Effective metrics management processes to identify, monitor, evaluate, and verify to improve processes, and prevent defects
    - Supplier management system that tracks and reports supplier performance, which includes a supplier quality assessment process
    - Manufacturing verification system that verifies the proposed production processes, tooling, and test equipment meet program requirements (including Special Tooling and Special Test Equipment)
    - Manufacturing assessment and self-assessment processes to measure progress in manufacturing maturation and risk reduction including suppliers
    - Management processes for COTS items, GOTS items, and NDIs
    - Management processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.) including roles and responsibilities
    - Production Process Verifications (PPVs) that verify manufacturing processes, tooling, and equipment are statistically capable of producing required parts and assemblies
    - Process control planning incorporating process capability studies
    - Variability Reduction (VR) processes and techniques
    - Manufacturing software and firmware management processes and integration (including the SDP, and SCMP
    - Development processes for in-process and acceptance tests (including prototypes, first articles, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP

- Assess the contractor's materials and inventory control systems for sufficiency and capability to effectively meet program requirements consistent with industry best practices including:
    - An appropriate materials, manufacturing, or enterprise resources planning system (MRP/MRP II/Enterprise Resource Plan (ERP)) including cost control, capacity and

facility planning, economic order quantities, inventory control, shop floor control, bills of material, scheduling, purchasing, etc.
    - Appropriate organization/expertise to effectively operate, analyze, and maintain the system

- Assess the contractor's Manufacturing Management System processes for incorporation of M&Q in the development, management, execution, and maintenance of the IMP/IMS including processes to:
    - Identify and assess actual progress versus planned progress
    - Monitor and manage the Critical Path
    - Monitor the status of risk, issue, and opportunity management
    - Manage Key Performance Parameters, Key System Attributes, Technical Performance Measures, and Key Characteristics
- Assess the contractor's Manufacturing Management System for capability to develop an Integrated Product Support Plan (if required) including planning for EMD, production, developmental and operational test, and life cycle sustainment
- Assess the contractor's Manufacturing Management System make or buy decision process for compliance with program M&Q objectives including:
    - Rationale for specific make/buy decisions
    - Identification of items that could become obsolete or are from a diminishing or fragile manufacturing source and contingency plans
    - Identification sole source, single source, or foreign sourced items and contingency plans
    - Availability and lead-times (including long lead)
    - ITAR and anti-tamper considerations
    - Security implications
    - COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
- Analyze the contractor's Supplier Management System capability to perform the anticipated design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including:
    - Effectiveness of prime and subcontractor communication and interaction processes to include:
        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Quality data exchange processes
        - Integration of risk, issue, and opportunity management
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions, communication, and end user feedback
        - Specification and production of prototypes

  - Key Characteristics management
  - Supplier risk, issue, and opportunity management processes for quality, technical, schedule, material, facility, scale-up, financial impacts, etc.
  - Make/buy processes for supplier quality performance and impacts
  - Approval/removal and qualification processes for suppliers, which includes period re-assessment
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials (*See* AS5553 and AS6174)
  - Identification of major and critical suppliers, and suppliers performing Critical Manufacturing Processes
  - Supplier development program that focuses on and measures continuous improvement
  - Effective metrics to monitor, evaluate, verify, improve processes, and prevent defects
- Analyze the contractor's Supplier Management System and Quality Management Plan for:
  - Management of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
  - Roles, responsibilities, and quality processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Software and firmware quality and integration into the program software quality Assurance Plan, Software Development Plan, and Software Configuration Management Plan
  - Acceptance tests (prototypes, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP
- Verify the contract and the subcontractor management plan includes right of access for both the contractor and the government to supplier facilities and documentation, where applicable.
- Request DMCA assistance in data collection, assessment, analyses, and verification of the contractor Manufacturing Management System including the supply chain.

Tools

- AS6500 Assessment
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Manufacturing Management/Control thread
- Manufacturing Maturation Plan
- Material Management and Accounting System Audit

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations

- Defense Technical Risk Assessment Methodology (DTRAM)
- DFAR 242.72, Contractor Material Management and Accounting System
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

L.4 Finalize Manufacturing Strategy and Plan for EMD

A manufacturing strategy should be updated prior to EMD and often includes considerations such as competition. Manufacturing voids, deficiencies, and dependencies on critical foreign source materials should be addressed. The producibility of each system design concept should be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and industrial base goals and thresholds.

The Manufacturing Plan should be updated for EMD and is about understanding everything it takes to produce all the items required by the contract, on time, on budget, and with the right performance features. It includes considerations of all the 5Ms, at the prime contractor and throughout the supply chain.

Manufacturing and Quality Tasks

- Update the Program Manufacturing Strategy for EMD to include:
    - Incorporation of direction and results from a completed PDR (e.g., date, open items, issues, etc.)
    - Incorporation of requirements for EMD that were included in the EMD RFP
    - Incorporation of all Risks, Issues, and Opportunities
    - Maturity and plans for manufacturing development and enabling manufacturing technologies
    - Manufacturing maturity and plans for system required technologies
    - Results of design feasibility, methodology, and producibility initiatives
    - Management of Intellectual Property and data rights
    - Revised rates and schedules (includes processes, surges, tooling, make/buy, etc.)
    - Key and critical characteristics
    - Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
    - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)

  - Revisions and updates to development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Revisions and updates for use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
  - Revised process capability requirements
  - Revised requirements for in-process and acceptance tests (including prototypes, first articles, hardware, software, and firmware), test procedures including test equipment
  - Revised workforce needs, capabilities, training, certifications, availability, etc.
  - Revised facilities, tooling, and test equipment (including GFE and assets) requirements
  - Revised processes and procedures for prevention and/or detection of counterfeit parts and materials
  - Revised acceptance testing (including incorporation in the IMP/IMS)
  - Revised environmental, security, and safety requirements
  - ITAR and anti-tamper
  - Revised plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations

- Update the Program Manufacturing Management Plan, based on assessments, analyses, and incremental updates (including issues, open items, etc.) conducted to address each key area of the Manufacturing Strategy (in accordance with AS6500) to include:

  - Manufacturing Management System
  - Design Analysis for Manufacturing

    - Design analysis
    - Producibility analysis
    - Key Characteristics
    - Failure Mode Effects Analyses

  - Manufacturing Risk Identification (including mitigation)

    - Manufacturing feasibility assessments
    - MRL assessments
    - Production readiness reviews

  - Manufacturing Planning

    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing cost
    - Modeling and simulations
    - Manufacturing system verification
    - Manufacturing workforce
    - Tooling, test equipment and facilities

  - Manufacturing Operations Management
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - Production Process Verification
    - First Article Inspection and test
    - Supplier Management
    - Supplier Quality

- Update the Program Manufacturing Management Plan for manufacturing software and firmware management processes and integration (including the program Software Development Plan, and Software Configuration Management Plan.
- Provide revised M&Q inputs to the Program Protection Plan (PPP) for considerations of contractor compliance, risks, and issues for EMD.
- Update the Program Manufacturing Strategy (and AS) for EMD to include development of appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA), DLA, National Test Facilities, etc.).
- Update M&Q planning for EMD, production, developmental and operational test, and life cycle sustainment of proposed products.
  - Initial manufacturing approach developed
  - All system related manufacturing events included in Integrated Master Plan and Schedule
  - Manufacturing risk mitigation approach for pilot line or technology insertion programs defined
  - Most material decisions complete (make/buy)
  - Material risks identified and mitigation plans developed

Tools

- Acquisition Strategy Template
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Manufacturing Management/Control thread
- Manufacturing Maturation Plan
- Manufacturing Plan (DID-MGMG-81889)

Resources

- Acquisition Strategy Plan Preparation Guide
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program

- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

L.5 Support Industrial Cybersecurity Management and Risk Assessment

Industrial cybersecurity is concerned with the ability of organizations to share information digitally (government to industry, prime contractor to subcontractors, labs to program offices, etc.). While the sharing of information is critical, it is equally important to do so in a safe and secure environment. Industrial cybersecurity is concerned with the transfer of digital data via operational technology (OT) inside a facility and through the cloud to other organizations and facilities.

NIST standard NIST SP 800-37, Risk Management Framework for Information Systems and Organizations, defines operational technology as:

> Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems/devices detect or cause a direct change through the monitoring and/or control of devices, processes, and events. Examples include industrial control systems, building management systems, fire control systems, and physical access control mechanisms.

There are three main types of operational technologies of concern:

- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution system (MES) to support the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers.
- Enterprise resource planning (ERP) system to support functional management resources within an enterprise, and control process performance.

These data systems are often digital and shared across multiple functions and organizations.

DFARS 252.204-7012 requires contractors to follow NIST SP 800-171 and to:

- Provide adequate security to safeguard covered defense information that resides on or is transiting through a contractor's internal information system or network.
- Report cyber incidents that affect a covered contractor information system or the covered defense information residing therein.

- Submit malicious software discovered and isolated in connection with a reported cyber incident to the DoD Cyber Crime Center.
- Submit media/information as requested to support damage assessment activities.
- Flow down the contract clause in subcontracts for operationally critical support, or for which subcontract performance will involve covered defense information.

Manufacturing, as an industry, is the most targeted industry for cyber-attacks. DoD policy and best business practices require that data be protected from attack. This includes classified data, controlled unclassified information (CUI), personal data, financial data, etc.

This thread (Industrial Cybersecurity) requires an analysis of the risk that the manufacturing environment may not be able to protect digital and other forms of data from cyber risks and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Identification of Cybersecurity Risks
- Cybersecurity Planning and Management (Execution)

M&Q personnel need to identify and manage industrial cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the AAF.

M&Q personnel need to develop and execute industrial cybersecurity planning for system concepts identified and execute the management of those plans. Programs will employ system security engineering methods and practices, including cybersecurity, cyber resilience, and cyber survivability in design, test, manufacture, and sustainment. Such methods and practices will ensure that systems function as intended, mitigating risks associated with known and exploitable vulnerabilities to provide a level of assurance commensurate with technology, program, system, and mission objectives.

Manufacturing and Quality Tasks

- Assess supply chain OT cybersecurity and vulnerability risks, and develop risk management plans
- Implement supply chain OT cybersecurity and vulnerability risk mitigation plans
- Demonstrate OT cybersecurity solutions in a production relevant environment
- Assess OT systems for facilities and equipment (i.e., in-house factory systems, production equipment, STE/SIE, and tooling) to ensure they include cybersecurity and physical/digital controls and access requirements
- Identify and assess OT cyber incidents throughout the supply chain
- Ensure that OT Cyber Incident Reporting procedures are in-place, including reporting, tracking, and corrective actions
- Train the workforce in current cybersecurity procedures for production environment

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (DAU)
- Cybersecurity Strategy ADDM Template
- Interactive MRL Users Guide (Checklist), Cybersecurity thread
- USMC Cybersecurity Management Checklist

Resources

- FAR 52.202.21 Basic Safeguarding of Covered Contractor Information Systems
- DFAR 252.7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.83 Technology and Program Protection
- DoDI 8500.01 Cybersecurity
- DoDI 5000.90 Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoD 5220.22-M National Industrial Security Program
- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle
- NIST SP 800-171 Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations
- NIST Special Publication 800-82 Guide to Industrial Control Systems (ICS) Security

.

Department of Defense
Manufacturing and Quality Body of Knowledge
(M&Q BoK)

Chapter 4
Engineering and Manufacturing Development (EMD) Phase (Post-Milestone B)

November 2022
Version 1.1

Office of the Under Secretary of Defense
Research and Engineering

Washington, D.C.

The appearance of external hyperlinks does not constitute endorsement by the United States Department of Defense (DoD) of the linked websites, or the information, products, or services contained therein. The DoD does not exercise any editorial, security, or other control over the information you may find at these locations.

Department of Defense Manufacturing and Quality Body of Knowledge (M&Q BoK)

Office of the Under Secretary of Defense for Research and Engineering
Executive Director, Systems Engineering and Architecture
3030 Defense Pentagon
Washington, DC 20301-3030
Email: osd.r-e.comm@mail.mil | Attention: SE&A
https://ac.cto.mil/engineering

Approved for public release. DOPSR Case # 23-S-0359.

Contents

Figures

This page is intentionally blank.

Introduction: How to Use the M&Q BoK

The Department of Defense (DoD) Manufacturing and Quality (M&Q) Body of Knowledge (BoK) is a compilation of best practices and lessons learned for completing M&Q activities across the DoD system acquisition life cycle. The office of the Executive Director, Systems Engineering and Architecture (ED, SE&A) prepared the BoK and will update the work periodically to reflect current policy, guidance, tools, and best practices. This document does not supersede DoD policy, guidance, or law.

The BoK details M&Q activities throughout the system life cycle but is not intended to be read from end to end. DoD Engineering and Technical Management (ETM) practitioners and managers may refer to the BoK to find information relevant to the phase of the program they are working on. Within a specific phase, the user may focus on the section and tasks that apply (with appropriate tailoring) for the M&Q activities the program is conducting.

The BoK chapters cover recommended M&Q activities and tasks during each acquisition life cycle phase to meet DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework.

The BoK includes 6 chapters:

- Chapter 1: Pre-Materiel Development Decision (Pre-MDD)
- Chapter 2: Materiel Solution Analysis (MSA)
- Chapter 3: Technology Maturation and Risk Reduction (TMRR)
- Chapter 4: Engineering and Manufacturing Development (EMD)
- Chapter 5: Production and Deployment (P&D)
- Chapter 6: Operations and Support (O&S)

Each chapter focuses on the DoDI 5000.02 activities and program documentation required for that phase. Each chapter uses the following format:

- **Introduction:** Discusses the objectives of that phase to allow the user to understand the environment and requirements.
- **Manufacturing and Quality Objectives:** Discusses roles, goals, and objectives of program M&Q during this phase.
- **Threads:** Twelve threads or topic areas include discussions of major M&Q functions based on the "5 Ms" (Manpower, Machines, Materials, Methods, Measurement); Manufacturing Readiness Level (MRL) criteria; and DoD-unique M&Q-related functions not found in industry (i.e., DoD acquisition system, defense contracting system, and surveillance system). The 12 threads are labeled with letters A through L as follows:

  A. DoD Acquisition System
  B. Defense Contracting System
  C. Surveillance System
  D. Technology and Industrial Base

E. Design
F. Cost and Funding
G. Materials Management
H. Process Capability and Control
I. Quality Management
J. Manufacturing Workforce
K. Facilities
L. Manufacturing Management and Control

Each thread includes several **Activities** represented by gray boxes in the corresponding chapter figure (Figure 1). Activities are numbered A.1, A.2, A.3 . . . B.1, B.2, B.3, etc. The BoK includes the following for each activity:

- Activity overview description
- **Tasks** that M&Q personnel could be expected to support or lead.
- **Tools** such as checklists, templates, and samples available to M&Q personnel intended to help them to accomplish these tasks.
- **Resources** including guidance documents, handbooks, manuals, instructions, memos, etc., that provide direction to M&Q personnel for tasks identified in the gray box.

Example: Figure 1 shows Threads, Documents, Activities, and Reviews for the EMD Phase.

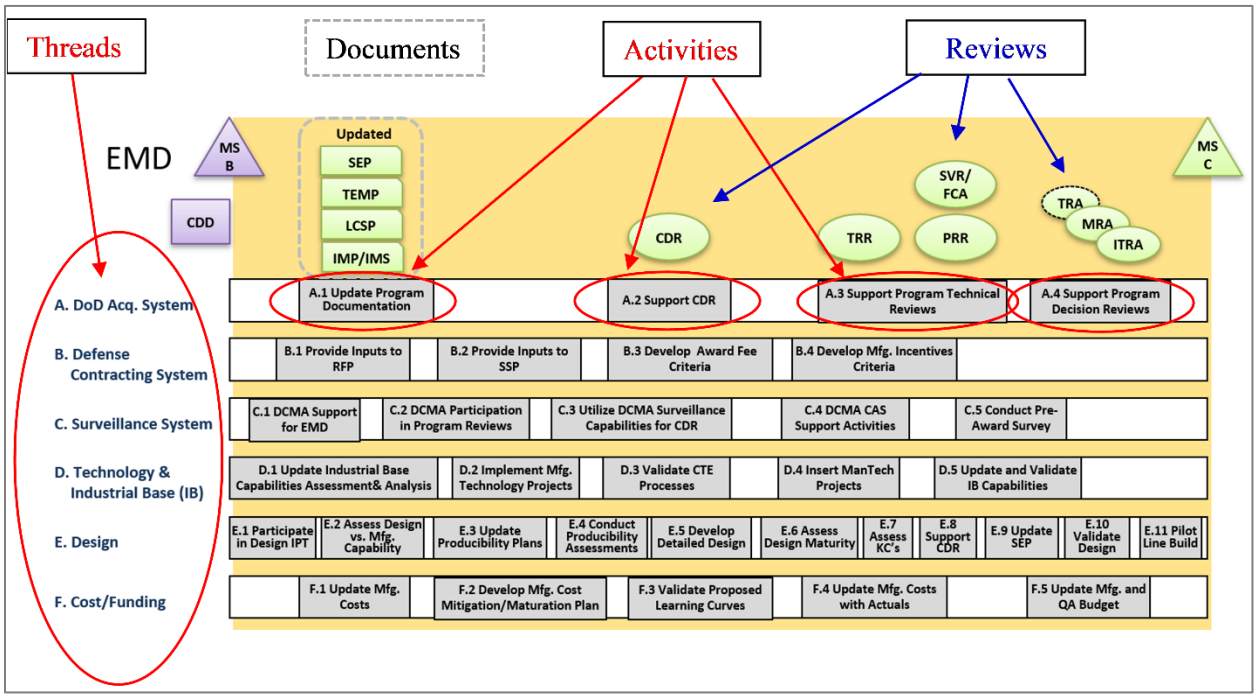
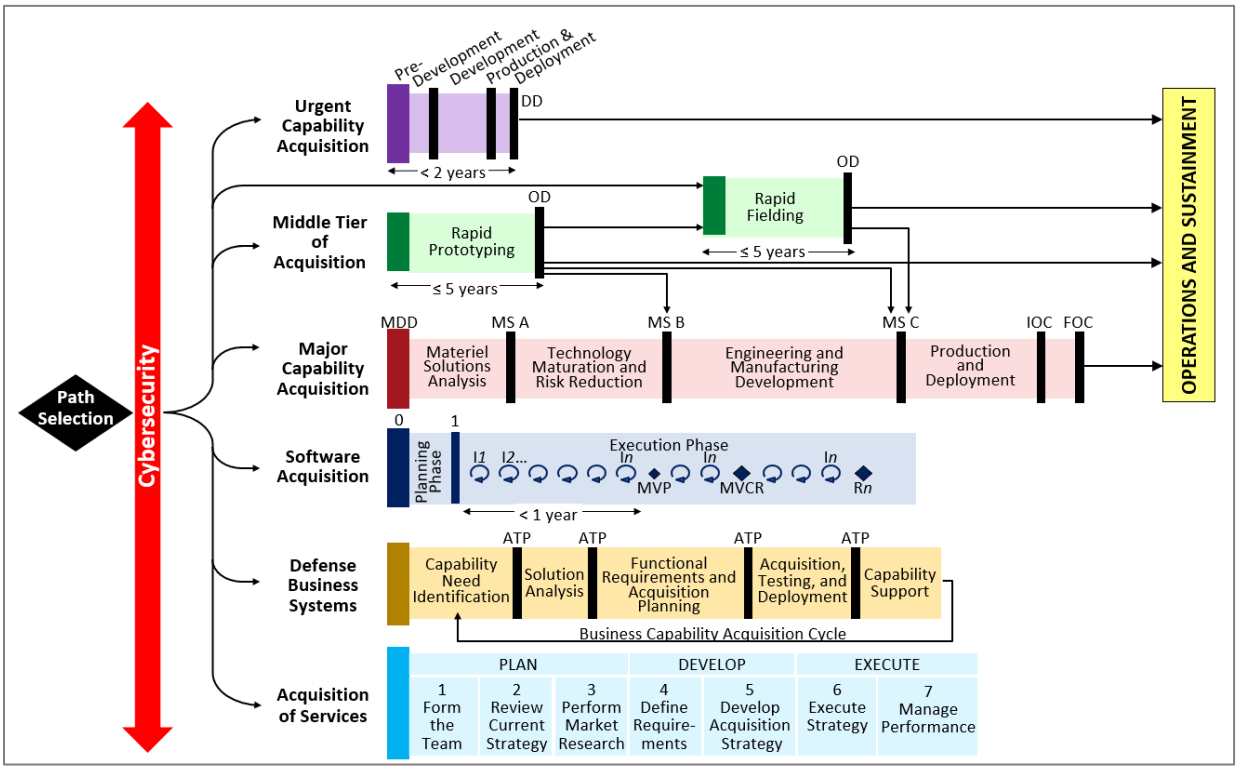


Figure 1. Sample Activity Chart

Adaptive Acquisition Framework (www.aaf.dau.edu)

This BoK follows DoDI 5000.02, Operation of the Adaptive Acquisition Framework (AAF), and for the most part will describe M&Q activities for the path labeled Major Capability Acquisition (MCA). This path includes a comprehensive and systematic approach for applying M&Q best practices; however, the M&Q BoK best practices are applicable to the alternative AAF pathways as well. AAF pathways are depicted in Figure 2.



Source: DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework, January 23, 2020

Figure 2. Adaptive Acquisition Framework Paths

For example, under the AAF, a program may have an Urgent Capability Acquisition (UCA) and may have less than 2 years to provide a solution to the Warfighter, or the program may be involved in a Middle Tier of Acquisition (MTA) approach focused on rapid prototyping or rapid fielding. If so, users can see how these efforts are aligned with the MCA process in Figure 2 and use those BoK chapters to identify and accomplish required tasks and activities.

In addition to DoDI 5000.02, the following associated policies provide information for the paths:

- DoD Instruction 5000.74, Defense Acquisition of Services
- DoD Instruction 5000.75, Business Systems Requirements and Acquisition
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.85, Major Capability Acquisition

- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation

With any acquisition model, the program office should include M&Q personnel on the technical Integrated Product Team (IPT) and to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

M&Q planning, control, and management activities represent an important and central effort that begins early in the life cycle (Pre-Materiel Development Decision (MDD) and/or Materiel Solution Analysis (MSA) phases) and continues throughout the life of a program though Operations and Support. Although planning is discussed in detail in each chapter, Figure 3 provides key elements of M&Q planning activities in relation to overall program life cycle activities.

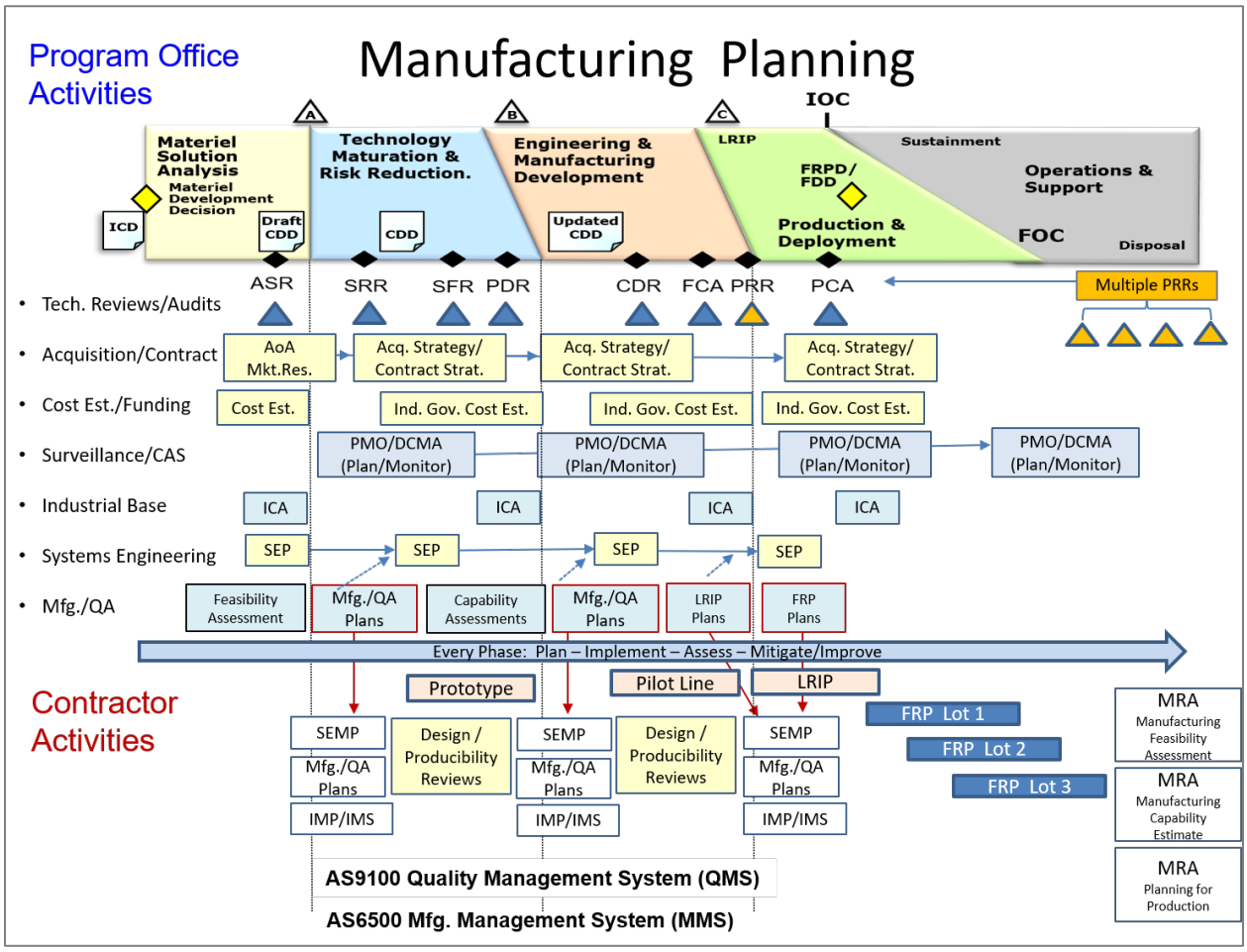


Figure 3. Typical Manufacturing and Quality Planning Activities

Most activities begin with the need to identify requirements, risks, and gaps, followed by planning activities. The top-most planning document is the Acquisition Strategy, and numerous documents feed into the Acquisition Strategy to include the Contracting Strategy and the Systems Engineering Plan (SEP). M&Q strategies should be a component of the SEP. Plans are then evaluated and updated on a recurring basis, usually just before a milestone decision.

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occur. The contractor is responsible for the execution of the program and in planning for success. The government Program Management Office (PMO), along with the Defense Contract Management Agency (DCMA) or other contract surveillance organizations and engineering support activities, is responsible for oversight and management of the acquisition. Risk assessment and mitigation is an ongoing effort that should be conducted throughout the system life cycle. Key references for DoD M&Q planning and management approaches include: MIL-HDBK-896, Manufacturing Management Program Guide; SAE Standard AS6500, "Manufacturing Management Program"; and Quality Management System (QMS) standards ISO 9100 and/or AS9100. In addition, MRL criteria and assessments are a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

DoD tools and resources are available from many sources. Most should be available through open web-based links, but some may require a ".mil" address or a Common Access Card (CAC), or they may be available only to users in a specific community. Commercial tools and resources should be available to everyone but may require the organization to purchase a user's license/rights (e.g., ISO 9001 Quality Management System industry standard). In many cases, commercial resources and tools have been identified as a best practice. The M&Q BoK lists these tools for reference only; DoD does not necessarily endorse these resources or the publishing organizations. In addition, this document may reference a source for a specific tool (i.e., Pareto Chart), but there may be other widely available sources for this tool or for similar tools.

Sections labeled "Tools and Resources" are provided throughout the document chapters. The following section includes a summary of key references and links by publisher or topic. A more comprehensive list of references is included in Appendix B.

Key Manufacturing and Quality Body of Knowledge References and Resources
Department of Defense (DoD) Issuances, Directives Division https://esd.whs.mil/DD/

- DoD Directive 5000.01, The Defense Acquisition System
- DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.84, Analysis of Alternatives

- DoD Instruction 5000.85, Major Capability Acquisition
- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation
- DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD
- DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD
- DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
- DoD Directive 4400.01E, Defense Production Act Programs
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures

Defense Acquisition University (DAU) www.dau.edu

- DAU Guidebooks and References https://aaf.dau.edu/guidebooks/
- Acquisition Notes (AcqNotes) www.acqnotes.com
- Adaptive Acquisition Framework (AAF) https://aaf.dau.edu
- Analysis of Alternatives (AoA) www.acqnote/acquisitions/analsis-of-alternatives
- Market Research www.acqnotes/acqnote/acquisitions/market-research
- Acquisition Strategy (AS) Process/Guidance https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf
- Systems Engineering Plan (SEP) Outline https://ac.cto.mil/erpo/ (Engineering Guidance tab)
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

Defense Contract Management Agency (DCMA) www.dcma.mil

- DCMA Policies https://www.dcma.mil/Policy/
- DCMA Instructions https://www.dcma.mil/Policy/
- DCMA-INST 204, Manufacturing and Production
- DMCA-INST 205, Program Support
- DMCA-INST 207, Engineering Surveillance
- DMCA-INST 309, Government Contract QA Surveillance Planning
- DCMA-INST 401, Industrial Analysis
- DCMA-INST 3401, Defense Industrial Base Mission Assistance

Defense Federal Acquisition Regulation (DFAR) Supplement https://www.acquisition.gov/dfars

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System

- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS Subpart 242.7200, Contractor Material Management and Accounting

Defense Logistics Agency (DLA) Website www.dla.mil

- DMSMS Guidebook, SD-22 https://www.dsp.dla.mil/Programs/DMSMS
- ASSIST (Database of specifications and standards) https://assist.dla.mil
- ASSIST Quick search https://quicksearch.dla.mil/qsSearch.aspx
- DoD 4140.01, Supply Chain Materiel Management Regulation www.dla.mil

Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
Manufacturing Readiness Levels (MRLs) www.dodmrl.org

- MRL Assessment Criteria Matrix www.dodmrl.org
- Interactive MRL Users Guide (MRL Assessment Criteria) www.dodmrl.org
- MRL Deskbook www.dodmrl.org
- MIL-HDBK-896, Manufacturing Management Program Guide www.dodmrl.org

National Institute of Standards and Technology (NIST) www.nist.gov

- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST Manufacturing https://www.manufacturing.gov

Office of the Director, Cost Assessment and Program Evaluation (CAPE) www.cape.osd.mil
OSD Manufacturing Technology (ManTech) Program Office https://www.dodmantech.mil
OUSD(R&E) Systems Engineering and Architecture (SE&A) https://ac.cto.mil/engineering
Relevant Government Publications (Available via Web/Internet Search)

- DoD 4245.7-M Manual, Transition from Development to Production, 1985
- NAVSO P-3687, Producibility Systems Guidelines, 1999
- MIL-HDBK-766, Design to Cost
- MIL-HDBK-727, Design Guidance for Producibility, 1984

Standards, Specifications, and Standards Organizations

- ASSIST (Defense Logistics Agency Database of Specifications and standards) https://assist.dla.mil
- ASSIST Quick Search https://quicksearch.dla.mil/qsSearch.aspx
- SAE International www.sae.org
- International Organization for Standards (ISO) www.iso.org
- Institute of Electrical and Electronics Engineers (IEEE) www.ieee.org
- *Note:* Many specifications and standards can be accessed at http://everyspec.com/

Technology Readiness Levels (TRLs)

- Technology Readiness Assessment Deskbook www.acqnotes.com
- Technology Readiness Assessment Calculator www.acqnotes.com
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

4. Engineering and Manufacturing Development (EMD) Phase (Milestone B)

Introduction

The purpose of the Engineering and Manufacturing Development (EMD) phase is to develop, build, and test a product to verify that all operational and derived requirements have been met, and to support production or deployment decisions. To accomplish this, the EMD phase involves completing all hardware and software detailed designs, mitigation and closure of open risks and issues, and building and testing of prototypes and/or first articles and verifying compliance with requirements. EMD also includes the Critical Design Review (CDR), which establishes the initial product baseline and transfers configuration control to the program. In preparation for transition to Low-Rate Initial Production (LRIP), the final stage of EMD is producing products that look and operate like final production units..

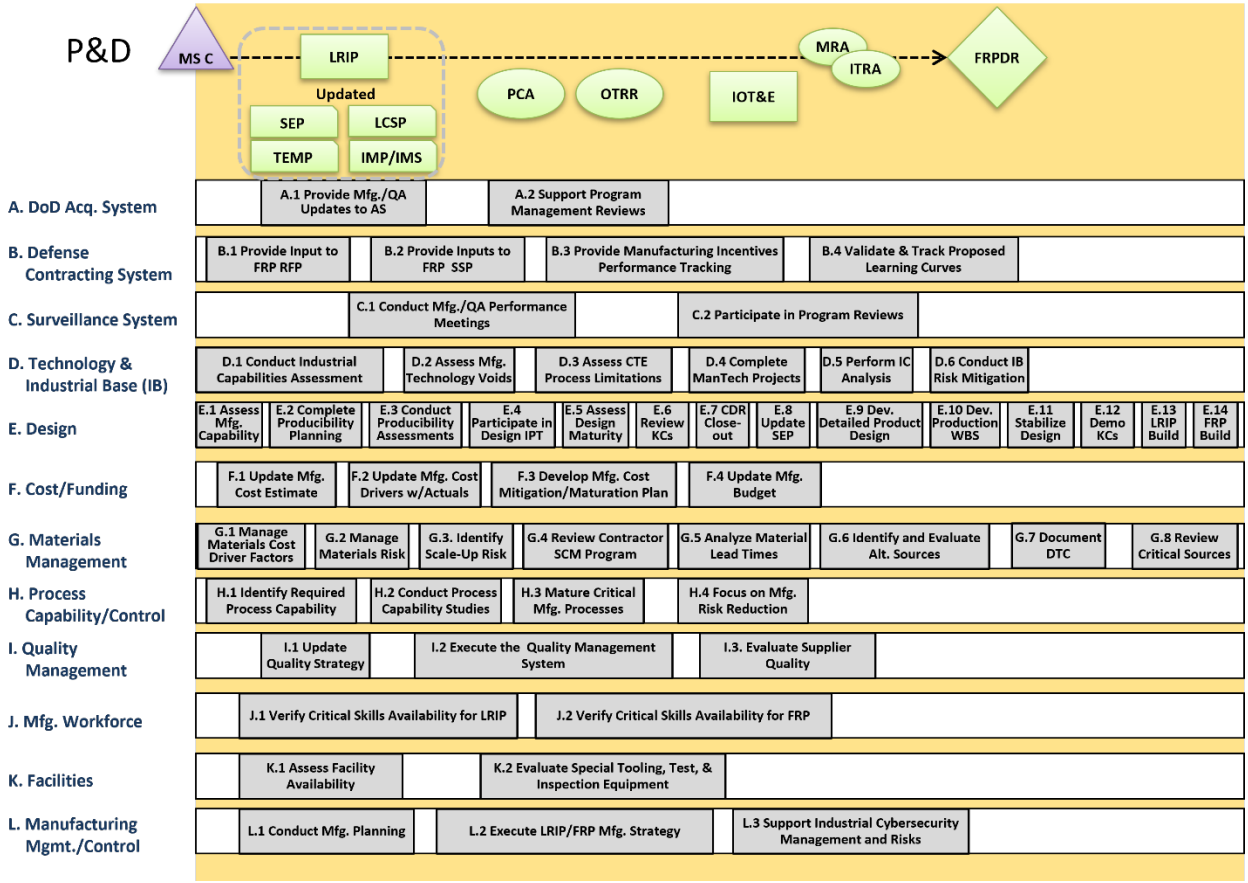


Figure 4-1. EMD Phase Manufacturing and Quality Activities

During EMD, the program will assess the maturity of critical manufacturing processes to ensure they are affordable and executable. Early in the EMD phase, the program's initial manufacturing and quality (M&Q) requirements are identified and allocated. They are refined during EMD based on the results

of assessments and analyses to include the design, the contractor, the supply chain, the industrial base, materials, processes, procedures, etc., and are finalized at CDR. Later in EMD, programs will demonstrate M&Q process maturity by production of initial systems on a pilot line. This enables the program to ensure M&Q producibility risks are acceptable, qualifications are complete throughout the supply chain, and manufacturing processes for Key Characteristics (KCs) and critical characteristics will be under statistical process control for LRIP, prior to the production decision at Milestone C.

M&Q managers have three major roles to perform:

- Influence the Design (for producibility)
- Prepare for Production (planning)
- Execute the M&Q Plans (execution)

The goal is to execute the manufacturing plan with a product that meets the design intent and has repeatable processes, and to focus on continuous product and process improvement.

The Technical IPT should have many opportunities to influence the design for producibility to include putting producibility in acquisition plans and contractual documents. In addition, there are numerous technical reviews in which systems engineering technical processes and technical management processes are addressed and assessed. Finally, executing the plan includes all those day-to-day activities that should be managed, assessed and risks identified and mitigated.

M&Q personnel should be key contributors and participants in all technical reviews and program documentation, providing inputs and recommendations based on results from assessments, analyses, and demonstrations. Key program documentation and reviews during EMD include:

- Acquisition Strategy (AS)
    - Manufacturing Strategy
    - Quality Strategy
- Systems Engineering Plan (SEP)
    - Manufacturing Plan
    - Quality Plan
- Test and Engineering Master Plan (TEMP)
- Capabilities Development Document (CDD)
    - Transitioning to Capabilities Production Document (CPD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)
- Critical Design Review(s) (CDR)
- Test Readiness Review (TRR)
- Pilot Line Demonstration(s)
- System Verification Review (SVR)/Functional Configuration Audit (FCA)

- Production Readiness Review(s) (PRR)
- Manufacturing Readiness Assessment (MRA)
- Independent Technical Risk Assessment (ITRA)
- Technology Readiness Assessment (TRA)
- Milestone C Decision

Adaptive Acquisition Pathway: Rapid Fielding

Under DoDI 5000.02 Operation of the Adaptive Acquisition Pathway, the objective of Middle Tier of Acquisition (MTA) Rapid Fielding is to begin production within 6 months and complete fielding within 5 years of the MTA program start date.

Rapid Fielding is an option from the Adaptive Framework and can be considered an advanced version of EMD where the system is fielded within five (5) years thus manufacturing processes used to implement these final system configuration must be significantly mature and assessed at a high MRL based on acceptable risk. As a best practice, manufacturing maturity should start at an MRL 8 and achieve MRL 8 prior to fielding. Critical manufacturing processes should be matured to support fielding.

When Rapid Fielding option is chosen the usual EMD phase requirements may be truncated and a tailored program initiated. M&Q personnel need to be able to support risk assessments with a tailored manufacturing readiness assessment and PRR is recommended prior to entering production.

Adaptive Acquisition Pathway: Urgent Capability Acquisition

For the Urgent Capability Acquisition (UCA) pathway, the objective is to field an urgent capability within two (2) years of the start date.

Urgent need is an option from the Adaptive Framework and can be considered an advanced version of EMD where the system is fielded in only two years thus the manufacturing processes used to implement these final system configuration must be significantly mature and assessed at a high MRL based on acceptable risk. Manufacturing maturity should start at an MRL 8 and achieve MRL 9 prior to fielding. Critical manufacturing processes must be mature prior to production.

When Urgent Capability is chosen the usual EMD phase requirements may be truncated and a tailored program initiated. M&Q personnel need to be able to support risks assessments with a tailored manufacturing readiness assessment and PRR is recommended prior to entering production.

Manufacturing and Quality Objectives

M&Q risks, issues, and opportunities are important factors in making the decision to proceed within all phases of development and production. The producibility of the design and risks were reviewed

prior to entry into the EMD phase; however, there may be a new contractor(s), a changed industrial base and/or technology base, etc., requiring new or additional assessments.

To meet the EMD phase objective, the program must demonstrate on a pilot line a product capable of meeting system performance requirements within cost and schedule constraints. This requires thorough planning and documentation of hardware and software designs, mitigation and closure of open risks and issues, and compliance with requirements. M&Q's contributions to the EMD phase objective are documented in updates to the Manufacturing Strategy and Plan and the Quality Strategy and Plan which are incorporated into the Acquisition Strategy, the SEP, and the Test and Evaluation Master Plan (TEMP). Risk assessments often occur during one of the many technical reviews and audits that can occur during this phase to include the Independent Technical Risk Assessment (ITRA).

The Office of the Under Secretary of Defense for Research and Engineering (USD(R&E)) established policy for the conduct of ITRAs in accordance with Title 10, United States Code (USC) section 2448b. These independent assessments should be conducted in accordance with the Defense Technical Risk Assessment Methodology (DTRAM). DTRAM focus areas include:

- Mission Capability
- Technology
- System Development and Integration
- Modular Open Systems Approach (MOSA)
- Software
- Security / Cybersecurity
- Manufacturing
- Reliability, Availability, and Maintainability (RAM) and Sustainment

To meet the Production and Deployment (P&D) phase objective of producing "products in Low-Rate Initial Production (LRIP) and deliver to receiving military organizations," M&Q personnel should have a key role during the EMD phase in development of the Request for Proposal (RFP) and the Source Selection Plan (SSP), including providing M&Q award fee and incentives criteria for the P&D phase. A cohesive effort between the Contracts and M&Q personnel is essential to ensuring that M&Q processes are sufficiently mature for entry into the P&D phase and LRIP.

Day-to-day surveillance of contractor and supply chain activities is key to monitoring progress and maturity of the program as it moves through finalizing the design and demonstration on a pilot line. Reviews and assessments are important oversight tools that the program can use to review and evaluate the state of the system and the program, re-directing activity if necessary. The Defense Contract Management Agency (DCMA) is key to providing monitoring, tracking, and reporting of contractor and supply chain performance, actions, and compliance with all contractual requirements. DCMA and program audits and reviews should be multi-disciplined to ensure that all functional aspects of the program are addressed. This systematic process assesses risk and issues and verifies the application of

M&Q best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.) at the contractor and in the supply chain.

DoD policy requires an analysis of the capabilities of the National Technology and Industrial Base (NTIB) to support the design, development, production, operation, uninterrupted maintenance support, and eventual disposal of the system. Without a supporting industrial base, the program may find that accomplishing objectives within the defined cost and schedule will be difficult because of incompatibilities between the requirements and the NTIB available to support program requirements. A key M&Q focus should be on risk mitigation measures needed to sustain a reliable, technologically superior, affordable, and resilient defense industrial base.

The necessity to reduce program risk and the desire to improve program performance while reducing costs can benefit from development, maturation, and implementation of advanced manufacturing technologies. As manufacturing technology project are matured, these ManTech projects should be completed, integrated, and demonstrated on a pilot line at the appropriate contractor and/or supply chain facilities. In addition, DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework, requires a systematic process that assesses the maturity of Critical Technology Elements (CTEs) for all acquisition programs. In completing the development of a system or incremental capability, one of the key tasks is to mature Critical Manufacturing Processes (CMPs) associated with KCs, and therefore with CTEs.

At CDR, all the design information necessary to plan the detailed manufacturing operations for the system should be available. M&Q participation early in the design process through active participation in the Design IPT is the key to creating a producible design. M&Q planning in EMD should address all areas of M&Q impacting cost, schedule, and performance requirements such as KCs, selection of specific materials, specific M&Q processes, changes in requirements, changes in workforce, facilities, tooling, equipment, etc.

Producibility assessments of the design should be conducted throughout the supply chain using industry best practice tools, techniques, and procedures. Prior to a system-level CDR, the detailed design must be developed from the component level up to the system level with CDRs conducted to assure meeting design requirements at all levels of the supply chain. Prior to release of drawings to manufacturing, the detailed design drawings, bills-of-material, and product and process specifications must be completed.

Risks associated with M&Q will have a major impact on the maturity of the design. Many system-level risks occur from immature designs and the failure to consider design risks. M&Q must assess maturity based on manufacturing feasibility, capability, producibility, and KCs, in accordance with industry best practices. Manufacturing maturity can be verified and validated by demonstrations of M&Q processes and procedures in a representative environment at the system, subsystem, item, and component level.

Prior to CDR the list of KCs may be reduced through producibility activities as the product design is refined to make KCs less sensitive to variation. As the KCs are finalized by CDR, the corresponding list of critical M&Q processes should also be completed. An assessment of manufacturing readiness to a system-level target of Manufacturing Readiness Level (MRL) 7 can be conducted to confirm manufacturing maturity for CDR.

The role of M&Q to influence the design culminates at CDR. Design decisions made at CDR related to M&Q have major impacts on future production and life cycle costs. These decisions should be documented in the SEP and the AS via updated M&Q Strategies and Plans. Post-CDR activities, including pilot line, will provide the basis for validation of the design and adequacy of the contractor's processes and capabilities including control of KCs.

A successful pilot line build provides validation of the system design, demonstrating the system design is complete. Outputs of the pilot line will produce articles subject to First Article Inspection (FAI) and/or First Article Test (FAT) and will provide validation that M&Q processes are stable, under control, and ready for LRIP.

M&Q cost estimates should be based on detailed M&Q processes and procedures according to industry best practices. Updates should be performed, as necessary, based on current program status and/or learning curves to develop a time-phased manufacturing cost. These updates will require analyses of contractor M&Q Plans regarding costs, cost controls, and cost drivers. As the design progresses to final design at CDR, cost estimates, cost models, and associated cost drivers should be updated with actual cost data from lower level (item and component) pilot lines and production.

Within any program there will be certain systems, subsystems, items, and components the cost of which will dramatically impact the overall system cost. These M&Q cost drivers originate with and evolve from:

- Emerging technologies
- Industrial base limitations and constraints
- Design producibility factors and impacts
- Maturing of M&Q processes (i.e., capability and control)
- Materials (e.g., sourcing, availability, handling, etc.)
- Environmental and Environmental, Safety, and Occupational Health (ESOH) impacts
- Security impacts
- M&Q management
- Supply chain management
- Workforce constraints
- Facilities, equipment, tooling, and test equipment constraints
- Program budget and funding resource limitations and constraints

M&Q should focus on producibility, planning, and risk and issue mitigation for reduction and mitigation of cost drivers.

M&Q should refine the learning curves for the system established in TMRR and collect data to maintain up-to-date cost estimates and budgeting through CDR. Learning curves are then validated by data collected on the pilot lines. Manufacturing cost estimates for LRIP should be based on the completed design, known manufacturing processes, execution of planned M&Q operations, and actual costs realized at the system level on a pilot line. Based on actual data, up to date M&Q cost estimates should be inputs to the program budget and spending plan.

One of the key elements in a successful program is aggressive materials management and planning. Materials management ranges from basic considerations of maturity and availability to understanding management of the supply chain and to details of government-furnished property (GFP), shelf life, security, safety, hazardous materials (HAZMAT), storage environment, etc. All program M&Q materials risks, issues, and opportunities should be assessed based on contractor data and plans to meet program M&Q requirements

M&Q should obtain key knowledge on scale-up efforts, and potential supply chain risks and issues to meet CDR exit criteria. Manufacturing capability should be assessed to baseline needed industrial capability. Materials cost drivers must be updated, and appropriate management plans implemented by CDR. This includes assessments of the contractor's materials supply chain for application, implementation, and adherence to industry M&Q best practices, as well as compliance to contractor company policies, processes, procedures, and contracts. Materials and components lead times are critical to both meeting program schedules and defining program requirements for long lead and advanced buys. Lead times for defense materials and components can be long and volatile due to various reasons, such as imbalances between capacity and demand, competition from commercial customers, etc. Pilot line and LRIP procurement requirements (e.g., schedule and quantities), and associated mitigation plans should be developed and implemented for all procurement risks and issues by CDR.

In the EMD phase, M&Q should focus on improving process capability and maturity, reducing costs, maintaining (or improving) schedule, supporting the industrial base, and promoting competition by qualification of alternative sources. Based on pilot line results, M&Q should validate the identification of critical sources throughout the supply chain, including sources of key and/or critical subsystems, items, parts, and components.

In support of updates to Industrial Capabilities Assessment required for Milestone C, M&Q should assess and verify material availability for LRIP. This assessment should address risks, issues, and changes in long-lead procurement, supply chain, counterfeit parts, industrial security (physical and cyber), handling, transportation, storage, and environmental compliance, business climate, diminishing sources, and program plans for P^3I.

Successful completion of the EMD phase with a thorough understanding of materials capabilities, capacities, and limitations and the aggressive management of and planning for materials will ensure effective transition to LRIP and the P&D phase.

M&Q process capability and control should be an integral part of any development program. M&Q efforts should lead to a producible system with the objective of achieving effective and efficient manufacturing processes with process controls to satisfy program requirements with consistent and repeatable products at minimum manufacturing costs. Manufacturing process capabilities and the quality data collected must be measured, controlled, documented, and understood with up-to-date process capability information and indices.

Contractor modeling and simulation (M&S) tools and or products should be familiar to M&Q program personnel, if not, an understanding of the contractor tools, as well as the industry state-of-the-art and best practices for M&S is necessary. The contractor tools should be up-to-date and validated for applicability, adequacy, and consistency with industry best practices.

During the EMD phase the contractor will conduct demonstrations that include testing and analysis to ensure products meet the program requirements. These products will be built on pilot lines. The processes used on the pilot lines should be evaluated to understand the difficulties and quantify the risks to be mitigated for LRIP. Results of the pilot lines and the associated assessments should be incorporated to provide an up-to-date, accurate M&S of the system. Actual data collected on the pilot lines provide up-to-date data for yields and rates, and validation of all M&Q learning curves for the system and subsystems.

These assessments and demonstrations should provide an understanding of the contractor's process capabilities, M&S tools, and yields and rates, and support program M&Q planning, resource loading, facilities management, etc., for future phases.

An effective Quality Management System (QMS) is required for operationally safe, suitable, and effective systems. A QMS compliant with industry standards ISO 9001 or AS9100 is the foundation to producing products that meet requirements. The quality system ensures the as-delivered configuration is the same as the as-designed and as-tested configuration. In early EMD, during design development, programs should assess that the contractor’s QMS supports and aligns with program M&Q strategy, objectives, and goals. This requires the use of process audits of the contractor’s and supply chain activities, resources, and behaviors. Participation of DCMA will provide expert assistance in conducting these audits.

The M&Q Strategies should require quality assessments of the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a pilot line, prior to Milestone C. Revision to the quality strategy, plans, and objectives may be required based on the results of process audits and quality assessments. For CDR, an assessment of the allocated baseline against the initial product baseline should ensure that quality parameters (e.g., tolerance, process capability

indices, etc.) for considerations such as weight, power, cooling, etc. have been appropriately specified in the detailed design. This includes completion of all drawings and specifications with tolerances and test points under configuration control for all KCs, Critical Safety Items (CSIs) and/or Critical Application Items (CAIs).

A system-level Functional Configuration Audit (FCA) should be conducted to assess performance of the system against the functional baseline and may be conducted in conjunction with the system-level System Verification Review (SVR). Engineering and quality personnel should be an integral element in both the FCA and the SVR. The system-level FCA should assess the collected data, test results, analysis results, and M&S output and accuracy of the system after completion of development testing and pilot line. The SVR should address all changes or additions generated since CDR to ensure the as-tested product on the pilot line includes all Engineering Change Proposals, specification change notices and revisions, interface control changes, and all M&Q process changes.

Quality assessments and analyses of pilot lines demonstrate that the M&Q processes and capabilities required for production have matured with high confidence of success. These results should be used to finalize the Quality Strategy and Plan to build production configuration products in the P&D phase.

Workforce skills identification and plans provide inputs to program planning. Workforce planning should align the skills required to the scope of the effort required to develop, field, and sustain the system. In EMD, a comprehensive assessment of contractor manufacturing plans for system development is necessary to understand the requirements for workforce skills, capabilities, training, and certifications in support of pilot line and LRIP workforce requirements. Based on contractor execution of the pilot line and the M&Q workforce results, the program workforce plans contained in the M&Q Strategies should be updated.

Based upon the results of PDR and program progress during early EMD, M&Q personnel should assess the contractor and supply chain facility, tooling, test, and inspection equipment plans. This should include pre-CDR assessments and an update to the M&Q Strategies and Plans for EMD. The results of these assessments should identify, and document risks, issues, and opportunities arising from facility and tooling shortfalls and document the required planning for mitigation prior to CDR. By CDR, plans should be finalized along with the associated risk and issue mitigation actions. M&Q plans must be finalized prior to execution of a pilot line.

Based on results of pilot line demonstrations, reassess facilities, tooling, equipment, and test equipment requirements, resource requirements, and schedules for LRIP and FRP using the actual data collected. Focused attention on facilities, tooling, equipment, and test equipment in EMD will decrease risk and can be a major factor in avoiding or preventing cost overruns and schedule delays for LRIP and FRP.

The Manufacturing Strategy and Plan are major aspects of development, test, initial production, and other activities essential for program success. During the EMD phase, the government may be working with new prime and subcontractors who will be responsible for completing the design and begin

production on a pilot line production. Therefore, the contractor Manufacturing Management System should be assessed, and the M&Q strategies and Plans updated. This includes an assessment of the contractor, and their supply chain for adequacy and alignment of manufacturing with the program Acquisition Strategy (AS). A well-structured manufacturing management system requires effective implementation of industry best practices to include management and mitigation of risks, issues, and opportunities. Assessment of the contractor's manufacturing management system should be performed against the recognized industry best practice (i.e., AS6500).

Contractor implementation of best practices should include processes and procedures for supply chain Management. This includes supply chain communications, risks and issues identification and mitigation, KCs control and management, management, control, and monitoring of Technical Performance Measures (and consequently Key Performance Parameters (KPPs), Key System Attributes (KSAs)), process control plans, cyber threat protection measures and manufacturing control systems, security, etc. Results of all these assessments are the basis for maintaining the currency of the program Manufacturing Strategy and Plans.

At CDR, the initial product baseline and documentation is transferred to the program for configuration control. This should include all drawings and specifications with tolerances and test points, all KCs, CSIs, and CAIs specifications, and may include process control plans, work instructions, etc. (i.e., the Technical Data Package (TDP)) to be incorporated in the Manufacturing Strategy and Plans. These should be sufficient, complete, and adequate to enable manufacture of all components and hardware with embedded software throughout the supply chain on a pilot line.

The contractor-designated pilot lines should be assessed for production realism and affordability in production of the system, subsystem, items, and components. Verification and validation of contractor and supply chain manufacturing plans, processes, and procedures should be analyzed during the demonstrations. Based upon these demonstrations and assessments, the Manufacturing Strategy and Plan should be updated, and the TDP should be finalized for LRIP.

The EMD phase ends when the design is stable, the system meets validated capability requirements demonstrated by developmental and initial operational testing as required in the TEMP, manufacturing processes have been effectively demonstrated and are under control, software sustainment processes are in place and functioning, industrial production capabilities are reasonably available, and the system has met or exceeds all directed EMD phase exit criteria and Milestone C entrance criteria.

A. DOD ACQUISITION SYSTEM

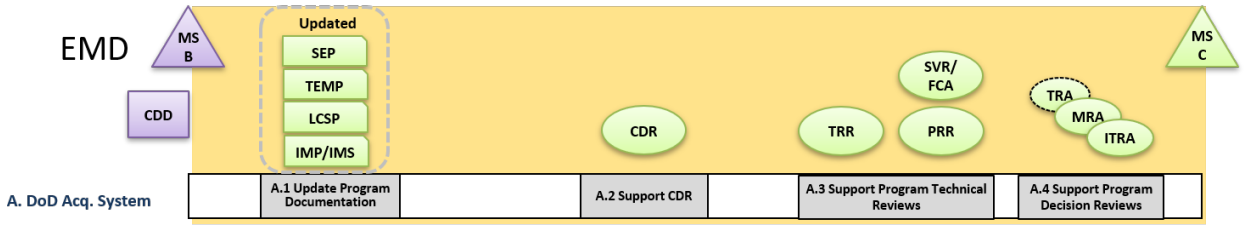


Figure 4-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

The acquisition process includes a series of processes, milestones (five phases), and reviews to determine whether a program will proceed into the next phase. MDAPs and major systems with production requirements should address industrial and manufacturing readiness in the Acquisition Strategy, during milestone reviews, and in various program documentation.

The EMD phase objective is to design, develop, and demonstrate on a pilot line a product capable of meeting system performance requirements within cost and schedule constraints. To complete all hardware and software detailed designs, mitigation and closure of open risks and issues, and building and testing of products and first articles, and verifying compliance with requirements, necessitates complete and thorough planning and documentation updates to the Acquisition Strategy, containing the M&Q Strategies, the Systems Engineering Plan (SEP), the TEMP, and plans for program reviews and pilot line demonstrations.

The EMD Acquisition Strategy should document the strategy for completing and verifying the system design and assessing the manufacturing and industrial base readiness. During EMD, industrial and manufacturing readiness should be assessed to include the effective demonstration of manufacturing processes in an appropriate environment, such as a pilot line environment, prior to Milestone C. The pilot line should incorporate key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in low-rate production, using the documented rate production processes planned to be used in LRIP. The Acquisition Strategy should describe the EMD phase plans to assess and demonstrate that manufacturing processes and/or capabilities have matured to a level of high confidence required for production products in the P&D phase.

EMD execution also requires appropriate planning updates in the SEP for all key program events. These reviews include the CDR, the Test Readiness Review (TRR), and after pilot line, the SVR/ FCA, and the end-of-phase Production Readiness Review (PRR) in preparation for transition to LRIP and the Milestone C Decision.

M&Q considerations should be important criteria at each decision point of the system life cycle, and manufacturing criteria used to ensure that a M&Q capabilities exist or will exist when required to produce the system. This capability includes the industrial base, factory, workers, processes, material, sub-contractors, etc. that will be required to produce the system at rate and quality standards necessary

to deliver the required capability. During early EMD phase, the producibility of the design and M&Q risks and issues are assessed and mitigated to support finalizing the design culminating in a CDR, which establishes the initial product baseline and transfers configuration control to the program.

M&Q should be a key contributor and participant in all technical reviews, providing documented inputs and recommendations based on results from assessments, analyses, and demonstrations. Post-CDR, the major technical reviews commonly conducted during EMD include the following:

- Test Readiness Review (TRR)
- Human Rating Certification, Flight Readiness Review (FRR), etc.
- System Verification Review (SVR)
- Functional Configuration Audit (FCA)
- Physical Configuration Audit (PCA)
- Production Readiness Review (PRR)
- Manufacturing Readiness Assessment (MRA)
- Independent Technical Risk Assessment (ITRA)

During the post-CDR phase leading up to the Milestone C Decision, the contractor should demonstrate manufacturing of the system on a pilot line. While TRR, certification reviews, SVR/FCA occur sequentially, pilot line can occur simultaneously with any of these reviews, but all should be complete prior to PRR. In addition to these reviews, M&Q should support and participate in both an MRL assessment of the system using MRL 8 criteria (the target for Milestone C) and a PRR to support Milestone C.

Based on post-CDR, pilot line, and PRR assessment results, M&Q should also provide inputs on the myriad of statutory and regulatory program required updates per DoDI 5000.02 by Milestone C. These include the Acquisition Strategy (e.g., contracting strategy, industrial base considerations, intellectual property (IP) considerations; risk, issue, and opportunity management approach, etc.), the Acquisition Program Baseline, the Cost Analysis Requirements Description (CARD), the Program Protection Plan (PPP), the SEP, etc.

Based on the effective demonstrations of manufacturing processes conducted on the pilot line, M&Q should support and participate in the program's decision processes on acceptability of manufacturing and producibility risks, supplier qualifications, and verification of manufacturing processes under statistical process control required for a Milestone C decision.

Another important review that should be conducted is an Independent Technical Risk Assessment (ITRA). 10 USC Section 2448b requires that ITRAs be conducted in support of milestone and production decisions for Major Defense Acquisition Programs (MDAPs). ITRAs will be conducted for all MDAPs prior to Milestone A, Milestone B, and Milestone C approval and prior to a FRP decision.

In general, technical risks are those events or conditions typically emanating from areas such as mission/requirements, technology, engineering, integration, test, software, manufacturing/quality, logistics, and system security/cybersecurity that may prevent a program from meeting cost, schedule, and/or performance objectives.

ITRAs will leverage ongoing program activities whenever practical, e.g., Technology Readiness Assessments (TRAs), Manufacturing Readiness Assessments (MRAs), and Systems Engineering Technical Reviews. These assessments and activities will inform the ITRA; however, the team will provide an independent assessment of any risks or maturity concerns identified. As such, there may not be a direct correlation between external assessments or measures, such as technology readiness levels, and the ITRA team's assessment.

A.1 Provide Updates to Program Documentation

M&Q personnel should be actively engaged in the development and update of numerous documents to include:

- **Acquisition Strategy (AS)**
  - Manufacturing Strategy
  - Quality Strategy
- **Systems Engineering Plan (SEP)**
  - Manufacturing Plan
  - Quality Plan
- Test and Engineering Master Plan (TEMP)
- Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
- Life Cycle Sustainment Plan (LCSP)
- Capabilities Development Document (updated-CDD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)

In accordance with DoDI 5000.02, programs shall develop a SEP for Milestone Decision Authority (MDA) approval in conjunction with each Milestone review and integrated with the Acquisition Strategy. This plan should describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It should also detail the timing, conduct, and success criteria of technical reviews.

Manufacturing and Quality Tasks

- Provide inputs and updates to the Acquisition Strategy (AS) based on results, action items, and resolutions pertaining to M&Q requirements, risks, issues, and opportunities from the PDR, CDR, pilot line, and PRR, (i.e., throughout EMD), to address technical progress and management strategy for:
    - Competition and contracting strategies
    - Program manufacturing priorities, allocations, and allotments, and justifications (Defense Priorities and Allocation System (DPAS) code)
    - Management of manufacturing, quality, supply chain, etc.
    - Design feasibility, producibility, KCs, critical characteristics, etc.
    - Implementation of new manufacturing technologies
    - Demonstrations of manufacturing processes in the appropriate environment prior to Milestone C
    - Application of Modular Open Systems Approach (MOSA)
    - Management of IP rights (including deliverables and associated license rights over the entire product life cycle)
    - Management of Materials (characteristics, sourcing, risks, etc.)
    - Manufacturing cyber threat protection measures (*See* L.2)
    - M&Q inputs Life-Cycle Sustainment Plan
    - M&Q process, rates, and quantities (capabilities, control, risks, etc.) (*See* H.1)
    - Facilities, Tooling, and Workforce (including government-furnished equipment (GFE)/government-furnished information (GFI), special test equipment (STE)/special inspection equipment (SIE), special requirements, etc.)
- Develop and provide detailed M&Q requirements and metrics in the Manufacturing Strategy and Plan and the Quality Strategy and Plan (for potential inclusion in appropriate program documentation and management reviews) for:
    - Manufacturing maturity and progress against M&Q goals required for each technical review (PDRs, CDRs, and at other appropriate reviews)
    - Production quantities per year and the total planned production quantity
    - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Environmental Safety and Health (ESOH) (Human safety and health)
    - HAZMAT management and pollution prevention
    - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
    - Security (physical and cyber) for both hardware and software
    - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
    - Manufacturing supportability and sustainment

  - Management of commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and government-furnished equipment (GFE) (including diminishing manufacturing sources)
  - Management of parts, materials, and processes (PM&P)

- Update the Manufacturing Strategy and Plan and the Quality Strategy and Plan to address the sustainment of industrial base capabilities (including manufacturing technologies and capabilities) and the maturation required during the EMD and subsequent phases.
  - Include M&Q inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystems, item, and component levels
  - Include M&Q inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
    - Domestic alternatives through regeneration of prior capability
    - Creation of new capability for manufacturing products and processes
    - Lifetime buy of items at the subsystems, and component levels
  - Include M&Q inputs on Diminishing Manufacturing Sources and Material Shortages (DMSMS)
  - Maintain a watch-list of critical items, parts, and components and their sources through a Critical Capabilities List (CCL)

- Provide M&Q industrial base (IB) capability analyses update for the AS (per DoDI 5000.02) and the RFP to include inputs on:
  - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical processes, parts, components, etc.)
  - Capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Impacts and interdependencies of the program on the NTIB and the analyses used to make this determination including management and future assessments
  - Government strategy and actions necessary to preserve the IB capabilities (e.g., incentivizing the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)

- Maintain M&Q inputs to Manufacturing Strategy and Plan and the Quality Strategy and Plan on ManTech and/or contractor manufacturing technology project implementation and status for high-risk manufacturing capabilities and processes (*See* D.2)
  - Include M&Q risks, issues, and opportunities
  - Include plans for insertion of the new manufacturing capability

- Provide and maintain updated M&Q inputs and plans to the IMP/IMS including:

  - Schedule for any planned use of government-furnished special test equipment, government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.)
  - Schedule impacts from the requirements for special materials and allotments with justification
  - M&Q internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
  - Inputs on reviews including the sub-tier level (including CDR, PRR, etc.), documentation inputs (e.g., CDD, TEMP, AS, SEP, CDR, PRR, etc.), production events, and deliveries

- Update the government Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan for EMD to include (*See* I.1 and L.1 for assessment of contractor and I.2 and L.2 for update considerations):
  - Updates to M&Q requirements
  - Definition and agreement on requirements for manufacturing environments pilot line, LRIP, and FRP
  - Up-to-date TDP
  - M&Q resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to M&Q organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
  - Changes to M&Q support organization required to meet program projected needs for P&D and subsequent phases including:
    - Earned Value Management requirements
    - Cost control requirements
    - Data collection, reporting, and management

- Update the M&Q requirements for the P&D contractor's Manufacturing Management System (MMS) and QMS to be included in the Acquisition Strategy and the RFP.
  - Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - If M&Q standards are not specified, develop alternative requirements for program specific manufacturing management plan and quality management plan.
  - Identify M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle

- Ensure a joint M&Q comprehensive Risk, Issue, and Opportunity Management System that can identify, and tracking risks and associated mitigation plans is in place.

  - Ensure requirements are up-to-date and maintained for identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program
  - Analyze mitigation plans for adequacy and completeness, and potential impacts on EMD and subsequent phases to include:
    - Industry being unable to provide program design and/or manufacturing capabilities at planned cost and schedule
    - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
    - Required maturation of critical technologies and manufacturing processes to the appropriate level
    - M&Q cost and schedule impacts

- Ensure other agencies are providing inputs on strategies (e.g., DCMA, DLA, etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.
- Provide, update, and maintain M&Q inputs to the SEP and Test Engineering Master Plan (TEMP) to address technical progress and strategy including the following:
  - M&Q updates on KCs, critical characteristics, and Technical Performance Measures, and the associated impacts on KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Updates on significant activities to the EMD program schedule including:
    - Risk and issue mitigations
    - Manufacturing assessments
    - Critical Design Reviews (including supply chain)
    - Long-lead or advanced procurements
    - Prototype builds and demonstrations
    - Projected lots or phases
    - Production Readiness Reviews
    - Independent reviews and audits
    - Changes or impacts to the workforce (i.e., strikes), supply chain (i.e., disruptions)
    - Environmental impacts (e.g., floods, fires, earthquakes, etc.)
  - Updated outputs and status from the joint Risk, Issue, and Opportunity Management System and mitigations.
  - Updated M&Q inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
    - Compliance with DFARS, PPP, ITAR, etc.

    - Management of Controlled Unclassified Information
    - Technical approaches to cybersecurity and related M&Q security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
  - Application of up-to-date industry best practices for manufacturing to include:
    - Manufacturing Management System
    - Design for Manufacturing
    - Manufacturing Risk Identification (including mitigation)
    - Manufacturing Planning
    - Manufacturing Operations Management
  - Up-to-date inputs on the M&Q organization, billets and key assignments including:
    - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
  - Up-to-date M&Q planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
  - Up to date M&Q inputs to the configuration managed IMP/IMS including critical path
  - Requirements for manufacturing environments (e.g., pilot line, LRIP, FRP)
  - Requirements for the TDP (including IP)
- Provide M&Q requirements for sustainment (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.) and sustainment processes and activities for the LCSP.

Tools

- Acquisition Strategy Outline
- AS6500 Manufacturing Management System Checklist
- AS9100 Quality Management System Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Integrated Master Plan/Integrated Master Schedule use MS Project
- Interactive MRL Users Guide (Checklist)
- ISO 9001 Quality Management System Checklist
- Life Cycle Sustainment Plan Outline
- Manufacturing Maturation Plan
- Risk Management Plan Template
- SEP Outline
- Technology Readiness Level (TRL) Assessment Checklist
  - Manufacturing Maturation Plan
  - Quality Assurance Plan

- Test and Evaluation Master Plan (TEMP) Outline

Resources

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems
- CDD-CPD Writing Guide
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities
- DoDI 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288, System and Software Engineering
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- ISO 9001:2015, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK Manufacturing Management Program Guide
- Risk, Issue, and Opportunity Management Guide for Defense Programs
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment (TRA) Deskbook
- Test and Evaluation Management Guide

A.2 Support Critical Design Review

M&Q personnel should be actively engaged in the organization and execution of the CDR during this phase. The CDR occurs roughly mid-point in the EMD phase. The CDR brings to closure design paths in detailed design. Any changes moving forward should only be accomplished through a formal Engineering Change Proposal (ECP). The completion of the CDR should provide:

- An established system initial product baseline
- An updated risk assessment for EMD
- An updated CARD based on the system product baseline
- An updated development schedule for fabrication, test and evaluation, software coding critical path drivers
- An approved Life Cycle Sustainment Plan

Manufacturing and Quality Tasks

- Ensure the program's Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan are updated for CDR.
    - Include program M&Q staffing, training, and certifications
    - Include an update to program M&Q processes and metrics
    - Ensure draft certification plans have been developed and cover all required system certifications (e.g., Flight Operations/Safety, Human Rating, etc.)
- Support an MRL assessment of the system using MRL 7 criteria as the target for CDR.
    - Assess and validate all threads including M&Q materials, facilities, tooling, etc.
- Ensure system baseline documentation for M&Q is under configuration control, and is sufficient, complete, and adequate to enable component manufacturing, hardware fabrication and software implementation to proceed.
    - Ensure all subsystem, item, and components are included in the system baseline
    - Ensure all KCs, CSIs, and CAIs have complete drawings and specifications under configuration control
    - Ensure all product data essential (e.g., drawings, specifications, interfaces, etc.) for component manufacturing has been released
- Ensure all M&Q inputs to the AS and the SEP are up to date for CDR (*See* A.1).
- Ensure all subsystem, item, and component CDRs are complete, under configuration control, and the results available for the system CDR.
    - Ensure all design maturity assessments are closed and approved for system CDR
    - Include all appropriate subsystem, item, and component reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.)
    - Include all system, subsystem, item, and component interfaces (internal and external)
- Ensure all M&Q trade studies and producibility assessments are complete and are incorporated into the system for CDR.
    - Include ongoing producibility enhancement efforts
- Ensure M&Q input to the schedule (IMP/IMS) and the associated critical path is up-to-date and is executable with acceptable risks.
    - Includes supply chain
    - Includes integration and test
- Ensure all key and critical manufacturing processes, including process control plans and metrics, have been defined, characterized, updated for the detailed design, and the capability to meet design tolerances and are tracked.
- Ensure M&Q data management system addresses:

  - Communications and availability
  - Data collection, capacity, processing, storage, and control
  - Security (physical and cyber), information security and access

- Analyze plans for make/buy and long-lead procurement requirements and incorporate results into procurement plans.
- Analyze the assessments of adequacy and completeness of M&Q requirements validation activities (*See* E.6):
  - Include prototypes and demonstrations in a representative environment at the system level for design maturity
  - Ensure all CSIs and/or CAIs are traceable to key and critical M&Q processes
  - Include demonstrations of manufacturing processes in appropriate environments for the required level of maturity (e.g., subsystem, item, and component)
  - Ensure all identified KCs, CSIs, and CAIs are incorporated into the Verification Cross-Reference Matrix (VCRM) for required testing and verification
- Ensure traceability of M&Q KCs to Critical Manufacturing Processes (CMP) to Technical Performance Measures (TPM) to allocated baseline requirements up to KPPs and KSAs.
- Support design reviews at all levels of the supply chain, assess adequacy and completeness of M&Q requirements verification and validation activities for system CDR including:
  - Producibility (subsystem, item, and component)
  - Product maturity
  - Technology maturity
  - Interoperability, interdependencies, and interfaces (internal and external)
  - Alternate sources to include availability and maturity
  - Systems Integration (HSI) and User interfaces
  - Environmental, Safety, and Occupational Health (ESOH)
  - HAZMAT management and pollution prevention processes
  - Modular Open Systems Architecture (MOSA)
  - Commercial, Off-The-Shelf (COTS)
  - Non-Developmental Item (NDI)
  - Government-Furnished Equipment (GFE)
- Provide M&Q inputs to the Life Cycle Sustainment Plan for CDR.
- Ensure contractor M&Q management systems for M&Q metrics and data collection and tracking to the component level are in place and functional.
- Ensure M&Q inputs to DT&E processes and assessments are complete and up to date for CDR.
  - Including environments (e.g., thermal, vibrations, shock, and accelerated life testing, etc.)
  - Include required traceability

- Ensure M&Q plans support of OT&E requirements for data and traceability at CDR.
- Ensure the TEMP incorporates all M&Q subsystems, items, and components into plans for tests, test facilities, and test equipment.
    - Include all identified KCs, CSIs, and CAIs are incorporated into the required testing and verification plans
        - Include M&Q impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
    - Include planned significant activities from the up to date EMD program schedule (e.g., manufacturing assessments, long-lead or advanced procurements, prototype demonstrations, projected lots, or phases, PRRs, etc.)
    - Include up-to-date inputs to the joint Risk, Issue, and Opportunity Management System including industrial base, manufacturing, quality, engineering, software (firmware), and risk reduction and/or mitigation efforts
    - Updated planning for M&Q tests, assessments, and verification and validation activities to be conducted, facilities and test equipment to be used, metrics to be tracked, progress against goals, thresholds, and objectives, etc.
- Assess and validate contractor M&Q plans for pilot line requirements.
    - Include materials, facilities, workforce, equipment, test facilities and equipment, tooling, etc.
    - Include EMI control processes and procedures
- Ensure the M&Q considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - Systems Security Engineering (SSE), Communications Security (COMSEC), cybersecurity, and PPP
    - SEMP
    - TEMP
- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure M&Q design producibility improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (*See* E.4).
- Ensure M&Q plans, activities, and processes are executable within the existing M&Q budget to support the approved product baseline and critical path.

- Provide up to date M&Q inputs to the program budget and the CARD.
    - Update and allocate M&Q (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure M&Q cost data including required production costs and production schedule estimates (*See* F.1) are provide for all cost and budget estimates for CDR.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) for M&Q risks, issues, and opportunities and appropriate mitigation plans.
- Ensure adequacy and completeness of mitigation activities for mitigation of M&Q risks, issues, and opportunities in the joint government/ contractor Risk, Issue, and Opportunity (RIO) Management System, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and HAZMAT management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment
- Analyze M&Q plans for adequacy and capability of achieving MRL 8 by initial production.

Tools

- Critical Design Review (CDR) Checklist
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1521B, Jun 1985 (retired)
- NDAA FY 2017 (Public Law 114-328)

A.3 Support Program Technical Reviews

M&Q personnel should be actively engaged in the organization and execution of numerous formal reviews and audits during this phase to include:

- Critical Design Review (CDR)
- Test Readiness Review (TRR)
- System Verification Review (SVR)
- Functional Configuration Audit (FCA)
- Physical Configuration Audit (PCA)
- Production Readiness Review (PRR)
- Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)
- Independent Logistics Assessment (ILA)

Program offices could request an informal review at any time and M&Q managers need to be prepared to support such reviews.

Sources of data used to assess and manage industrial and manufacturing readiness include: technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Manufacturing Readiness Assessments, Industrial Capabilities Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

Manufacturing and Quality Tasks

- Provide M&Q support and inputs to the Test Readiness Review to include:
    - SEP review and recommendations
    - TEMP review and approval process
    - Need for verification and validation of M&Q requirements for Critical Manufacturing Processes (CMP) (and therefore KCs)

  - Results of changes in M&Q processes (flowing from design changes since CDR, other than CMPs) impacting testing requirements and events
  - Requirements for M&Q configuration management of system, subsystem, item, and components (hardware and software) to be tested
  - Status of system, subsystem, item, and components manufacturing process maturity including:
    - Certification processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Process capability indices (C_{pk}) on demonstrated processes
  - Requirements for process capabilities (target $C_{pk)}$
  - Status of established bi-directional traceability (M&Q TPMs to CMPs to KCs
  - Definition of M&Q development test environments used (e.g., thermal, vibrations, shock, and accelerated life testing, etc.)
  - Requirements for M&Q security (physical, cyber, and industrial)
  - Processes, procedures, and documentation of the Failure Reporting, Analysis, and Corrective Action System (FRACAS)
  - Verification that system, subsystem, item, and component parts are produced to approved specifications
  - Direct support of quality personnel to test execution
- Participate in and support the SVR, including:
  - Provide verification that all M&Q CDR action items have been closed and any corrective actions have been successfully completed
  - Provide M&Q inputs on:
    - Verification of requirements from all system, subsystem, item, and component M&Q test data and analyses
    - Verification of performance to the function baseline based on M&Q data
    - Verification through analysis of M&Q data the adequate management and integrity of all critical program information (CPI) (e.g., performance data, yield, and rate data, etc.)
    - Verification that M&Q risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
    - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available M&Q test data, analysis, and inspection
    - Required “certification” activities (e.g., human rating, flight, space, etc.)
    - Analyses of support and maintenance requirements for incorporation into the LCSP
    - Risks of operational test failures during Initial Operational Test and Evaluation (IOT&E)

  - Provide M&Q inputs to:
    - Ensure adequate M&Q processes and metrics are in place
    - Analysis of contractor' s SEMP for appropriate incorporation of M&Q activities and data collection, analysis, and storage
    - Detailed M&Q planning and schedules (with required resources for proceeding into LRIP and IOT&E)
    - Updates of the SEP and contractor's SEMP for the production and deployment (P&D) phase
    - The CARD for up-to-date cost of quality inputs
    - The LCSP (is up to date)
    - The TEMP (i.e., up to date)
    - The Configuration Management Plan (CMP) (s up to date)
- Provide M&Q inputs and support of the FCA to include:
  - Support to program and the contractor agreements that development is complete and data from development tests (DT), analyses, and simulations are sufficient to achieve performance goals
  - M&Q inputs for:
    - Verification of M&Q performance to the baseline
    - Verification traceability documentation for each M&Q requirement
    - Validity and the completeness of embedded software and integration
  - M&Q verification of all approved engineering change proposals (ECP), requests for deviation, and requests for waiver impacting M&Q
  - Verification that all KCs, CSIs, and CAIs are identified, managed, and included in the Verification Cross-Reference Matrix (VCRM)
  - Ensure M&Q provides support to verification activities and tasks to include:
    - Each requirement listed in the VCRM is traceable and is verified with test data, analysis, and/or inspection
    - Demonstration of M&Q processes to provide the capability to satisfy TPMs, KPPs and KSAs thresholds
    - Review of acceptance test reports and deficiencies with root cause and closed corrective actions
    - Certification activities (e.g., human rating, flight/safety, etc.)
- Provide M&Q support and inputs to all Production Readiness Reviews (PRR) in accordance with industry best practices (e.g.., AS6500, AS9100, etc.) on a pilot line to include:
  - All M&Q processes including continuous improvement efforts
  - Manufacturing surveillance and quality data collection and analyses (including supply chain data for items and components)

  - Physical and functional interfaces
  - All work instructions, sequencing, and procedures
  - Process capabilities and process control plans
  - Production scheduling and control
  - Model and Simulations
  - Materials
  - Workforce capabilities
  - Manufacturing technology implementations
  - Tooling, work holding fixtures, jigs, etc.
  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
  - Facilities, transportation, storage, and handling equipment
  - Interdependencies (not all will be validated on the pilot line)
  - Safety processes, procedures, and compliance
  - ESOH processes, procedures, and compliance
  - Security processes, procedures, capabilities, and compliance
  - Risk and issue mitigation results and adequacy of resolution
  - M&Q costs, schedule, performance
  - Materials sources and selections
  - Integration of embedded software

- Provide for PRR results and recommendations of M&Q assessments of industrial base capability and support, conducted for CDR and pilot line demonstrations, for changes in:
  - Sources and alternatives
  - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
  - Vulnerabilities (supply chain)
    - Sole, single, foreign, etc.
    - Military
    - Counterfeit
    - Potential exploitation
    - Fragility and uncertainty of demand
  - Production capability and capacity
  - Security requirements (physical, cyber, and industrial)
  - Availability (e.g., materials, components, equipment, facilities, etc.)
  - Required COTS and NDIs
  - External dependencies
  - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
  - Required government and/or contractor Depot and Maintenance and Repair Operations

- Provide for PRR results and recommendations of M&Q assessments of outputs from the pilot line for adequacy and completeness and validate:
  - Process control plans, including key and critical processes
  - All Production Process Verifications (PPV) performed
  - Attainability of KCs (will be capable and under process control for LRIP)
  - Variability Reduction including updates based on process improvements
  - All FAIs and FATs against specifications, drawings, models, etc.
  - Design changes and process changes identified during pilot line operations, testing, and qualification
  - Certification processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
- Provide M&Q support and inputs to the Critical Design Review (CDR).
- Provide M&Q support and inputs to Manufacturing Readiness Assessments (MRAs).
- Provide M&Q support and inputs to Technology Readiness Assessments (TRAs).
- Provide M&Q support and inputs to Independent Technical Risk Assessments (ITRAs).

Tools

- Acquisition Strategy Outline
- Army Acquisition Logistician's Assessment Checklist v.5
- Critical Design Review (CDR) Checklist
- Functional Configuration Audit (FCA) Checklist
- Physical Configuration Audit (PCA) Checklist
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Production Readiness Review (PRR) Checklist
- System Verification Review (SVR) Checklist
- Technology Readiness Assessment (TRA) Checklist
- Technology Readiness Assessment Calculator
- Test Readiness Review (TRR) Checklist

Resources

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- CDD-CPD Writing Guide

- Defense Manufacturing Management Guide for Program Managers, Chapter 3.7.4 Technical Reviews, and Chapter 12.5 Technical Reviews and Audits
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89 Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Independent Logistics Assessment Guidebook
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- ISO 9001:2015, Quality Management System
- Logistics Assessment Guidebook Tool
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide
- TRA Deskbook

A.4 Support Program Management Decision Reviews

M&Q managers should support the Milestone C decision by providing insight into various M&Q considerations. The goal of Milestone C is to determine if a program has met all its Exit Criteria and can move into Low-Rate Initial Production. M&Q managers need to assess risks to ensure that there are no significant manufacturing risks, that industrial production capabilities are reasonably available, assess the maturity of critical manufacturing processes to ensure that they are affordable and executable, and ensure the manufacturing and producibility risks are acceptable, supplier qualifications are completed, and applicable manufacturing processes are under statistical process control.

Manufacturing and Quality Tasks

- Support an MRL assessment of the system using MRL 8 criteria as the target for the Milestone C decision.
    - Capture the results of M&Q processes, demonstrated on a pilot line, as inputs
    - Verify and validate attainability of KCs (i.e., will be capable and under process control for LRIP) including yields and rates
    - Incorporate results of the required Technology Readiness Assessment

  - Incorporate industrial base viability
  - Verify and validate producibility issues, design stability, and configuration management
  - Verify and validate all LRIP M&Q requirements (e.g., materials, supply chain, workforce, facilities, tooling, manufacturing planning and management, etc.)

- Assess the contractor-designated pilot lines for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:
  - Manufacturing readiness for manufacture of equipment
  - Materials, components, and tooling availability
  - Adequacy of M&Q workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
  - Capability to meet M&Q requirements for LRIP
  - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
  - Capability and capacity to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule
- Provide M&Q inputs and updates, for the Milestone C Decision following post-CDR, pilot line, and PRR assessment results (per DoDI 5000.02) to:
  - The Acquisition Strategy
    - Acquisition Approach
    - Benefit Analysis and Determination (required if no Milestone B decision)
    - Business Strategy
    - Contracting Strategy (type and termination liability)
    - Cooperative Opportunities (if necessary)
    - General Equipment Valuation
    - Industrial Base Considerations
    - Intellectual Property (IP) Considerations
    - Modular Open Systems Approach
    - Multiyear Procurement
    - Risk, Issue, and Opportunity Management Approach
    - Small Business Innovation Research/Small Business Technology Transfer
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives (regulatory)
  - Bandwidth Requirements Review
  - Capability Production Document
  - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
  - Exit Criteria

  - Item Unique Identification Implementation Plan
  - Life-Cycle Sustainment Plan (LCSP)
  - Programmatic Environmental Safety and Occupational Health Evaluation (PESHE)and National Environmental Policy Act (NEPA) compliance Schedule
  - Preservation and Storage of Unique Tooling Plan
  - Program Protection Plan (PPP)
  - Request for Proposal (RFP)
  - Should Cost Target
  - Spectrum Supportability Risk Assessment
  - Systems Engineering Plan (SEP)
  - Technology Readiness Assessment (TRA)
  - Test and Evaluation Master Plan (TEMP)
  - Validated On-line Life-cycle Threat (VOLT) Report
- Provide M&Q inputs, updates, and proposed changes for the proposed Production and Deployment (i.e., LRIP) contract, based on post-CDR, pilot line, and PRR assessment results.
- M&Q personnel provide support for the Program Manager's decision process for acceptability of manufacturing and producibility risks, supplier qualifications, and verification of manufacturing processes under statistical process control.
- M&Q personnel provide support for the Program Manager's modular approach to product design and IP.
- M&Q personnel provide verification and validation of adequacy and completeness of TDP (to include management of IP) for Production and Deployment
- M&Q personnel provide support to the corrosion prevention and control process to reduce, control, or mitigate corrosion in sustainment.
- M&Q personnel provide input to the Program Managers for assessment of ESOH risks and acceptance decisions.
- M&Q personnel provide updates to M&Q exit criteria metrics for EMD.
  - Update the M&Q personnel support plan for an assessment of manufacturing readiness and the mandated independent assessment
- Provide M&Q personnel updates to the joint Risk, Issue, and Opportunity Management System for the Milestone C decision.

Tools

- Acquisition Decision Memorandum (ADM) Milestone C Template
- Integrated Master Plan/Schedule
- Interactive MRL Users Guide (Checklist)
- Life Cycle Sustainment Plan
- Manufacturing Maturation Plan
- Market Research using Pugh Template

- MDD ADM Template, Air Force, no date
- Technology Readiness Assessment (Checklist)
- Test and Evaluation Master Plan (TEMP)
- Transition to Production Assessment

Resources

- DoD 4245.7-M, Transition from Development to Production
- DoDI 5000.02, Operation of the Defense Acquisition System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook

B. DEFENSE CONTRACTING SYSTEM

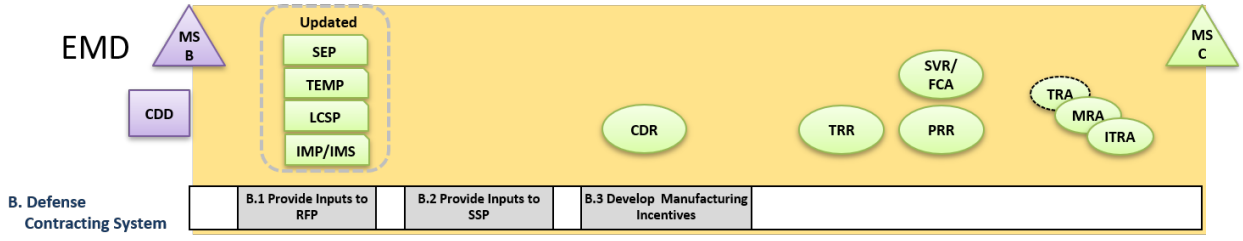


Figure 4-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

DoD contracting requirements and activities are required by various statutory and regulatory requirements to include the FAR/DFAR and by many DoD, Service and agency regulations, policies, and guidance documents.

The contract is the vehicle used to establish the formal relationship between the government and a prime contractor. Government business processes include the business strategy or acquisition strategy, contracting approach, contracting strategies, contract language, and financial strategies. M&Q personnel often are called upon to support various contracting functions and activities.

This thread (Defense Contracting System) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Market Research
- Contract Strategy

- Source Selection Plan
- Request for Proposal
- M&Q Inputs to the Contract (Section C, E, L and M) (refer to MIL-HDBK-245E)
- Contract Evaluation and Award

During the latter part of the EMD phase an essential program activity is to prepare the Request for Proposal (RFP) for the milestone C decision and entrance to the P&D phase. This RFP will delineate what is required from the contractor to produce and deliver requirements compliant products to receiving military organizations. A cohesive effort between all program functional areas and Contracts is essential to managing and completing the steps in this phase of the contracting process.

Prior to RFP development, Market Research is a pre-solicitation activity that involves the identification of the Market or Market of Interest, the sources of market information, the collection of market information, and the evaluation of the market's ability to satisfy the user needs. M&Q personnel need to support market research to identify suppliers and evaluate potential sources and opportunities to assess the risks associated with these opportunities. ,

An RFP is a formal negotiated solicitation resulting in a contract that includes the contract form, contract clauses, work statements, specifications, the delivery schedule, and payment terms. The contract's primary function is technical with the administrative function secondary. The RFP must contain clear and sufficient technical guidance, so the contractor has a definite picture of how the system is envisioned to perform once delivered. It is also important that a technical functional description of hardware requirements is included and that those requirements are clearly defined and scoped. Inconsistencies, insufficient detail, and inappropriate requirements in the RFP will result in an inadequate response from industry. From a M&Q perspective, the RFP should include, at a minimum:

- Manufacturing Management and Control (best practices)
- Design Development and Demonstration
- Quality Management and Systems (best practices)
- M&Q Costs
- Industrial Base
- Process Control and Capability (best practices)
- Materials, Workforce, Facilities, and Tooling
- Risk, Issues, and Opportunity Management

The RFP should specify the requirements for best practices for the contractor's Manufacturing Management System (MMS) and QMS and what quality level contract requirement should be met per FAR 52.246-11 (e.g., ISO 9000, AS9100, etc.). M&Q should ensure that the RFP includes specific requirements for the integration of producibility into the design process.

During each stage of development, an organized and systematic pattern of events must take place if a design is to fully meet all its objectives. Implicit in these objectives is the requirement that a design

achieve the highest possible degree of producibility. The requirements for the contractor to identify and describe in detail in the RFP their proposed specific processes and procedures, methods, and actions to address manufacturing, producibility, and quality risks and issues associated with the proposed system should also be included.

M&Q inputs provided to the RFP development process should be used in development of the Source Selection Plan (SSP) and the Statement of Work (SOW) to ensure availability of the necessary disciplines from the contractor. This includes general and specific requirements for developing data packages, designing special purpose production equipment, and performing computer modeling or simulation of the manufacturing process.

Based on the SSP, proposal evaluation is an assessment of the proposal and the offeror's ability to perform the prospective contract successfully. The SSP evaluations generally include one or more of the following evaluations:

- Cost and/or Price
- Past performance
- Producibility
- Technical and Quality processes
- M&Q capabilities
- M&Q risks, issues, and opportunities
- Application of best practices for the MMS and QMS

SSP should delineate and include metrics and scoring for the above including preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, and quality associated with the proposed system. Additionally, the SSP should include accommodation and support of on-site government Quality personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA).

The proposal evaluation criteria must be clearly identified and defined in the RFP and applied in the SSP. Proposal evaluations must be conducted so the government can select the proposal providing the best value to the government.

Management tools such as award fees and incentive fees can provide increased interaction of program and contractor M&Q management and provide the program with increased visibility into the contractor’s best practices for manufacturing, quality, and supply chain processes and procedures. award fees in the contract should be based on contractor performance to industry M&Q best practices and program goals and objectives, rewarding specific accomplishments such as:

- Producibility improvements
- Materials characterization in production relevant environment
- Manufacturing cost reduction efforts

- Manufacturing maturation plan risks burned down
- Variation and variability reduction
- Manufacturing process definition and characterization
- Progress in achieving the targeted MRL
- Progress in maturation and demonstration of KCs (i.e., meeting KPPs/KSAs)
- Progress in achieving specific yield and rate goals
- Progress in meeting the EMD exit criteria

Incentive fees in the contract should be consistent with the Acquisition Strategy (AS) and tied to goals for exceeding contract requirements and program expectations. M&Q incentives in contracts should be designed to obtain specific M&Q objectives by establishing reasonable and attainable criteria that can meet the goals or targets. These criteria must be clearly communicated to the contractor; and include appropriate incentive arrangements that will motivate contractor efforts that might not otherwise be emphasized and discourage contractor inefficiency and waste.

Important M&Q management goals and expectations to be exceeded in contract incentives include:

- Cost (e.g., Cost reductions, Should Costs, Life Cycle Costs)
- Schedule (e.g., expedited development or delivery, early delivery, on-time delivery, etc.)
- Technical (e.g., quality, cycle-time reduction, product improvement, etc.)
- Management commitment
- Producibility processes
- Risk, Issue, and Opportunity Management processes
- Commercial best practices

Contractual incentives assist both government and contractor in understanding of program progress and expedites resolution of M&Q issues. This interaction can serve as a forcing function for the top contractor design personnel to communicate and coordinate decisions with their own manufacturing personnel.

B.1 Provide Input to Request for Proposal

The Request for Proposal (RFP) is an opportunity to communicate to the contractor the government's requirements for a specific proposal. The RFP should identify the information required in the contractor's proposal and the criteria that will be used to evaluate the proposal and the relative importance of those criteria. M&Q managers typically support the development of the Request for Proposal by identifying M&Q considerations and criteria for inclusion in the REP and subsequent contract. These considerations need to ensure that there is linkage between the M&Q consideration and the warfighter requirements and evaluation factors and sub-factors. Evaluation factors often include cost or price, and Quality of product or service which includes technical, past performance and others.

Manufacturing and Quality Tasks

- Ensure that M&Q personnel are included in the RFPs writing and review teams.
- Support the development of performance and detail specifications:
    - Support the requirements process and the identification and the flow down of requirements into performance, detail, process, and/or material specifications
    - Ensure traceability between requirement or capability and production/quality verification
    - Ensure identification and development of rigorous verification methods for incorporation of all requirements
    - Ensure incorporation of rigorous, statistically based acceptance requirements including: qualification (i.e. design verification), First Article, and conformance inspections
- Ensure M&Q personnel support the development of RFP requirements, inputs, and outputs and provide M&Q requirements on:
    - Risk, Issue, and Opportunity Management System and processes
    - Design producibility, process capability, and manufacturability assessments, analyses, and reviews (i.e., CDR)
    - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
    - Prototypes, demonstrations, and development tests and analyses
    - Materials characterizations, scale-ups, and analyses
    - Make/buy processes, procedures, and analyses
    - Costs and budget analyses
    - Market research and analyses
    - M&S analyses
    - Process capability and production process verification analyses
    - ESOH, environmental, HAZMAT, safety, security analyses and risks
    - M&Q processes, procedures, and associated data (especially CMPs)
    - Workforce availability, training, and certification analyses
    - Work measurement/learning curve analyses
    - Industrial base assessments and analyses
    - ManTech projects
    - supply chain assessments and analyses
    - DCMA surveillance reports
- Specify the requirements for best practices for the contractor's Manufacturing Management System (MMS) (per Section L.2) and QMS (per Section I.2 and per FAR 52.246-11, Higher-Level Contract Quality Requirement) to be used (e.g., AS6500, ISO 9000, AS9100, etc.).

  - Specify the requirements for the contractor to identify and describe in detail their proposed specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and M&Q risks and issues associated with the proposed system
  - Specify a requirement for on-site government Quality personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA)
  - Specify a requirement for on-site government Quality personnel to have access to and inputs on:
    - Perform source inspections and data monitoring
    - Failures and Corrective Actions and resolutions (i.e., FRACAS)
    - Material Review actions and dispositions (i.e., Material Review Boards)
    - Requests for Variance actions and approvals
    - Engineering Change process and approvals

- If AS6500 is not invoked in the contract(s), the manufacturing management requirements cited in AS6500 should be the basis for specific contractual requirements for a contractor Manufacturing Management System and Plan. The requirements, at a minimum, should specify that the contractor addresses:
  - Manufacturing Management System
    - Documenting how, when, and by whom each requirement of their system is to be accomplished and define the authority and responsibility for each.
  - Design Analysis for Manufacturing
    - Conducting producibility analyses
    - Identifying and managing key and critical characteristics in the TDP
    - Implementing Variability Reduction (VR) to reduce part to part variation of key and critical characteristics
    - Identifying and managing key and critical manufacturing processes
    - Conducting Failure Modes Effects Analysis (FTA, FMEA, DFMEA, and/or PFMEA) on critical manufacturing processes
  - Manufacturing Risk Identification
    - Integrating manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
    - Conducting and documenting manufacturing feasibility assessments for a competing design alternative
    - Identifying MRL targets and documenting manufacturing risks through the MRL assessments

        - Conduct Pre-award Survey
    - Manufacturing Planning
        - Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing M&S, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities.
    - Manufacturing Operations Management including:
        - Production Scheduling and Control
        - Manufacturing Surveillance
        - Continuous Improvement
        - Process Control Plans
        - Process Capabilities
        - Production Process Verification
        - First Article Inspections and First Article Tests
        - Supplier Management and Quality
- If ISO 9000 or AS9100 is not invoked in the contract(s), the quality management requirements cited in the standards should be the basis for specific contractual requirements for a contractor QMS and Quality Plan. The requirements, at a minimum, should specify that the contractor addresses:
    - Quality Management Leadership
        - Leadership and Commitment
        - Policy
        - Organizational Roles, Responsibilities, and Authorities
    - Quality Planning
        - Actions to Address Risks and Opportunities
        - Quality Objectives and Planning
        - Planning of Changes
    - Quality Support
        - Resources
        - Competence
        - Awareness
        - Communication
        - Documented Information
    - Operation
        - Operational Planning and Control
        - Requirements for Products and Services

        - Design and Development of Products and Services
        - Control of Externally Provided Processes, Products, and Services
        - Production and Service Provision
        - Release of Products and Services
        - Control of Non-conforming Outputs
    - Quality Performance
        - Monitoring, Measurement, Analyses, and Evaluation
        - Internal Audit
    - Quality Improvement
        - Nonconformity and Corrective Actions (i.e., FRACAS)
        - Root Cause Identification
        - Continual Improvement
- Identify appropriate M&Q Contract Data Requirements List (CDRL), Data Item Description (DID), etc. to support M&Q processes, include the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.)
    - Specify a requirement for on-site government Quality personnel will have access to perform source inspection of the plan (include on-site government Quality personnel (i.e., DCMA) in contractual distribution of the Program Quality Plan (ref. I.2))
- Provide M&Q inputs and support for specification of industry best practices for Systems Engineering to be used (e.g., IEEE 15288, -1, -2, etc.) in the RFP.
    - Include requirements for the contractors to identify and to describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Provide M&Q inputs and support to contractual requirements for:
    - Content for Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (*See* B.4)
    - Conducting M&Q reviews of engineering and software (with frequency of reviews)
    - IP and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
    - Identification and description of producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
    - Facilities, tooling, test equipment, and workforce
    - Supply chain management
    - Management of parts and materials (e.g., make/buy, planning, etc.) including:
        - Long-lead
        - Sources and risks (sole, single, foreign, fragile, and critical)

    - Handling and storage
    - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
    - Conservation of critical/strategic materials
    - Counterfeit avoidance
    - Obsolescence
    - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
    - Reduction/elimination of foreign dependency
    - Standardization of components, items, and parts
- Configuration management
- Life-Cycle Sustainment Plan (LCSP)
- Performing analyses of failure mode effects and criticality (e.g., FTA, PFMEA, FMECA, etc.) from the system level down to the component level
- Traceability of CSIs and/or CAIs to all key and critical M&Q processes (CMP)
- Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Providing systematic application of statistical process controls and meeting required process capability (C_{pk}) goals
- Providing a system for collection, storage, analysis, and management of M&Q data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
- Manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- A joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
- M&Q Variability Reduction program to include root cause corrective action
- Appropriate cyber threat protection program including:
    - Safeguarding M&Q information, designed in systems protection, supply chain risks, hardware, and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
    - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
    - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
    - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security

  - Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
  - COTS, GOTS, GFE, and NDIs
  - Metrics to be met as exit criteria
- Provide M&Q inputs and support to specialized system requirements and/or certifications, such as Flight Operations, Space Operations, etc.
- Specify the M&Q requirements that the contractor support and/or conduct, as required:
  - Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to Full-Rate Production Decision Review (FRPDR)
  - MRL assessments with trained personnel using the MRL criteria
  - Independent risk assessments as directed
  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
  - Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities
- Provide M&Q inputs on requirements for the contractor to:
  - Support of on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
  - Address capital investments
  - Provide specific, detailed workforce, facilities, and capacity plans for LRIP and FRP including:
    - Relocations
    - Restarts
    - Changes in materials, manufacturing processes, and/or suppliers
    - Processes, procedures, improvements, etc.
  - Address meeting program schedule and critical path
  - Manage the supply chain (e.g., products, locations, capacities, capabilities, monitoring, etc.)
  - Manage tooling, Special Test Equipment (STE), and Special Inspection Equipment (SIE)
  - Support and conduct a Continuous Process Improvement (CPI) program
  - Use, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
  - Support and maintain the IMP/IMS including the critical path
- Provide M&Q inputs on requirements for the contractor to define manufacturing methods and production flow to include:

  - Advanced or unique manufacturing technologies required
  - Production flow including the planned fabrication and assembly key points
  - Production test and/or inspections
  - Planned flow of major manufacturing operations
  - Expected process yields and statistical or other methods for process control
- Provide M&Q inputs on requirements for contractor support and maintenance of and up-to-date TDP.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IG5315.204-5(b), Section L Guide and Template
- IG5315.204-5(c), Section M Guide and Template
- ISO 9001, Quality Management System Checklist
- DOORS or other Requirements Management Tool
- DCMA Pre-award Survey System (PASS)
- SF 1403 DCMA Pre-award Survey General
- SF 1404 DCMA Pre-award Survey Technical
- SF 1405 DCMA Pre-award Survey Production
- SF 1406 DCMA Pre-award Survey Quality Assurance
- SF1407 DCMA Pre-award Survey Financial Capability

Resources

- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288, System and Software Engineering
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs

- IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- ISO 9000, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- SD-15 Performance Specification Guide
- DI-IPSC-81431 System/Subsystem Specification Data Item Description
- DI-SDMP-81484A, Detail Specifications Data Item Description
- DI-SDMP-81465A, Performance Specification Data Item Description
- DI-SDMP-81493, Program Unique Specification Document Data Item Description
- MIL-STD-961, Defense and Program-Unique Specifications Format and Content
- MIL-HDBK-245E, Preparation of Statement of Work
- MIL-STD-882, DoD System Safety
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- AFMC Instruction 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-award Survey Guide
- Pre-award Survey User's Manual
- DCMA Post-award Orientation Conference (FAR 42.502 and DFARS 242.5)
- DCMA Post-award Orientation Conference Record (DD1484)

B.2 Provide Input to Source Selection Plan

FAR 15.101, "Best Value" section, states that an agency can obtain best value in negotiated acquisitions by using any one or a combination of source selection approaches. The Source Selection Plan (SSP) is a key document which specifies how the source selection activities will be organized, initiated, and conducted. The SSP serves as the guide for conducting the evaluation and analysis of proposals, and the selection of contractor(s) for the acquisition. SSP must clearly and succinctly express the government's minimum needs (evaluation factors) and their relative order of importance. M&Q managers, as members of the technical IPT, should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Ensure that M&Q personnel are included in the Source Selection Plan (SSP) writing and review teams.
- Specify metrics and scoring that at a minimum address the contractor(s) plans, processes, and procedures based on analyses of EMD M&Q outputs, for:

  - Quality Management System (QMS)
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, process capability, and manufacturability assessments, analyses, and technical and management reviews
  - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
  - Demonstrations and development tests
  - Materials
  - Materials management (i.e., make/buy processes, procedures, and analyses)
  - Costs and budget estimates
  - Market research and analyses
  - Modeling and simulations
  - Process capability and production process verifications
  - ESOH, environmental, HAZMAT, safety, and security (physical, cyber, and industrial)
  - M&Q and associated data (especially CMPs)
  - Workforce (e.g., availability, training, and certification)
  - Work measurement (i.e., learning curve analyses)
  - ManTech project implementation
  - Supply chain assessments and analyses

- Specify in the SSP metrics and scoring for application of best practices for the contractor(s) Manufacturing Management System (MMS) and Plan and QMS and Plan (e.g., AS6500, ISO 9000, AS9100, etc.).
  - SSP should delineate and include metrics and scoring for preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and M&Q risks and issues associated with the proposed system
  - Plan should delineate and include metrics and scoring for accommodation and support of on-site government Quality personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA) including:
    - Source inspections and data monitoring
    - Failures and Corrective Actions and resolutions (i.e., FRACAS)
    - Material Review actions and dispositions (i.e., Material Review Boards)
    - Requests for Variance actions and approvals
    - Engineering Change process and approvals
- Ensure the requirements cited in AS6500 are the basis for specific SSP metrics and scoring of the contractor(s) Manufacturing Management System and Plan even if manufacturing management industry best practice requirements (i.e., AS6500) are not invoked in the contract. The SSP should delineate and specify metrics and scoring for:
  - Documenting how, when, and by whom each requirement of their system is to be accomplished, and define the authority and responsibility for each

  - Conducting producibility analyses
  - Identification and management key and critical characteristics in the TDP
  - Implementation of VR to reduce part to part variation of key and critical characteristics
  - Identification and management of key and critical manufacturing processes
  - Conducting Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
  - Integration of manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
  - Conducting and documenting manufacturing feasibility assessments for a competing design alternative
  - Identification of MRL targets and documenting manufacturing risks through the MRL assessments
  - Establishing and maintaining a manufacturing plan that includes:
    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing M&S
    - Manufacturing costs
    - Manufacturing system verification
    - Manufacturing workforce
    - Tooling, test equipment, and facilities
  - Management of operations including:
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - Production Process Verification
    - First Article Inspections and First Article Tests
    - Supplier Management and Quality

- Ensure that the requirements cited in quality standards (ISO 9001 or AS9100) are the basis for specific SSP metrics and scoring of the contractor(s) QMS and Plan even if these standards are not called out in the contract. The SSP should delineate and specify metrics and scoring for:
  - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
  - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management

  - Quality support with resources, competence, awareness, communication, and documented information
  - Operation including operational planning and control, products and services requirements, and design and development
  - Control of externally provided processes, products, and services
  - Production and service provision
  - Release of products and services
  - Control of non-conforming outputs
  - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
  - Quality improvement including nonconformities and corrective actions, and continual improvement

- Specify metrics and scoring to rank contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment with program goals (and corrective actions and/or mitigation plans, if required) for managing M&Q CDRLs, DIDs, etc., including the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.).
- Specify in the SSP metrics and scoring for contractor(s) application of industry best practices for M&Q aspects of Systems Engineering management (e.g., IEEE 15288, -1, -2, etc.).
  - Include metrics and scoring for the contractors proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specify M&Q metrics and scoring for contractor(s) plans for timeliness, completeness, accuracy, and alignment to program goals (with corrective actions and/or mitigation, if required) to include:
  - Meeting each requirement in the Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (*See* B.4)
  - M&Q reviews of engineering and software (with frequency of reviews)
  - IP management and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
  - Utilization of facilities, tooling, test equipment, and workforce
  - Supply chain management (e.g., products, locations, capacities, capabilities, monitoring, etc.)
  - Parts and materials management (e.g., make/buy, planning, etc.) including:
    - Long-lead
    - Sources and risks (sole, single, foreign, fragile, and critical)
    - Handling and storage

- Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
- Conservation of critical/strategic materials
- Counterfeit avoidance
- Obsolescence
- Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
- Reduction/elimination of foreign dependency
- Standardization of components, items, and parts

- Configuration management
- Analyses of failure mode effects and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
- Management (including traceability) of CSIs and/or CAIs to all key and critical M&Q processes (CMP)
- Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Application of statistical process controls and meeting required process capability (C_{pk}) goals
- Collection, storage, analysis, and management of M&Q data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
- Manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- Investments in workforce development including processes, work systems, and skill development
- Joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
- M&Q Variability Reduction program
- Cyber threat protection including:
  - Safeguarding M&Q information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
  - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security

  - Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
  - Utilization of COTS, GOTS, GFE, and NDIs
  - M&Q in the Life-Cycle Sustainment Plan (LCSP)
  - Metrics to be met as exit criteria for LRIP

- Specify metrics and scoring to rank the contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specify M&Q metrics and scoring on timeliness, completeness, accuracy, and alignment with program objectives for contractor planning and processes to support and/or conduct as required M&Q:
  - Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to FRP Decision Review (FRPDR)
  - MRL assessments with trained personnel using the MRL criteria
  - Independent risk assessments as directed
  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
  - Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities

- Specify M&Q metrics and scoring for the contractor(s) plans to:
  - Support on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
  - Address capital investments
  - Support LRIP and FRP with specific, detailed workforce, facilities, and capacity plans including:
    - Relocations
    - Restarts
    - Changes in materials, manufacturing processes, and/or suppliers
    - Processes, procedures, improvements, etc.
  - Address meeting program schedule and critical path
  - Manage Special Test Equipment (STE), and Special Inspection Equipment (SIE)
  - Support and conduct a Continuous Process Improvement (CPI) program
  - Use, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
  - Support and maintain the IMP/IMS including the critical path

  - Support and maintenance of an up-to-date TDP
- Specify M&Q metrics and scoring for the contractor(s) plans for manufacturing methods and production flow to include:
  - Advanced or unique manufacturing technologies
  - Planned fabrication and assembly key points
  - Production test and/or inspections
  - Flow of major manufacturing operations
  - Process yields and statistical or other methods for process control

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- Source Selection Plan Template, USMC

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoD Source Selection Procedures Memo
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288, System and Software Engineering
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Program
- ISO 9001:2015, Quality Management System
- MIL-HDBK 245E, Preparation of Statement of Work
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-882, DoD System Safety
- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- Source Selection Plan Guide, IG5315.303 SSP Guide

B.3 Develop Manufacturing Incentives

FAR Subpart 16.4 notes that *"incentive contracts are designed to obtain specific acquisition objectives by establishing reasonable and attainable targets that are clearly communicated to the contractor; and include incentive arrangements designed to motivate the contractor to improve or discourage contractor inefficiency and waste."*

Contracts should produce measurable performance outcomes that cumulatively contribute to the system Key Performance Parameters (KPP)/Key Systems Attributes (KSAs), to their threshold or objective levels. To motivate the contractor to achieve the desired behavior, appropriate contract incentives (including award fee, incentive fee, award term, and cost sharing) need to be developed to promote and facilitate contractor performance.

M&Q managers need to support the development of award fee/incentive cee criteria in their areas. These criteria may focus on manufacturing investments and outcomes, process capability and control, reduction of waste, producibility improvements, etc.

Manufacturing and Quality Tasks

- Develop and provide M&Q input to the contract in the form of award or incentive fee Criteria, appropriate to the contract type and consistent with the Acquisition Strategy, that specify program goals and address the necessary M&Q (including supply chain) cost, schedule, and performance improvements (to include progress against goals, partial progress, recovery, and penalty) in the areas of:
    - M&Q CDRLs, DIDs, etc. (e.g., timely submission and approval)
    - Compliance with cyber-threat protection and industrial security requirements (e.g., PPP, DFARS 252.204-7012, NIST 800-82, etc.)
    - M&Q industrial base risk mitigations to schedule goals (#/%, milestones)
    - Manufacturing readiness progress (MRL assessments) against targets
    - Assessments of lower tier supply chain for manufacturing readiness and maturity in advance of the System maturity targets (#/%)
    - M&Q risk and issues mitigations complete (schedule/#)
    - Manufacturing and producibility projects planned and implemented (#/%)
    - Progress of learning curves (% to goals) including rates, yields, variability, process times, re-work, and repair, etc.
    - M&Q systems operations (production line, tooling, equipment, ManTech insertion, etc.) performance to goals (schedule/ %)
    - Key and critical manufacturing process capability improvements and variability reduction (i.e., C_{pk} improvements on key and critical processes beyond contract)
    - KC maturation and management to goals (% to goal and schedule progress)
    - Technical Performance Measures (TPMs) (% progress to schedule)
    - Manufacturing processes and advanced manufacturing capability improvement, and implementation (#/% to goals)

- Materials characterization schedule improvements in additional environments beyond contract requirements (time)
- Management of CSIs and CAIs to requirements
- Process Capability improvement (Cpk value to goals)
- Quality improvement projects planned and completed (#/% to goals)
- Quality improvement positive trends (acceleration of improvements %)
- Exceeding quality improvement goals
- Variation and Variability reduction efforts (yields/rates/trends)
- Manufacturing improvement projects implemented (#/% to goals)
- Parts and materials management against appropriate M&Q goals (e.g., availability, capacity, sourcing, standardization, etc.) (#/%)
- Facilities and equipment utilization (% to plan)
- Workforce development and management to plan (e.g., hiring, training, and reductions) (#/% to plan)
- Testing completion to schedule (% successfully completed) and testing improvements and positive trends (%)
- Testing and demonstration beyond contract requirements (include test reductions)
- Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
- Manufacturing Plan progress against completion (cost and schedule)
- Manufacturing cost (Δ$), cost reduction (%/$), and cost avoidance
    - Cost sharing when goals are not met must also be specified.
- Improvements in schedule (e.g., increased slack time, expedited development, early delivery, or just-in-time implementation, etc.)
- Quality Management System compliance to best practices and/or contract requirements (# to standard)
- Quality Plan progress against completion (cost and schedule)
- Quality costs and cost reduction (including cost of quality) (schedule/#/%)
- M&Q safety system requirements (% compliance)
- System Engineering management compliance to best practices for M&Q technical processes, technical management processes, and essential specialty engineering (# to standard)
- Performance to IMP/IMS (schedule)
- Progress toward meeting LRIP exit criteria
- Predictive and pro-active maintenance and modernization of facilities, tooling, and equipment (including GFE)
- Investments in modern manufacturing methods, software, and equipment including ManTech and other investments (cost share %)
- Qualification and investments in additional sources within the U.S. IB ($)

Tools

- Award Fee Template, USAF
- Award Fee/Incentive Fee Plan

Resources

- Air Force Award Fee Guide
- Army Award Fee Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoD Guidance on Using Incentive Contracts
- DoD/NASA Incentive Contracting Guide
- FAR Subpart 16.4, Incentive Contracts
- ISO 9001:2015, Quality Management System
- Navy Award Fee Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)

C. SURVEILLANCE SYSTEM

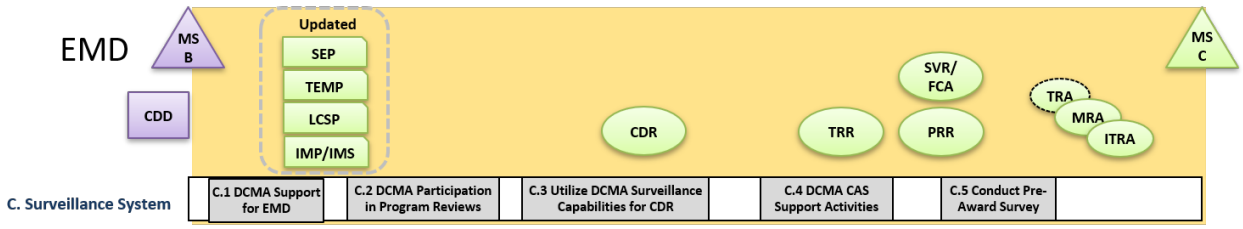


Figure 4-4. Surveillance System Manufacturing and Quality Activities

Introduction

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DoD contractor surveillance requirements and activities are required by the FAR/DFAR and by many DoD, Service, and agency

regulations, policies, and guidance documents. DFAR Part 242.2 Contract Administration Services; DFAR Part 242.3, Contract Administration Office Functions; and PGI 242.3 Contract Administration Functions outlines the 70 CAS functions that are required and the many that may require M&Q support in order to accomplish. M&Q personnel often are called upon to support numerous CAS functions and activities.

Often these activities may be performed under mutual agreement by the program office and the Defense Contract Management Agency. In many cases these contractor surveillance activities may be performed by on-site engineering support activity, program office contract administrators, delegated Service contract surveillance offices or a variety of engineering support activities (i.e., supervisor of shipbuilding (SUPSHIP), development command field activities). This thread (Surveillance) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Contract Administration Service (CAS) Functions
- Engineering Support Activity (ESA)
- DCMA Support
- DCMA Documentation
- Monitor and Track Risks
- Participate in Program Reviews

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DFAR subpart 242.3 identifies seventy-one (71) Contract Administration Services (CAS) functions that need to be accomplished and managed. Contractor surveillance is defined by several FAR and DFAR clauses. Many CAS activities fall under the umbrella of production or quality surveillance activities.

Contractors often depend on their own policies, procedures, processes, plans, controls, and schedules to meet government requirements. Often their plans, procedures and processes mirror government regulations, directives, instructions, and other documentation that may or may not be contractual. Government surveillance is often multifunctional requiring the support of business and technical personnel. Personnel from the program office as well as from DCMA may be required or asked to support surveillance functions at the prime and subcontractor facilities. M&Q managers play an integral and vital role in the total scope of contract administration. Most program office s delegate many CAS activities to DCMA as a best practice. This may require a Memorandum of Agreement (MOA) or a Letter of Delegation (LOD). The program office should coordinate with DCMA on required support, provided there is adequate manpower and funding to support the proposed MOA/LOD.

The Program Manager should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. This may require the program office to establish a Memorandum of Agreement (MOA) or a Quality Assurance Letter of Delegation (QALI) with DCMA. DCMA may then, based on manpower availability and funding, utilize a systematic approach deploying surveillance through the supply chain to evaluate the supply

chain and supplier improvement initiatives. At resident and non-resident facilities DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes. Most contractors will have implemented a higher-level quality management process IAW AS9100 or ISO 900/9100 as a best practice. Some contractors, but not all, may have implemented a manufacturing management process IAW AS6500. No matter what management processes the contractor has implemented, DCMA personnel should have access to that data and should be reviewing it on a continuous basis.

DCMA audits, support for program reviews, and day-to-day surveillance of contractor and supply chain activities are tools that provide a way to assess progress and maturity of the program as it moves through finalizing the design and demonstration on a pilot line. DCMA and program audits and reviews should be multi-disciplined to ensure that all functional aspects of the program are addressed. This systematic process that assesses risk and issues should facilitate transition from final design development to initial production and beyond by assessing the maturity of the design effort, verifying and validating design requirements, verifying the system configuration, and providing a database of surveillance results and technical decisions with rationale.

Reviews and assessments are important oversight tools that the program can use to review and evaluate the state of the system and the program for CDR, re-directing activity if necessary. DCMA can provide status of the application of M&Q best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.), which includes contractor and supply chain use of Failure Mode, Effects and Criticality Analysis (FMECA), FRACAS, etc., and monitoring and review of TPM status. In addition, DCMA monitoring, tracking, and reporting of contractor and supply chain performance, actions, and compliance with all contractual requirements is major input to the CDR.

DCMA conducts nearly all pre-award surveys required by government buying activities. The process begins with a buying activity's request for a survey and concludes with a Procuring Contracting Officer's (PCO) decision based on a recommendation by a DCMA Contract Management Office (CMO) survey team. A Production and Deployment pre-award survey can focus on virtually every facet of the contractor’s business operations from technical capability to financial stability, from quality assurance to plant safety. M&Q should provide recommendations and inputs to program management for the pre-award survey requirements to be addressed by DCMA. In a sense, the survey process is the contractor’s opportunity to provide evidence (i.e., Plan of Performance) that they can successfully fulfill the terms of the contract.

C.1 DCMA Support for EMD Activities

The EMD phase is where a system is developed and designed before going into production. The goal of this phase is to complete the development of a system, complete system integration, develop affordable and executable manufacturing processes, complete system fabrication, and test and evaluate the system. Many major activities take place at the contractor’s design and production facilities and at subcontractor and vendor facilities throughout the supply chain. Program offices often delegate

oversight and surveillance responsibilities to DCMA and rely on their expertise to provide the program office with a day-to-day presence. M&Q managers need to create letters of delegation and agreements are in place and communicated with DCMA to ensure that DCMA can and will provide adequate support for EMD activities.

Manufacturing and Quality Tasks

- Ensure M&Q provides inputs to the program development of a Letter of Delegation for DCMA support.
- Ensure M&Q participates in the development of a Memorandum of Agreement (MOA) for DCMA support.
- Ensure M&Q provides inputs on contractual requirements for contractor and supply chain activities and functions to be monitored, tracked, and reported by DCMA and/or program personnel in support of EMD, including DCMA support for:
    - Surveillance of contractor and supply chain use and application of best practices (e.g., AS6500, AS9100, ISO 9000, etc.)
    - Participation in Post Award Orientation Conference
    - Verify closure of PDR actions supply chain (required in the PDR if the PDR was conducted in the TMRR phase)
    - Updates on supply chain CDRs, developmental testing, PCAs, FCAs, other "critical path" events, and notifications to the program office of potential or actual program milestone issues
    - Government surveillance of contractor and supply chain FAIs/FATs and Qualifications (QUAL)
    - Surveillance support of contractor's Earned Value Management System (EVMS)
        - Conduct cost, schedule, and technical performance variance evaluations
    - Surveillance of Human Rating Certification processes (e.g., Flight Operations, etc.) with unrestricted government access to inspect and/or test processes (i.e., Safety of Flight (SOF) characteristics)
    - Government Contract Quality Assurance (GCQA) of engineering development models, engineering models, production prototypes, production representative models/articles, production readiness models/articles, as requested by the program office in the contract
    - Authority to accept or reject minor Requests for Variation (RFVs), Material Review Board (MRB) proposals for Use-As-Is (UAI), and post-CDR repair non-conformances (i.e., after the final product (configuration) baseline (PBL) is established)
    - Surveillance of the supplier's compliance to DFARS 252.242-7004, Material Management and Accounting System (MMAS)
    - Verification of contractor and supply chain compliance with contractual Special Packaging Instructions (SPIs) for end item systems and spares

- Verification of contractor and supply chain compliance with Surveillance Critical Designator (SCD) (FAR 42.11) requirements applied to the contract
- Surveillance of M&Q processes, procedures, and contractor program systems (e.g., Risk, Issue, and Opportunity Management System, Configuration Management System, FRACAS, FMECA processes, test, and evaluation processes, etc.)
- Other CAS functions as outlined in FAR Subpart 42.3 CAS Functions

Tools

- DCMA Program Assessment Report
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- Post-award Orientation Conference FAR

Resources

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-401, Industrial Analysis
- FAR Subpart 30.6, CAS Administration
- FAR Subpart 42.3, CAS Functions

C.2 DCMA Participation in Program Reviews

During the EMD phase there are eight formal technical reviews and audits and many informal reviews directed by the program office and other activities. M&Q managers as a member of the Technical IPT need to support these reviews and audits. DCMA personnel need to support these reviews if delegated CAS activities by the program office.

Manufacturing and Quality Tasks

- Requests DCMA support and participation in program reviews (e.g., IPRs, IPT meetings, etc.), including government only, to provide data on:
  - Contractor operations (technical, performance and financial)
  - Supply chain operations (technical, performance and financial)
  - Program goals and metrics

- M&Q managers should be a member of the Technical IPT that supports the following reviews and audits:
  - Integrated Baseline Review (IBR)
  - Test Readiness Review (TRR)
  - Flight Readiness Review (FRR)
  - System Verification Review (SVR)
  - Functional Configuration Audit (FCA)
  - Physical Configuration Audit (PCA)
  - Production Readiness Review (PRR)
  - Technology Readiness Assessment (TRA)
  - Manufacturing Readiness Assessment (MRA)
  - Independent Technical Risk Assessment (ITRA)
- Request DCMA input on ongoing M&Q contractor and supply chain activities concerning:
  - Technical Performance Measures (TPMs)
    - Including CIs, CSIs, KCs, and critical characteristics
  - Design status
  - Manufacturing capabilities and capacities
  - Quality assurance processes and procedures (i.e., compliance to best practices)
  - EVMS processes, procedures, and data
  - Government Property Control (e.g., GFE, GFP, etc.)
  - Transportation, storage, and packaging processes and controls
  - Security (physical, cyber, and industrial)
  - System Safety
  - Plant safety, materials handling, hazardous waste disposal, etc.
  - Environmental and Energy compliance with applicable policies and statutes
  - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
  - Configuration management processes and procedures
  - Software surveillance
  - Test planning, test equipment, and test results

Tools

- DCMA Program Assessment Report
- Interactive MRL Users Guide (Checklist)
- Independent Technical Risk Assessments (ITRAs) Execution Guidance

Resources

- DoD Systems Engineering Guidebook

- Engineering of Defense Systems Guidebook
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-401, Industrial Analysis
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

C.3 Use DCMA Surveillance Capabilities for Critical Design Review

M&Q personnel from DCMA should be actively engaged in the organization and execution of the CDR during this phase along with program office personnel. The completion of the CDR should provide:

- An established system initial product baseline,
- An updated risk assessment for EMD,
- An updated CARD based on the system product baseline,
- An updated development schedule for fabrication, test and evaluation, software coding, critical path drivers, and
- An approved Life Cycle Sustainment Plan.

Manufacturing and Quality Tasks

- Use DCMA surveillance capabilities in monitoring, tracking, and reporting for contractor and supply chain use and application of M&Q best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.).
- Use DCMA surveillance capabilities to monitor M&Q FMECA contract requirements for contractor and supply chain for:
    - Identification of subsystems, items, components, characteristics and/or features, and processes, which if nonconforming, could result in a catastrophic or critical failure of the system:
        - Items and components will be designated as either a critical item (CI) or CSI
        - Product characteristics and/or features will be designated as either KCs or critical characteristics
        - Processes will be designated as critical manufacturing processes (CMPs)

  - Review of the FMECA and/or Critical Items List (CIL) for CIs, CSIs, KCs, and critical characteristics to specify the need for government surveillance of these items
  - Verification of updates of FMEA/FMECA based on FRACAS and developmental testing results

- Use DCMA surveillance capabilities to monitor M&Q aspects of System Safety contract requirements including:
  - Review Safety Assessment Reports (SARs) and/or CIL for CIs, CSIs, KCs, and critical characteristics

- Use DCMA surveillance capabilities to monitor M&Q aspects of Test and Evaluation contract requirements for surveillance of contractor's and supply chain's:
  - Physical Configuration Audits (PCAs) of the required subsystems/components identified in the contract. Perform government surveillance, as required
  - Functional Configuration Audits (FCAs) of the required subsystems/components identified in the contract. Perform government surveillance, as required
  - Developmental Testing for achievement of Critical Technology Elements (CTEs), KPPs, and KSAs
  - Software Testing, to include Software Acceptance Test (SAT)/Software Formal Qualification Test (SFQT), if conducted in the EMD phase
  - Environmental testing (e.g., Environmental Stress Screening (ESS), Highly Accelerated Life Testing (HALT), Highly Accelerated Stress Screen (HASS), Thermo-Cycling, Thermo-Shock, Pyrotechnic Shock, Vibration, etc.), if conducted
  - Live Fire Test and Evaluation), if applicable
  - Acceptance Testing

- Use DCMA surveillance capabilities to enhance M&Q monitoring of KPPs and KSAs progress and periodic review of TPMs.
- Use DCMA surveillance capabilities to monitor contractor's and supply chain's M&Q FRACAS contract requirements including:
  - Government personnel attending FRACAS meetings, or review minutes, and adjusting Government surveillance based on FRACAS results, as required
  - Verifying contractor and supply chain updates of FMEA/FMECA based on FRACAS result, when required

- Use DCMA surveillance capabilities to monitor M&Q contract requirements for contractor and supply chain compliance to M&Q aspects of Systems Engineering best practices as specified in IEEE 15288.2.
- Use DCMA surveillance capabilities to monitor M&Q Risk, Issue, and Opportunity (RIO) Management contract requirements.

- Use DCMA surveillance capabilities to monitor M&Q contract Parts Management requirements including:
    - Contractor' compliance to Parts Management contract requirements (i.e., MIL-STD-11991A)
    - Verification that contractor and supply chain use parts and/or components in the design that are qualified under a government or Industry specifications or standards
    - Validation of Non-Standard Parts Approval Requests (NSPARs) made to the program office for approval in accordance with specified CDRLs, or DDF1423, that specifies what the supplier must provide as part of the NSPAR
- Use DCMA surveillance capabilities to monitor M&Q contract Configuration Management requirements including contractor's and supply chain compliance to requirements (e.g., SAE/EIA649B, Service specific policies, etc.).
- Use DCMA surveillance capabilities to monitor M&Q contract Software Development, Quality Assurance, Configuration Management and Testing requirements including:
    - Contractor's and supply chain compliance to software development, quality assurance, configuration management and testing requirements
    - Contractor's progress in performance of SAT/SFQT

Tools

- Critical Design Review Checklist
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- FCA Checklist
- PCA Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DD 1423, Contract Data Requirements List
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD-11991A, General Standard for Parts, Materials, and Processes
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management
- SAE EIA 649B, Configuration Management Standard

C.4 DCMA Contract Administration, Management, and Support Activities

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DFAR subpart 242.3 identifies seventy-one (71) Contract Administration Services (CAS) functions that need to be accomplished and managed. Contractor surveillance is defined by several FAR and DFAR clauses. Many CAS activities fall under the umbrella of production or quality surveillance activities. M&Q managers play an integral and vital role in the total scope of contract administration. Most Program office s delegate many CAS activities to DCMA as a best practice.

Manufacturing and Quality Tasks

- Request the following M&Q support from the appropriate (local) Contract Administration Office (CAO)/Contract Management Office (CMO) in attending, monitoring, and reporting on contractor reviews, performance, and meetings including:
    - Inputs from DMCA monitoring, tracking, and reporting on contractor and supply chain M&Q activities and functions to meet contractual requirements as delineated in C.3
    - Interim Program Reviews (IPRs) including supply chain
    - Performance of Physical Progress Reviews (PPRs) in support of Program Progress Payments
    - Corrective Action Board (CAB) or similar meetings (e.g., quality, manufacturing, supply chain, engineering, and software issues, corrective actions, and dispositions)
- Request M&Q support from the appropriate (local) CAO/CMO in monitoring, tracking, reporting on contractor performance and actions related to and including the following:
    - Estimates to Completion (EACs) as requested
    - Delivery delay notices to the customer
    - Performance Base Payment requests (validation and/or verification)
    - Support to customer priority delivery requests (DX rating)
    - Contractor and supply chain pilot lines
- Ensure M&Q provides inputs for updates to the Memorandum of Agreement (MOA) between the program and the government contract administration for necessary activities.

Tools

- DCMA Pre-Award Survey System (PASS) review
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations

- DD 1423, Contract Data Requirements List
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD-11991A, General Standard for Parts, Materials, and Processes
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management
- SAE EIA 649B, Configuration Management Standard

C.5 Conduct Pre-Award Survey

A Pre-award Survey may be required per FAR 9.106 and is an evaluation of a prospective contractor's capability to perform under the terms of a proposed contract. It typically requires an on-site visit to the prospective contractor's facility and could be an assessment of their technical, production, quality, and financial capabilities. M&Q managers need to support assessments at the contractors' facilities and should involve the support by DCMA personnel stationed at the facility.

Manufacturing and Quality Tasks

- Ensure M&Q personnel provide inputs for the request to DCMA to conduct Pre-award Surveys of potential LRIP contractor(s) (including their designated supply chain) for M&Q capabilities in the areas of:
    - Compliance to appropriate industry best practices (e.g., AS6500, AS9100, etc.)
    - Technical Performance including TPMs, CIs, CSIs, KCs, and critical characteristics
    - Design
    - Manufacturing capabilities and capacities
    - Quality assurance including processes and procedures compliance to best practices
    - EVMS processes, procedures, and data
    - Government property management and control (e.g., GFE, GFP, etc.)
    - Transportation, storage, and packaging processes and controls
    - Security (physical, cyber, and industrial)
    - System safety
    - Plant safety, materials handling, hazardous waste disposal, etc.
    - Environmental and Energy compliance with applicable policies and statutes
    - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Configuration management processes and procedures
    - Software surveillance
    - Test planning, test equipment, and test results

Tools

- DCMA Pre-Award Survey System (PASS) review
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- SF 1404 Pre-award Survey – Technical
- SF 1405 Pre-award Survey – Production
- SF 1406 Pre-award Survey – Quality Assurance
- SF 1407 Pre-award Survey – Financial Capability

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DD 1423, Contract Data Requirements List
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD-11991A, General Standard for Parts, Materials, and Processes
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management
- Pre-Award Survey System (PASS) 2.0 (Online)
- Pre-Award Survey System Users Guide (Online)
- SAE EIA 649B, Configuration Management Standard

C.6 Conduct Post-Award Orientation Conference

A Post-Award Orientation Conference may be performed as prescribed in FAR 42.5. A post-award orientation aids both Government and contractor personnel to (1) achieve a clear and mutual understanding of all contract requirements, and (2) identify and resolve potential problems. However, it is not a substitute for the contractor's fully understanding the work requirements at the time offers are submitted, nor is it to be used to alter the final agreement arrived at in any negotiations leading to contract award. M&Q managers need to support DCMA in this assessment at the contractors' facilities.

Manufacturing and Quality Tasks

- Ensure M&Q personnel provide inputs for the request to DCMA to conduct a Post-Award Orientation Conference. All aspects of the contract are subject to discussion with emphasis in the areas of:
    - Compliance to appropriate industry best practices (e.g., AS6500, AS9100, etc.)
    - Technical Performance including TPMs, CIs, CSIs, KCs, and critical characteristics
    - Design
    - Manufacturing capabilities and capacities

- Quality assurance including processes and procedures compliance to best practices
- EVMS processes, procedures, and data
- Government Property management and control (e.g., GFE, GFP, etc.)
- Transportation, storage, and packaging processes and controls
- Security (physical, cyber, and industrial)
- System Safety
- Plant safety, materials handling, hazardous waste disposal, etc.
- Environmental and Energy compliance with applicable policies and statutes
- Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
- Configuration management processes and procedures
- Software surveillance
- Test planning, test equipment, and test results

Tools

- DCMA Post-Award Orientation Conference Checklist

Resources

- FAR Part 42.5, and DFARS, 242.5
- Multiple DCMA standards, documents, and procedures
- DCMA Post-award Orientation Conference Checklist

D. TECHNOLOGY AND INDUSTRIAL BASE

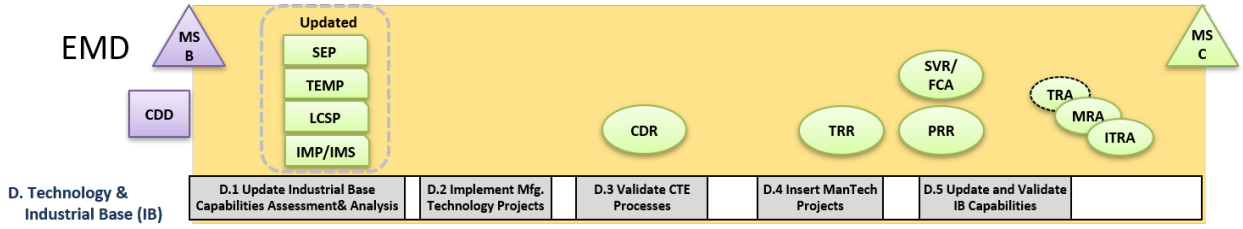


Figure 4-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC 2440 requires the Secretary of Defense to consider the NTIB in the development and implementation of acquisition plans for each MDAP. The NTIB consists of national security and dual-use research and development (R&D), production, maintenance, and related activities within the United States, Canada, the United Kingdom, and Australia. Acquisition planning and plans shall include considerations of the NTIB for all MDAPs. These considerations should include:

- The ability to support development and production (rates and quantities)
- The identification of IB risks in the supply chain

- The identification of single points of failure in the supply chain (sole source, foreign source, etc.)
- Support for a resilient supply base for critical defense capabilities
- Support for procurement surges and contractions

This thread (Technology and Industrial Base) requires an analysis of the capabilities of the NTIB to support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal (including environmentally conscious manufacturing). This thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Industrial Base Assessments (IBAs)
- Industrial Base Risks
- Critical Enabling Technologies
- ManTech Projects
- Industrial Base Mitigation Plans

During the Engineering and Manufacturing Development (EMD) phase, industrial base (IB) readiness to support program objectives should be assessed to identify risks, issues, and opportunities. The M&Q Strategies, and subsequent inputs to the program Acquisition Strategy (AS), should highlight the strategy for assessing and mitigating any industrial and manufacturing risks as identified in any reports generated from the industrial base assessments. According to DODI 5000.02 Acquisition Strategies must consider industrial base capabilities at Milestones B and C and provide an update to the Analysis of Alternatives (AoA) conducted in the MSA phase which included an assessment of manufacturing feasibility and required an assessment of the industrial base capabilities.

Policy requires an analysis of the capabilities of the NTIB to support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal. Without this assessment, the program may find that the program cannot be accomplished within the defined cost and schedule thresholds because of incompatibilities between the system requirements and the NTIB available to support it.

Manufacturing risk resolution involves assessing risks through the formal technical reviews and in demonstrating the manufacturing capability and maturity. Manufacturing technology development needs to be accomplished in a phased approach to define and demonstrate capabilities. The TMRR developer should have demonstrated that the required advanced processes or material capabilities were achievable in a production relevant environment. The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. These ManTech projects or other projects must be implemented in time to support production. The focus is on providing a reasonable expectation that the advanced manufacturing materials and processes, required in EMD and production, can be achieved.

A systematic process that assesses the maturity of Critical Technology Elements (CTEs) is a DoDI 5000.02 requirement for all acquisition programs. In completing the development of a system or incremental capability, one of the key tasks is to mature Critical Manufacturing Processes (CMPs)

associated with KCs, and therefore with CTEs. Manufacturing process demonstrations include affordable and executable manufacturing processes, system fabrication, production of prototypes and first articles that demonstrate system integration, interoperability, supportability, safety, and utility. The focus of demonstrations is on risk reduction in a pilot line environment.

Based on funding, schedule, and implementation progress, ManTech projects should be updated and managed to achieve program objectives. Projects should address and reduce risks, improve M&Q processes, and improve cost and schedule performance. ManTech projects should be completed, integrated, and demonstrated on a pilot line at the appropriate contractor and/or supply chain facilities.

A key M&Q focus should be on continually analyzing risks and identifying risk mitigation measures needed to sustain a reliable, technologically superior, affordable, and resilient defense industrial base. DoDI 5000.60 provides policy and identifies responsibilities for assessing defense industrial capabilities. These assessments ensure that the industrial capabilities needed to meet current and future national security requirements are available and affordable. The industrial base assessment will be used to use to determine if a specific industrial capability is required to meet DOD needs, and if any action should be taken to ensure the continued availability of the capability.

The effectiveness of actions or investments made in areas of manufacturing capability, obsolescence, fragility, capacity, and resilience to address M&Q industrial base risks to cost, schedule, performance should be assessed and validated. These results should be incorporated into the joint Risk, Issues, and Opportunity Management System in support of LRIP and Production and Deployment phase. Additionally, the updated M&Q inputs should be included in the industrial base Capabilities Considerations Summary Report for Milestone C.

D.1 Update Industrial Base Assessment and Analyses

The program office as a member of the Integrated Product Team (IPT) should update previous Industrial Base Assessments to satisfy the requirements of 10 USC 2440 and DFAR Subpart 207.1.

Manufacturing and Quality Tasks

- Support and provide updates to any previous Industrial Base Assessments of the capability of the NTIB to develop, produce, maintain, and support the program, including foreign dependency. The analyses should include the following components:
    - Relevant sources including identification of:
        - Unique manufacturing capabilities
        - Capabilities not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
        - Major systems and items available only from sources outside the NTIB
        - Alternatives for obtaining such items from within the NTIB if such items become unavailable from sources outside the NTIB

        - Government and contractor Depot and Maintenance and Repair Operations (as part of the industrial base)
    - Vulnerabilities of and effect on the supply chain including sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
    - Capability to produce using existing manufacturing capabilities and capacities while meeting quality, production rate and cost requirements
    - Capability to protect program and system information and data (software and firmware) including system definition, design, and test, contracting, and competitive prototyping
    - Capability to protect industrial resources, materials, equipment, and control systems
    - Capability and capacity to cost-effectively design, develop, produce, maintain, and support the system with tooling, production and test equipment, and operation, maintenance, and sustainment of systems
    - Capability and capacity to meet rate and quantity changes that support a response to contingency and support objectives (surges and contractions)
    - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
    - Potential obsolescence of components, parts, and materials
    - Impacts of external dependencies and integration
    - New and unique capabilities and processes
    - Sources for key technologies, components, and processes, including known gaps and risks
    - Technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact the program
    - DCMA industrial analysis data and reports to include:
        - Industrial Capability Assessments
        - Appropriate Analytical Products
        - Defense Business and Economic Analysis
        - Acquisition Planning Support
- Update any Industrial Base Assessments and reports and maintain the relevance and applicability of M&Q inputs to the AS and SEP:
    - Include recommended actions or investments that address risks to cost, schedule, performance, and qualitative considerations that define and recommend how and when the actions would be incorporated into the budget and schedule and, if possible, identify budget offsets
    - Ensure the report is finalized for Milestone C

    - Note: If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components and approved by the Under Secretary of Defense For Acquisition, Technology, And Logistics per DoDI 5000.60.

- M&Q personnel will analyze, update, and maintain inputs to the joint Risk, Issues, and Opportunity Management System for industrial base capabilities and capacities throughout EMD and in support of LRIP and Production and Deployment,
    - Include manufacturing, re-manufacturing, and overhaul opportunities

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist) for Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoD 5000.60-H, Assessing Defense Industrial Capabilities
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook

D.2 Implement Manufacturing Technology Projects

M&Q managers as members of the Technical IPT need to implement ManTech projects that have been identified in previous studies and gap analysis. ManTech implementation must be managed and completed in a timely fashion to be integrated into the system. ManTech projects focuses on efforts to enhance the manufacturability and producibility of defense essential and unique processes or components.

Manufacturing and Quality Tasks

- Update program manufacturing technology plans, including approved and funded ManTech proposals, which should address:
    - Identified high-risk manufacturing process areas
    - Identified risks and issues with associated event-based mitigation plans
    - Identified manufacturing technology efforts to be funded other sources
    - Any new or emerging manufacturing technology gaps

  - Scheduled completion of manufacturing technology efforts to support program
  - Contractor/subcontractor participation in the project
  - Relevant data to support the plan (e.g., DCMA, Title III, etc.)
  - Review other program portfolios for potential alternatives/solutions (e.g., ManTech, Title III, DARPA, Procurement Technical Assistance Centers (PTAC), Manufacturing Extension Program (MEP), National Institute of Standards and Technology (NIST), etc.)
- Execute approved and funded manufacturing technology projects.
- Monitor and track progress of projects against the goals (e.g., process improvement, quality improvement, etc.)
- Monitor ongoing DoD/Service ManTech projects for potential applicability to program needs.

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Technology Readiness Assessment Calculator
- TRL Assessment Checklist

Resources

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- Defense Production Act, Title III
- DoDD 4200.15, ManTech
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook
- Service ManTech guidance, e.g., Air Force Technology and Transition Strategy Guidebook
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.3 Validate Critical Technology Element Processes

The ManTech program focuses on advancing state-of-the-art manufacturing technologies and processes from the research and development environment (laboratory) to the production and shop floor environment. These technologies are often immature and have the process limitations of critical technologies need to be assessed and validated prior to inclusion into the next system level or element.

Manufacturing and Quality Tasks

- Update M&Q assessments to ensure all CTEs have been identified and all CTE risks and issues have been mitigated to acceptable levels.
    - Including integration, interdependencies, and associated risks and issues
    - Exceptions have matured alternative components or subsystems identified, approved, and budgeted
- Ensure all CTEs have been decomposed to specific M&Q processes.
    - Assess each M&Q processes for maturity (e.g., process capability, work instruction status, appropriate yield, etc.)
    - Validate CTEs for feasibility, affordability, and supportability

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet (PAW)
- Technology Readiness Assessment
- TRL Calculator

Resources

- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.4 Insert Manufacturing Technology Projects

Accelerating the flow of technology to the warfighter is one of the top priorities of DoD, services, and agencies. Technology transition involves the maturation of technologies to the point where they are proven to be mature and ready of insertion into a system or element. M&Q managers as members of the Technical IPT need to support the analysis of maturity and the insertion of technologies into production programs.

Manufacturing and Quality Tasks

- Update program manufacturing technology plans based on status (funding and schedule) and results of project, which should address:
    - Risk reduction manufacturing process areas
    - Improvements in manufacturing processes (cost and schedule)
    - Resulting quality improvements (e.g., Cpks, yields, rates, etc.)

  - Other source manufacturing technology efforts (e.g., Title III, PTACs, MEPs, NIST, etc.)
  - Demonstrations of completed manufacturing technology projects to industry in the appropriate facility
  - Contractor/subcontractor level of participation in the project
  - Scheduled manufacturing technology project insertion at the contractor/subcontractor facility
  - Relevant data collected to support insertion (e.g., DCMA, Title III, etc.)
- Manage manufacturing technology projects to plan to ensure that the technologies are inserted into a system or element as appropriate.
- Conduct demonstrations of completed ManTech projects to industry in the appropriate facility.
- Implement, monitor, and track manufacturing technology projects at contractor/ subcontractor facility for effectiveness and performance.
  - Demonstrate manufacturing technology development solutions in a production representative environment
  - Continue manufacturing technology efforts for validation on the Pilot Lines

Tools

- Army ManTech Proposal Rating spreadsheet
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- ManTech Phase I project questionnaire
- Manufacturing Maturation Plan
- TRL Assessment Checklist

Resources

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- Defense Production Act, Title III
- DoDD 4200.15, ManTech Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook
- Service ManTech guidance (e.g., Air Force Technology and Transition Strategy Guidebook)
- Technology Readiness Assessment Guidance

D.5 Update and Validate Industrial Base Capabilities

The industrial base assessment (ICA) must be updated to evaluate the skills and knowledge, processes, facilities, and equipment needed to design, develop, manufacture, repair, and support DoD products. The purpose of the assessment is to identify potential IB/program risks.

Industrial base risk mitigation activities may be a result of a formal study or analysis or may be a result of routine oversight that identifies a risk or an issue. M&Q managers need to assist in the development and management of risk management strategies and implementation plans.

Manufacturing and Quality Tasks

- Update and validate prior industrial base assessments based on CDR and Pilot Line demonstrations for program management and technical reviews (e.g., PRR, SVR, FCA, etc.) prior to LRIP for (*see* D.1) changes in:
    - Sources and alternatives
    - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
    - Vulnerabilities
        - Sole, single, foreign, etc.
        - Military
        - Counterfeit
        - Potential exploitation
        - Fragility and uncertainty of demand
    - Production capability and capacity
    - Security (threat physical and cyber)
    - Availability (e.g., materials, components, equipment, facilities, etc.)
    - LRIP required COTS and NDIs
    - External dependencies
    - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
    - Government and contractor Depot and Maintenance and Repair Operations
- Incorporate into the update changes in M&Q maturity of new and unique capabilities and processes that are included in the system.
    - Include technological developments, market trends, processes, environmental factors, and policies, etc.
- As part of the update, include reporting and analyses from DCMA and DLA on relevant industrial base capabilities, status, and trends.
- Assess effectiveness of actions or investments made to address M&Q industrial base risks to cost, schedule, performance; areas that should have been included are:

- Capabilities required throughout the life of the system
- Product or technology obsolescence
- Business fragility for unique services, products, or M&Q capabilities
- Industrial base resilience to rates, vulnerabilities, capacity,
- Availability of system required material (e.g., materials, special alloys and composites, components, tooling, equipment, alternatives, etc.)
- Maturation of new and unique capabilities

- Update the M&Q inputs to the joint Risk, Issues, and Opportunity Management System (to include mitigation status) for industrial base capabilities and capacities in support of LRIP and Production and Deployment phase.
- Update the M&Q inputs to the Industrial Base Capabilities Considerations Summary Report for Milestone (MS) C.

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist) for Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60-H, Assessing Defense Industrial Capabilities
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook

E. DESIGN

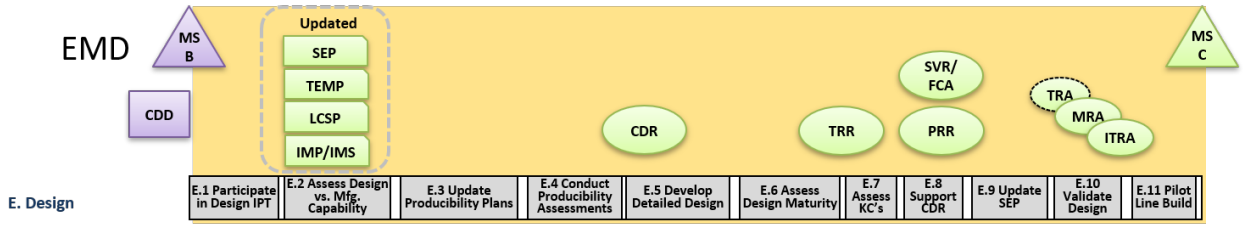


Figure 4-6. Design Manufacturing and Quality Activities

Introduction

DoD Systems Engineering (SE) is a disciplined approach for the specification, design, development, realization, technical management, operation, and retirement of a weapon system. SE is an interdisciplinary and collaborative effort requiring close interaction with many disciplines to include operations, maintenance, logistics, test, production, quality, etc. SE accomplishes these activities by focusing on eight technical processes and eight technical management processes. M&Q personnel need to support these SE activities.

This thread (Design) requires an analysis of the degree to which the identified, evolving or system design will meet user requirements and is producible.

During the EMD phase, by CDR, all the design information necessary to plan the detailed manufacturing operations for the system should be available. M&Q participation early in the design process through active participation in the Design IPT is the key to creating a producible design. Participants should support and provide inputs on design trade studies (producibility, materials, IB capabilities, etc.), analyses, testing, configuration control, design reviews, etc. This information should be the basis for the Manufacturing Strategy and Plan and the Quality Strategy and Plan, which cover the issues of M&Q organization, make or buy planning, subcontract management, resources and capabilities, and the required detailed fabrication and assembly planning to include pilot line and ramp-up for LRIP. The contractors' and supply chain M&Q capabilities should be assessed throughout the EMD phase as these capabilities will be required in this phase and must be in place for LRIP.

Producibility planning started during the concept exploration phase and has influenced the entire design effort from that point on. The objectives of producibility include both engineering design criteria and the producibility planning requirements. The program is required to "reduce manufacturing risk and demonstrate producibility" prior to FRP (per DoDD 5000.01). This requires producibility plans to be assessed and updated on a periodic basis and producibility activities to be monitored and assessed on a continuing basis. Additionally, producibility planning in EMD should address all areas of M&Q impacting cost, schedule, and performance requirements such as KCs, selection of specific materials, specific M&Q processes, changes in requirements, changes in workforce, facilities, tooling, equipment, etc.

Producibility assessments of the design should be conducted at the contractor and in the supply chain using of a wide range of producibility tools, techniques, and procedures including M&S, Failure Mode and Effects Analyses (and Criticality), Design for Manufacture and Assembly, product and process capabilities with measurements using Statistical Process Control, etc. Results of M&Q design producibility assessments should generate recommendations for design improvements to be integrated into the detailed system design and/or system specifications according to a joint government/ contractor producibility schedule.

For EMD, to identify and obtain the required M&Q processes and resources, the design should be specified in detail. The final design (i.e., approved at CDR) results from performance requirements, outcomes of the testing accomplished, producibility studies, and other design influences related to cost, schedule, and performance. Prior to a system-level CDR, detailed design must be developed from the component level up to the system level with design reviews conducted to assure meeting design requirements and goals at all levels of the supply chain. Prior to release of drawings to manufacturing, the detailed design drawings, bills-of-material, and product and process specifications must be completed. Further, it is essential that assessments be conducted to ensure that the contractor is complying with requirements and meeting cost/design goals.

Many system-level risks evolve from immature designs and failure to consider design risks. Risks associated with M&Q processes will have a major impact on the maturity of design. M&Q must assess design maturity based on manufacturing feasibility, capability, producibility, and KCs, in accordance with industry best practices. Through support of all design reviews at all levels of the supply chain, the adequacy and completeness of M&Q requirements verification and validation activities can be determined. Additional design maturity can be achieved through demonstrations of M&Q processes and procedures in a representative environment at the system, subsystem, item, and component level.

M&Q program personnel should monitor and assess the maturity of KCs and critical characteristics, as well as the associated M&Q processes, and risk and issues mitigation activities. The correctness, adequacy, and completeness of key and critical processes for KCs and critical characteristics should be verified as part of this monitoring and assessment of maturity to include the closure of post-PDR M&Q mitigation measures.

As the design progresses from preliminary design to detailed design, the Design IPT must ensure that all design considerations are maturing on schedule for CDR and address all design risk contributors including trade studies, design policies, processes, and analyses, parts and materials selections, software design, testing, configuration control, and design reviews. The PDR and CDR are the systems engineering technical reviews that are used to measure design maturity. By CDR, the design should be mature, stable and with few engineering changes. Producibility is a best practice for ensuring that the design is producible and affordable.

Identification of KCs was initiated in the early phases of development, and the list of KCs should be continually updated and refined. In EMD phase, the list should matured to a final list of all KCs, corresponding to the finalized design at CDR. Prior to completing design, the list of KCs could be reduced through producibility activities as the product design is refined to make KCs less sensitive to variation. As the KCs are finalized, the corresponding list of critical M&Q processes should also be completed. Post-CDR activities, including pilot line, will provide the basis for validation and adequacy of the contractor's processes, capabilities, and control of KCs.

The role of manufacturing to influence the design culminates at CDR. M&Q design decisions have major impact on future production and life cycle costs. By the time, the CDR is held the production

and life cycle costs commitment is approximately 90 percent. Therefore, manufacturing, quality, and other considerations must be finalized by CDR to enhance affordability. All key and critical manufacturing processes, including process control plans, should be defined, characterized, and up to date for the final detailed design. Government and contractor producibility analyses should identify M&Q risk and issues. The associated mitigation activities should be ongoing, up-to-date, and monitored in the joint government/contractor Risk, Issue, and Opportunity Management System for resolution prior to the Milestone C decision.

Programs prepare a SEP for each milestone review, beginning with Milestone A. It is intended to be a living document, tailored to the program, and a roadmap that defines comprehensive SE activities, addressing both government and contractor technical activities and responsibilities. Additionally, the SEP describes the timing, conduct, entrance criteria, and success/exit criteria of technical reviews. A well-managed, periodically maintained SEP should be updated post-CDR by M&Q to facilitate program success.

The M&Q Strategies should include assessments of the M&Q processes effective demonstrations in an appropriate environment, such as a pilot line environment, prior to Milestone C. These demonstrations on a pilot line should incorporate all key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce components, items, subsystems, or systems and validate meeting design requirements for LRIP. M&Q processes and procedures required for production must be matured to a level of high confidence for LRIP in the P&D phase.

A successful pilot line build provides the means to validate that system design is complete and sufficiently stable to enter LRIP. All materials, manpower, tooling, test equipment and facilities, STE/SIE, processes, and procedures are proven on the pilot line, meeting the planned LRIP schedule, and known M&Q risks are under control, posing no significant challenges. Outputs of the pilot line will produce articles subject to FAIs/FATs and will provide validation of the design and that M&Q processes are under control and ready for LRIP.

E.1 Participate in Design Integrated Product Team

Major programs are organized around core design team, usually comprised of 20-50 of the contractor's best engineers. This core design team makes 90-95% of all critical decisions with most design decision made prior to production. If M&Q are not one of their primary concerns, then these considerations will be delegated to secondary teams or not accomplished until late in the program causing serious problems with cost, schedule, and performance.

The PM and Technical team need to ask M&Q questions and ask them often. The contractor will follow the government's lead. If the government shows concern for these areas in the development of the design and integration with M&Q, then the contractor receives the message and will show like concern.

M&Q personnel must participate with the Design IPT in the development and review of the design and design documentation.

Manufacturing and Quality Tasks

- M&Q personnel as Design IPT participants assess and monitor continuing adherence to M&Q design best practices (e.g., AS6500, AS9100, ISO 9001, etc.).
- Update M&Q requirements based on analyses of system requirements and design concepts from TMRR developments and the PDR including:
    - System capabilities and constraints
    - The required M&Q capabilities baseline
    - M&Q cost drivers and impact on schedule and performance
- Provide M&Q input to design trade studies (i.e., functional and performance requirements) that include criteria concerning:
    - KCs and the associated KPPs, KSAs, and APAs
    - M&Q process capabilities, limitations, and concerns
    - Materials, components, and items sourcing (e.g., domestic vs. foreign risks)
    - Embedded software and firmware development and re-use
    - Use of IP and proprietary data
    - Safety, handling, storage, and disposal considerations and restrictions
    - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
    - Manufacturing costs, materials, special tooling, and test equipment
    - Manufacturing facility and equipment capacity, workforce availability and capability, and schedule impacts
- M&Q personnel participation in the design producibility process provides:
    - Analyses of products and processes that would benefit from producibility analyses (i.e., DFM/DFA)
    - Monitoring and reporting on producibility processes and testing with respect to risks, issues, and opportunities
    - Integration of producibility with other design activities including software and firmware development and re-use
    - Analyses and results of producibility design trade studies to include process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
    - Assessment of additional innovative manufacturing technology opportunities (beyond current ManTech projects)

- Provide a focal point for producibility assessments and integration with other design activities (e.g., engineering, producibility, reliability, maintainability, costs, safety, manpower, schedule, etc.).
- Provide assessments of key and critical M&Q assembly and test processes to be evaluated and matured.
- Provide ongoing M&Q assessments of risks, issues, and opportunities (e.g., technologies, manufacturing, software development, and sustainment).
- Provide monitoring, reviews, analyses, and reports on multiple FMEAs (e.g., FTA, DFMEA, PFMEA, etc.) as part of the M&Q inputs to the FMECA process.
- For the Engineering and Manufacturing Development and demonstration process, M&Q participants should provide:
    - Inputs that establish, implement, and maintain appropriate processes to manage key and critical subsystems, components, and items including process controls for KCs
    - Criteria and metrics for design and production process verification, test, inspection, product verification and acceptance (including statistical techniques)
    - Monitoring and managing the data from the development process with acceptable frequency, quantity, and metrics
    - Criteria for and monitoring of M&Q development testing for validating design outputs (products)
    - M&Q inputs for design configuration management (including verification, validation, and change control)
- Update the analyses of M&Q design activity impacts and interdependencies to other functional areas or activities (e.g., engineering, producibility, reliability, maintainability, costs, safety, manpower, schedule, etc.).
- Perform re-assessments of M&Q risks, issues, and opportunities and the associated mitigation activities, based on the changes to and progress of the design, in meeting critical design entrance criteria (e.g., technology, manufacturing, cybersecurity, software development, and sustainment).
- Provide M&Q support to Design IPT participation in program reviews (e.g., PMRs, CDR, etc.).
- Assess and monitor the development of the system design for use of COTS, GOTS, GFP/GFE, and NDIs for impacts to M&Q, potential obsolescence requiring re-design and design changes, and sustainment (e.g., availability, storage, etc.)
- Provide updated M&Q inputs to program documentation (e.g., SEP, TEMP, Acquisition Strategy, CDD, etc.) based on design changes and progress:
    - Include inputs and support for CPD efforts
    - Include inputs for Manufacturing Plan updates (including changes, investments, etc.)

- M&Q participants should provide support to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.).
- Provide M&Q inputs to program management in support of assessments and reports mandated by Congress.
    - Inputs on M&Q risks associated with the program
    - Inputs on M&Q processes that need to be matured

Tools

- CDR Checklist
- CPD template
- Design for Manufacturing and Assembly (DFMA)
- FCA Checklist
- IMP/IMS template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Life Cycle Sustainment Plan template
- Manufacturing Maturation Plan
- PRR Checklist
- SVR Checklist
- Systems Engineering Plan (SEP) Outline
- TEMP template
- TRA Checklist
- TRR Checklist

Resources

- 10 USC 144B, Sections 2366 and 2448
- Acquisition Strategy Guide, DSMC
- CDD-CPD writing Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- LCSP memo, and DAG
- Manufacturing Readiness Level (MRL) Deskbook
- Production Readiness Review, DAG
- System Verification Review, DAG

- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment (TRA) Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide
- Test and Evaluation Master Plan (TEMP) Guide

E.2 Assess Design vs. Manufacturing Capability

M&Q managers as members of the technical Integrated Product Team (IPT) should accomplish an assessment of the design and the capability of the factory floor to build to the design. This includes assessing manufacturing readiness and effective integration of industrial capability considerations into the design process. The first consideration is a need to understand current manufacturing capabilities to see if they match up against the design requirements so that the program can plan for the enhancements of capabilities where there is a gap between the design and factory floor capabilities.

Current "Design Best Practices" include the use of computer-aided design (CAD) and computer-aided manufacturing (CAM).

CAD is the use of computer software to design and document a product's design process. CAD is used to accomplish preliminary design and layouts, design details and calculations, creating 3-D models, creating, and releasing drawings, as well as interfacing with analysis, marketing, manufacturing, and end-user personnel.

CAM is the use of software and computer-controlled machinery to automate a manufacturing process. Based on that definition, you need three components for a CAM system to function:

- Software that tells a machine how to make a product by generating toolpaths.
- Machinery that can turn raw material into a finished product.
- Post-processing converts toolpaths into a language machines can understand.

Manufacturing and Quality Tasks

- Assess the organizations approach to systems engineering and the use of best practices to manage design and manufacturing considerations
- Perform M&Q design trade studies and analyses on system, subsystems, items, and components for:
    - Interdependencies and interfaces
    - Design for Manufacturing and Assembly
    - M&Q "ilities": (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.)
- Perform M&Q assessments of the contractor(s) and supply chain capability to mature and manufacture the design(s) within the program overall cost, schedule, and performance goals, including:

  - Design status and progress for CDR including exit criteria
  - Quantification of risks, issues, opportunities, and status of mitigation plans
    - Including shortfalls to the required baseline M&Q capability
    - Including materials, producibility, equipment, and schedule (e.g., availability, hazardous, long-lead, etc.)
  - All competing technologies, prototypes, systems, etc.
    - Including M&Q inputs to production unit cost and schedule estimates realism
  - M&Q processes and techniques, not yet part of the contractor's baseline, development requirements driven by the design, including:
    - Facilities, equipment, manpower, quality technologies,
    - Planned and/or anticipated M&Q developmental testing and demonstration efforts
    - Capabilities with respect to safety, security, environmental, HAZMAT, etc.
- Update the list of KCs, critical characteristics, CAIs, Key M&Q processes, and CSIs, based on design trade studies and assessments, and PDR results.
- Assess required M&Q budget and investments for necessary capabilities (e.g., facilities, capital equipment, tooling, test equipment, ManTech, GFE processes, M&S, etc.)

Tools

- CDR Checklist
- CPD template
- Design for Manufacturing and Assembly (DFMA)
- FCA Checklist
- IMP/IMS template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Life Cycle Sustainment Plan template
- Manufacturing Maturation Plan
- PRR Checklist
- SVR Checklist
- Systems Engineering Plan (SEP) Outline
- TEMP template
- TRA Checklist
- TRR Checklist

Resources

- 10 USC 144B, Sections 2366 and 2448
- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program

- CDD-CPD writing Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- LCSP memo, and DAG
- Manufacturing Readiness Level (MRL) Deskbook
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline
- Test and Evaluation Management Guide
- TRA Guidance

E.3 Update Producibility Plans

Producibility Engineering and Planning should be directed toward generating a design which is compatible with the current capability of the factory floor. Producibility is a major driver of product affordability because of the effect on both production and sustainment costs. The Producibility Plan should guide the design effort and describe activities that will be accomplished, the responsible organization, and the management controls that will be established to ensure successful accomplishment. M&Q managers should be updating the Producibility Plans with a focus on the realism, completeness and clarity of the planning accomplished by the contractor.

Manufacturing and Quality Tasks

- Review and analyze the contractor(s) design plans for scope, realism, completeness, and clarity of specific processes, methods, and actions to address manufacturing feasibility, producibility, and quality to include:
    - A schedule for regular reviews to monitor and support design progress
    - Delineation of responsibilities and management controls
    - Application of producibility design criteria
    - Interdependencies and integration factors
    - M&Q technology project insertion
    - Technology insertion opportunities, schedule, and budget
- Ensure updates to contractor producibility plans for identified and potential M&Q risks, issues, and opportunities to include:
    - KCs and critical design characteristics

  - M&S results from design, manufacturing, and production modeling
  - M&Q processes, capacity, capability, yield, rates, and variability
  - Materials and components (including embedded software)
  - Cost, schedule, and performance
  - Facilities, tooling, testing, and qualification
  - Workforce

- Ensure updated contractor producibility plans for design, manufacturing, and quality include:
  - Security (physical and cyber)
  - System safety and HAZMAT management criteria
  - Interdependencies and integration
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
  - Benchmarking
  - Costing
  - Management of M&Q data
  - Results of Failure Mode and Effects Analysis (FMEA)
    - Fault Tree Analysis (FTA)
    - Design Failure Mode and Effects Criticality Analysis (DFMECA)
    - System Failure Mode and Effects Criticality Analysis (SFMECA)
    - Process Failure Mode and Effects Analysis (PFMEA)
  - Results from prototype builds and demos
- Evaluate updated contractor producibility plans for the specific applications of producibility design tools such as:
  - Failure Mode and Effects Analyses (including Design, Process, and Criticality)
  - Design of Experiments (DOE)
  - Quality Functions Deployment (QFD)
  - Root Cause Analyses
  - Statistical Process Control (SPC)
  - Tolerance Analyses
  - Design for Manufacture/Assembly (DFMA)
  - Design for Six Sigma
  - Lean manufacturing
- M&Q personnel should evaluate contractor's design producibility process for factors such as:
  - Robust tolerances (dimensions, mechanical, electrical)
  - Materials that provide optimum machinability, formability, and weldability
  - Economic use of shapes and forms designs for castings, stampings, extrusions, etc.
  - Optimum inspection and test requirements
  - Use of available and standard inspection equipment

- Economical methods and procedures
- Optimized requirements for manufacturing tooling and/or special skills

Tools

- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Producibility Engineering and Planning (PEP) Data Item Description
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- Defense Manufacturing Management Guide for Program Managers
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-727, Design Guidance for Producibility
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering and Planning (PEP)
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center
- Systems Engineering Plan (SEP) Outline

E.4 Conduct Producibility Assessments

The Program Manger should reduce M&Q risk and demonstrate producibility prior to FRP. Producibility engineering and producibility assessments should be a part of the ongoing systems engineering process. Producibility is directly connected to the complexity of a system. As complexity increases, so does the acquisition costs. Therefore, producibility programs are necessary as a management means for assuring that the cost increases associated with the growing complexity of systems are minimized. Producibility analysis accomplished by the PMO must be performed by a team of specialists assembled from the program office: and supporting organizations. M&Q managers are key to the successful implementation of a producibility program.

Manufacturing and Quality Tasks

- M&Q personnel as Design IPT participants support and/or perform producibility assessments using updated and approved contractor producibility plans and other contractor and/or programmatic information and data including the following factors in the assessments:
  - Planned producibility goals and metrics
  - Management roles, responsibilities, and controls

  - Updates to KCs and critical design characteristics
  - Contractor core capabilities and processes (e.g., M&Q technologies, design, and process disciplines, etc.)
  - Design analyses and testing (i.e., prototypes)
  - Results from design, manufacturing, and production modeling (i.e., M&S)
  - Changes in M&Q processes, capacity, capability, yield, rates, and variability
  - Changes in materials and components (including embedded software)
  - Build and test data (from subsystem, items, components, and/or the supply chain)
  - Updates to cost, schedule, and performance
  - Updates to interdependencies and integration
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
  - Risks, issues, and opportunities
  - Insertion points for M&Q technology projects
  - Technology insertion schedule and budget
  - Review of goals, realism, completeness, and clarity
  - Implementation of industry best practices, tools, and techniques
  - System safety design and HAZMAT management criteria
  - Security (physical and cyber) including all digital communications and connectivity for design, facilities, equipment, etc.
  - Facilities, tooling, testing, and qualification updates
  - Workforce changes (e.g., skill sets, availability, training, turnover, etc.)
  - GFE, etc.

- Incorporate and investigate producibility possibilities that exist in the industrial base outside the contractor's supply chain from the assessments of the IB. (*See* D.1)
- M&Q personnel as Design IPT participants monitor, recommend, and support use of a wide range of producibility tools, techniques, procedures that include:

  - State-of-the-art M&S software including element analyses software packages
  - Failure Mode and Effects Analyses (FMEA)

    - Design Failure Mode and Effects Criticality Analysis (DFMECA)
    - System Failure Mode and Effects Criticality Analysis (SFMECA)
    - Process Failure Mode and Effects Analysis (PFMEA)

  - Design for Manufacture and Assembly (DFMA)
  - Design of Experiments (DOE)
  - Design for Six Sigma (DSS)
  - Quality Function Deployment (QFD)
  - Value Stream Mapping (VSM)
  - Benchmarking
  - Materials and process design guides (e.g., standards organizations, materials supplier, industry association, etc.)

  - Interdependencies and integration analyses
  - Tolerance analyses (e.g., stacking, robustness, geometric, etc.)
  - Requirements validation analyses
  - Trade studies on alternative product and process designs
  - Product complexity analyses
  - Manufacturing process analyses (i.e., Lean Manufacturing)
  - Quality and quality process analyses
  - Costs, cost drivers, and controls analyses
  - Materials characterization and availability
  - Prototyping of component, item, subsystem, competitive, etc.
  - Learning curve goals and projections
  - Product, process capabilities, and measurements using Statistical Process Control (SPC)
  - Data and database management
  - Developmental testing
- Provide program M&Q support to design producibility analyses, to validate and recommend appropriate producibility improvements (by rank and/or priority) to be implemented in the system design and/or specifications.
- Prepare a joint government/contractor schedule for implementation of the producibility improvements based determined rank and priority.

Tools

- CAS/CAM software
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- ISO 9001:2015, Quality Management System
- MIL-HDBK-727, Design Guidance for Producibility
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering Standard Practice Manual, U.S. Army Belvoir R&D Center

- Systems Engineering Plan (SEP) Outline

E.5 Develop Detailed Design

Detailed product design includes the realization (build) effort down to the lowest level system elements and includes the fabrication/production processes required to complete the build effort. As a best practice, the Systems Engineer should develop an implementation plan that includes implementation procedures, fabrication processes, tools and equipment, implementation tolerances and verification uncertainties. M&Q managers/engineers need to be a part of the development and assessment of detailed design efforts.

Manufacturing and Quality Tasks

- M&Q personnel support and participate in design reviews at all possible levels of the supply chain to assure that the contractor is complying with the M&Q design requirements within the cost/design goals to include:
    - Adherence to M&Q best practices (e.g., AS6500, AS9100, ISO 9001, etc.)
    - Ensure all PDR action items are closed, and corrective actions completed.
    - Results of appropriate producibility studies including manufacturing technology improvements, recommended design changes, and recommended facilities and equipment changes
    - Results of ManTech projects
    - Detailed design drawings, bills-of-material, and product and process specifications are on track for completion by CDR
    - Performance requirements, the outcomes of the testing accomplished, producibility studies, and other design influences are part of the final design
    - Design is specified to the lowest level of detail to meet capability and capacity requirements
- As part of detailed design activities, M&Q personnel should identify and quantify risks with associated mitigation (e.g., re-direct, re-design, etc.) to minimize M&Q risks in the completed design for CDR.
- As part of detailed design, ensure KCs whose variation has a significant influence on product fit, performance, service life, or manufacturability are specified and monitored for CDR.
- M&Q personnel should identify requirements for in-process and acceptance testing to be included in M&Q processes.
- Ensure M&Q requirements for physical, digital, and industrial security follow DoD policies and NIST standards incorporated into the design and manufacturing system.
- Ensure that required M&Q products and processes comply with specified security (e.g., SSE, COMSEC, and PPP) requirements of the program including trusted production of products down to the component level.

- Assess requirements for required system certifications (e.g., statutory, safety, environmental, airworthiness, others as required) and the impacts on M&Q requirements and associated costs, budget, schedule, etc.
- Assess design requirements for the following (include associated costs, budget, schedule, etc.):
    - Incorporation of all ESOH, environmental, hazardous material, etc. requirements into the detailed design
    - EMI requirements and constraints for the design, control processes, procedures, and planned facilities and equipment (including EMI susceptibility)
    - Radiation hardening, thermal, vibration, and shock environments, all environmental parameters, and Highly Accelerated Life Testing (HALT) requirements for impacts to and requirements of M&Q (e.g., facilities, tooling, equipment, test equipment and facilities, processes, procedures, storage, waste disposal, etc.)
    - Impacts to and requirements of M&Q personnel (e.g., operators, assemblers, welders, platers, coatings specialists, etc.)
    - Corrosion, contamination, hazards, hazardous combinations of materials, and impacts on manufacturing processes, quality control processes, and procedures for both
    - Impacts on M&Q data requirements (e.g., collection, processing, storage, security, access, availability, etc.)
    - Impacts to M&Q from materials, components, and items maturity and availability; lead-times; source availability, capability, and capacity to include the supply chain
    - Necessary M&Q equipment, fixtures, tooling, work-holding, parts interim storage and handling equipment, ancillary equipment, etc.
- Assess the adequacy of M&Q sustainment requirements (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.) and processes, and activities being considered and addressed in the design specifications.
- Assess contractor's and supplier's configuration management systems for traceability, accuracy, sufficiency, and accessibility in preparation for CDR.
- As the system, subsystem, items, and components are being specified, analyze these to ensure M&Q constraints and requirements have been incorporated into design specifications and requirements.
- Analyze results of demonstrations in a relevant environment from the previous phases of all new technologies to be incorporated into the design to ensure they can be incorporated and integrated into a system with acceptable M&Q risks.
    - If not conducted, recommend demonstrations prior to CDR.
- Assess M&Q physical architectures, development specifications, and detailed designs for key manufacturing processes (i.e., KCs), CSIs and CAIs to be under contractor's configuration control and on track for completion by CDR.
- Ensure all long lead production requirements are identified for CDR.

- Assess the system design for parts, materials, and processes to ensure appropriate allocation of M&Q requirements in the detailed design.
- Based on the results of the detailed design development activities, M&Q personnel should provide updated inputs to the program Work Breakdown Structure (WBS).
- Prior to finalizing the design for CDR, M&Q personnel should assess: (*See* E.8)
    - Results of all design trade studies for M&Q impacts and changes to KCs and therefore associated KPPs to verify that all requirements are being met
    - Bi-directional traceability among all M&Q considerations:
        - Allocated and physical requirements
        - Engineering trade study results
        - Technical, schedule and cost risks, issues, and opportunities

Tools

- CDR Checklist
- CPD template
- Design for Manufacturing and Assembly (DFMA)
- FCA Checklist
- IMP/IMS template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Life Cycle Sustainment Plan template
- Manufacturing Maturation Plan
- PRR Checklist
- SVR Checklist
- Systems Engineering Plan (SEP) Outline
- TEMP template
- TRA Checklist
- TRR Checklist

Resources

- 10 USC 144B, Sections 2366 and 2448
- Acquisition Strategy Guide, DSMC
- CDD-CPD writing Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- LCSP memo, and DAG

- Manufacturing Readiness Level (MRL) Deskbook
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- TEMP Guide, and DAG
- Test and Evaluation Management Guide

E.6 Assess Design Maturity

Prior to the CDR the contractor is finalizing the design as may be evidenced by a lot of design changes. The CDR assesses the systems final design as captured in the product specifications for each configuration item and ensures that the configuration item has been captured in the detailed design documentation. The CDR should be conducted when the product baseline has been achieved, allowing fabrication of hardware and coding of software deliverables to proceed. A rule of thumb is that 75 percent to 90 percent of (manufacturing quality) product drawings, software design specification(s) and associated instructions should be complete, and that 100 percent of all safety-critical component (Critical Safety Items and Critical Application Items) drawings are complete.

After CDR the design should be maturing and should be stable and mature by the Production and Operations phase and may be considered mature when the number and type (Class I and Class II) of engineering change traffic is tapering off and when the drawing packages have been released to manufacturing. Configuration of the item should be stable as should be the requirements. M&Q (M&Q) managers as a part of the Technical IPT should support the CDR and assessment of design maturity as the program approaches a Milestone C Decision.

Manufacturing and Quality Tasks

- M&Q personnel will assess design maturity based on assessments of manufacturing feasibility, capability analyses, producibility, and KC analyses, in accordance with industry best practices (e.g., AS6500, AS9100, etc.) and assess readiness for the CDR (per IEEE 15288).
- Update M&Q assessments of the contractor(s) and supply chain capability to mature and manufacture the detailed design within the overall cost, schedule, and performance goals (e.g., producibility, feasibility, and capability)
    - Assess manufacturing processes and quality results for each individual configuration item to verify each meets the stated performance requirements
    - Assess completeness of product data required for component manufacturing
    - Assess adequacy and robustness of the parts management and configuration control processes (e.g., design, engineering, and software)

- M&Q personnel support design reviews at all levels of the supply chain, assess adequacy and completeness of M&Q requirements verification and validation activities including demonstrations in a representative environment at the system, subsystem, item, and component levels.
    - Assess and verify product and technology requirements and features as ready for system CDR including
        - Products producibility (subsystem, item, and component)
        - Products and technology maturity
        - Alternate sources and products producibility, maturity, and availability (i.e., second sources)
        - MOSA
        - COTS, NDIs, and GFE
    - Assess M&Q results of TPM maturation activities to support design maturity
    - Assess and validate if product data essential for item and component manufacturing is under configuration control and has been released
    - Verify completion of physical and functional interface designs for the system
    - Verify long-lead production requirements have been established and are understood
    - Verify M&Q safety requirements are in the detailed design to include all safety hazards
    - Assess and validate prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software
    - Verify completion of subsystem design (with closure schedule for open items) and percentage of subsystems in current production
- Monitor and assess the maturity of KCs and critical characteristics, the associated M&Q processes, and associated mitigation activities.
    - Verify correctness, adequacy, and completeness of key and critical processes for KCs and critical characteristics (e.g., C_{pk}, tolerances, etc.)
    - Verify correctness, adequacy, and completeness of KCs and critical characteristics to the associated KPPs
    - Verify contractor M&Q engineering and management activities for adequacy and completeness (e.g., demonstrations, documentation, drawings, testing, data collection and management, etc.)
        - Analyze data from demonstrations of key and critical M&Q processes in a production-representative environment to satisfy design tolerances and meet objectives
- Monitor post-PDR M&Q mitigation measures and maintain the status of all mitigation measures up to date for all gaps, risks, and issues including those from:
    - Key and critical manufacturing processes including embedding software

  - Materials
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and HAZMAT management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment
- Assess adequacy and completeness of mitigation activities for reducing M&Q risk, issues, and opportunities in the joint government/contractor RIO Management System.

Tools

- Design for Six Sigma
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD 882E, System Safety
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.7 Assess Key Characteristics

AS9103 is the industry best practice of the identification and control of KCs and requires the producer to maintain documentation of KCs and control those manufacturing processes that directly influence variation of those KCs. KCs should be capable and have a Cpk of 1.33 or greater or as specified by the customer. The concept of identifying KCs is linked to the Pareto principle, which asserts that a relatively small number of features will have the most significant impact on performance. M&Q

managers should be involved in the identification and assessment of KCs to see if they meet customer requirements and identify risks from not meeting those requirements.

Manufacturing and Quality Tasks

- Analyze and verify of the flow down of requirements to M&Q from the functional baseline to the lowest-level system detailed design element for all end items in the specification tree to ensure all are traced to specific manufacturing processes and quality metrics in the detailed design.
- Analyze all internal and external interface KCs (e.g., physical, electrical, digital, etc.) for M&Q specifications and requirements (e.g., flatness, attachment, connectivity, bi-directionality, compatibility, etc.) and changes since PDR to ensure acceptable risks for proceeding into fabrication, integration and testing.
- Analyze each specific manufacturing process and quality metric in the detailed design to verify that each is a KC (these should have been previously identified, but additional KCs may be identified).
    - Ensure each component level KCs is traceable to system design and is under control by the contractor specified in the documentation appropriately
- Analyze identified KCs for validity and adequacy using contractor tolerances and/or process capability indexes and supporting data.
- Ensure survivability and vulnerability threat (KPPs) allocations incorporated into the design down to the component level that are tied to specific manufacturing processes and quality metrics in the detailed design have been specifically identified by the contractor as such.
    - Ensure M&Q processes have been identified, analyzed, and are under configuration control
- Ensure that the contractor has established and is maintaining lists of Key and/or critical items, CSIs, and CAIs with the lists including:
    - Rationale for designation
    - Control and risk mitigation plan(s)
    - Where produced or accomplished (including potential changes)
- Ensure all identified KCs are incorporated into the Verification Cross-Reference Matrix (VCRM) for required testing and verification.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Critical to Quality Tree
- Failure Mode and Effects Analysis

- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Level Assessment Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100 Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- JCIDS Manual
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Calculator
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

E.8 Support Critical Design Review

M&Q personnel should be actively engaged in the organization and execution of the CDR during this phase. The CDR occurs roughly mid-point in the EMD phase. The CDR brings to closure design paths in detailed design. Any changes moving forward should only be accomplished through a formal Engineering Change Proposal (ECP). The completion of the CDR should provide:

- An established system initial product baseline,
- An updated risk assessment for EMD,
- An updated CARD based on the system product baseline,
- An updated development schedule for fabrication, test and evaluation, software coding, critical path drivers, and
- An approved Life Cycle Sustainment Plan.

Manufacturing and Quality Tasks

- Ensure initial product baseline documentation for M&Q is sufficient, complete, and adequate to enable component manufacturing, hardware fabrication and software implementation to proceed.

  - Ensure all KCs, CSIs, and CAIs have completed drawings and specifications under configuration control
  - Ensure all product data essential (e.g., drawings, specifications, etc.) for component manufacturing has been released
- Ensure all M&Q design trade studies and producibility assessments are completed and incorporated into the design for CDR.
  - Ensure producibility enhancement efforts ongoing for optimized integrated system (e.g., Design for Manufacturability, Design for Assembly, etc.)
- Ensure all subsystem, item, and component CDRs are complete and the results available for the system CDR.
  - Analyze the results of design maturity assessments (*See* E.6) including all appropriate reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.) for closure or approved rationale to enter CDR without completion is documented and accepted by the program office.
- Ensure M&Q input to the schedule (IMP/IMS) is up-to-date and is executable with acceptable risks.
- Ensure M&Q plans, activities, and processes are executable within the existing M&Q budget to support the approved initial product baseline and critical path.
- Ensure all key and critical manufacturing processes, including process control plans, have been defined, characterized, updated for the detailed design, and the capability to meet design tolerances has been determined.
- Analyze contractor M&Q plans for materials, facilities, equipment, test facilities and equipment, and tooling to support the pilot line requirements.
- Analyze M&Q plans for adequacy and capability of achieving MRL 8 by initial production.
- Analyze plans for long-lead procurement requirements and incorporate results into procurement plans.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) for M&Q risks, issues, and opportunities and appropriate mitigation plans.
- Analyze the assessments of adequacy and completeness of M&Q requirements validation activities (*See* E.6) which included prototypes and demonstrations in a representative environment at the system, subsystem, item, and component levels for design maturity.
  - Include demonstrations of manufacturing processes in a representative environment
  - Include demonstrations of M&Q processes for KCs, CSIs, and CAIs
- Provide M&Q inputs to the Life Cycle Sustainment Plan for CDR.
- Ensure contractor M&Q management systems for M&Q metrics and data collection and tracking to the component level are in place and functional.

- Ensure the TEMP incorporates all M&Q subsystems, items, and components into plans for tests, test facilities, and test equipment.
- Ensure the M&Q considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - PPP
    - SEMP
    - TEMP
- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure M&Q design producibility improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (*See* E.4).
- Provide up to date M&Q inputs to the program budget and the CARD.
    - Update and allocate M&Q (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure adequacy and completeness of mitigation activities for mitigation of M&Q risks, issues, and opportunities in the joint government/contractor RIO Management System, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and HAZMAT management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment

Tools

- CDR Checklist

- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline

E.9 Provide Updates to the Systems Engineering Plan

The SEP is a living document that details the execution, management, and control of the technical aspects of an acquisition program. The SEP outlines how the systems engineering process is applied and tailored to meet objectives for the program and is updated for each acquisition phase. M&Q managers, as members of the Technical IPT, should be providing input into the SEP.

Manufacturing and Quality Tasks

- At a minimum M&Q should ensure updates are provided for the following:
    - System architectures and interfaces
    - Required DoD certifications (e.g., Space-worthiness, Airworthiness, Insensitive Munitions, etc.)
    - M&Q risk, issue, and opportunity assessments, including schedule, costs, performance, PRRs, pilot lines, prototypes, demonstrations, milestones, etc.
    - Program M&Q structure and organization including WBS, positions, staffing, etc.
    - M&Q Technical Performance Measures and metrics including yields, rates, process capability indices, etc.
    - Planned M&Q activities for the next phase including Value Engineering, ManTech, and other improvements, learning curves, initiating production, etc.
    - M&Q requirements tracking and change processes including changes from prototypes, demonstrations, development testing, etc.
    - M&Q configuration and Engineering Change Proposal (ECP) management

- KCs considerations and impacts critical to the achievement of the program's technical requirements

Tools

- Critical to Customer/Critical to Quality Tree
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Manufacturing Plan (included in the SEP)
- Producibility Assessment Worksheet
- Quality Assurance Plan (included in the SEP)
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Systems Engineering Plan (SEP) Outline

E.10 Validate Design

Product design should have been stable by the time the CDR was conducted, however detailed design often continues well into the Production and Deployment phase. The Physical Configuration Audit (PCA) is a formal examination of the "as-built" configuration of the system or a configuration item against its technical documentation to establish or verify its product baseline. A successful PCA provides the Milestone Decision Authority with evidence that the design is stable. At the conclusion of the PCA, the final product baseline is established, and all subsequent changes are processed by a formal engineering change action and under the control of configuration management practices. M&Q managers should support the validation of the design during the CDR and PCA.

Manufacturing and Quality Tasks

- Ensure all product level M&Q design requirements are defined and validated to be consistent with the specifications.

- Ensure all M&Q inputs to the product design support meeting the program requirements.
  - Verify M&Q requirements meet program cost, schedule, and performance requirements
  - Verify M&Q requirements are met at the subsystem, item, and component levels
- Assess prototypes and demonstrations, including system, subsystem, item, and component prototypes, for adequacy and completeness to include:
  - Verification that prototypes and demonstrations occur in the appropriate environment for the system, subsystem, or component (e.g., production representative, pilot line, or production line)
  - Verification and validation of M&Q specifications, processes, procedures, metrics, etc.
  - Verification and validation of KCs and critical characteristics and the associated key and critical manufacturing processes
  - M&Q validation activities to support proof of building the right product
  - Subsystem, item, and component development specifications
  - Verification of product and technology requirements and features necessary for system pilot line and/or LRIP including:
    - Producibility (subsystem, item, and component)
    - Products and technology maturity
    - Sources maturity and availability (including second sources)
    - MOSA
    - COTS, NDIs, and GFE
  - Verification of M&Q status and results of TPMs
  - Verify long-lead production requirements have been established and are understood
  - Verify completion of subsystem design (with closure schedule for open items)
- Analyze prototype demonstrations and M&Q demonstrations at the system, subsystem, item, and component levels for validation of:
  - Product data essential for item and component manufacturing
  - Physical and functional interface designs for the system
  - Interdependencies
  - M&Q safety processes and procedures
  - ESOH processes and procedures
  - Security processes, procedures, and compliance
  - Risks and issues mitigation
  - M&Q costs, schedule, performance
  - Materials sources and selections
  - Facilities, tooling, and test equipment requirements
  - Workforce requirements
  - Transportation, storage, and handling
  - Embedded software

- Ensure known producibility issues have been resolved and pose no significant risks or issues for pilot line and/or LRIP.
- Develop M&Q metrics and data requirement to support successful transition to pilot line, LRIP, and FRP
    - Metrics should provide the capability to assess, monitor, manage, and control the transition process
- Assess and update the M&Q inputs to the WBS for planning, execution, and control of the pilot line and LRIP based on demonstrations, prototypes, results of CDR.
- M&Q personnel should ensure that all product data essential for system manufacturing will be released for pilot line.
- M&Q personnel should ensure the adequacy and completeness of all mitigation activities in the joint government/contractor Risk, Issue, and Opportunity (RIO) Management Process, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and HAZMAT management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment

Tools

- Functional Configuration Audit Checklist
- IMP/IMS Template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- System Verification Review Checklist
- Systems Engineering Plan (SEP) Outline
- Test and Evaluation Template

Resources

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline
- Test and Evaluation Management Guide

E.11 Pilot Line Build

Typically, the Pilot Line begins around the time the CDR has been completed. The Pilot Line should reflect the proposed production line and include all materials, manpower, tooling, test equipment, and facilities that will be on the production line. STE/SIE should be validated as part of pilot line validation in accordance with validation plans. M&Q processes and procedures should be proven on a pilot line and are under control and ready for low-rate production. Known producibility risks and issues should pose no significant challenges for low-rate production. Cost model and yield and rate analyses should have been updated with pilot line results. Supplier qualification testing and first article inspections should have been completed. The industrial base has been assessed for Milestone C and shows industrial capability is established to support LRIP.

Manufacturing and Quality Tasks

- Assess the contractor-designated pilot lines for production realism of elements required to manufacture systems, subsystems, items, and components.
    - Evaluate the M&Q readiness to manufacture of equipment, workforce skill levels, facilities, materials, components, initial work instructions, processes, tooling, temperature, cleanliness, lighting etc.
    - Evaluate capability to meet design requirements for LRIP
    - Evaluate the use of FRP processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
    - Evaluate production processes for capability to meet rate production (ramp-up to FRP)
    - Evaluate the production capability and capacity to meet program objectives for cost and schedule
- Validate the contractor's manufacturing processes for affordability and execution including work instructions.
- Evaluate contractor Production Process Verifications (PPVs) to verify process outputs for compliance to process capabilities and requirements.

- Capture necessary M&Q design and process changes identified during pilot line operations.
- Capture the results of M&Q processes, demonstrated on a pilot line, as inputs to the system MRL assessment, PRR, and to the Industrial Base Capabilities Considerations that are required for Milestone C.
- Assess contractor's LRIP verification and validation M&Q efforts in accordance with industry best practices (i.e., AS6500) on a pilot line including:
    - All M&Q processes including continuous improvement efforts
    - Manufacturing surveillance and quality data collection and analyses (including supply chain data for items and components)
    - Physical and functional interfaces
    - All work instructions, sequencing, and procedures
    - Process capabilities and process control plans
    - Production scheduling and control
    - Model and Simulations
    - Materials
    - Workforce capabilities
    - Manufacturing technology implementations
    - Tooling, work holding fixtures, jigs, etc.
    - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
    - Facilities, transportation, storage, and handling equipment
    - Interdependencies (not all will be validated on the pilot line)
    - Safety processes, procedures, and compliance
    - ESOH processes, procedures, and compliance
    - Security processes, procedures, capabilities, and compliance
    - Risk and issue mitigation results and adequacy of resolution
    - M&Q costs, schedule, performance
    - Materials sources and selections
    - Integration of embedded software
- Assess contractor's conduct of FAIs/FATs and the outputs for M&Q impacts.
- Based on pilot line operations and demonstrations, assess all M&Q risks and issues for impacts to LRIP (e.g., producibility, quality, manufacturability, etc.)
    - Include newly identified risks, issues, and opportunities
- Based on the results of the Pilot Line build, finalize the TDP including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Tools

- First Article Inspection Checklist

- First Article Test Checklist
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Production Part Approval Process (PPAP) Checklist
- Production Verification Test
- Systems Engineering Plan (SEP) Outline

Resources

- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- AS6500, Manufacturing Management System
- DCMA Instruction 302, First Article and Production Lot Testing
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline

F. COST/FUNDING

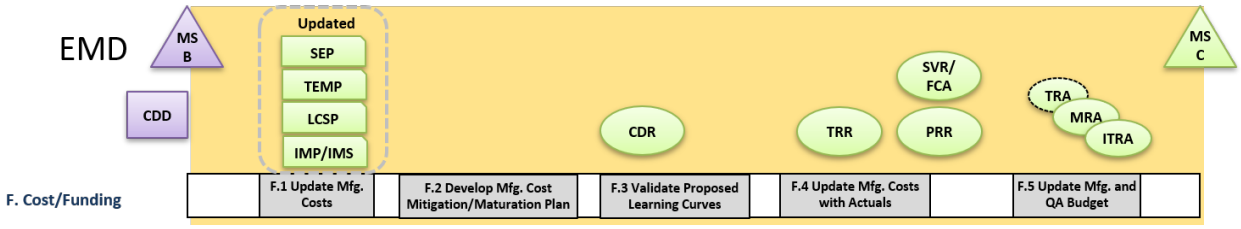


Figure 4-7. Cost and Funding Manufacturing and Quality Activities

Introduction

Services and agencies develop Program Objective Memorandums (POMs) to identify and request resources to acquire capabilities and perform operations. The POM is part of the Programming phase of the Program, Planning, Budget, and Execution (PPBE) process. The DoD combines the various Service and agency POM inputs and Budget Estimate Submission (BES) and submits a DoD Budget Request to the Office of Management and Budget (OMB).

DoD efforts at cost estimating and analysis plays a critical role is supporting DoD procurement activities to include planning, programming, budgeting, acquisition, and requirements generation.

This thread (Cost and Funding) requires an analysis of the risk that the system development and deployment will not meet the DoD cost and funding goals and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Cost Modeling (Initial Estimates)
- Identification of Cost Drivers
- Assessment of M&Q Costs
- Preparation of M&Q Budgets
- Development of M&Q Cost Mitigation Plans
- Development and Validation of Learning Curves

M&Q cost estimates require updating regularly, based on the increasing degree of detail available from work completed during EMD, the M&Q Strategies and Plans, and progress toward final design. These estimates should be based on detailed M&Q processes and procedures to industry best practices with updates to be performed and adjusted, as necessary, for current program status and/or learning curves to develop a time-phased manufacturing cost. This will require analyses of contractor M&Q Plans regarding costs, cost controls, and cost drivers. As the design progresses, cost estimates, cost models, and associated cost drivers should be updated with actual cost data from lower level (item and component) pilot lines and production.

Using the DoD funding and management approach, both the should-cost and will-cost analyses, and the cost reduction and/or control plans should be updated based on the results of CDR and maintained current. Tracking and monitoring of the contractor's planning and ongoing efforts is intended to not only evaluate proposed contractor costs, but to track and monitor costs and to identify further savings opportunities that will lead to further cost reductions. Using this process M&Q cost mitigation and/or maturation plans are maintained current to include the schedule (i.e., IMP/IMS).

Based on data collected post-PDR through CDR, established learning curves (cost improvement curve, or experience curve) should be up-to-date and validated by data collected on the pilot line. M&Q should continue to refine the learning curves for the system and the plans for data collection to support up-to-date cost estimates and budgeting. Manufacturing cost estimates for LRIP are based on the completed design, known manufacturing processes, and execution of planned M&Q operations. Actual costs at the system level are realized for the first time on a pilot line. Once the system is being produced or constructed, the actual cost method can be accumulated for budgeting.

A program's approved cost estimate is often used to create the budget and spending plan. Since resources are not infinite, budgeting requires the rate of spending matches the resources and funding available. This requires M&Q costs to be as accurate as possible, based on actual data. This process facilitates the development of realistic cost estimates for the Program.

F.1 Update Manufacturing Costs

DoDD 5000.01 requires the preparation of realistic program life cycle cost estimates as a part of a program managers focus on affordability. M&Q managers need to support to development and update of various government cost estimates and the assessment of contractor cost estimates to include:

- Affordability Analysis and Cap Estimate
- DoD Component Cost Estimate
- DoD Component Cost Position
- Independent Cost Estimate (ICE)
- Economic Analysis
- Cost Analysis Requirements Description (CARD)
- Should Cost Target and Will Cost

Manufacturing and Quality Tasks

- M&Q personnel should support the analysis of design changes for technical content and impact on M&Q processes, and costs for all cost documents based on results of the PDR and MS B activities and ensure that the program can achieve the approved system specification and budget for CDR to include:
    - Include updates to the Affordability Analysis and/or Cap estimate
    - Include updates to the DoD Component Cost Estimate
    - Include updates to the DoD Component Cost Position
    - Include updates to the Independent Cost Estimate
    - Include updates to the Economic Analysis
    - Include updates to the CARD
    - Include updates to the should cost and will-cost models based on industry best practices
    - Include updates to M&Q cost sensitivity analyses
- M&Q personnel should support the analysis of design changes, and program progress, analyze and update M&Q cost drivers derived from manufacturing, quality, materials, and/or unique requirements, and associated risks, issues, and opportunities for the CDR to include:
    - Identified subsystems, parts, items, and components
    - Sourcing risks from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
    - Should-cost and will-cost analyses
    - Required trade studies and engineering change requests
    - Updates to predicted life cycle estimates and their associated models
    - Interdependencies
    - Uncertainties from quantification of cost drivers
- Analyze the contractor M&Q Plans for costs and cost drivers based on:

  - Processes and procedures (i.e., best practices)
  - Producibility program and plans
  - Supplier Chain management
  - Materials (e.g., processing, handling, storage, etc.)
  - Workforce (e.g., availability, training, etc.)
  - Facilities (e.g., location, condition, maintenance, etc.)
  - Capital equipment, tooling, and test equipment, etc.
  - Special handling and environmental compliance (including disposal)
  - Security (physical and cyber), etc.
  - Updates for the cost of quality
  - Updates for costs and impacts of testing
  - Impacts from other work performed throughout the supply chain
- Ensure cost estimates, cost models, and associated cost drivers are updated with actual cost data from lower level (item and component) from subsystem and system-level prototypes and demonstrations including:
  - Systems and subsystems produced in a production representative environment
  - Production plant layout and design
  - Obsolescence solutions
  - Rolled up manufacturing system and subsystem actual costs vs. targets
- Update Learning Curves based on results of PDR and actual M&Q data collected from prototypes, and demonstrations.
- Ensure the updated cost estimates and associated drivers include the costs associated with the M&Q risks, issues, and associated mitigation plans and activities, and opportunities.
- Update the contract to include cost monitoring by DCMA throughout the contractor's facilities and supply chain.
- Update the letter of delegation to DCMA to include cost monitoring and tracking.
- Ensure updated M&Q costs including costs for outstanding M&Q risks, issues, and mitigations for CDR and estimates for meeting manufacturing readiness requirements for Milestone C are included in all budget estimates.
- If an Independent Cost Estimate (ICE) or verified Program Office Economic Analysis is requested, provide M&Q inputs and support.
  - Provide validated M&Q capability requirements
  - Provide M&Q inputs on required funding for the FYDP
  - Verify M&Q compliance with affordability goals for production and sustainment

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost/Schedule Control System Criteria (*See* EVM)

- Design to Cost Estimates
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- *See also* CAPE website for tools

Resources

- CARD Website and process
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- MIL-HDBK-766, Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook
- Should-cost and Affordability Memo

F.2 Develop Manufacturing Cost Mitigation Plan

Affordability is always a concern for the DoD. M&Q managers need to support the development and implementation of cost mitigation plans. Cost mitigation plans are often focus on manufacturing cost drivers and continuous improvement opportunities.

Manufacturing and Quality Tasks

- Ensure appropriate inputs are provided for required investments and planning for contractor and supply chain M&Q capabilities (e.g., facilities, equipment, tooling, hardware, firmware, software, etc.) based on M&Q planning for CDR.
- Update the should-cost and will-cost analyses, and cost reduction and/or control plans using the outputs from CDR to include:
    - Coordinated, in-depth review of the contractor's planning and ongoing efforts against best practices
    - Up-to-date cost drivers
    - Up to date tracked and monitored costs to support further savings opportunities
    - Risks and issues mitigation plans and activities

- Ensure DCMA cost monitoring and tracking data are used to develop and/or update M&Q cost mitigation plans.
- Update M&Q cost targets, post CDR, to include assessments of:
    - Producibility
    - M&Q process capabilities, implementations, obsolescence, and sustainment including key and critical processes
    - Schedule (i.e., IMP/IMS)
    - Supply chain, materials, and sourcing availability
    - Environmental management and disposal impacts
    - Process capability and throughput (setup, yield, scrap, rework, Work in Progress)
    - Data management (collection, storage, cyber security, etc.)
    - M&Q risks and issues including Supplier Chain
    - Workforce risks and issues
    - Tooling, equipment availability, capacity, and constraints
    - Facilities and facility conditions (e.g., temperature control, cleanliness, lighting, factory floor, process flows, assembly lines, cycle times, etc.)
    - Yields and rates (e.g., projected, and actual throughputs)
    - Inventory (e.g., WIP, backlog, customer demand, etc.)
    - System security, cyber protection, safety, and HAZMAT management
    - Testing and test equipment (including in-process tests)
    - Transportation, storage, and handling
    - New equipment and new manufacturing technologies
    - Life cycle sustainment
- Update M&Q cost models based on outputs from CDR to include:
    - Updated cost targets
    - Actuals, where available, in place of estimates
    - Cost impacts of specific design changes, production process changes, or changes in materials
- Monitor and track contractor performance of M&Q activities in meeting the Earned Value Management System (EVMS) requirements including the critical path as an input to cost mitigation planning.
- Develop Manufacturing Maturation Plans (MMPs) for any areas assessed that do not comply with the appropriate MRL criteria.

Tools

- Parametric, Engineering and Actual estimating techniques
- CARD - Cost Analysis Requirements Description (*See* CAPE website for tools)
- Interactive MRL Users Guide (Checklist) for the Cost thread

- Manufacturing Maturation Plan
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Manufacturing Cost Estimating Worksheet

Resources

- 10 USC Sec. 2334 Independent Cost Estimation and Cost Analysis
- DoDI 5000.73 Cost Analysis Guidance and Procedures
- Public Law 114-328, §807, Cost, Schedule, and performance of major defense acquisition programs
- CARD - Cost Analysis Requirements Description Template (*See* CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide
- DODI 5000.73 Cost Analysis Guidance and Procedures
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook

F.3 Validate Proposed Learning Curves

Most manufacturing cost estimates include learning curves. During the EMD phase the initial manufacturing cost estimate should be updated on a regular basis to reflect the increasing degree of detail available. These estimates should be based upon application of detailed manufacturing standards to the operations to be performed and adjusted, as necessary, by realization factors and/or learning curves to develop the time phased manufacturing cost. Learning curves are a graphical representation of how an increase in learning decreases the amount of time to accomplish a task. Initial learning curves need to be identified and applied on the Pilot line and then validated to see of the correct level of learning is occurring. Since the program is in EMD the pilot line may not have shown much learning in the on the few items that are being or have been produced.

Manufacturing and Quality Tasks

- Update all M&Q learning curves for the system and subsystems based on CDR results, contractor and supply chain improvements, program progress to date to include:
    - Contractor and supply chain data as required by contract
    - DCMA data to validate contractor data for the learning curve updates
    - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
    - Design changes
    - Producibility program results

  - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
  - Planning and scheduling
  - Throughput (yield and rates)
  - Labor efficiency and ergonomics
  - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
  - Handling, transportation, and storage (including WIP)
  - Supply chain changes
  - Standardization and common processes
- Use data from pilot line production for validation of learning curves.
- Plan for collection of data in LRIP to support learning curve refinement that includes the following factors, improvements, and investments (at a minimum):
  - Update of cost models
  - Workforce learning, worker, and supervisor
  - Process, line, and workstation
  - Machinery, equipment, and tooling
  - Design producibility changes
  - Reduced Engineering Change activities
  - Mitigations of risks and issues
  - Work methods and processes
  - Planning and scheduling processes
  - Lot and batch sizing (increases) and optimization (just-in-time)
  - Engineering and test activities and changes
  - Quality inspections/tests sampling requirements
  - Reduction in Scrap and Rework
  - Inventory levels and storage
  - Operation sequencing and synchronization
  - Pre-Planned Product Improvement (P^3I) program and processes

Tools

- Learning Curve Calculator (Estimator)
- Manufacturing Cost Estimating Spreadsheet
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Maturation Plan

Resources

- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook

- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8 Learning Curve

F.4 Update Manufacturing Costs with Pilot Line Actuals

During the EMD phase, more and more manufacturing costs should be based on actual cost data provided by the contractor. This is especially true after the Critical Design Review and the implementation of the Pilot line. Cost drivers could be high-cost items, or items that have high manufacturing costs due to several factors (long processing times, low yield rates, etc.). These cost drivers need to be updated.

Manufacturing and Quality Tasks

- Ensure cost models are updated and maintained current with up-to-date information based on data collected for updated cost drivers and learning curves (*See* F.3) including results from pilot line, and:
    - Drivers and estimates
    - Roll up of all tracked M&Q costs from the component level
    - Engineering change requests
    - Cost reduction and avoidance strategies
    - Mitigation of risks and issues
    - Analyses (of pilot line actual costs)
    - Analyses of proposed changes to M&Q processes and procedures
- Analyze and update M&Q cost inputs based on the results of CDR and the pilot line, for consistency with the current Cost Analysis Requirements Document (CARD); and provide updates, if necessary.
- Provide inputs to the program life cycle cost estimate and schedule (IMP/IMS) for PRR based on validated stable detailed design and supply chain (from pilot line).
- Provide M&Q cost estimate and realistic production unit cost goals for the P&D budget process.

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost/Schedule Control System Criteria (*See* EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Maturation Plan
- *See* CAPE website for tools

Resources

- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- MIL-HDBK-766, Design to Cost
- Should-cost and Affordability Memo
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- CARD website and process

F.5 Update Manufacturing and Quality Budget

Budget estimates are developed to provide the financial resources to needed to improve affordability, reduce risks, mature emerging technologies for insertion and to help resolve several manufacturing related issues. The budget estimate needs to be updated to support the program through EMD. M&Q managers need to support the review and update of M&Q budgets.

Manufacturing and Quality Tasks

- Ensure all M&Q Milestone C risks and issues (i.e., MRL 8) are understood with approved and budgeted mitigation plans in place including:
    - A reasonable budget estimate for achieving required M&Q capability by the FRP decision point (i.e., MRL 9)
    - Investment required for LRIP and FRP
- Provide M&Q cost estimates for the P&D budget process (LRIP and FRP) including the following considerations:
    - Ongoing cost reduction initiatives.
    - M&Q costs and cost drivers
    - Updated M&Q learning curves
    - Validation of M&Q processes (from pilot line) for affordability and executability
    - Results of analyses of M&Q risks, issues, and the status of mitigations
    - Required facilities, equipment, tooling, test equipment, GFE, etc. for scale-up to LRIP quantity production
    - Results of analyses of the contractor's proposed manufacturing labor hours and material costs for adequacy, reasonableness, and necessity
    - Recommended M&Q cost reduction and avoidance initiatives
    - Results of cost performance analyses and trends

- Manufacturing investment opportunities for future manufacturing improvement and development efforts (*See* F.3)
- Funding and budgeting requests for applicable and/or emerging M&Q initiatives
- Industrial base investment programs that create, expand, or preserve assured, affordable, robust, and commercially viable M&Q capabilities and capacities for LRIP and FRP

Tools

- Manufacturing Cost Estimating Spreadsheet
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Maturation Plan
- Technology Readiness Level Assessment Checklist

Resources

- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Technology Readiness Assessment Guidance
- Public Law 114-328, §807
- Manufacturing Readiness Level (MRL) Deskbook

G. MATERIALS MANAGEMENT

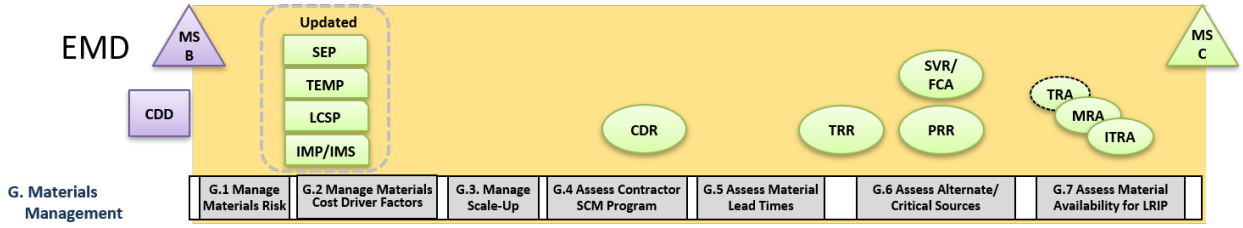


Figure 4-8. Materials Management Manufacturing and Quality Activities

Introduction

Materials Management is a core function of supply chain management including the process for planning and controlling material requirements and material flow for industrial and other organizations. Materials management will require assessment of the maturity, the materials availability, the capability and capacity of the proposed supply chain to provide the materials, and the potential need for special handling, government-furnished property (GFP), shelf life, security, storage, and environmental requirements. The process begins with the customer (demand signal), and this information flows throughout the supply chain, down many tiers, from raw materials, to fabrication, assembly, test, quality control, distribution and to the customer. The assessment will identify the need for any additional research to mature materials and identify the properties, characteristics, and quality deemed necessary to support the concepts being considered. Material properties, characteristics, and quality will require experiments for validation and assessment for basic manufacturability.

This thread (Materials) requires an analysis of the risks associated with materials (including basic/raw materials, components, semi-finished, parts, and sub-assemblies).

One of the key elements in a successful program is aggressive materials management and planning. Materials management ranges from basic considerations of maturity and availability to understanding management of the supply chain and to details of GFP, shelf life, security, safety, HAZMAT, storage environment, etc. All program M&Q materials risks, issues, and opportunities should be assessed based on contractor data and plans to meet program M&Q requirements.

The assessment should include analyses for materials fluctuations, rarity, availability, capacity, regulatory issues, ITAR, anti-tamper, and military vulnerability, as well as alternate materials that may mitigate known risks and issues. Additionally, M&Q risks, issues, and opportunities based on potential materials obsolescence and lack of availability from business climate impacts (e.g., business failures, market changes, political, etc.) should be included in assessments. Results of these assessments should be incorporated into recommended changes and updates for appropriate government/contractor mitigation plans.

For CDR, materials cost drivers must be updated, and appropriate management plans implemented for control of all aspects of materials costs (actual and planned) for both the government and contractor. The industrial and manufacturing capability should be assessed to baseline needed industrial capability and to obtain key knowledge on scale-up efforts, and potential supply chain issues. Managing scale-up for EMD should include planning that addresses new M&Q processes and techniques, meeting delivery dates, critical and long-lead materials, facility, equipment, tooling availabilities and capabilities, tests and demonstrations, conservation of critical and strategic materials, and transportation and security including ITAR considerations. Management also includes planning for mitigation of risks and issues, as well as exploiting opportunities. M&Q should assess the contractor's materials supply chain for application, implementation, and adherence to industry M&Q best practices, as well as contractor's compliance with Company policies, processes, procedures, and contracts.

The materials and components lead times are extremely critical to both meeting program schedules and defining requirements for long lead and advanced buys. Lead times for defense materials and components can be long and volatile due to various reasons, such as imbalances between capacity and demand, competition from commercial customers, testing cycles, materials availability, budgeting, funding and contracting processes, transportability, workforce issues, etc. All of these can have an impact on capacity, quality, and schedule, thus driving lead times and the program must maintain visibility of the status and the forecast changes in lead times.

The program's objectives should be to improve capabilities and quality and reduce costs by maintaining (or improving) schedule, supporting the industrial base, and promoting competition by qualification of alternative sources. There are many factors that can interfere with these objectives, requiring alternative sources. Natural disasters such as earthquakes and tsunamis can severely disrupt production operations for many industries as can counterfeit parts and the loss of sources of items or

material. Additionally, programs must account for Diminishing Manufacturing Sources and Material Shortages (DMSMS) to mitigate risks to life cycle support and viability of the weapon system or equipment. As a resource for this process, the Government-Industry Data Exchange Program (GIDEP) was established as the central repository within the DOD for all parts discontinuance and counterfeit notices. GIDEP receives notices from manufacturers and participants and distributes alerts to DOD and to private industry.

There are several ways the DoD can address material needs and shortages. One is through the Defense Production Act of 1950 and the implementation of the DPAS in which the government can designate programs as "high priority" and put them at the front of the contractor's production queue. Another is the Defense Industrial Capabilities Handbook, DoD 5000.60-H which identifies alternative actions the government can take when facing material shortages to include:

- Finding foreign sources of supply
- Finding alternative or substitute parts
- Making a Lifetime buy to meet all planned future needs
- Maintaining a current capability
- Developing an Alternative solution

Future requirements (i.e., Operations and Support phase) for items which represent recurring spare parts requirements and substantial cost for annual buys, require aggressive action to develop alternative sources of supply. These sources ensure continuing part availability and competitive sources for these parts. The process of establishing competitive sources for these parts starts early in the production phase and continues as long as the parts are in the supply system. Based on pilot line results, M&Q should validate the identification of critical sources throughout the supply chain. Include sources of key and/or critical subsystems, items, parts, and components, including KCs, Configuration Items (CIs), and CSIs, required to meet program requirements.

Based on updates to Industrial Capabilities Assessments in support of Milestone C, M&Q should assess and verify material availability for LRIP, include availability risks, issues, and mitigations, costs and schedule updates, long-lead procurement risks, mitigation, and status, obsolescence, Supply chain management including first, second, and lower tier suppliers, counterfeit detection and avoidance, physical, cyber, and industrial security, special handling, transportation, storage, and environmental compliance risks and issues, etc. This assessment should consider emerging technology advancements in materials and processes, changes in Government statute, policy, and regulations, changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.), changes in environmental impacts (e.g., natural disasters, etc.), DMSMS, and program plans for P^3I in LRIP.

Successful completion of EMD with a thorough understanding of materials capabilities, capacities, and limitations and the aggressive management of and planning for materials will ensure effective transition to LRIP and Production and Deployment phase.

G.1 Manage Materials Risk

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Material risks have and issues can slow or delay a program, can add additional costs to a program, or can create field failures because of poor material reliability. Material risks could include availability of the material, maturity of the material, or need for special handling and control. Material risks can occur anywhere in the supply chain all the way down to the lowest level (dirt). M&Q managers need to support the identification and management of material risks especially as suppliers and vendors are brought on board and the program is begin collecting actual data.

Manufacturing and Quality Tasks

- Analyze the contractor's plans to meet M&Q requirements for maturity of materials by CDR, including:
    - Risks and issues
    - Associated cost drivers (*See* G.2)
    - Design requirements
    - Configuration Management
    - Materials processes maturity
    - Materials specifications
    - Emerging materials
    - Cost reduction and avoidance
    - Materials availability and lead times
    - Environmental factors
    - Management of the supply chain
    - Counterfeit parts and obsolescence
    - Security, required special handling, physical and cyber protection
    - Facilities, capital equipment, tooling, and test equipment
    - Storage, handling, transportation, etc.
- Assess all materials for M&Q risks, issues, and opportunities Based contractor data:
    - Update evaluation of material maturity and availability from TMRR for adequacy to support pilot line
        - Assess validity and maturity of emerging materials for manufacturability
        - Assess maturity in a production environment
    - Update the M&Q evaluation of lead times including:
        - Long lead materials
        - Impacts to schedule, budget, and critical path, etc.
        - Impacts from fluctuations, availability, capacity, regulatory issues, ITAR, Anti-Tamper, etc.

  - Identify opportunities for alternative materials (to avoid or mitigate known risks and issues)

- Assess and identify M&Q risks, issues, and opportunities for materials obsolescence and lack of availability based on analyses of the business climate (e.g., business failures, market changes, political, etc.) for the CDR including:
  - Availability from single or sole sources (domestic or foreign), within the NTIB, only from sources that are outside the NTIB, vulnerable to foreign acquisition
  - Disruptive business climate conditions (e.g., natural disasters, strikes, etc.)
  - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
  - Counterfeit Parts
- Develop risk mitigation plans as appropriate (specified in the program SEP) for:
  - Known risks to critical and strategic materials
  - Availability issues to be addressed for pilot line and LRIP builds
- Monitor contractor mitigation processes and plans as specified in the contractor SEMP for alignment with the program SEP.
- Analyze and assess the contractor's Make/Buy process for adequacy and completeness including capabilities, capacities, and processes for:
  - Key and/or critical subsystems, items, parts, and components to include volatility
  - Management of the supply chain (including other divisions)
  - Vendors to meet quality requirements, schedule, and cost targets
  - Identification and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
  - Management of GFE, GFM, etc.
- Analyze and assess the contractor's hazardous and special handling, storage, and environmental compliance procedures for risks and issues to include:
  - Regulatory requirements
  - HAZMAT and handling procedures
  - Security requirements (physical, cyber, industrial, etc.)
  - Transportation, storage, and shelf life
  - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
  - Disposal

Tools

- DCMA Material Management and Accounting System Audit
- PESHE Assessment/Template
- ISO 14001 Gap Analysis Toolkit
- DMSMS Product Life Cycle Assessment (DLA)

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist) for the Materials thread
- Manufacturing Maturation Plan
- Supply chain Management Risk Assessment Checklist
- Producibility Assessment Worksheet
- TRL Assessment Questionnaire

Resources

- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- ESOH in Acquisition Guide
- ISO 14001 Environmental Management Systems
- DMSMS Guidebook, SD-22
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60-H, Assessing Defense Industrial Capabilities
- DoDM 4140.01, DoD Supply Chain Management Procedures
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Producibility Systems Guidelines, NAVSO P-3687

G.2 Manage Materials Cost Drivers

Production costs are driven by product complexity (design), rate of production and total numbers produced. Direct labor and direct material cost often make up a large portion of product costs and must be assessed. Material cost drivers could include long-lead items, items that require special handling, storage, or treatment. Some materials are just more expensive (titanium vs steel), and other materials are harder to work with or have low yield rates. M&Q managers need to pay special attention to materials that are cost drivers and manage those as these cost drivers make themselves known on the Pilot Line.

Manufacturing and Quality Tasks

- Analyze and update M&Q materials cost drivers for the CDR based on manufacturing, quality, and unique and/or specialized requirements, specifications, and tolerances, and associated risks and issues to include:
    - Contractor plans for materials, materials processes, rates, and quantities (including lot buys),
    - Risk mitigation processes (ongoing, identification, reduction, etc.)

  - Supplier Chain (e.g., capability, capacity, quality, etc.)
  - Special handling and training
  - Environmental compliance and training,
  - Materials security (physical, cyber, industrial, etc.)
  - Planned subsystems, parts, items, and components (supply chain commodities) to include alternative sources
  - Planned rates and quantities for pilot line and LRIP
  - Updated "should-cost" analyses and actuals
  - Updated materials cost driver uncertainties (based on actuals)
  - Cost drivers' updates impacted by conservation critical and strategic materials
  - Cost drivers for mitigation of supply disruptions
  - Updated estimates for the cost of quality
  - Updated estimates for the cost of materials testing

- Analyze and update the contractor planning (producibility) with respect to materials cost drivers and associated risks (*See* G.1) for the CDR to include:

  - Design requirements
  - Configuration management
  - Emerging materials
  - Price stability, cost reduction and avoidance
  - Rates and quantities
  - Materials process maturity including quality processes
  - Materials specifications
  - Materials availability (lead times)
  - Cost reduction and avoidance
  - Environmental factors and compliance
  - Management of supply chain
  - Processes and quality
  - Counterfeit parts avoidance
  - Obsolescence
  - Security, required special handling, physical, cyber, and industrial
  - Facilities, capital equipment, tooling, and test equipment
  - Storage, handling, and transportation, etc.

- Assess and identify M&Q materials cost drivers based on industrial base analyses of the business climate (e.g., business failures, acquisitions, market changes, political changes, etc.) for the CDR including:

  - Materials availability only from single or sole sources, foreign sources (only from sources that are outside the NTIB), and sources vulnerable to foreign acquisition
  - Disruptive business climate conditions (e.g., natural disasters, strikes, etc.)

- Materials subject to Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
- Materials market stability (commodities)

Tools

- Earned Value Management (EVM)
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Interactive MRL Users Guide (Checklist) for the Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment

Resources

- Cost/Schedule Control System Criteria
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328

G.3 Manage Scale-Up Risk

As programs starts to establish a Pilot Line, M&Q managers are forced to deal with issues and concerns relating to scaling up. The Pilot Line is just being formed and the program is collecting data on initial production units and preparing the line for LRIP. The entire factory floor including the 5Ms (manpower, machines, materials, methods, and measurement) must be capable of responding adequately to the requirements imposed by scaling up and M&Q managers need to be able to manage scale-up risks.

Manufacturing and Quality Tasks

- Analyze and update materials producibility assessments, manufacturing processes, techniques, procedures, capacity, and availability to meet program requirements (scale-up for pilot line, LRIP, and FRP) and assess materials risks, issues, and opportunities including:
  - New materials (to the industry, to the program, to the suppliers)
  - Supply chain and/or source capability and capacity
  - Source criticality and fragility (e.g., sole, or single sources, foreign sources, domestic foreign owned, etc.)
  - Workforce (e.g., knowledge, availability, etc.)

  - Lead times for required quantities (un-proven suppliers)
  - Rates that are higher and/or lower than typical
  - Introduction of counterfeit materials
  - Obsolescence due to product improvements and market/technology changes
  - Regulatory requirements and impacts (e.g., US law, ITAR, environmental, REACH concerns, etc.)
  - Testing aspects throughout the production processes and supply chain
  - Security (e.g., special handling, physical, cyber, industrial, etc.)
  - Facilities, equipment, and tooling
  - Transportation, storage, and handling
- Update and ensure M&Q plans for CDR address scale-up risks, issues, and opportunities to include:
  - Manufacturing processes, techniques, and procedures (including special handling)
  - Meeting schedule
  - Addressing impacts from critical and long-lead time materials
  - Addressing facility, equipment, and tooling availability (acquisition and/or scheduling)
  - Cost models, drivers, and schedules
  - M&Q materials alternatives
  - Required testing
  - Conservation of critical and strategic materials
  - Workforce
  - DMSMS
  - Counterfeit avoidance
  - Supply disruption
  - Regulatory requirements and impacts (e.g., environmental, HAZMAT, etc.)
  - Security (e.g., special handling, physical, cyber, industrial, etc.)
  - Transportation, storage, and handling

Tools

- Interactive MRL Users Guide (Checklist) for the Materials thread
- ManTech Strategic Plan
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet

Resources

- Air Force Technology Development and Transition Strategy Guidebook
- EC 1907/2006, Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)

- Manufacturing Readiness Level (MRL) Deskbook DoD Directive 4200.15, ManTech Program
- Producibility Systems Guidelines, NAVSO P-3687

G.4 Assess Contractor Supply Chain Management Program

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then Supply Chain Management (SCM) becomes a pivotal task. Often program problems originate in the supply chain, but do not manifest themselves until the component is integrated into the system. Program offices and contractors often have efforts to identify and manage problems at the first tier, but do not do well below that level. M&Q managers need to routinely review and assess contractors supply chain and procurement activities and efforts.

Manufacturing and Quality Tasks

- Assess the contractor's materials supply chain Management (SCM) program for implementation and adherence to industry M&Q best practices to include:
  - Manufacturing management standards (e.g., AS6500, MIL-STD-896, etc.)
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)
  - Configuration management (EIA-649-1, MIL-HDBK-61A, etc.)
  - Systems Engineering standards (e.g., IEEE 15288, etc.)
- Assess the contractor's materials supply chain Management (SCM) program for:
  - Management of suppliers and sub-tier materials manufacturing processes and procedures, especially suppliers performing key and/or critical materials manufacturing processes impacting KCs
  - Implementation and compliance to security processes, plans, and procedures for materials including:
    - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
    - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
  - Materials special handling, storage, safety, and environmental compliance procedures to include:
    - Regulatory requirements
    - HAZMAT and handling procedures
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal
  - Materials supplier sourcing processes for:

        - Supplier evaluation, qualification, approval, re-qualification, and removal
        - Management of sole or single sources, foreign sources, domestic foreign owned, etc.
        - Management of capabilities and capacities
    - Development of strategic partnerships with vendors and suppliers
    - Materials sub-contract management for:
        - Monitoring sub-tier compliance to M&Q contractual requirements
        - Monitoring sub-tier processes (e.g., configuration management, parts management, obsolescence, counterfeit parts management, electro-static discharge program, etc.)
        - Communications (e.g., two-way flow of quality data, requirements, forecasting data, etc.)
        - Materials data (e.g., testing, analyses, storage, and traceability, etc.)
        - Quality program implementation (e.g., SPC, process capabilities, predictive indicators, variability reduction, etc.)
    - Materials procurement processes for:
        - Specification of requirements (e.g., drawings, revisions, packaging, kitting, identification, etc.)
        - Specification of quality standards and metrics
        - Scheduling, quantities, etc.
        - Supplier assistance programs
        - Monitoring and evaluations
        - Deficiencies and corrective actions (i.e., FRACAS)
    - Internal logistics and inventory management processes for materials including:
        - Production scheduling, kitting, identification, etc.
        - Pre- and post-production storage, scheduling, kitting, packaging, environmental, security, etc.
        - Transportation methods, special handling, packaging, environmental controls, identification, and tracking, etc.
        - Vendor Managed Inventory (e.g., quality, schedule, quantity, packaging, kitting, identification, and tracking, etc.)
    - Integration of supply chain risks and issues for KCs, security, compliance, sourcing (counterfeit, obsolescence, etc.), and procurement into the joint contractor's Risk, Issue, and Opportunity System
- Assess the contractor M&Q materials processes for compliance with or adherence to Company policy, process, and contracts, using DCMA support (requires a Letter of Delegation) to include:
    - Implementation of industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
    - Performing first article/qualification(s) (i.e., AS9103)

  - SCM of interdependencies
  - Sourcing to minimize risks, criticality, and obsolescence
  - Supplier qualification, approval, and monitoring processes to include
    - Suppliers with known risks
    - Supplier parts usage and sources (i.e., GIDEP prohibited)
  - Processes for data flow (two-way)
    - Program reviews, milestones, and metrics
    - Demand Planning
    - Quality, safety, technical, and inspection requirements and changes
    - Key and critical characteristics
  - Make or buy decision analysis processes
  - Counterfeit and DMSMS management processes
  - Inventory management
  - FRACAS process
  - Security processes
  - ESOH management
  - Material waiver process (should only be used in limited circumstances)
  - Implementation of supply chain Management oversight processes
    - Vendor survey requirements
    - Identification and management of risks, issues, and opportunities
    - Surveillance

- Ensure assessments of critical first, second, and lower tier supply chain for compliance to purchase order/subcontract quality, manufacturing/ production, engineering, and software requirements are completed.
- Initiate SCM planning for EMD, production, developmental and operational test, and life-cycle sustainment.

Tools

- AS5553, Supply Chain Assessment
- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist) for the Materials thread
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronics Parts
- AS6500, Manufacturing Management Systems
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- AS9103, Variation Management of Key Characteristics

- AS9133, Qualification Procedure for Aerospace Standard Parts
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896 Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security

G.5 Analyze Material Lead Times

Lead time analysis can be a trick endeavor, especially for long lead items. Contractors and government managers have many tools available to them to support forecasting and lead time analysis to include:

- Straight Line based on historical data and constant growth rate
- Moving Average based on historical data and repeated forecast
- Simple Linear Regression based on a sample of relevant observations and comparing one independent variable with one dependent variable
- Multiple Linear Regression based on a sample of relevant observations and comparing several independent variables with one dependent variable

The contractor may go out to their suppliers and ask for lead times or delivery dates, but how accurate are those dates? What happens when there is a disruption in the supply chain caused by weather, political unrest, change in suppliers, etc.? Forecasting and lead time assessment gets harder to do the further out the delivery date is. Furthermore, there is always a balance between the cost of holding an item and the cost of ordering. If the contractor orders too much or it comes in early, it could cause additional cost and risks. M&Q managers need to be able to support the analysis of lead times for materials.

Manufacturing and Quality Tasks

- Perform an analysis of contractor's M&Q schedule and quantities for subsystems, items, and components to meet program IMP/IMS and critical path requirements.

- Analyze results of assessments of contractor and key supply chain to ensure identification of M&Q risks, issues, and opportunities associated with scheduling procurement of materials (e.g., subsystems, items, and components) to include:
  - Long-lead Items
  - Lead time fluctuations
  - Impacts from single or sole sources, sources that are outside the NTIB, and sources vulnerable to foreign acquisition
  - Business climate conditions (e.g., acquisitions and mergers, natural disasters, strikes, policies and political changes, etc.)
  - Market changes (e.g., technological changes and obsolescence, workforce, etc.)
  - Impacts from scale-up
  - Impacts from regulatory issues, ITAR, Anti-Tamper, etc.
- Assess pilot line and LRIP procurement requirements (e.g., schedule and quantities).
- Ensure government M&Q funding supports contractor schedule and procurement requirements.
- Ensure mitigation plans are developed and implemented for all identified procurement risks and issues for CDR.

Tools

- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Manufacturing Readiness Level (MRL) Deskbook

G.6 Assess Alternate/Critical Sources

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole source, single source and foreign sources of supply come with a lot of risks. In addition, suppliers come and go in the marketplace. One day there might have four sources of supply and the next one or none. Diminishing Manufacturing Sources and Obsolescence is a very real problem on DoD programs, even programs that are pushing the state of the art may have components that are past their prime. One way to mitigate those risks and to increase competition (reduce cost) is to identify and develop alternative sources of supply. But this is not a quick or a cheap fix as the new supplier will probably need to go through a qualification program and prove that they have the capability to produce one, the capacity to produce all that is needed and the financial stability to be able to perform for the entire contract period of performance.

Manufacturing and Quality Tasks

- Analyze the contractor's M&Q sourcing plans, policies, and procedures (e.g., make/buy, alternate sources, etc.) for subsystems, items, and components for:
    - Meeting qualification requirements
    - Contingency planning (e.g., capacity, economic/political impacts, disaster impacts, etc.)
    - Competitive sources (e.g., dual source, GFE, etc.)
    - Costs (e.g., per unit, investment, storage, and handling, etc.)
    - Materials with environmental or ESOH concerns
    - Vulnerability mitigation for single, sole, foreign, foreign-owned domestic, fragile, critical, etc.
    - Materials only available outside the NTIB
    - Quality, schedule, transportation, fulfillment, etc.
    - HAZMAT
    - Difficulty to obtain and/or process materials
    - Meeting Government requirements for support of the NTIB
    - Counterfeit detection and prevention (including GIDEP data)
- Review, and update assessment of the contractor's Make/Buy process for adequacy and completeness including capabilities, capacities, and processes based on pilot line results for: (*See* G.1)
    - Key and/or critical subsystems, items, parts, and components to include volatility
    - Management of the supply chain (including other divisions)
    - Vendors to meet quality requirements, schedule, and cost targets
    - Identification and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
    - Management of GFE, GFM, etc.
- Assess the Bill of Materials (BOM) for LRIP to include:
    - Make/buy process and decisions
    - Identification of key and/or critical items, parts, and components
        - All configuration items (CIs)
        - All CSIs
        - All KCs
    - Identification of risks, issues, and opportunities
- Review and update the Manufacturing Strategy and Plan and Quality Strategy and Plan (from CDR) based on pilot line results for changes to the contractor's:
    - Materials planning and control systems
    - Bill of Materials and make/buy decisions
    - Materials processes and procedures

  - Facilities, equipment, tooling
  - Tests, test facilities and equipment
- Ensure required material maturity has been proven and validated for LRIP based on pilot line assessments and results, including:
  - Properties and characteristics
  - Material producibility, predictability, manufacturability, etc.
- Develop recommendations for alternate sources and options for pilot line, LRIP, and O&S, based on M&Q analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Ensure alternate materials sources and/or materials mitigate current risks and issues and/or do not introduce new risks and issues to the program.
- Ensure contractor's alternate M&Q sourcing plans, policies, and procedures are consistent with program plans for program plans for Product Improvement (P^3I).
- Ensure continuing parts and materials availability for future requirements (i.e., Operations and Support phase) by assessing the supply chain for its long-term viability and competitive sourcing.

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- Contractor Purchasing System Review (CPSR) Guidebook
- DFAR 15.407-2, Make or Buy Programs
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- Manufacturing Readiness Level (MRL) Deskbook
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328

G.7 Assess Material Availability for LRIP

Material Management is concerned with the ability of a program to have the right materials, at the right place, at the right time, at the right cost and quality levels. This includes raw materials, components, semi-finished parts, and subassemblies. Material availability is a major concern and supply chain managers need to constantly assess their sources of supply. M&Q managers need to support assessments of material availability and ramp up from the pilot line to LRIP.

Manufacturing and Quality Tasks

- Assess and verify material availability for LRIP, based on updates to Industrial Capabilities Assessments (*See* D.5 in support of Milestone C), including the following considerations:
    - Availability risks, issues, and mitigations (including for FRP)
    - Costs and schedule
    - Long-lead procurement risks and mitigation
    - Obsolescence
    - Long lead procurements
    - Supply chain
    - Effective supply chain management processes (including first, second, and lower tier suppliers as necessary)
    - Counterfeit detection and avoidance
    - Security (physical, cyber, industrial, anti-tamper, etc.)
    - Make/Buy decisions
    - Special handling, transportation, storage, and environmental compliance risks and issues
    - GFE, GFF, etc.
- Assess, and verify material availability for LRIP, based on M&Q analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, including the following considerations:
    - Emerging technology advancements in materials and processes
    - Changes in Government statute, policy, and regulations
    - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
    - Changes in environmental impacts (e.g., natural disasters, etc.)
    - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Assess materials availability to for contractor's M&Q materials plans to meet program plans for P^3I in LRIP.

Tools

- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist) for the Materials thread
- Manufacturing Maturation Plan

- Supply Chain Management Risk Assessment Checklist

Resources

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Supply Chain Metrics Guide
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System

H. PROCESS CAPABILITY/CONTROL

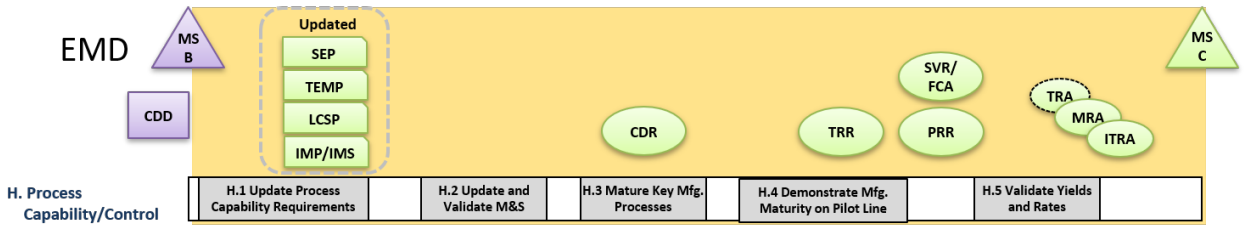


Figure 4-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with "uniform, defect free product that has consistent performance and is affordable. Product quality comes from robust product and process design and process control activities to include continuous process improvement to identify and remove sources of variation.

Process Capability and Control is a requirement of AS6500 Manufacturing Management Program, and both ISO 9001 and AS9100 quality standards and requires a process control plan, which describe the actions and activities that will demonstrate process capabilities. Process capability clarifies the inherent process variability of a given characteristic or process. Typical process capability measures include Cp/Cpk and Pp/Ppk. A capability study is generally used to assess the ability of a process to meet a drawing/specification requirement.

Statistical Process Control tools are used to determine if a process is in a state of statistical control (predictable). Typical process control tools include the X bar and R charts, plus many others. For each concept being considered, a determination of the manufacturing processes capability will be completed. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Critical and key manufacturing processes can also be identified during the assessment and analysis either through M&S or experimentation.

Advances in digital engineering including modeling and simulation (M&S), along with continual improvements in computer performance, have made it possible to perform comprehensive analysis of virtual parts and to test and assess the capability of processes before actual manufacturing begins. The use of solid modeling, finite element analysis, multi-paradigm numerical computing environments, and simulation software analysis tools, allows users to simulate different conditions that are likely to occur during manufacturing processes and model the behavior of systems under real-world conditions. An understanding of the capabilities to model products and processes for each of the concepts under consideration can be a valuable discriminator.

This thread (Process Capability and Control) requires an analysis of the risk that the manufacturing processes may not be able to reflect the design intent (repeatability and affordability) of key characteristics.

M&Q process capability and control should be an integral part of any development program. M&Q efforts should lead to a producible system with the objective of achieving effective and efficient manufacturing processes with process controls to satisfy program requirements with consistent and repeatable products at minimum manufacturing costs.

M&Q process capability and control should be a part of any development program. A process is “in control” if it is stable. A stable process does not mean that the contractor is producing only good product, it means that the process is predictable. A capable process is one that is producing conforming product. Process capability is usually measured using either a Capability Ratio (Cp) or a Capability Index (Cpk). Contractors should be working to get their processes to be both capable and in control. Note: There is no one standard process capability measurement for all process and product characteristics; however, key and critical characteristics should receive the most focus on development of a standard and on the management of those characteristics during the life of the product.

In preparation for CDR, previously identified M&Q process capabilities should be refined and updated based on data collected and the contractor’s plans, processes, and procedures to identify the process capabilities required for the system. During the development process, additional studies at the system, subsystem, item, and component levels will be conducted to define the appropriate level of process capability and control. A thorough knowledge of a contractor’s and supply chain's process capabilities is critical to developing a successful system. Process capabilities and data must be understood, measured, controlled, and documented, and process capability information must be up to date.

Program M&Q personnel should understand the contractor’s M&S tools or products, as well as the industry state-of-the-art and best practices manufacturing and production M&S. The contractor should have and be using M&Q M&S tools which must be validated for applicability, adequacy, and consistency. Additionally, program M&Q personnel must assess and understand the correlation of demonstration results with M&S results and ensure M&Ss are updated to reflect maturity of M&Q systems, systems performance, and capability.

During the EMD phase the contractor will conduct pilot line demonstrations that will include testing and analysis to ensure products meet the program requirements. These products will be built on pilot lines. This means all of the key production realism elements (e.g., equipment, personnel skill levels, facilities, materials, components, work instructions, processes, tooling, temperature, cleanliness, lighting, etc.) required to manufacture products (e.g., items, subsystems, or systems) meet requirements for LRIP and have been incorporated into the demonstrations. The processes used on the pilot lines should be evaluated to understand the difficulties and quantify the risks to be mitigated for LRIP. Results of the pilot lines and the associated assessments should be incorporated into the appropriate M&Ss to provide an up-to-date, accurate M&S of the system.

Pilot line demonstrations of system and subsystem M&Q processes, and production line M&Q data for components and items provide opportunity to collect up-to-date data for yield and rate analyses. These analyses should be used to validate all M&Q learning curves for the system and subsystems to include evaluation of yields and rates against pilot line and LRIP targets, goals, and projections for rate production.

These assessments and demonstrations should provide an understanding of the contractor's process capabilities, M&S tools, and yields and rates, and support program M&Q planning, resource loading, facilities management, etc. for future phases.

H.1 Update Process Capability Requirements

One of the goals of manufacturing is to have uniform, defect-free product. In order to achieve that goal, the production processes must be capable, that is the outcome of the production process is a product that meets spec. M&Q managers need to be working continuously on production processes to identify where variation has the most impact, reduce variation and make the process robust to design requirements. Process control studies are often accomplished when the contractor finds that they are producing product that does not meet spec. But why wait for bad outcomes when the program can plan for success. Identify upfront and early what the design requirements are and make the processes capable of meeting those requirements even before the start of production.

Manufacturing and Quality Tasks

- Analyze process capability index (C_{pk}) goals for each key manufacturing process throughout the supply chain for support to M&Q program goals.
    - Review contractor and supply chain processes, process control plans, process yields, and Process Failure Modes and Effects Analyses (PFMEAs) for identification of appropriate key and/or critical manufacturing processes and verify the need for and validity of process C_{pk} goals and targets

- Update M&Q process capability risks, issues, and opportunities for the Manufacturing Strategy and Plan and the Quality Strategy and Plan, and the SEP, using results of the PDR and current program status, including:
    - KCs
    - New equipment and new manufacturing technologies (including ManTech)
    - Potential M&Q cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - ESOH and Safety
    - Testing and qualification
    - Security
    - Environmental, transportation, storage, etc.
    - Data management (collection, storage, cyber security, etc.)
- Update and maintain required M&Q process capability requirements for consistency with product design as design progresses to CDR including producibility, manufacturability, supportability, affordability, etc.
- Update targeted process capability (Cp/Cpk) and process performance (Pp/Ppk) metrics
- Ensure system-level manufacturing processes will be demonstrated in a production representative environment by CDR with subsystem, item, and component processes, at a minimum, demonstrated on a pilot line.
    - Ensure subsystems, items, and components manufacturing processes and equipment process capabilities from variability studies and analyses meet pilot line targets
- Continue to collect, monitor, manage, and analyze (or estimate where necessary) process capability data from subsystem, item, and component processes to include:
    - Subsystems, items, and components that are currently or have been previously manufactured for other systems by the supply chain
    - Data collected from supply chain yields, rates, and process capabilities from other similar subsystems, items, components, and prototype builds
- Refine process capability requirements based on collected data from manufacture of subsystems, items, and components (e.g., production representative, pilot lines, etc.).
- Ensure DCMA support and/or external agency support for Government surveillance of and updates to M&Q process capability requirements is requested and used (for the entire supply chain).

Tools

- AS6500 Checklist
- AS9100 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread

- Manufacturing Maturation Plan
- Process Capability Study (Cp and Cpk assessment)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- AS9103, Variation Management of Key Characteristics
- AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896 Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

H.2 Update and Validate Models and Simulations

The DoD uses M&S to deliver new or enhanced capability better, faster, and cheaper. M&S can be used to understand manufacturing processes and their capability and capacity to produce compliant products. Early M&S studies based on prototypes need to be updated and validated during the EMD phase as the design matures and the factory floor processes become realized on the pilot line. M&Q managers need to support the update and validation of M&S for manufacturing systems and processes.

Manufacturing and Quality Tasks

- Assess contractor M&S system prior to product and/or process implementation for the capability to model (product and processes) and assess the system for CDR and pilot line to include:
    - Integration with supply chain M&S Systems
    - Integration with CAD, MRP, scheduling, time standards, work instructions, planning, etc.
    - Yield and rate modeling to predict first pass yields including key design and process attributes
    - Manufacturing ergonomics M&S to ensure human factors considerations are applied in manufacturing
    - Production process M&S addressing material flow, surges, processing times, scrap, rework, and repair levels, etc.
    - Supply chain M&S including impacts of disruptions, supplier capabilities and yields, learning curve effects, obsolescence issues, etc.
    - Other tools such as:
        - Value stream mapping completes with all types of information, material, parts, physical processing times, physical movements, wait times, etc.

        - Factory simulations for system production including facility, production lines, transportation, storage, handling, security, etc.
        - Lean Manufacturing, Six-Sigma, etc.
    - Capability to evaluate the design and manufacturing processes to meet program M&Q objectives including quantification of risk and issue mitigation including:
        - Factory floor, process flows, assembly lines, yields/ throughput/variability, cycle times, etc. with estimated quantities of tooling, personnel, and inventory
        - Throughput concurrent with other ongoing production
    - Capability to provide estimated yields, rates, cycle times, schedule, and cost performance to meet program M&Q goals
        - Use data from production of subsystems, items, and components to validate M&S System
        - Use data from production of subsystems, items, and components to identify of M&Q bottlenecks or constraints
        - Validate M&Q cycle times achievability
- Assess the results and data from M&Q demonstrations, tests, production of items and components, etc. by the contractor and supply chain in production representative environment to validate M&S of subsystems, components, and items for CDR, including:
    - A mix of mature hardware, prototypes, and models and simulations
    - Interfaces, integration, and interdependencies
    - Ergonomics
    - Identification of constraints
    - Performance
    - Throughput
    - Sufficient complexity to match the complexity of the system

Tools

- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Plant M&S tools (FlexSim, SimFactory, etc.)
- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- System Capabilities Analytic Process (SCAP)

Resources

- AS9100, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896 Manufacturing Management Program Guide
- Modeling and Simulation Guidance for the Acquisition Workforce
- Manufacturing Readiness Level (MRL) Deskbook

H.3 Mature Key Manufacturing Processes

Immature processes are a major source of risks on acquisition programs, especially during the EMD phase when most production are just emerging and starting to mature. As a program moves forward process maturity takes on greater importance. According to DoDI 5000.02 the EMD Milestone C decision requires that there be no significant manufacturing risks, that industrial production capabilities are reasonably available, and that the maturity of critical manufacturing processes has been assessed to ensure that they are affordable and executable. If these processes are not capable, in control and affordable, then the program office needs to continue to mature those processes.

Manufacturing and Quality Tasks

- Define and document the appropriate M&Q production representative and pilot line environments to be placed on contract, and used for process demonstrations and maturations, verifications and validations, qualifications, first articles, etc., based on contractor, supply chain, Government IPT, and contracting personnel interactions.
    - Ensure provisions for Government surveillance of contractor and supply chain “proof-of-builds” and/or “product/process walkthroughs” are included
- For CDR, assess demonstrations of M&Q processes in an environment with as much production realism as possible, considering the maturity of the design throughout the supply chain including:
    - Equipment (e.g., capability, capacity accuracy, calibration, age and condition, suitability, etc.)
    - Workforce (i.e., training, skills, and certifications)
    - Human factors (i.e., noise, vibrations, ergonomics)
    - Environmental conditions (i.e., temperature, humidity, air quality)
    - Testing and test equipment
    - Capability to meet the cost, schedule, and performance requirements
    - Estimates of costs, yields, rates, etc.

- Assess risks, issues, and impacts of the manufacturing environment (i.e., production representative) on M&Q processes and develop recommended mitigation plans for both the contractor and the supply chain for CDR.
- Collect data from process demonstrations and production of components and items in a production representative environment throughout the supply chain to support verification, validation, and authentication of M&S for CDR.
    - Ensure data is under configuration control
- Update status of the comprehensive M&Q Plans based on demonstrations of M&Q processes in a production representative environment for CDR
    - Include all M&Q risks and issues
    - Use Process Failure Modes and Effects Analyses (PFMEAs) on all M&Q processes
    - Update plans for achieving pilot line process capability targets
- Ensure key M&Q processes are sufficiently mature by conducting a system-level MRL assessment in support of CDR.
    - System-level target should utilize MRL 7 criteria and metrics
    - Subsystem, item, and components targets should utilize MRL 8 and/or MRL 9 criteria and metrics

Tools

- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Assessment
- Production Part Approval Process (PPAP)

Resources

- AS9100, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoDI 5000.02, Operation of the Defense Acquisition System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook ISO 9001:2015, Quality Management System

H.4 Demonstrate Manufacturing Maturity on Pilot Line

A Pilot line is an environment that incorporates all of the key production realism elements (equipment, personnel skill levels, facilities, materials, components, work instructions, processes, tooling, temperature, cleanliness, lighting etc.) required to manufacture production configuration items, subsystems or systems that meet design requirements in low-rate production. To the maximum extent practical, the pilot line should utilize FRP processes. The Pilot Line is where the demonstration of manufacturing maturity should take place.

Manufacturing and Quality Tasks

- Assess the progress and status of pre-CDR mitigations (i.e., production representative environment) for risks, issues, and impacts during pilot line demonstrations of M&Q processes, procedures, and schedules.
    - Update or develop mitigation plans for LRIP
- Assess demonstrations of manufacturing processes in an environment with all the key production realism elements required to manufacture production configuration items, subsystems or systems that meet design requirements in low-rate production (i.e., pilot line) including:
    - Equipment (e.g., accuracy, calibration, age and condition, suitability, capacity, etc.)
    - Personnel skill levels
    - Facilities, storage and handling, waste disposal, etc.
    - Hazmat
    - Security and safety
    - Materials and components
    - Work instructions and processes (e.g., cleaning, heat treating, ESD protection, clean rooms, etc.)
    - Tooling
    - Testing and test equipment
    - Environmental conditions (e.g., temperature control, cleanliness, lighting etc.)
    - Costs, yields, rates, etc.
- Collect data from pilot line demonstrations of M&Q processes and production line M&Q processes for components and items to support verification, validation, and authentication of system-level M&S for PRR and Milestone C.
- Verify that the contractor conducts process capability studies that meet program targets (C_{pk}s) to include:
    - All manufacturing processes for KCs and critical characteristics
    - Process capability studies conducted throughout the supply chain

- Based on process capability targets and pilot line results, update the comprehensive M&Q Plans for P&D to
  - Maintain currency of M&Q M&S
  - Maintain all M&Q risks, issues, and mitigations status
  - Update PFMEAs for all M&Q processes from pilot line changes
  - Update plans for achieving LRIP process capability targets in P&D
- Ensure key M&Q processes are sufficiently mature by conducting an MRL assessment to support PRR and Milestone C.
  - System-level target should utilize MRL 8 criteria and metrics
  - Subsystem, item, and components targets should utilize MRL 9 criteria and metrics
- Ensure Government surveillance of contractor and supply chain key and/or critical manufacturing processes for compliance to best practices or AS6500 (depending on contract).
- Ensure all policies, procedures, processes, work instructions, data, plans, metrics, tooling, equipment, and documentation are under program configuration management and control.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Pilot Line Demonstration and Assessment

Resources

- AS9100, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoDI 5000.02, Operation of the Adaptive Acquisition Systems
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896 Manufacturing Management Program Guide

H.5 Validate Yields and Rates

Companies often look closely at their yield and defect rates as a measure of factory floor performance and ability to produce uniform, defect-free product that meets the warfighters requirements and is affordable. Typical quality measures of output include first pass yield, cost of quality, scrap, rework,

and repair rates. M&Q managers need to be able to estimate their quality measures early and then validate those estimates during the pilot line build.

Manufacturing and Quality Tasks

- Collect up-to-date data from system and subsystem pilot line demonstrations of M&Q processes, and production line M&Q data for components and items as the basis for yield and rate analyses to validate "as is" status.
    - Rate of quality processes (actual time to complete) vs. planned
    - Quality data actuals vs. estimated
    - Quality process yield actuals vs. planned
    - Changes in processes (actual vs. planned)
    - Cost of quality actuals vs. desired
- Validate all M&Q learning curves for the system and subsystems based on pilot line results, contractor and supply chain improvements, program progress to date to include:
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
    - Planning and scheduling
    - Throughput (yield and rates)
    - Labor efficiency and ergonomics
    - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
    - Materials handling, transportation, and storage (including WIP)
    - Supply chain changes
    - Standardization and common processes
- As a potential impact on yields and rates, validate completeness of all related risk mitigation activities or acceptance of these risks (included in the joint Risk, Issue, and Opportunity Management Process), including:
    - Key and critical manufacturing processes including embedding software (KCs)
    - Supply chain, materials, and sourcing, including multiple
    - Facilities, tooling, and equipment
    - Testing, test equipment, and in-process tests
    - System security, safety, and HAZMAT management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability, obsolescence, and sustainment
- Evaluate all yields and rates from pilot line and lower level production against pilot line and LRIP targets, goals, and projections.
    - Validate achievement of targets (e.g., pilot line, LRIP, etc.)
    - Refine yields and rates required for LRIP

- Based on results of analyses develop and implement improvement plans as required

Tools

- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Yield Rate Assessment

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook

I. QUALITY MANAGEMENT

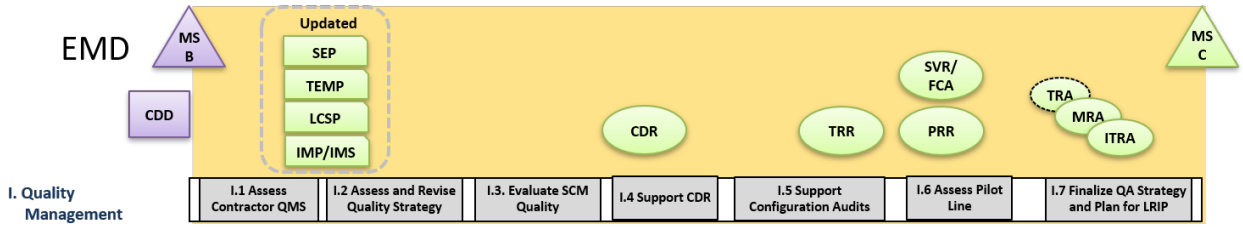


Figure 4-10. Quality Management Manufacturing and Quality Activities

Introduction

DoD has increased focus on M&Q management during early program phases. Quality is the degree to which material attributes, performance features, and characteristics of a product satisfy a given need. Quality may apply to a product, process, or system and may be physical, sensory, behavioral, temporal, ergonomic, or functional.

Quality management is an integral part of design and development efforts. QMS standards include industry best practices such as ISO 9001, Quality Management Systems–Requirements. AS9100, Quality Management Systems–Requirements for Aviation, Space and Defense Organizations, Product Realization (clause 7) includes typical systems engineering tasks under sub-clause 7.3, Design and Development. The typical systems engineering processes included in the QMS are:

- Design and Development Planning – SE Management, Failure Modes, Effects, and Criticality Analysis (FMECA), System Safety, etc.
- Design and Development Inputs/Outputs – T&E, Reviews, and Audits

- Design and Development Review, Verification and Validation
- Control of Design and Development Changes – Hardware and Software Configuration Management
- Hardware and Software Configuration Management
- Risk, Issue, and Opportunity Management
- Corrective Action System

The requirements for quality assurance and control come from the FAR/DFAR, and general industry guidance comes from ISO 9001 and AS9100 quality standards. These standards require that an organization establish a formal quality policy and submit documentation on its internal processes, procedures, and standards. The following are mandatory requirements of ISO 9001:

- Monitoring and measuring equipment calibration records
- Records of training, skills, experience, and qualifications
- Product/service requirements review records
- Record about design and development outputs review
- Record about design and development inputs
- Records of design and development controls
- Records of design and development outputs
- Design and development change records
- Characteristics of product to be produced and service to be provided
- Records about customer property
- Production/service provision change control records
- Record of conformity of product/service with acceptance criteria
- Record of nonconforming outputs
- Monitoring measurement results
- Internal audit program
- Results of internal audits
- Results of the management review
- Results of corrective actions

Note: AS9100 standard includes all of the above, and more.

This thread (Quality Management) requires an analysis of the risk and management efforts to control quality, and foster continuous quality improvement and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Quality Management System (QMS)
- Quality Strategy and Plan
- Product Quality
- Supply Chain Quality
- Quality Risk

An effective QMS is required for operationally safe, suitable, and effective weapon systems. A QMS should be compliant with industry standards ISO 9001 or AS9100 and is foundational to producing products that meet contractual requirements. The quality system ensures the as-delivered configuration is the same as the as-designed and as-tested configuration. The quality system serves as the management and control function, requiring controls over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. It also requires monitoring and measuring of processes and products to ensure they conform to requirements. An effective quality system is critical to ensuring delivered products meet all the requirements of the approved design.

Most contractors have QMSs certified to industry standards (best practices) and should not need assessment for compliance as ongoing audits are part of the certification process. Program should assess that the contractor's QMS supports and aligns with Program strategy, objectives, goals, and the contract. This will involve the use of process audits as to whether the contractor's and supply chain activities, resources, and behaviors are being managed efficiently and effectively including participation of DCMA, KCs control and management, use of acceptance testing, application of Statistical Process Controls (SPCs), etc., which are more than just evaluations of the sequential steps and interactions of a process within the QMS. Similarly, these audits should be conducted on the supply chain, as necessary.

The M&Q Strategies should require quality assessments of the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a pilot line, prior to Milestone C. Revision to the quality strategy, plans, and objectives may be required based on the results of process audits and quality assessments.

For CDR, initial product baseline documentation for quality, included in the Quality Strategy and Plans, should be sufficient, complete, and adequate to enable inspections and testing of all components, hardware, and embedded software throughout the supply chain. The system-level CDR assesses the system design as captured in product specifications for each subsystem, item, and component in the system's initial product baseline, and helps ensure that each has been captured in the detailed design and quality documentation. Assessment of the allocated baseline against the initial product baseline should assure that quality parameters (e.g., tolerance, process capability indices, etc.) for considerations such as weight, power, cooling, etc. have been appropriately specified in the detailed design. This includes drawings and specifications with tolerances and test points under configuration control for all KCs, CSIs, and CAIs having been completed.

A system-level FCA should be conducted to assess performance of the system against the functional baseline and may be conducted in conjunction with the SVR. Quality and quality personnel should be an integral element in both the FCA and the SVR. The main difference between the two activities is that a system-level FCA focuses primarily on verification of the functional baseline, while SVR assesses system functionality as well as other details to include program readiness to proceed into the

Production and Deployment phase. This includes assessments for quality of all program, contractor, and supply chain policies, processes, and procedures.

The system-level FCA should assess the collected data, test results, analysis results, and M&S output and accuracy of the system after completion of development testing and pilot line and verifies that actual system performance satisfies quality requirements. For quality requirements that cannot be completely verified during pilot line, tests or simulations using approved methods can provide valid data that LRIP performance will be met with acceptable risks.

The SVR should address all changes or additions generated since CDR to ensure the as-tested product on the pilot line includes all Engineering Change Proposals, specification change notices and revisions, interface control changes, and all M&Q process changes.

As the pilot line environment incorporates all key equipment, personnel skill levels, materials, components, work instructions, tooling, etc. required to manufacture the product, quality analyses should be performed during pilot lines to provide verification and validation of actual yields, rates, and costs to be realized during LRIP. The environment should utilize production processes forecasted to be used in LRIP. Based on quality analyses of program, contractor, and supply chain, quality assessments of maturity, quality analyses of affordability and quality costs, quality risks, issues, and opportunities, all demonstrate that the M&Q processes and capabilities required for production have matured with high confidence of success in building production configuration products in the P&D phase.

The combination of a robust QMS and advanced quality and defect prevention practices are critical to successful program execution, and it is mandated under Federal Acquisition Regulation (FAR) Part 46.202-4.

I.1 Assess Contractor Quality Management System

FAR Part 46 is used by quality managers to identify contractual quality requirements. Most DoD programs will require a higher-level quality clause. ISO 9001 and AS9100 both satisfy the requirements for a higher-level QMS. Often contractors will note in their proposal that they will follow one of the two QMS's identified above and it is up to the procuring activity to assess the contractor and their implementation to see if it does in fact satisfy their requirements and will result is conforming product.

As a best practice, contractors should be required to comply with either ISO 9001 Quality Management System or AS9100 Quality Management System. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

Manufacturing and Quality Tasks

- Assess the contractor's corporate strategic vision, objectives, policies, plans, processes, and procedures for alignment to the contracted program needs and industry best practices (e.g., AS9100, ISO 9000, etc.) for quality both in-house and in suppliers' facilities to include:
    - Established quality policy, at the highest level in the company, based on industry best practices, which commits to continuously improving processes and exceeding customer expectations
    - Organizational direction and values regarding quality are communicated throughout the supply chain
    - Management provides structures and resources supporting full implementation of the QMS
    - Management solicits quantitative and qualitative feedback on the effectiveness and efficiency of QMS and takes actions based on that feedback
    - Procedures for internal reviewing of the QMS periodically with goals and objectives throughout the organization for customer satisfaction, and continuous improvement
    - Procedures independent reporting channels for quality functions and audits
    - Management accountability with emphasis on quality results and customer satisfaction
- Ensure that the results of an analyses of corporate strategic vision, objectives, policies, plans, processes, and procedures has been documented in the Acquisition Strategy (AS), M&Q Plans, the SEP, program documentation for CDR, and other appropriate program documentation.
- Evaluate the QMSs in use for the following:
    - Management responsibility
    - Resource management
    - Quality System
    - Contract Review
    - Product Realization
    - Design Control
    - Document Control
    - Purchasing
    - Purchaser-Supplied Product
    - Product Identification and Traceability
    - Process Control
    - Measurement, Analysis, and Improvement (metrology and calibration)
- Conduct a process audit of the contractor's QMS including assessment of:
    - Quality processes and supply chain quality including:
        - Identification, control, and auditing of critical manufacturing processes
        - Role and participation of DCMA (contractor and supply chain)

        - KCs control and management
        - Acceptance testing including software
        - In-process and final inspection functionality
        - Statistical process controls, rates, and yields (and management of same)
        - Execution of and adherence to quality plans including control plans and quality improvement plans
        - Certification processes (e.g., flight safety, man-ratings, etc.)
        - Continuous process improvement results
        - Software quality assurance results
        - Data storage, management, and security (physical and cyber)
        - Management of safety, environmental, transportation, storage, etc.
        - Use of COTS items, GOTS items, and NDIs
        - GFE/GFP management (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
        - Internal and supply chain audits and verification results
    - Processes for management, control, and monitoring of KPPs, KSAs, and KCs, CSIs, and CAIs, and their integration into the QMS.
    - FRACAS processes for sufficiency and adequacy including results of dispositions (i.e., material review boards and processes)
    - QMS impacts on tasks, costs, schedules, and outcomes
    - QMS compliance to standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
    - Planning, integration, and execution of the Risk, Issue, and Opportunity Management System processes
- Request DCMA support and assistance to assess adequacy and completeness of contractor and supply chain QMSs application to system, subsystems, items, and components.

Tools

- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist) for the Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Management System – Aerospace
    - AS9102 First Article Inspection
    - AS9103 Variation Management of Key Characteristics
    - AS9133 Qualification Procedure for Aerospace Parts
    - AS9134 Supply Chain Management Guidelines

  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
  - AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- DoD Risk, Issue, and Opportunity Management Guide
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide

I.2 Assess and Revise Quality Strategy

M&Q managers support the development and updates to the Acquisition Strategy by providing their inputs into the SEP. Quality managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and to the success of a program.

Manufacturing and Quality Tasks

- Update and revise the program Quality Management Strategy based on the contractor's QMS, and quality strategy and plans to include:
  - The contractor's strategy and plan to address compliance to established industry standards and best practices (e.g., AS9100, ISO 9000, etc.)
  - Alternatively, the contractor's quality management strategy and plans should address:
    - Leadership responsibilities and requirements
    - QMS requirements and planning
    - Support and resource management requirements
    - Operational requirements (e.g., risk management, design, and development, purchasing, etc.)
    - Risks, issues, and opportunities
    - Performance evaluation including measurement, analysis, and improvement requirements
- Update and revise the program Quality Management Strategy and Plan based on the results from process audits (adequacy and sufficiency) of the contractor's and supply chain QMSs conducted (*see* I.1).
- Develop required contract modifications or updates to ensure alignment of contractor with program Quality Management Strategies and Plans based on results of quality audits conducted (*see* I.1).

- M&Q should conduct internal audits at planned intervals to ensure the program quality management system conforms to the program's requirements and is effectively implemented and maintained.
- M&Q personnel should review and revise program quality objectives for adequacy and sufficiency at the appropriate levels, and for the appropriate processes to meet program objectives. The quality objectives should consider applicable requirements and be:
    - Consistent with the quality policy
    - Measurable
    - Monitored
    - Communicated
    - Updated, as appropriate
- M&Q personnel should verify and update the program Quality Management Strategy and Quality Plan to ensure they include:
    - All required quality technologies and processes (state of the art), unique product quality requirements, metrics, and the frequency of review
    - Compliance with FAR 52.246-11, Higher-Level Contract Quality Requirements
    - M&Q personnel may also consider related clauses to include:
        - Inspection of supplies and services clauses, 52.246-2 through 52.246-9 to ensure appropriate government access, oversight, and protection
        - Warranty for supplies and/or services: 52.246-17 through 52.246-21 though mainly -18, -19, & -20 depending on what work is being done and what product is being delivered
    - The quality aspects of contractor compliance to industry best manufacturing practices (i.e., AS6500)
    - Management, measurement, and control of key and critical characteristics and processes
    - Addresses use of and appropriate quality requirements for COTS items, GOTS items, and non-developmental items (NDIs) and their incorporation into the contractor's QMS (i.e., shock and vibe requirements beyond normal COTS design envelope)
    - Requirements for supply chain:
        - Focused supplier quality management requirements
        - Quality management planning
        - Use of best practices and standards (e.g., AS9100, ISO 9000, etc.)
        - Metrics and review frequency
        - Solutions, tools, techniques, and procedures
        - Use of Government furnished quality and testing equipment and assets
    - Appropriate agreements, delegations, and contracts with other agencies, e.g., the DCMA and/or DLA throughout the supply chain
    - Software and firmware development quality assurance and configuration management

- M&Q personnel should assess the program's quality management system, at planned intervals for continuing suitability, adequacy, effectiveness, and alignment with the strategic direction of the program. The assessment should include:
    - Status of actions from previous assessments
    - Changes in external and internal issues that are relevant to the QMS
    - Performance and effectiveness of the QMS, including:
        - Extent to which quality objectives have been met
        - Process performance and conformity of products
        - Nonconformities and corrective actions
        - Monitoring and measurement results
        - Audit results
        - Performance of the supply chain
    - Adequacy of resources
    - Effectiveness of actions taken to address risks, issues, and opportunities
    - Opportunities for improvement

Tools

- Acquisition Strategy Template
- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan

Resources

- AFMC Instruction 63-145, Manufacturing and Quality
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9134, Supply Chain Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- DSMC Acquisition Strategy Guide
- DoDI 5000.88, Engineering of Defense Systems
- FAR 52.246-11, Quality
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook DAG Chapter 14.3.1.3.6 Quality Plans

I.3 Evaluate Supply Chain Quality

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then the development and execution of a Supplier QA program becomes a pivotal task. Often program problems originate in the supply chain, but do not manifest themselves until the component is integrated into the system. This is especially a problem as the program ramps up production from the pilot line build to the LRIP environment. Program offices and contractors often have efforts to identify and manage problems at the first tier, but do not do well below that level. QA managers need to routinely review and assess contractors supply chain and procurement activities and efforts.

Manufacturing and Quality Tasks

- Ensure that the contractor supplier management system for subsystems, items, and components requires QMS processes and procedures are in alignment with industry best practices (e.g., AS9100, ISO 9000, AS9134 Supply Chain Management Guidelines, etc.) to include elements such as:
    - Management responsibility requirements
    - Quality management system requirements
    - Resource management requirements
    - Product Realization requirements (e.g., risk management, design, and development, purchasing, etc.)
    - First Article Inspection if required
    - Risks, issues, and opportunities
    - Measurement, analysis, and improvement requirements
- Assess the contractor's supply chain management system capabilities for performance of M&Q processes and procedures in accordance with industry best manufacturing practices (i.e., AS6500, AS9134 Supply Chain Management Guidelines, etc.) including:
    - Effectiveness of prime and subcontractor communications and interactions to include:
        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Design and engineering changes traceability and compliance
        - Quality data exchange, analysis, storage, and traceability processes
        - The joint Risk, Issue, and Opportunity Management System
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions and program feedback
    - Management of KCs and critical characteristics (CSIs and CAIs)
    - Supplier risk, issue, and opportunity, and mitigation management processes for quality (e.g., technical, schedule, material, facility, scale-up, financial impacts, etc.)
    - Make/buy processes for supplier quality performance and impacts

  - Qualification, approval, and removal processes for suppliers, monitoring and tracking of supplier performance, and periodic re-assessment
  - Utilization of processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
  - Verification of supplier's processes and procedures to control quality, including suppliers performing key and/or critical manufacturing processes and changes to those processes
  - Process control plans for variability reduction
  - Statistical control of process capabilities (i.e., C_{pk}s)
  - Production process verification
  - Predictive indicators to provide early detection of potential quality problems
  - Subsystem, item, and component First Article Inspections (FAIs) and First Article Tests (FATs)
  - Continuous manufacturing surveillance and effective metrics to monitor, evaluate, verify, improve processes, and prevent defects
- Establish supply chain quality management metrics for each of the concepts being considered for incoming quality inspection to include the identification of acceptable quality levels (AQLs)
  - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Collect and analyze supply chain quality data from the production representative environment for subsystems, items, and components and utilize analyses results to develop recommended improvement plans.
- Ensure control plans are in place for management of KCs.
- Ensure development of test and inspection plans underway for EMD prototypes.

Tools

- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Supplier QA Questionnaire

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6081, Fraudulent/Counterfeit Electronic Parts: Avoidance Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace

  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Risk, Issue, and Opportunity Guide
- Manufacturing Readiness Level (MRL) Deskbook

I.4 Quality Support to the Critical Design Review

Quality subject matter experts should be actively engaged in the organization and execution of the CDR during this phase. The CDR occurs mid-point in the EMD phase. The CDR brings to closure design paths in detailed design. Any changes moving forward should only be accomplished through a formal Engineering Change Proposal (ECP). The completion of the CDR should provide:

- An established system initial product baseline,
- An updated risk assessment for EMD,
- An updated CARD based on the system product baseline,
- An updated development schedule for fabrication, test and evaluation, software coding, critical path drivers, and
- An approved Life Cycle Sustainment Plan.

Quality Tasks

- Ensure Quality Strategy and Plan, including initial product baseline documentation for quality, is sufficient, complete, and adequate to enable inspections and testing of components, hardware, and embedded software in support of the CDR.
  - Ensure all KCs, CSIs, and CAIs have completed drawings and specifications with tolerances and test points under configuration control
  - Ensure all product data essential for component quality has been released
- Provide quality inputs on program, contractor, and supply chain implementation status of industry best practices (e.g., ISO 9000, AS9100, and other standards on quality management and quality management systems) in support of the CDR.
- Ensure all quality design trade studies and assessments are completed and incorporated into the design for CDR.
  - Ensure quality enhancement efforts ongoing for optimized integrated system (e.g., Design for Inspection and Testability, Design for Six Sigma, etc.)

- Ensure all subsystem, item, and component CDRs are complete and the results impacting quality available for the system CDR.
    - Analyze the results of design maturity assessments (*See* E.6) including all appropriate reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.) for closure or approval of quality related risks, issues, and opportunities
- Ensure quality inputs to the schedule (IMP/IMS) are up-to-date and are executable with acceptable risks.
- Ensure quality plans, activities, and processes are executable within the existing quality budget to support the approved initial product baseline and critical path.
- Ensure all key and critical manufacturing processes process control plans, have been analyzed, updated, and approved for the capability to meet design tolerances.
- Analyze contractor quality plans for materials, facilities, equipment, test facilities and equipment, and tooling to support the pilot line requirements.
- Analyze the contractor FRACAS for adequacy to meet needs based on the Quality Plan.
- Analyze quality plans for adequacy and capability of achieving MRL 8 by initial production.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality management, ESOH, etc.) for quality risks, issues, and opportunities and appropriate mitigation plans.
- Analyze the assessments of adequacy and completeness of quality requirements validation activities (*see* E.6), which included prototypes and demonstrations in a representative environment at the system, subsystem, item, and component levels for design maturity.
    - Include demonstrations of quality processes in a representative environment
    - Include demonstrations of quality processes for KCs, CSIs, and CAIs
- Provide quality inputs to the Life Cycle Sustainment Plan for CDR.
- Ensure contractor quality management systems for M&Q metrics and data collection and tracking to the component level are in place and functional.
- Ensure the TEMP incorporates all subsystems, items, and components into plans for tests, test facilities, and test equipment.
- Ensure the quality considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - PPP
    - SEMP
    - TEMP

- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure quality design improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (*See* E.4).
- Provide up-to-date cost of quality inputs to the program budget and the CARD.
    - Update and allocate quality (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure adequacy and completeness of mitigation activities for mitigation of quality risks, issues, and opportunities in the joint Government/ contractor Risk, Issue, and Opportunity Management System, including quality risks to:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and HAZMAT management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment

Tools

- Critical Design Review Checklist
- Interactive MRL Users Guide (Checklist) for the Quality thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9134, Supply Chain Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving

  - AS9138, Statistical Process Acceptance

-
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook

I.5 System and Program Configuration Audits

Product design should have been stable by the time the CDR was conducted; however, detailed design often continues well into the Production and Deployment phase. The Physical Configuration Audit (PCA) is a formal examination of the "as-built" configuration of the system or a configuration item against its technical documentation to establish or verify its product baseline. A successful PCA provides the Milestone Decision Authority with evidence that the design is stable. At the conclusion of the PCA, the final product baseline is established, and all subsequent changes are processed by a formal engineering change action and under the control of configuration management practices. M&Q managers should support the validation of the design during the CDR and PCA.

Manufacturing and Quality Tasks

- Ensure M&Q personnel participate in and support program, contractor, and supply chain system audits to be performed in accordance with the process focused requirements in AS9101 for (but not limited to):
  - Risk, Issue, and Opportunity System
  - Supply chain management system
  - Development test operations and evaluations
  - Quality Management System
  - Development (hardware and software)
  - Production control
  - Security (physical and cyber)
  - ESOH
  - Hazardous and/or special materials
  - Human Machine Interface
  - EVM system
  - Transportation, handling, and storage
  - Workforce management
  - Facilities
  - Documentation and data management
- Ensure M&Q personnel participation in, inputs to, and support of the FCA to include:

  - Support to program and the contractor agreements that development is complete and data from development tests (DTs), analyses, and simulations are sufficient to achieve performance goals
  - Provide quality input to:
    - Verification of performance to the baseline
    - The verification traceability documentation for each M&Q requirement
    - The validity and the completeness of embedded software and associated documentation
  - Verify all approved engineering change proposals (ECP), requests for deviation, and requests for waiver impacting M&Q have been incorporated into the M&Q Plans
  - Verification that all KCs, CSIs, and CAIs are identified, managed, and included in the Verification Cross-Reference Matrix (VCRM)
  - Ensure quality provides support to verification activities and tasks to include:
    - Ensuring each requirement listed in the VCRM is traceable and has been verified with test data, analysis, and/or inspection
    - Ensuring demonstration M&Q processes to provide the capability to satisfy TPMs, KPPs and KSAs thresholds
    - Review of acceptance test reports and deficiencies with root cause and closed corrective actions

- Ensure M&Q participates in the Configuration Control Boards (CCBs) to ensure changes are in accordance with program direction, program Quality Strategy, and are consistent with industry quality standards and best practices, supplier instructions, processes, and procedures, etc.
- Participate in and support the System Verification Review (SVR) including:
  - Provide verification that all M&Q CDR action items have been closed and any corrective actions have been successfully completed
  - Provide quality inputs on:
    - Verification of requirements from all system, subsystem, item, and component quality test data and analyses
    - Verification of performance to the function baseline based on quality data
    - Verification through analysis of quality data the adequate management and integrity of all critical program information (CPI) (e.g., performance data, yield, and rate data, etc.)
    - Verification that quality risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
    - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available quality test data, analysis, and inspection
    - Required certification activities

  - Support and maintenance analyses for incorporation into the LCSP
  - Risks of operational test failures during IOT&E
- Provide quality inputs to:
  - Ensure adequate quality processes and quality metrics are in place
  - Analysis of contractor' s SEMP for appropriate incorporation of quality activities and data collection, analysis, and storage
  - Detailed planning and schedules with required resources for proceeding into LRIP and IOT&E
  - Updates of the SEP and contractor's SEMP for the production and deployment (P&D) phase
  - The CARD for up-to-date cost of quality inputs
  - The LCSP
  - The TEMP (i.e., up to date)
  - The Configuration Management Plan (CMP) (i.e., up to date)

Tools

- Functional Configuration Audit Checklist
- Interactive MRL Users Guide (Checklist) for the Quality thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- AS9101, Quality Management Systems – Audit Requirements for Aviation, Space, and Defense Organizations
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook

I.6 Assess Pilot Line

M&Q personnel need to identify the potential product quality requirements of an identified material based on FAR 46.202, Types of Contract Quality Requirements, and FAR 52.246.1, Contractor Inspection Requirements. In addition, the organizations need to identify the process of measuring, examining, testing, or otherwise comparing the product to the requirements for acceptance. FAR 46.291 Production Lot Testing identifies the purpose of production lot testing is to validate quality conformance of products prior to lot acceptance which usually occurs after acceptance testing.

Typically, the Pilot Line begins around the time the CDR has been completed. The Pilot Line should reflect the proposed production line and include all materials, manpower, tooling, test equipment, and facilities that will be on the production line. STE/SIE should be validated as part of pilot line validation in accordance with validation plans. M&Q processes and procedures should be proven on a pilot line and are under control and ready for low-rate production. Known producibility risks and issues should pose no significant challenges for low-rate production. Cost model and yield and rate analyses should have been updated with pilot line results. Supplier qualification testing and first article inspections should have been completed. The industrial base has been assessed for Milestone C and shows industrial capability is established to support LRIP.

Manufacturing and Quality Tasks

- Assess contractor and supply chain pilot lines and demonstrations for quality verification and validation efforts including:
    - Quality processes and procedures including continuous improvement efforts
    - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)
    - Quality and process controls in place (e.g., plans, audits, process capabilities (C_{pk}s), SPC, FRACAS, etc.)
    - Adequacy and completeness of acceptance and qualification testing for LRIP
    - All quality instructions, sequencing, in-process tests, and test procedures (including those in work instructions)
    - Quality scheduling and control
    - Quality model and simulations
    - Quality workforce capabilities
    - Implementations of quality technologies
    - Tooling, work holding fixtures, jigs, etc. for inspection and test
    - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
    - Quality processes for transportation, storage, and handling equipment
    - Potential requirements for additional quality tools, equipment, and software
    - Safety of quality processes and procedures
    - Quality of ESOH processes and procedures

  - Quality of security processes, procedures, capabilities, and compliance
  - Impacts from direct and indirect infrastructure
  - Mitigation results of quality and adequacy of risks and issues resolutions
  - Quality costs (and impacts to schedule and performance)
  - Quality of materials' sources and selections
  - Quality of embedded software (integration)
- Identify and manage product quality requirements:
  - Identify product acceptance methods and determine sampling plans as appropriate
  - Conduct First Article Inspection if required
  - Incorporate and mature quality technologies and process into product quality requirements
  - Identify and manage product quality requirements on pilot line items (i.e., specific product characteristics)
  - Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Analyze quality processes performed during the pilot lines operations, (including simulations) to include:
  - Rate of quality processes (actual time to complete) vs. planned
  - Quality data actuals vs. estimated
  - Quality process yield actuals vs. planned
  - Changes in processes (actual vs. planned)
  - Cost of quality actuals vs. desired
- Assess process control plans, including all plans for process control of key and critical processes, for adequacy and completeness on the pilot line.
- Assess all work instructions for required quality outputs (e.g., data, in-process inspections and tests, process capability indices, etc.) based on build-to documentation and information gathered during the pilot line.
  - Verify updated work instructions, processes, drawings, etc.
  - Include KCs and their control plans
- Assess quality outputs from the pilot line and demonstrations for adequacy and completeness and validate:
  - All Production Process Verifications (PPVs) performed
  - Implementation of manufacturing technology solutions (including ManTech)
  - Attainability of KCs (will be capable and under process control for LRIP)
  - Data collected for the Variability Reduction program
    - Data should demonstrate progress to metrics
    - Include updates based on process improvements

  - All FAIs and FATs against specifications, drawings, models, etc.
  - Continuous improvement plans.
    - Include assessment of quality targets (gaps)
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements
- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards
- Provide quality input for a Letter of Delegation or Memorandum of Agreement to DCMA for support to, witness of, and assessment of demonstrations, pilot line operations, FAIs and/or FATs, etc.

Tools

- AS9100 Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001 QMS Audit Checklist
- Manufacturing Maturation Plan
- Lot Acceptance Testing Calculator

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
  - AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- DoD Risk, Issue, and Opportunity Management Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896 Manufacturing Management Program Guide
- MIL-STD-1916 DoD Test Method Standard, Apr 1996,
- ANSI Z1.4 Sampling Procedures and Tables for Inspection by Attributes

- ANSI Z1.9 Sampling Procedure and Tables for Inspection by Variables for Percent Nonconforming
- DCMA-INST 302 First Article and Production Lot Testing
- DoD Systems Engineering Guide

I.7 Finalize Quality Strategy and Plan for LRIP

M&Q managers in planning for LRIP should support the development and updates to the Acquisition Strategy by providing their inputs into the SEP. Quality managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and to the success of a program.

Manufacturing and Quality Tasks

- Verify and validate the quality processes capability for LRIP (including simulations) based on analyses of quality processes performed for the pilot line, and update the Quality Strategy and Plan accordingly to include:
    - Rate of quality processes (actual time to complete) vs. planned
    - Quality data actuals vs. estimated
    - Quality process yield actuals vs. planned
    - Changes in processes
    - Cost of quality actuals vs. desired
    - Potential requirements for additional equipment
    - Continuous improvement process and requirements
- Ensure process control plans, including all plans for process control for key and critical processes, are updated from pilot line and in place for LRIP.
- Verify Quality Strategy and Plan are updated based on all build-to documentation from the pilot line, including KCs and critical characteristics and their control plans for LRIP.
    - Include updates based on process capability data collected for those processes affecting KCs and critical characteristics
    - Include process stability data for key and critical processes and provide estimates for those with insufficient data
- Adjust Quality Strategy and Plan based on validated data collected for the Variability Reduction program
    - Data should indicate progress to metrics
    - Include updates based on process improvements

- Update Quality Strategy and Plan to include all First Article Inspections and First Article Tests (completed with plans in place to correct findings).
- Ensure that the Quality Strategy and Plan for LRIP requires:
    - Includes Letter of Delegations for DCMA support at the appropriate levels of the supply chain
    - Adequate acceptance and qualification testing
    - Continuous collection and periodic review of quality data to identify areas for improvement (i.e., Continuous Process Improvement (CPI)).
    - Supplier risk and issue mitigation planning complete and being implemented
    - Periodic supplier process control verification and validation
    - Periodic assessment of Variability Reduction processes
    - Implementation of Six Sigma, lean manufacturing processes, etc.
- Update the Program Quality Strategy and Plan (i.e., AS6500) based on contractor's M&Q system verification and validation efforts, including pilot line and demonstrations, and direct and indirect infrastructure, including:
    - Quality processes including continuous improvement efforts
    - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)
    - All quality instructions, sequencing, in-process tests, and procedures (including those in work instructions)
    - Process capabilities (C_{pk}s) and process control plans
    - Quality scheduling and control
    - Quality model and simulations
    - Quality workforce capabilities
    - Implementations of quality technologies
    - Tooling, work holding fixtures, jigs, etc. for inspection and test
    - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment validation in accordance with plans)
    - Quality processes for transportation, storage, and handling equipment
    - Safety of quality processes and procedures
    - Quality of ESOH processes and procedures
    - Quality of security processes, procedures, capabilities, and compliance
    - Mitigation results of quality and adequacy of risks and issues resolutions
    - Quality costs (and impacts to schedule and performance)
    - Quality of materials' sources and selections
    - Quality of embedded software (integration)
- Develop recommendations for sourcing and options for LRIP based on quality analyses of program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, including:

  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages
- Ensure contractor's quality plans, policies, and procedures are consistent with program plans for program Plans for Product Improvement for LRIP.
- Update all quality risks, issues, and mitigation plans for LRIP based on pilot line operations, demonstrations, and simulations.
- Ensure mitigations of current risks and issues are on track and/or do not introduce new risks and issues to the program for LRIP.
- Finalize the TDP including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details based on the results of the Pilot Line build.

Tools

- Acquisition Strategy Template
- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan

Resources

- AFMC Instruction 63-145 Manufacturing and Quality
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- FAR 52.246-11, Quality
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide

- Manufacturing Readiness Level (MRL) Deskbook
- DAG, Quality Plans

J. MANUFACTURING WORKFORCE

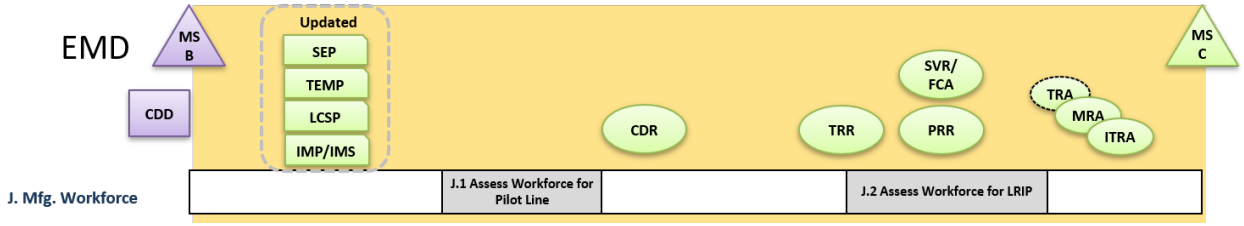


Figure 4-11. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

This thread (Workforce) outlines activities and tasks to assess required manufacturing workforce skills (capabilities) and availability in required numbers (capacity) of personnel to support the manufacturing effort.

Workforce skills identification and plans provide inputs to program planning. Workforce planning should align the skills required to the scope of the effort required to develop, field, and sustain the system. To determine the scope of the M&Q workforce plans necessary for the system during EMD, the following considerations should be analyzed and understood, including the Work Breakdown Structure (WBS), the contractor's make/buy plans and M&Q plans, processes, and procedures, the risks, issues, and opportunities and associated plans, the IMP/IMS, and other supporting resources.

A comprehensive assessment of contractor manufacturing plans for system development is necessary to understand the requirements for workforce skills, capabilities, training, and certifications. In support of pilot line workforce requirements, contractor plans should be assessed for human resource policies, processes, and procedures, forecasts for the number of workers, skills, and capabilities, etc. Additionally, the current training, certifications, and education, sourcing availability and stability, demographics of the contractor and supply chain should be evaluated for adequacy, as well as their capability and capacity to expand the workforce, through hiring, training, and certification, for pilot line and LRIP.

Based on contractor execution of the pilot line and the M&Q workforce results, update the program workforce plans contained in the M&Q Strategies for required skills, capabilities, training, and certifications for LRIP in the P&D phase.

J.1 Assess Workforce for Pilot Line

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on a regular and on-going basis. Two major focus areas are:

- Workforce Skills availability
- Workforce Skills capability

A 2018 Deloitte research report "2018 and The Manufacturing Institute Skills Gap and Future of Work Study" reveals that *"the skills gap may leave an estimated 2.4 million positions unfilled between 2018 and 2028, with a potential economic impact of $2.5 trillion."* Part of the problem is the aging of the manufacturing workforce, and part of the problem is that many young people are no longer interested in manufacturing jobs. This is due in part to the elimination of shop classes from most high schools and thus many students are not exposed to it. Manpower skills availability and capability should have been assessed to ensure that there is enough capability to meet the demands of the Pilot Line.

Manufacturing and Quality Tasks

- Assess the contractor's M&Q Plans for manufacturing, quality, and supporting pilot line workforce requirements for adequacy and capacity to meet program requirements and schedule including:
    - Human resource policies, processes, and procedures to include forecasting and scheduling
    - Number of workers by category by schedule
    - Skillsets and capabilities by category by schedule
    - Current level and forecasting for training, certifications, and education
    - Capacity and capability to train, certify, etc.
    - Labor regulations, relations, union agreements, etc.
    - Labor Sourcing – internal and external
    - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
    - Demographics (e.g., citizenship, retirement eligibility, etc.)
    - Security
- Assess contractor's facility and personnel statistics (e.g., turnover, accidents, ESOH violations, etc.) and M&Q Plans for M&Q workforce risks, issues, and opportunities for the Pilot Line.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management

- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Workforce thread
- Learning Curve Calculator (Estimator)
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Systems
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

J.2 Assess Workforce for LRIP

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on a regular and on-going basis. Two major focus areas are:

- Workforce Skills availability
- Workforce Skills capability

Manpower skills availability and capability should have been assessed prior to the Milestone C decision, and now that the program in in LRIP, then manpower needs to be assessed to ensure that there is enough capability to meet the demands of LRIP and the ramp up in production.

Manufacturing and Quality Tasks

- Based on pilot line results, assess the updated contractor's M&Q Plans for manufacturing, quality, and supporting LRIP and/or FRP workforce scale-up requirements for adequacy and capacity to meet program requirements and schedule including updates to the following:
    - Human resource policies, processes, and procedures to include forecasting and scheduling
    - Number of workers by category by schedule

  - Skillsets and capabilities by category by schedule
  - Current level and forecasting for training, certifications, and education
  - Capacity and capability to train, certify, etc.
  - Labor regulations, relations, union agreements, etc.
  - Sourcing – internal and external
  - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
  - Demographics (e.g., citizenship, retirement eligibility, etc.)
  - Security
- Update contractor's facility and personnel statistics (e.g., turnover, accidents, ESOH violations, etc.) for M&Q workforce risks, issues, and opportunities for LRIP and/or FRP.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Workforce thread
- Learning Curve Calculator (Estimator)
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Systems
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896 Manufacturing Management Program Guide

K. FACILITIES

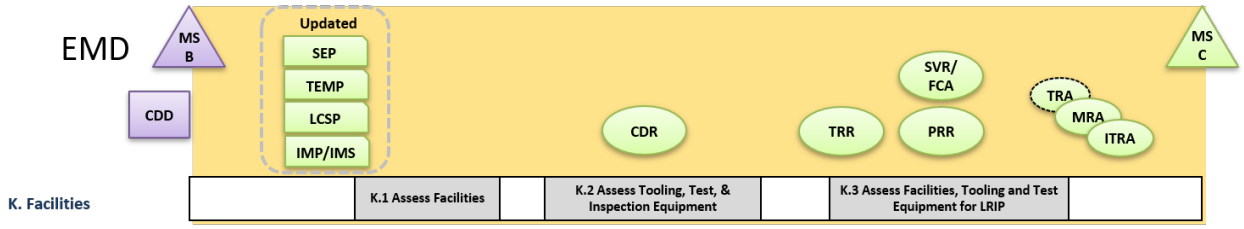


Figure 4-12. Facilities Manufacturing and Quality Activities

Introduction

Facilities management encompasses a variety of professional skills that focus on the design, construction, management, of an installation to include plant and equipment. Life cycle management includes all permanent and semi-permanent real property required to support a system throughout the systems life cycle. Facility management includes studies of facility requirements to include location, environmental and security considerations, and maintenance of such property through disposal.

This thread (Facilities) outlines the analysis of the capabilities and capacity (Prime, Subcontractor, Supplier, Vendor, and Maintenance Repair) that are key risks in manufacturing.

Based upon the results of PDR and program progress during early EMD, M&Q personnel should assess the contractor and supply chain facility and tooling plans developed for the pilot line and LRIP. This should include pre-CDR assessments of proposed production (e.g., pilot line, LRIP, FRP, etc.) facilities, and an update to the M&Q Strategies and Plans for EMD and future phases.

Based on the system design and results of assessments of existing assets, new facilities, tools, and equipment may be required to meet rates and schedules. Additionally, depending on final CDR design, new materials, new technologies, new processes, and new tooling and equipment may be required. The program and the contractor(s) need to address the assessment results, current and known future facility workload (i.e., other programs), and any new requirements, and plan accordingly for the capability and capacity to develop, produce, maintain, and support the program throughout the supply chain.

The assessments conducted for EMD should include subcontractors and key suppliers identified in the contractor's Manufacturing Management Plan, which should include tooling and facilities plans with utilization, and any relocation/consolidation considerations, schedules, and requirements for manufacturing maturity. These assessments should be conducted on-site and can be included as part of the MRL assessment. These should include all "special test equipment" and "special tooling" as defined in FAR 2.101 in assessments conducted.

The results of these assessments should identify, and document risks, issues, and opportunities arising from facility and tooling shortfalls and document the required planning for mitigation. Prior to CDR and pilot line, the program Tooling Plan for facilities, tooling, equipment, and test equipment (part of

the M&Q Strategies and Plans) should be finalized along with the associated risk and issue mitigation actions. Final validation of M&Q plans must be accomplished prior to CDR, prior to execution of a pilot line.

Facilities, tooling, equipment, and test equipment requirements, resource requirements, and schedules should be re-assessed based on results of pilot line demonstrations and assessments for LRIP and FRP. Using the actual data collected from pilot line assess equipment capability, capacity, and availability for scale-up. Additionally, assess M&Q operations and environmental requirements, floor space utilization and expansion requirements, facility data requirements, and equipment maintenance requirements for LRIP and FRP. Focused attention on facilities, tooling, equipment, and test equipment in EMD will decrease risk and can be a major factor in avoiding or preventing cost overruns and schedule delays for LRIP and FRP.

K.1 Assess Facilities

Manufacturing facilities assessment includes an analysis if the capabilities and capacity of the key production facilities to include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur. This assessment is looking at the capabilities and capacity for the Pilot Line and preparations for ramping up production during LRIP.

Manufacturing and Quality Tasks

- Identify facility and resource requirements by phase and schedule (e.g., pilot line, LRIP, and FRP) to include the following:
    - Current facility availability, capacity (including surge), capitalization plan, and expansion potential
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and scale-up
    - Floor space requirements (including feeding, storage, transportation, re-work, work-in-process, etc.) and expansion
    - Manufacturing facility data requirements (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
    - Maintenance requirements (facilities and spares)
- Assess contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and required resources for meeting pilot line and LRIP requirements to include:
    - Current and future facility availability and capacity
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.)
    - Floor space requirements (including feeding, storage, transportation, re-work, work-in-process, etc.) and planned expansion
    - Maintenance requirements (facilities and spares)

Tools

- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Systems
- DCMA-INST-204 Manufacturing and Production
- DoDI 5000.02, Operation of the Defense Acquisition System
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896 Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- Risk, Issue, and Opportunity Management Guide

K.2 Assess Tooling, Test, and Inspection Equipment

Manufacturing tooling, test and inspection equipment assessment includes an analysis if the capabilities and capacity of production tooling, special test equipment, special inspection equipment to include those at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur. This assessment is looking at the capabilities and capacity for the Pilot Line and preparations for LRIP.

Manufacturing and Quality Tasks

- Develop M&Q equipment, tooling, test, and inspection equipment maintenance strategy:
    - Include processes and procedures in accordance with industry best practices (i.e., AS9100)
    - Include objectives and requirements for tooling, testing, funding, resources, and scheduling
- Update the TMRR Tooling Plan for EMD to include:
    - Tooling and Special Test Equipment/Special Inspections Equipment requirements for development (i.e., pilot line ramp up to LRIP, ramp up to FRP)
        - Limited quantity or soft tooling
        - Rate quantity or hard tooling
        - Necessary only for development (pilot)
        - Necessary only for production (LRIP/FRP)

        - Necessary for Operations and Sustainment support
        - Available government assets (GFE)
    - Tooling used for the development or production of supplies or parts or to the performance of functions for the program to include:
        - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
        - Requirements for identification, calibration, frequency, and traceability to international or national measurement standards
        - Requirements for collection, monitoring, and maintenance of data and a register for validation purposes
        - Requirements for safeguarding from adjustments, damage, or deterioration
    - Use and application of single or multipurpose integrated specialized test equipment (STE/SIE) (e.g., engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items, assemblies of equipment including inter-connected or interdependent, foundations and similar improvements, etc.)
    - Use and application of GFE, COTS, etc.
    - Tooling and STE/SIE test and validation plans (including demonstrations)
- Ensure that production tooling and test equipment design and development efforts are underway.
- Perform a M&Q assessment of the contractor's and supply chain tooling, test, and inspection equipment resources provided for:
    - Suitability for the specific type of monitoring and measurement activities required
    - Maintenance and accountability to required standards with appropriate documentation
- Assess contractor and supply chain demonstrations of tooling and STE/SIE for subsystems, item, and components in the appropriate production environment (e.g., representative, pilot line, production line) for functionality, sufficiency, and capacity.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist) for the Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Material Requirements Planning

- Plant Design and Facility Layout Software Evaluation Tools
- Rough Cut Capacity Planning Spreadsheet

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DCMA-INST-204 Manufacturing and Production
- DoDI 5000.88, Engineering of Defense Systems
- FAR Part 2, §2.101 Definitions
- ISO 9000, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896 Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

K.3 Assess Facilities, Tooling, and Test Equipment for LRIP

Manufacturing facilities and tooling assessment includes an analysis if the capabilities and capacity of the key production facilities, special tooling, special test, and special inspection equipment to include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur. This assessment is looking at the capabilities and capacity in preparation for LRIP and the ramp up in production.

Manufacturing and Quality Tasks

- Based on pilot line demonstrations and assessments, assess facilities, facilities resource requirements, and facilities schedules for LRIP and FRP to include the following:
    - Current facilities availability, capacity (including surge), and expansion requirements
    - Facilities capitalization plan
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and scale-up
    - Manufacturing operations and environmental requirements (e.g., noise, lighting, vibrations, temperature, humidity, cleanliness, dust, foreign object detection (FOD), etc.)
    - Floor space utilization (including processes and requirements for feeding, storage, transportation, re-work, work-in-process, etc.) and expansion requirements
    - Manufacturing facility data requirements (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
    - Manufacturing equipment maintenance requirements (facilities, spares, and frequency)
- Assess contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and required facilities resources for LRIP and FRP to include:
    - Current and future facility availability and capacity

  - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and requirements for additional resources
  - Environmental and manufacturing operations (regulatory and program) requirements (e.g., noise levels, lighting levels, vibration and isolation, temperature and humidity control, cleanliness requirements, FOD and preventions requirements, etc.)
  - Floor space utilization (including processes and requirements for feeding, storage, transportation, re-work, work-in-process, etc.) and expansion requirements
  - Maintenance requirements (facilities and spares)

- Support assessments of manufacturing workplace safety for compliance with applicable statutes, regulations, and policies.
- Assess results of M&Q equipment, tooling, test and inspection equipment maintenance strategy demonstration and adequacy on the pilot line for:
  - Processes and procedures implementation according to industry best practices (i.e., AS9100)
  - Tooling, testing, resources, and scheduling meeting requirements
- In accordance with validation plans, validate tooling and STE/SIE based pilot line demonstrations and results.
- Based on pilot line demonstrations and results, update the program Tooling Plan for LRIP to include:
  - Tooling and STE/SIE requirements for ramp up to LRIP and FRP (e.g., soft, hard, development, production, O&S, GFE, etc.)
  - Updated detailed requirements for:
    - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
    - Identification, calibration, frequency, and traceability to international or national measurement standards
    - Collection, monitoring, and maintenance of data and a register for validation purposes
    - Safeguarding from adjustments, damage, or deterioration (physical security)
    - Digital safeguarding from tampering (cyber security) (i.e., Additive Manufacturing (AM) software and firmware)
    - Tooling and STE/SIE test, validation maintenance, and re-validation plans
  - Use and application of single or multipurpose integrated STE/SIE
  - Use and application of GFE, COTS, etc.
- Ensure that LRIP tooling, inspection, and test equipment efforts are complete, and FRP tooling and test equipment efforts are underway.
- Update the M&Q assessment of the contractor's and supply chain tooling, test, and inspection equipment LRIP resources based on pilot line demonstrations and results for:

  - Suitability for the specific type of monitoring and measurement activities required
  - Maintenance and accountability to required standards with appropriate documentation
- Update the assessment of contractor and supply chain tooling and STE/SIE for subsystems, item, and components in the appropriate production environment (e.g., production line for LRIP or FRP) for functionality, sufficiency, and capacity based on pilot line demonstrations and results.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist) for the Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Material Requirements Planning
- Plant Design and Facility Layout Software Evaluation Tools
- Rough Cut Capacity Planning Spreadsheet

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DCMA-INST-204 Manufacturing and Production
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- FAR Part 2, §2.101 Definitions
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Public Law 114-328

L. MANUFACTURING MANAGEMENT/CONTROL

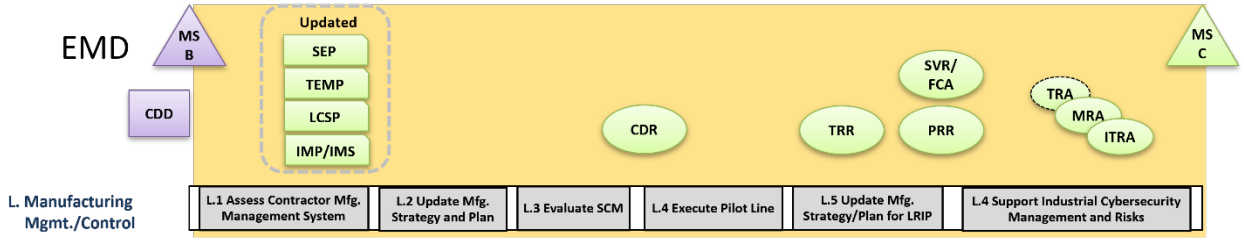


Figure 4-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

Programs with manufacturing aspects will require a manufacturing management system. The timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risks and issues throughout the program life cycle will only be met by a comprehensive system. Meeting this objective is best accomplished by including best practices and standards (i.e., AS6500, Manufacturing Management Program) in contracts with industry.

The Manufacturing Strategy and Plan are major aspects of development, test, initial production, and other activities essential for program success. With the potential for a new contractor or contractors responsible for engineering and manufacturing development through completion of pilot line production, updated M&Q strategies will be required. This begins with an assessment of the contractor(s), and their supply chain(s), manufacturing plans for adequacy and alignment with the program Acquisition Strategy (AS).

Manufacturing is a complex combination of resources consisting of facilities, materials, machines, manpower, methods, measurement systems, and capital that are used in converting or transforming raw materials and component parts into end products. The contractor must have an effective combination of people and systems to plan for, monitor, and control these manufacturing resources, as well as a well-structured manufacturing management system. This requires effective implementation of industry best practices. Assessment of the contractor's manufacturing management system (and QMS) should be performed against the recognized industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.).

Many acquisition programs experience difficulties in smoothly transitioning from development to production and fielding supportable systems. Assessments of the contractor's manufacturing strategy and planning should ensure adequacy and sufficiency of their manufacturing planning and capability to perform the final design and manufacturing work scope to achieve production. These should include processes, procedures, and work instructions encompassing the supply chain and supply chain communications, KCs control and management, management, control, and monitoring of KPPs, KSAs, CSIs, and CAIs, process control plans, control or avoidance of obsolescent items, high-risk sources, counterfeit parts and materials, etc. Additionally, the government requires implementation of cyber

threat protection measures and manufacturing control systems which include safeguarding M&Q information, designed in systems protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security. Implementing all these protections and controls is the basis for maintaining the currency of the program Manufacturing Strategy and Plans.

For CDR, initial product baseline documentation for manufacturing, included in the Manufacturing Strategy and Plans, should be sufficient, complete, and adequate to enable manufacture of all components and hardware with embedded software throughout the supply chain on a pilot line.

At CDR manufacturing capability and capacity of the contractor and supply chain are assessed for the system design for each subsystem, item, and component in the system's initial product baseline. This assessment should include all key and critical manufacturing processes, and their process control plans, for definition, characterization, and currency to the detailed design, and the capability to meet requirements. Additionally, the assessments should include contractor plans for meeting schedule, rates, yields, long-lead procurement requirements, demonstration requirements, safety and security, test, etc. on a pilot line. This means a detailed review of contractor production plans for ramping up to LRIP and then to FRP.

The government and contractor-designated pilot lines should be assessed for production realism and affordability in production of the system, subsystem, items, and components. Verification and validation of contractor and supply chain manufacturing plans, processes, and procedures should be analyzed during the demonstrations. Additionally, process control plans, work instructions, facilities, tooling, manufacturing data output, etc. should be included. Based upon these assessments and demonstrations, the Manufacturing Strategy and Plan should be updated, and the TDP should be finalized for LRIP

L.1 Assess Contractor Manufacturing Management System

A Manufacturing Management System (MMS) is used to implement manufacturing management practices aimed at promoting timely development, production, modification, fielding, and sustainment of affordable products by addressing manufacturing throughout the programs live cycle. The industry best practice for manufacturing management is AS6500 Manufacturing Management Program. Even if not called out on contract, the requirements of AS6500 are worth reviewing while assessing a contractors manufacturing management program.

Manufacturing and Quality Tasks

- Assess the contractor’s Manufacturing Management Strategy and Plan for:
    - Incorporation of industry and government M&Q best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896, etc.)
    - Compliance with policy directives and regulations

  - The Risk, Issue, and Opportunity Management plans
  - Development and incorporation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
  - Development and incorporation of system required technologies (and constraints)
  - Requirements and schedules for manufacturing development projects
  - Design feasibility, methodology, and producibility initiatives
  - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
  - Management of key and critical characteristics
  - Configuration management and control
  - Costs and schedule requirements, including IMP/IMS with critical path
  - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues
  - Management of the supply chain
  - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Processes and process capability control requirements
  - Workforce needs, capabilities, training, certifications, availability, etc.
  - Facilities, Tooling, and Test Equipment (including GFE and assets) requirements
  - Acceptance testing
  - Environmental, security, and safety requirements

- Assess and audit (where necessary) the contractor's Manufacturing Management System (MMS) capability to perform the final design and manufacturing work scope in accordance with industry best practices (e.g., AS6500, AS9100, ISO 9000, etc.) and program policies, objectives, and goals including:
  - Effective implementation and integration of the QMS processes throughout the MMS and supply chain to include (*See* I.1):
    - Organization direction, values, policies, and procedures
    - Management commitment, resources, communications, feedback, and accountability
  - Effectiveness of program and contractor communication and interaction processes to include:
    - Cost, schedule, and performance requirements and timely notification of changes
    - Manufacturing data management processes (to include responses, status, and reports for cost, schedule, and performance actuals)
    - Integration of risk, issue, and opportunity management processes
    - Failures, corrective, and preventative actions, communication processes
    - Specification and production of prototypes
  - Design analyses for manufacturing to include:
    - Producibility and manufacturing feasibility

  - Failure mode analyses
  - KCs
- Risk, issue, and opportunity management processes (to include quality, technical, schedule, material, facility, scale-up, financial impacts, and audits if necessary, etc.)
- Processes, procedures, and work instructions for the following:
  - KC control, management, and inclusion in the TDP
  - Management, control, and monitoring of Key Performance Parameters (KPPs), Key System Attributes (KSAs), and KCs, CSIs, and CAIs
  - Process control plans including statistical process controls, rates, yields, and management of process capabilities (C_{pk}s)
  - Make/buy (to include performance and impacts)
  - Control or avoidance of items and components that could become obsolete or are from a diminishing or fragile manufacturing source
  - Control or avoidance of sources that are sole, single, foreign, or vulnerable to interruption, interference, or compromise
  - Prevention and/or detection of counterfeit parts and materials (*See* AS5553 and AS6174)
  - Continuous process improvement (CPI)
  - Effective metrics management to include monitoring, evaluating, and verifying
  - Conduct of Process Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
  - Support of the FRACAS and the associated corrective actions (i.e., manufacturing process changes)
- Supply chain management system that tracks and reports supplier performance and supplier quality assessment processes
- A system for manufacturing verification that verifies the proposed production processes, tooling, and test equipment meet program requirements (including Special Tooling and Special Test Equipment)
- Systematic manufacturing self-assessments and supply chain assessments to measure progress in manufacturing maturation and risk and issue reduction
- MRL assessments throughout the supply chain and independent assessments as required by statute.
- Manufacturing management processes including roles and responsibilities for:
  - Materials management and control, including availability and lead-times
  - Data storage, management, and security (physical and cyber)
  - Safety, environmental, transportation, storage, etc.
  - COTS items, GOTS items, and NDIs
  - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)

  - Production Process Verifications (PPVs) that verify manufacturing processes, tooling, and equipment are statistically capable of producing required parts and assemblies
  - Variability Reduction (VR) plan for incorporation of mature processes and techniques
  - Manufacturing software and firmware management processes and integration (including the program Software Development Plan (SDP), and Software Configuration Management Plan (SCMP)
  - Manufacturing processes for inclusion of in-process and acceptance tests encompassing:
    - Prototypes, first articles, hardware, software, and firmware
    - First Article Inspections (FAIs)/First Article Tests (FATs)
    - Test procedures including test equipment
    - Quality plans including control plans and quality improvement plans (included in the TEMP)
- Assess the contractor's MMS processes for the management, execution, and maintenance of the IMP/IMS.
  - Include MMS impacts on critical path, schedule, costs, and outcomes
- Assess the contractor's MMS for capability to support a Life-Cycle Sustainment Plan (if required) which includes planning for production, developmental and operational test, deployment, and life-cycle sustainment.
- Verify the contract and the subcontractor management plan includes right of access for both the contractor and the Government to supplier facilities and documentation, where applicable.
- Request DCMA support and assistance to assess in conducting assessments and audits of contractor and supply chain MMSs.

Tools

- AS6500 Manufacturing Management Program
- Interactive MRL Users Guide (Checklist), Manufacturing Management thread
- Manufacturing Maturation Plan
- Material Management and Accounting System Audit

Resources

- AS5553, Counterfeit Electronic Parts
- AS6174, Counterfeit Material
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DFAR 242.72 Contractor Material Management and Accounting System
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation

- IEEE 15288, Technical Reviews and Audits on Defense Programs
- Manufacturing Maturation Plan
- MIL-HDBK-896, Manufacturing Management Program Guide
- Public Law 114-328

L.2 Update Manufacturing Strategy and Plan

A manufacturing strategy is developed as part of the program acquisition strategy and often includes considerations such as competition. Manufacturing voids, deficiencies, and dependencies on critical foreign source materials should be addressed. The producibility of each system design concept should be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and industrial base goals and thresholds.

Manufacturing planning is about understanding everything it takes to produce all the items required by the contract, on time, on budget, and with the right performance features. It includes considerations of all the 5Ms, at the prime contractor and throughout the supply chain.

Manufacturing and Quality Tasks

- Update the manufacturing inputs to the program Manufacturing Strategy and Plan (government) for EMD based on the results of assessment of the contractor's Manufacturing Strategy and Plans and to include:
    - Implementation of industry and government M&Q best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896, etc.)
    - Requirements for compliance with policy directives and regulations
    - Requirements for the EMD AS and RFP
    - Government IB risk and issue mitigation plans (complementary to contractor plans)
    - The joint Risk, Issue, and Opportunity Management plans
    - Implementation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
    - Implementation of system required technologies (and constraints)
    - Requirements and schedules for implementing ManTech projects
    - Requirements for IP management and control, and impacts to the TDP
    - Results of producibility initiatives
    - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
    - Management of key and critical characteristics
    - Costs, schedule, budgets, and affordability requirements, including IMP/IMS with critical path
    - Updates to requirements for program management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)

  - Updates to requirements for and approach to program management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
    - Including DCMA and DLA support and data
  - Updates for schedule contingencies, variances, and risks
  - Updates to program plans and methodologies for prototypes, competitive or dual sources, co-production, etc.
  - Updates to program requirements for process capability control
  - Additional program workforce requirements for program personnel capabilities, SMEs, training, certifications, availability, etc.
  - Updates to program GFE and assets requirements for facilities, tooling, and test equipment
  - Manufacturing updates for the program Manufacturing Plan and Schedule (IMP/IMS) for integration of independent or Service testing (DoD)
  - Updates to manufacturing requirements for environmental, security, and safety
- Provide updated manufacturing inputs based on results of assessments of the contractor's MMS and plans for security to:
  - Program Manufacturing Strategy and Plan for industrial security and anti-tamper including risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Program security (physical, digital, and cyber) strategies, plans, processes, and procedures (e.g., SSE, COMSEC, and PPP)
- Update manufacturing inputs to manufacturing requirements in the Life-Cycle Sustainment Plan for the program and updates the program Manufacturing Strategy accordingly based on results of assessments and audits.
- Provide manufacturing updates for the program Manufacturing Strategy and AS to include appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, etc.) for support and inputs based on results of assessments of the contractor's MMS and plans.
- Provide updates to manufacturing inputs for the program Configuration Management Plan based on results of assessments.
- Provide manufacturing recommendations for required contract modifications or updates to ensure alignment of contractor with program Manufacturing Management Strategy and Plans (*See* I.1 and L.1) based on results of assessments of the contractor's Manufacturing Management Plan (MMS) and program/technical plans.
- Provide manufacturing updates for the program Manufacturing Strategy to address status or completion of all mitigation measures for all gaps, risks, and issues (*See* E.6) based on monitoring of post-PDR M&Q mitigation measures.

Tools

- Acquisition Strategy Template
- Interactive MRL Users Guide (Checklist), Manufacturing Management thread
- Manufacturing Maturation Plan

Resources

- Acquisition Plan Preparation Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.02, Cybersecurity
- DoDI 5000.02, Operation of the Defense Acquisition System
- DSMC Acquisition Strategy Guide
- IEEE 15288, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- Service-specific policies and regulations (i.e., AFI 63-145)

L.3 Evaluate Supply Chain Management

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then Supply Chain Management and the implementation of a Manufacturing Management System (MMS) throughout the supply chain becomes a pivotal task. Often program problems originate in the supply chain, but do not manifest themselves until the component is integrated into the system. Program offices and contractors often have efforts to identify and manage problems at the first tier, but do not do well below that level. M&Q managers need to routinely review and assess contractors MMS activities and efforts at the prime contractor level and below.

Manufacturing Tasks

- Ensure that the contractor supply chain management system for subsystems, items, and components requires MMS processes and procedures are in alignment with industry best practices (i.e., AS6500) to include elements such as:
    - Manufacturing Management System

  - Design Analysis for Manufacturing including producibility analyses, KCs, and Failure Mode Effects Analyses (DFMEA and PFMEA)
  - Manufacturing Risk Identification including manufacturing feasibility and MRL assessments, and Production Readiness Reviews
  - Manufacturing Planning including:
    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing cost
    - Modeling and simulations
    - Manufacturing system verification
    - Manufacturing workforce
    - Tooling, test equipment and facilities
  - Manufacturing Operations Management including:
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - PPVs
    - FAIs and FATs
    - Sub-tier supplier management
    - Sub-tier supplier quality
- Assess the contractor's supply chain management system capabilities for performance of manufacturing processes and procedures including:
  - Subcontractor audit process with an emphasis on critical manufacturing processes
  - Effectiveness of contractor, supplier, and sub-tier communications and interactions including:
    - Flow down of cost, schedule, and performance requirements to sub-tier suppliers and timely notification of changes
    - Design and engineering changes traceability and compliance
    - Manufacturing data exchange, analysis, storage, and traceability processes
    - The joint Risk, Issue, and Opportunity Management System
    - Responses, status, and reports for cost, schedule, and performance actuals
    - Corrective and preventative actions and feedback
  - Management of KCs and critical characteristics (CSIs and CAIs)
  - Supplier and sub-tier risk, issue, and opportunity mitigation management processes for manufacturing (e.g., schedule, material, facility, scale-up, financial impacts, etc.)

  - Make/buy processes for supplier and sub-tier manufacturing capability, capacity, performance, and impacts
  - Qualification, approval, re-qualification, and removal processes for suppliers, monitoring and tracking of supplier performance, and periodic re-assessment
  - Supplier and sub-tier manufacturing assistance and mentoring program
  - Utilization of processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
  - Verification of suppliers and sub-tier manufacturing processes and procedures, especially suppliers performing key and/or critical manufacturing processes
  - Manufacturing process control plans
  - Appropriate application of statistical control techniques for manufacturing
  - Predictive processes and systems to provide early detection of manufacturing issues (e.g., tooling wear indicators, tracking, predictive and preventative maintenance, etc.)
  - Continuous manufacturing surveillance and effective metrics
- Collect and analyze supply chain manufacturing data from the subsystems, items, and component production to:
  - Develop and recommend manufacturing process improvements
  - Meet planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
- Assess the supply chain for manufacturing security processes, plans, and procedures including:
  - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
- Assess the supply chain for implementation and compliance with Program manufacturing processes and requirements for:
  - Configuration Management
  - ESOH
  - Environmental, safety, HAZMAT, waste handling, etc.
  - Testing, qualifications, and certifications (e.g., TEMP, etc.)
  - The LCSP
  - Facilities and tooling (GFE/GFP)
- Request DCMA perform Government surveillance of supplier and sub-tier compliance to manufacturing management program contract requirements.

Tools

- Interactive MRL Users Guide (Checklist), Manufacturing Management thread
- Manufacturing Maturation Plan

- Supply Chain Assessment

Resources

- AS5553, Counterfeit Electronic Parts
- AS6174, Counterfeit Material
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.228-7001, Ground and Flight Risk
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoD Supply Chain Management Guide
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management Systems
- MIL-STD-882
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82 Guide to Industrial Control Systems Security

L.4 Execute Pilot Line

A Pilot line is an environment that incorporates all of the key production realism elements (equipment, personnel skill levels, facilities, materials, components, work instructions, processes, tooling, temperature, cleanliness, lighting etc.) required to manufacture production configuration items, subsystems or systems that meet design requirements in low-rate production. To the maximum extent practical, the pilot line should utilize FRP processes. The Pilot Line is where the demonstration of manufacturing maturity should take place.

Manufacturing and Quality Tasks

- Assess the contractor-designated pilot lines for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:
    - Manufacturing readiness for manufacture of equipment
    - Materials, components, and tooling availability,

  - Adequacy of workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
  - Capability to meet design requirements for LRIP
  - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
  - Capability and capacity to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule

- Ensure contractor and supply chain manufacturing plans, processes, and procedures are demonstrated, verified, and validated on the pilot line in accordance with industry best practices (i.e., AS6500) to include the following:
  - Continuous process improvement efforts
  - Manufacturing surveillance, data collection, and analyses (including supply chain data for items and components)
  - Manufacturing process controls in place (e.g., plans, process capabilities (C_{pk}s), SPC, etc.)
  - Adequacy and completeness of acceptance processes for LRIP
  - All manufacturing work instructions, sequencing, and in-process tests (including quality test points and procedures)
  - Manufacturing scheduling, workflow, and optimization
  - Manufacturing resource planning, and scheduling
  - Physical and functional interfaces
  - Manufacturing models and simulations
  - Manufacturing workforce capabilities, skills, and training
  - Implementations of manufacturing technologies including ManTech
  - Tooling, work holding fixtures, jigs, etc.
  - Manufacturing equipment and facilities (including GFE, etc.)
  - Manufacturing processes for movement, storage, and handling equipment
  - Manufacturing safety processes and procedures
  - Manufacturing ESOH processes and procedures
  - Manufacturing security processes, procedures, capabilities, and compliance
  - Impacts from direct and indirect infrastructure
  - Mitigation results for manufacturing risks and issues resolutions
  - Manufacturing cost changes (and impacts to schedule and performance)
  - Adequacy of materials sources and selections
  - Integration (manufacturing processes) of embedded software

- Analyze manufacturing processes performed during the pilot lines operations, (including simulations) to include:
  - Rate of manufacturing processes (actual time to complete) vs. planned
  - Manufacturing data actuals vs. estimated

  - Process yield actuals vs. planned
  - Changes in processes (actual vs. planned)
  - Cost of manufacturing actuals vs. desired
- Assess process control plans, including all plans for process control of key and critical processes, for adequacy and completeness on the pilot line.
- Assess all work instructions for required outputs and changes based on build-to documentation and information gathered during the pilot line.
  - Verify updated work instructions, processes, drawings, etc.
  - Include KCs, Critical Manufacturing Processes, and their control plans
- Assess manufacturing output from the pilot line for adequacy and completeness and validate:
  - All Production Process Verifications (PPVs) performed
  - Attainability of KCs (will be capable and under process control for LRIP)
  - Manufacturing data collected for the Variability Reduction program
    - Data should demonstrate progress to metrics
    - Include updates based on process improvements
  - All FAIs and FATs against specifications, drawings, models, etc.
  - Requirements for design changes and process changes identified during pilot line operations, testing, and qualification
- Capture the results of manufacturing processes, demonstrated on a pilot line, as inputs to the system MRL assessment, PRR, and to the Industrial Base Capabilities Considerations that are required for Milestone C.
- Based on the results of the Pilot Line build, finalize the TDP including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.
- Provide manufacturing input for a Letter of Delegation to DCMA for support to, witness of, and assessment of demonstrations, pilot line operations, FAIs and/or FATs, etc.

Tools

- Interactive MRL Users Guide (Check), Manufacturing Management thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

L.5 Update Manufacturing Strategy and Plan for LRIP

A manufacturing strategy should be updated prior to LRIP and often includes considerations such as competition. Manufacturing voids, deficiencies, and dependencies on critical foreign source materials should be addressed. The producibility of each system design concept should be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and industrial base goals and thresholds.

The Manufacturing Plan should be updated for LRIP and is about understanding everything it takes to produce all the items required by the contract, on time, on budget, and with the right performance features. This is especially a problem as the program ramps up production from the pilot line build to the LRIP environment. It includes considerations of all the 5Ms, at the prime contractor and throughout the supply chain.

Manufacturing and Quality Tasks

- Update and finalize the Program Manufacturing Strategy and Plan for Production and Deployment (P&D) to include updates for:
    - Results from pilot line and the resulting manufacturing updates
    - Results from FAIs, FATs, and FRACAS activities
    - Findings, results, and direction from the SVR/FCA
    - Final TDP
    - Requirements from the CPD
    - Findings from the MRL assessment
    - Direction and results from a completed PRR (e.g., date, open items, issues, etc.)
    - Requirements for P&D from the RFP
    - The joint Risk, Issue, and Opportunity System
    - Maturity and plans for manufacturing development
    - Manufacturing maturity and plans for system required new technologies
    - Results of pilot line design updates and producibility improvements
    - Results from continuous process improvement efforts
    - Management of IP and data rights
    - Actual rates and schedules (includes processes, tooling, make/buy, etc.)
    - Verification and validation of models and simulations
    - Estimates for Learning Curves, LRIP (subsequent ramp-up to rate), surges, etc.
    - Changes to management of KCs and critical characteristics and associated processes
    - Manufacturing inputs on costs, schedule, budgets, affordability requirements, and IMP/IMS critical path
    - Management of materials (e.g., critical and controlled, lead-times, long-lead, sourcing, risks, issues, sole, single, foreign, counterfeit, obsolescence, etc.)
    - DMSMS strategies and plans

  - Use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
  - Finalized process capability requirements
  - Requirements for in-process and acceptance tests, test procedures, and test equipment (hardware and software)
  - Program and contractor workforce needs, capabilities, training, certifications, availability, etc.
  - Changes in contractor facilities, manufacturing equipment and tooling, and test equipment requirements
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials
  - ESOH, environmental, security, and safety requirements
  - Management of ITAR and anti-tamper
  - Plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations

- Ensure the Program Manufacturing Strategy for P&D includes industry best manufacturing practices (in accordance with AS6500) to include:
  - Manufacturing Management System
  - Design for Manufacturing including:
    - Producibility analyses
    - KCs
    - Failure Mode Effects Analyses (DFMEA and PFMEA)
  - Manufacturing Risk Identification including:
    - Manufacturing feasibility assessments
    - MRL assessments
    - Production Readiness Reviews
  - Manufacturing Planning including:
    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing costs
    - Modeling and simulations
    - Manufacturing system verification
    - Manufacturing workforce
    - Tooling, test equipment and facilities
  - Manufacturing Operations Management including:
    - Production Scheduling and Control
    - Manufacturing Surveillance

  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - PPVs
  - FAIs and FATs
  - Sub-tier supplier management

- Update the Program Manufacturing Management Strategy and Plan for manufacturing management of software and firmware.
- Provide updated manufacturing inputs to the PPP for considerations of contractor compliance, risks, and issues for P&D.
- Update the Program Manufacturing Strategy and Plan for P&D for required agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, National Test Facilities, etc.).
- Update the Manufacturing Strategy and Plan to include the contractual definition and agreement to manufacturing environments for LRIP and FRP.
- Ensure the WBS defines the tasks to be accomplished for LRIP in P&D.
- Develop recommendations for sourcing and options for LRIP based on manufacturing analyses of Program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Ensure contractor's manufacturing plans, policies, and procedures are consistent with Program plans for Program Plans for Product Improvement (P^3I) for LRIP.
- Update all manufacturing risks, issues, and mitigation plans for LRIP based on pilot line operations, demonstrations, and simulations.
  - Ensure mitigations of current risks and issues are on track and/or do not introduce new risks and issues to the Program for LRIP.
- Finalize the TDP including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details based on the results of the Pilot Line build.

Tools

- AS6500, Manufacturing Management Program Assessment
- Interactive MRL Users Guide (Checklist), Manufacturing Management thread
- Manufacturing Maturation Plan

- Material Management and Accounting System Audit

Resources

- AS6174, Counterfeit Material
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- ASISO5553, Counterfeit Electronic Parts
- DFAR 242.72, Contractor Material Management and Accounting System
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288, Systems and Software Engineering
- MIL-HDBK-896 Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

L.6 Support Industrial Cybersecurity Management and Risk Assessment

Industrial cybersecurity is concerned with the ability of organizations to share information digitally (government to industry, prime contractor to subs, labs to program offices, etc.). While the sharing of information is critical, it is equally important to do so in a safe and secure environment. Industrial cybersecurity is concerned with the transfer of digital data via Operational Technologies (OT) inside a facility and through the cloud to other organizations and facilities.

NIST standard NIST SP 800-37, Risk Management Framework for Information Systems and Organizations, defines Operational Technology as:

> *Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems/devices detect or cause a direct change through the monitoring and/or control of devices, processes, and events. Examples include industrial control systems, building management systems, fire control systems, and physical access control mechanisms.*

There are three main types of operational technologies of concern:

- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution system (MES) support the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers
- Enterprise resource planning (ERP) system supports functional management resources within an enterprise, and control process performance.
- These data systems are often digital and shared across multiple functions and organizations.

DFARS 252.204-7012 requires contractors to follow NIST SP 800-171 and to:

- Provide adequate security to safeguard covered defense information that resides on or is transiting through a contractor's internal information system or network.

- Report cyber incidents that affect a covered contractor information system or the covered defense information residing therein.
- Submit malicious software discovered and isolated in connection with a reported cyber incident to the DoD Cyber Crime Center.
- Submit media/information as requested to support damage assessment activities.
- Flow down the contract clause in subcontracts for operationally critical support, or for which subcontract performance will involve covered defense information.

Manufacturing, as an industry, is the most targeted industry for cyber-attacks. DoD policy and best business practices require that data be protected from attack. This includes classified data, controlled unclassified data (CUI), personal data, financial data, etc.

This thread (Industrial Cybersecurity) requires an analysis of the risk that the manufacturing environment may not be able to protect digital and other forms of data from cyber risks and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Identification of Cybersecurity Risks
- Cybersecurity Planning and Management (Execution)

M&Q personnel need to identify and manage industrial cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the AAF.

M&Q personnel need to develop and execute industrial cybersecurity planning for system concepts identified and execute the management of those plans. Programs will employ system security engineering methods and practices, including cybersecurity, cyber resilience, and cyber survivability in design, test, manufacture, and sustainment. Such methods and practices will ensure that systems function as intended, mitigating risks associated with known and exploitable vulnerabilities to provide a level of assurance commensurate with technology, program, system, and mission objectives.

Manufacturing and Quality Tasks

- Assess supply chain OT cybersecurity and vulnerability risks, and develop risk management plans
- Implement supply chain OT cybersecurity and vulnerability risk mitigation plans
- Demonstrate OT cybersecurity solutions in a production representative environment
- Validate OT cybersecurity procedures and controls on a pilot line.
- Assess the design of OT systems for facilities and equipment (i.e., in-house factory systems, production equipment, STE/SIE, and tooling) to ensure they include cybersecurity and physical/digital controls and access requirements

- Plan for and document that LRIP facilities and equipment OT systems include cybersecurity and physical/digital controls, and access requirements
- Identify and assess OT cyber incidents throughout the supply chain
- Ensure that OT Cyber Incident Reporting procedures are in-place, including reporting, tracking, and corrective actions
- Train the workforce in current cybersecurity procedures for production environment

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (DAU)
- Cybersecurity Strategy ADDM Template
- Interactive MRL Users Guide (Checklist), Cybersecurity thread
- USMC Cybersecurity Management Checklist

Resources

- FAR 52.202.21, Basic Safeguarding of Covered Contractor Information Systems
- DFAR 252.7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.83, Technology and Program Protection
- DoDI 8500.01, Cybersecurity
- DoDI 5000.90, Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoD 5220.22-M, National Industrial Security Program
- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle
- NIST SP 800-171, Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations

NIST Special Publication 800-82 Guide to Industrial Control Systems (ICS) Security

This page is intentionally blank.

Department of Defense
Manufacturing and Quality Body of Knowledge
(M&Q BoK)

Chapter 5
Production and Deployment (P&D) Phase

November 2022
Version 1.1

Office of the Under Secretary of Defense
Research and Engineering

Washington, D.C.

The appearance of external hyperlinks does not constitute endorsement by the United States Department of Defense (DoD) of the linked websites, or the information, products, or services contained therein. The DoD does not exercise any editorial, security, or other control over the information you may find at these locations.

Department of Defense Manufacturing and Quality Body of Knowledge (M&Q BoK)

Office of the Under Secretary of Defense for Research and Engineering
Executive Director, Systems Engineering and Architecture
3030 Defense Pentagon
Washington, DC 20301-3030
Email: osd.r-e.comm@mail.mil | Attention: SE&A
https://ac.cto.mil/engineering

Approved for public release. DOPSR Case # 23-S-0359.

Contents

Figures

This page is intentionally blank.

Introduction: How to Use the M&Q BoK

The Department of Defense (DoD) Manufacturing and Quality (M&Q) Body of Knowledge (BoK) is a compilation of best practices and lessons learned for completing M&Q activities across the DoD system acquisition life cycle. The office of the Executive Director, Systems Engineering and Architecture (ED, SE&A) prepared the BoK and will update the work periodically to reflect current policy, guidance, tools, and best practices. This document does not supersede DoD policy, guidance, or law.

The BoK details M&Q activities throughout the system life cycle but is not intended to be read from end to end. DoD Engineering and Technical Management (ETM) practitioners and managers may refer to the BoK to find information relevant to the phase of the program they are working on. Within a specific phase, the user may focus on the section and tasks that apply (with appropriate tailoring) for the M&Q activities the program is conducting.

The BoK chapters cover recommended M&Q activities and tasks during each acquisition life cycle phase to meet DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework.

The BoK includes 6 chapters:

- Chapter 1: Pre-Materiel Development Decision (Pre-MDD)
- Chapter 2: Materiel Solution Analysis (MSA)
- Chapter 3: Technology Maturation and Risk Reduction (TMRR)
- Chapter 4: Engineering and Manufacturing Development (EMD)
- Chapter 5: Production and Deployment (P&D)
- Chapter 6: Operations and Support (O&S)

Each chapter focuses on the DoDI 5000.02 activities and program documentation required for that phase. Each chapter uses the following format:

- **Introduction:** Discusses the objectives of that phase to allow the user to understand the environment and requirements.
- **Manufacturing and Quality Objectives:** Discusses roles, goals, and objectives of program M&Q during this phase.
- **Threads:** Twelve threads or topic areas include discussions of major M&Q functions based on the "5 Ms" (Manpower, Machines, Materials, Methods, Measurement); Manufacturing Readiness Level (MRL) criteria; and DoD-unique M&Q-related functions not found in industry (i.e., DoD acquisition system, defense contracting system, and surveillance system). The 12 threads are labeled with letters A through L as follows:

  A. DoD Acquisition System
  B. Defense Contracting System
  C. Surveillance System
  D. Technology and Industrial Base

E. Design
F. Cost and Funding
G. Materials Management
H. Process Capability and Control
I. Quality Management
J. Manufacturing Workforce
K. Facilities
L. Manufacturing Management and Control

Each thread includes several **Activities** represented by gray boxes in the corresponding chapter figure (Figure 1). Activities are numbered A.1, A.2, A.3 . . . B.1, B.2, B.3, etc. The BoK includes the following for each activity:

- Activity overview description
- **Tasks** that M&Q personnel could be expected to support or lead.
- **Tools** such as checklists, templates, and samples available to M&Q personnel intended to help them to accomplish these tasks.
- **Resources** including guidance documents, handbooks, manuals, instructions, memos, etc., that provide direction to M&Q personnel for tasks identified in the gray box.

Example: Figure 1 shows Threads, Documents, Activities, and Reviews for the EMD Phase.

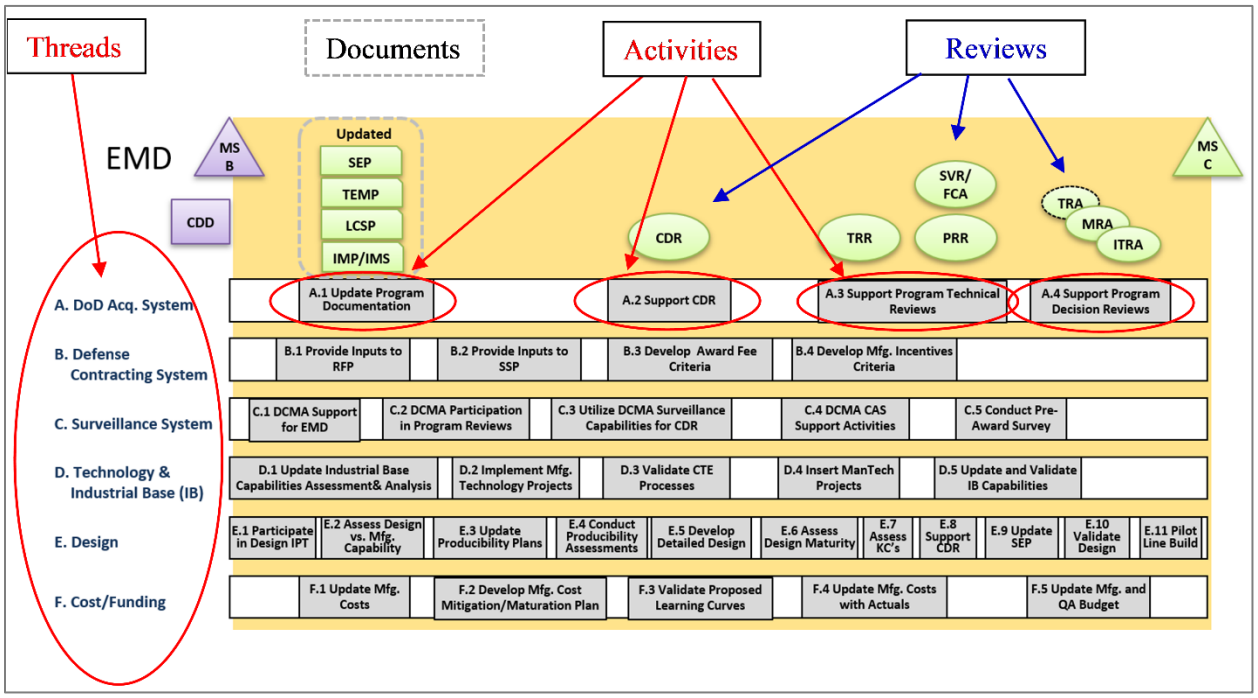
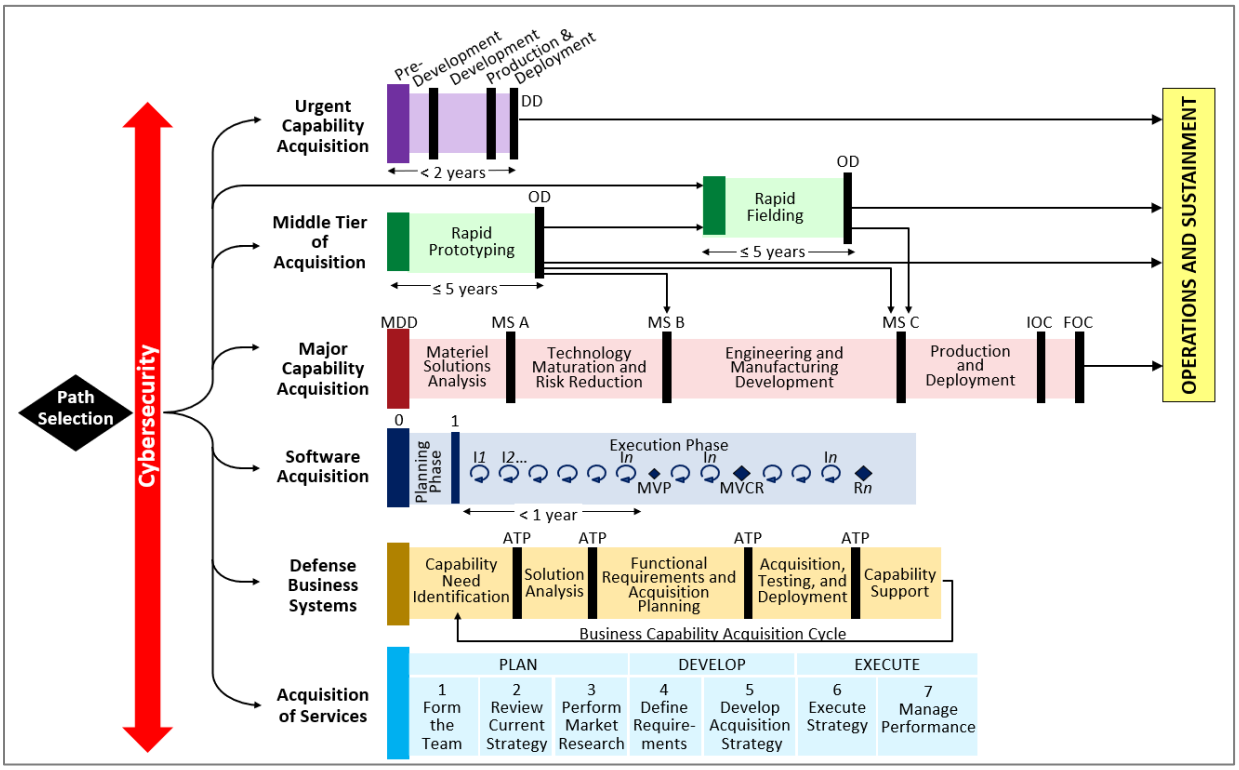


Figure 1. Sample Activity Chart

Adaptive Acquisition Framework (www.aaf.dau.edu)

This BoK follows DoDI 5000.02, Operation of the Adaptive Acquisition Framework (AAF), and for the most part will describe M&Q activities for the path labeled Major Capability Acquisition (MCA). This path includes a comprehensive and systematic approach for applying M&Q best practices; however, the M&Q BoK best practices are applicable to the alternative AAF pathways as well. AAF pathways are depicted in Figure 2.



Source: DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework, January 23, 2020

Figure 2. Adaptive Acquisition Framework Paths

For example, under the AAF, a program may have an Urgent Capability Acquisition (UCA) and may have less than 2 years to provide a solution to the Warfighter, or the program may be involved in a Middle Tier of Acquisition (MTA) approach focused on rapid prototyping or rapid fielding. If so, users can see how these efforts are aligned with the MCA process in Figure 2 and use those BoK chapters to identify and accomplish required tasks and activities.

In addition to DoDI 5000.02, the following associated policies provide information for the paths:

- DoD Instruction 5000.74, Defense Acquisition of Services
- DoD Instruction 5000.75, Business Systems Requirements and Acquisition
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.85, Major Capability Acquisition

- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation

With any acquisition model, the program office should include M&Q personnel on the technical Integrated Product Team (IPT) and to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

M&Q planning, control, and management activities represent an important and central effort that begins early in the life cycle (Pre-Materiel Development Decision (MDD) and/or Materiel Solution Analysis (MSA) phases) and continues throughout the life of a program though Operations and Support. Although planning is discussed in detail in each chapter, Figure 3 provides key elements of M&Q planning activities in relation to overall program life cycle activities.

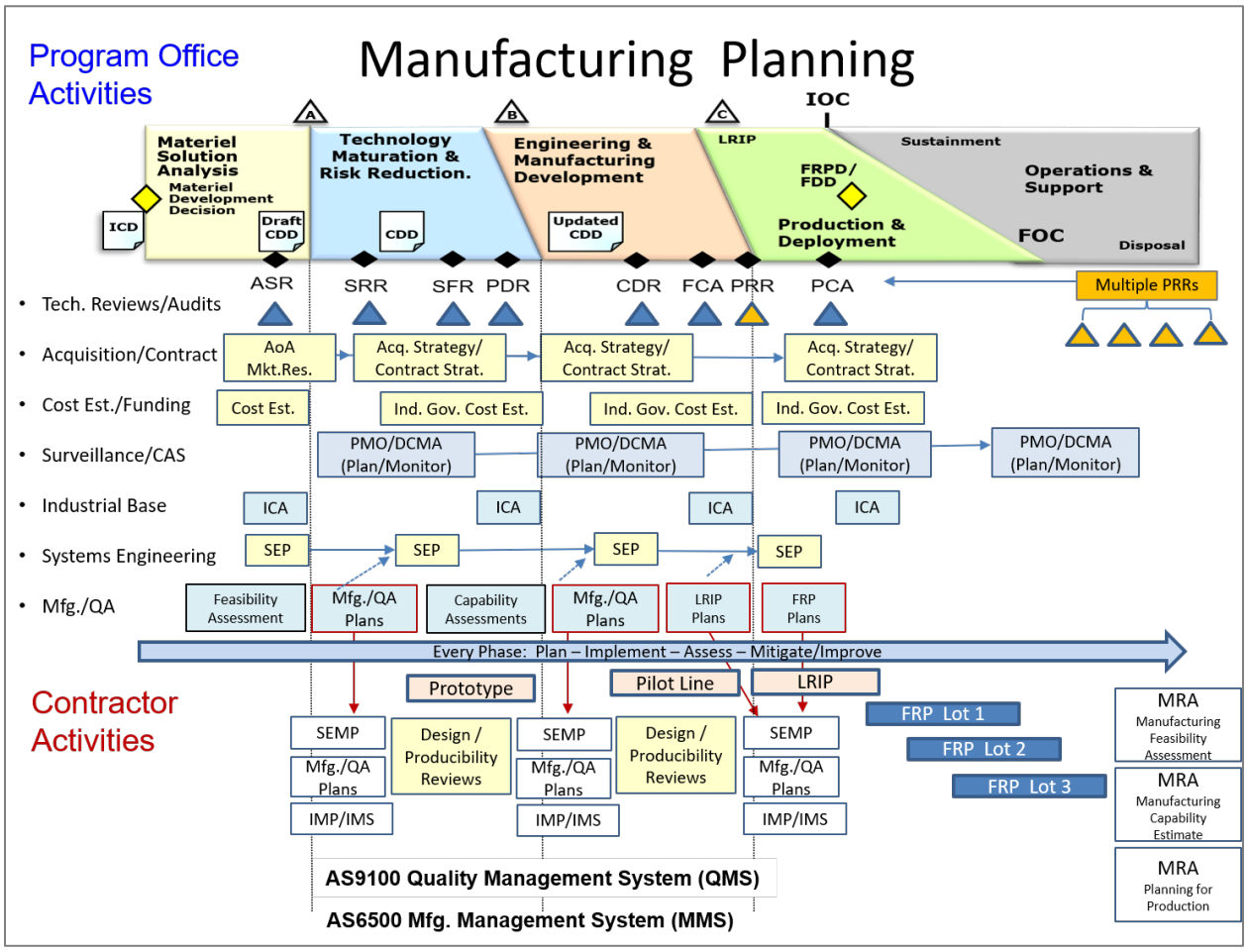


Figure 3. Typical Manufacturing and Quality Planning Activities

Most activities begin with the need to identify requirements, risks, and gaps, followed by planning activities. The top-most planning document is the Acquisition Strategy, and numerous documents feed into the Acquisition Strategy to include the Contracting Strategy and the Systems Engineering Plan (SEP). M&Q strategies should be a component of the SEP. Plans are then evaluated and updated on a recurring basis, usually just before a milestone decision.

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occur. The contractor is responsible for the execution of the program and in planning for success. The government Program Management Office (PMO), along with the Defense Contract Management Agency (DCMA) or other contract surveillance organizations and engineering support activities, is responsible for oversight and management of the acquisition. Risk assessment and mitigation is an ongoing effort that should be conducted throughout the system life cycle. Key references for DoD M&Q planning and management approaches include: MIL-HDBK-896, Manufacturing Management Program Guide; SAE Standard AS6500, Manufacturing Management Program; and Quality Management Systems standards ISO 9100 and/or AS9100. In addition, MRL criteria and assessments are a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

DoD tools and resources are available from many sources. Most should be available through open web-based links, but some may require a ".mil" address or a Common Access Card (CAC), or they may be available only to users in a specific community. Commercial tools and resources should be available to everyone but may require the organization to purchase a user's license/rights (e.g., ISO 9001 Quality Management System industry standard). In many cases, commercial resources and tools have been identified as a best practice. The M&Q BoK lists these tools for reference only; DoD does not necessarily endorse these resources or the publishing organizations. In addition, this document may reference a source for a specific tool (i.e., Pareto Chart), but there may be other widely available sources for this tool or for similar tools.

Sections labeled "Tools and Resources" are provided throughout the document chapters. The following section includes a summary of key references and links by publisher or topic. A more comprehensive list of references is included in Appendix B.

Key Manufacturing and Quality Body of Knowledge References and Resources
Department of Defense (DoD) Issuances, Directives Division https://esd.whs.mil/DD/

- DoD Directive 5000.01, The Defense Acquisition System
- DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.84, Analysis of Alternatives

- DoD Instruction 5000.85, Major Capability Acquisition
- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation
- DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD
- DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD
- DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
- DoD Directive 4400.01E, Defense Production Act Programs
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures

Defense Acquisition University (DAU) www.dau.edu

- DAU Guidebooks and References https://aaf.dau.edu/guidebooks/
- Acquisition Notes (AcqNotes) www.acqnotes.com
- Adaptive Acquisition Framework (AAF) https://aaf.dau.edu
- Analysis of Alternatives (AoA) www.acqnote/acquisitions/analsis-of-alternatives
- Market Research www.acqnotes/acqnote/acquisitions/market-research
- Acquisition Strategy (AS) Process/Guidance https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf
- Systems Engineering Plan (SEP) Outline https://ac.cto.mil/erpo/ (Engineering Guidance tab)
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

Defense Contract Management Agency (DCMA) www.dcma.mil

- DCMA Policies https://www.dcma.mil/Policy/
- DCMA Instructions https://www.dcma.mil/Policy/
- DCMA-INST 204, Manufacturing and Production
- DMCA-INST 205, Program Support
- DMCA-INST 207, Engineering Surveillance
- DMCA-INST 309, Government Contract QA Surveillance Planning
- DCMA-INST 401, Industrial Analysis
- DCMA-INST 3401, Defense Industrial Base Mission Assistance

Defense Federal Acquisition Regulation (DFAR) Supplement https://www.acquisition.gov/dfars

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System

- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS Subpart 242.7200, Contractor Material Management and Accounting

Defense Logistics Agency (DLA) Website www.dla.mil

- DMSMS Guidebook, SD-22 https://www.dsp.dla.mil/Programs/DMSMS
- ASSIST (Database of specifications and standards) https://assist.dla.mil
- ASSIST Quick search https://quicksearch.dla.mil/qsSearch.aspx
- DoD 4140.01, Supply Chain Materiel Management Regulation www.dla.mil

Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
Manufacturing Readiness Levels (MRLs) www.dodmrl.org

- MRL Assessment Criteria Matrix www.dodmrl.org
- Interactive MRL Users Guide (MRL Assessment Criteria) www.dodmrl.org
- MRL Deskbook www.dodmrl.org
- MIL-HDBK-896, Manufacturing Management Program Guide www.dodmrl.org

National Institute of Standards and Technology (NIST) www.nist.gov

- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST Manufacturing https://www.manufacturing.gov

Office of the Director, Cost Assessment and Program Evaluation (CAPE) www.cape.osd.mil
OSD Manufacturing Technology (ManTech) Program Office https://www.dodmantech.mil
OUSD(R&E) Systems Engineering and Architecture (SE&A) https://ac.cto.mil/engineering
Relevant Government Publications (Available via Web/Internet Search)

- DoD 4245.7-M Manual, Transition from Development to Production, 1985
- NAVSO P-3687, Producibility Systems Guidelines, 1999
- MIL-HDBK-766, Design to Cost
- MIL-HDBK-727, Design Guidance for Producibility, 1984

Standards, Specifications, and Standards Organizations

- ASSIST (Defense Logistics Agency Database of Specifications and standards) https://assist.dla.mil
- ASSIST Quick Search https://quicksearch.dla.mil/qsSearch.aspx
- SAE International www.sae.org
- International Organization for Standards (ISO) www.iso.org
- Institute of Electrical and Electronics Engineers (IEEE) www.ieee.org
- *Note:* Many specifications and standards can be accessed at http://everyspec.com/

Technology Readiness Levels (TRLs)

- Technology Readiness Assessment Deskbook www.acqnotes.com
- Technology Readiness Assessment Calculator www.acqnotes.com
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

5. Production and Deployment (P&D) Phase

Introduction

During the Production and Deployment (P&D) phase the following production risks that can greatly affect cost, schedule, and performance if the program office is not proactive in managing them.

- Unstable requirements and too many engineering changes
- Unstable production rates and quantities
- Insufficient process proofing
- Insufficient material characterization
- Changes in proven materials, processes, subcontractors, vendors, and components
- Lack of producibility consideration
- Configuration management
- Subcontractor management
- Special tooling and test equipment

These risks can occur early in the program's life, not just during production, and need to be assessed and managed throughout the program's life cycle.

A key Program Manager (PM) role is to reduce manufacturing risk and demonstrate producibility before Full-Rate Production (FRP).

Manufacturing and quality (M&Q) managers have three major roles to perform:

- Influence the design (for producibility)
- Prepare for production (Planning)
- Execute the manufacturing and QA plans (Execution)

The goal is to execute the manufacturing plan with a product that meets the design intent and has repeatable processes, and to focus on continuous product and process improvement.

As members of the Technical Integrated Product Team (IPT) there should be many opportunities to influence the design for producibility to include putting producibility in acquisition plans and contractual documents. In addition, there are numerous technical reviews in which systems engineering technical processes and technical management processes are addressed and assessed. Finally, executing the plan includes typical day-to-day activities that should be managed and assessed, and risks to be identified and mitigated.

At Milestone C, M&Q risks are assessed. Key manufacturing readiness considerations include:

- Industrial base viability
- Design stability
- Process maturity
- Supply chain stability and management

- Quality management throughout the supply chain
- Manufacturing process control
- Facilities/Tooling availability and capability
- Manufacturing skills availability

The Program Management Office (PMO) should update the Acquisition Strategy and identify remaining risks prior to the FRP decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include various technical reviews and audits such as Production Readiness Review (PRR), Industrial Capabilities Assessment (ICA), Manufacturing Readiness Assessment (MRA), Independent Technical Risk Assessment (ITRA), Program Status Review (PSR), etc., pre-award surveys, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or manage remaining risks.

Figure 5-1 shows typical M&Q activities that occur during the P&D phase.

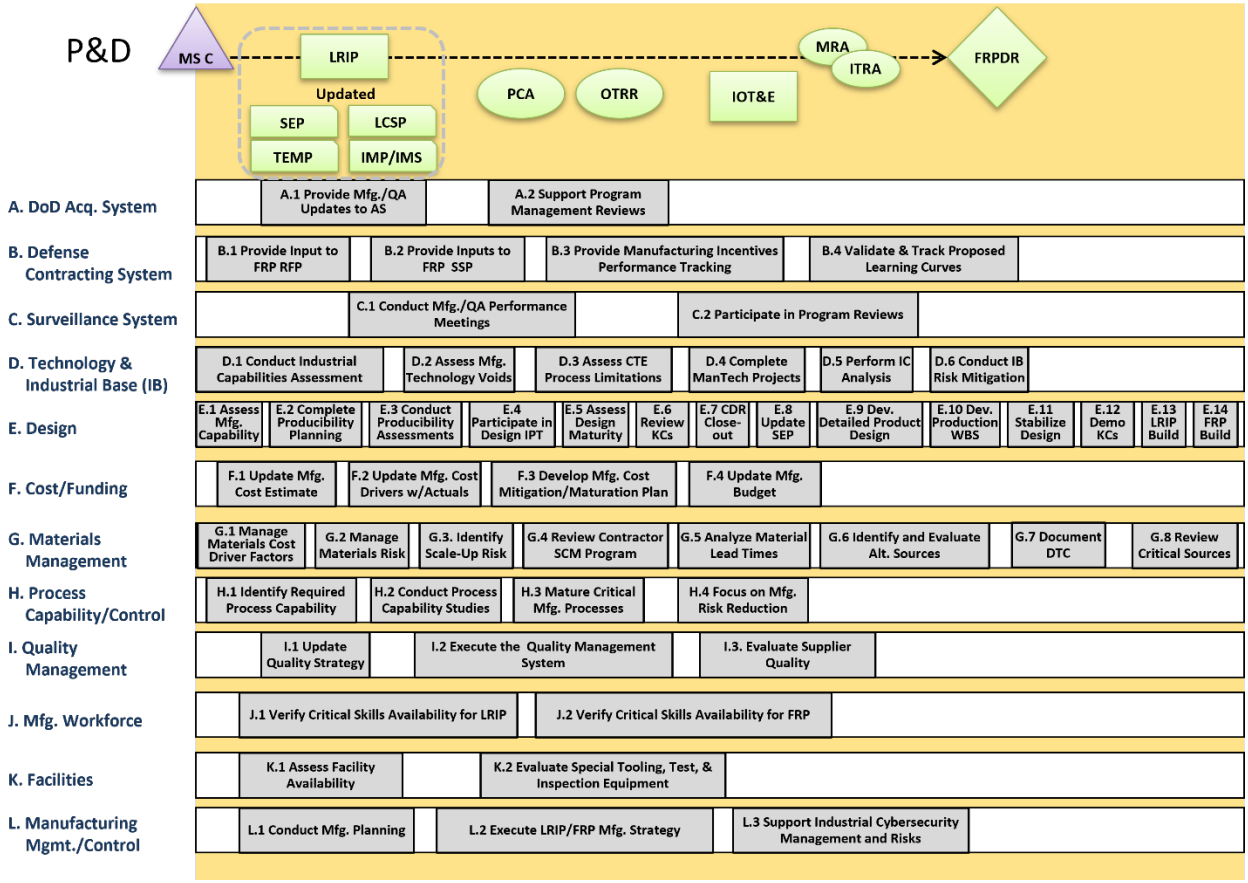


Figure 5-1. P&D Phase Manufacturing and Quality Activities

Specific requirements must be identified for inclusion in the Statement of Work (SOW) for the production phase. The requirements reflect the areas that have been determined to be of importance, given the acquisition strategy of the program. Typical areas to be considered for inclusion are:

- Manufacturing management systems
- Work measurement
- Manufacturing data (including manufacturing plan updates)
- Initial production facilities
- Production and material control systems
- Manufacturing reporting systems (especially line of balance)
- Control of subcontractors and vendor
- Make or Buy program
- Government Furnished Property
- System audit
- Technical data
- Competition

Incentives may be included to motivate contractors to improve performance and control costs. The benefits attainable through use of multiyear contracting should also be explored.

The purpose of P&D is to produce items for the warfighter that will achieve operational capability and satisfy mission needs. To achieve those goals, the items being produced must have achieved design stability, had their technologies matured and their manufacturing processes must be capable, stable and under control. There are two primary related production efforts during the PD phase: Low-Rate Initial Production (LRIP) and FRP. LRIP is often identified as up to 10 percent of the estimated production volume.

LRIP typically demonstrates the production of articles beyond a pilot line environment. Engineering and Manufacturing Development (EMD) items were typically built in a pilot line environment but now need to be able to transition to a low-rate production environment. All systems engineering/design requirements should have been met such that there are minimal system changes. Major system design features are stable and have been proven in test and evaluation. Materials are available to meet planned rate production schedules. Manufacturing process capability in a low-rate production environment is at an appropriate quality level to meet design key characteristic tolerances. Production risk monitoring is ongoing. This means that at some point after LRIP has been ongoing the program office should conduct a Manufacturing Readiness Assessment (MRA) at a Manufacturing Readiness Level (MRL) 9 level. LRIP cost targets have been met and learning curves have been analyzed with actual data. The cost model has been developed for the FRP environment and reflects the impact of continuous improvement.

P&D phase objectives include the following:

- Produce authorized quantities; on time and within budget.
- Conduct technical reviews and audits:
    - Integrated Baseline Review (IBR)
    - Operational Test Readiness Review (OTTR)
    - Manufacturing Readiness Assessment (MRA)

  - Independent Technical Risk Assessment (ITRA)
  - Independent Logistics Assessment (ILA)
  - Physical Configuration Audit (PCA)
- Create the following documents:
  - Acquisition Program Baseline (APB)
  - Systems Engineering Plan (SEP)
    - Manufacturing Management Plan
    - Quality Assurance Management Plan
  - Test and Evaluation Master Plan (TEMP)
  - Life Cycle Sustainment Plan (LCSP)
  - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
  - Programmatic Environmental, Safety and Occupational Health Evaluation (PESHE) product support elements
- Achieve Low-Rate Initial Production (LRIP), that is, to demonstrate LRIP
- Support the FRP decision
- Achieve FRP, demonstrate FRP
- Refine logistics support plans to include the Life Cycle Sustainment Plan
- Review the following manufacturing considerations, including:
  - Complete initial production facilities
  - Execute the manufacturing program
    - Integrate spares production
  - Maintain production surveillance
- Provide and support proposal efforts
  - Source Selection Plan (SSP)
  - Request for Proposal (RFP)
- Accomplish value engineering
- Accomplish second sourcing/component breakout
- Complete industrial preparedness planning
- Plan for the system transition/deployment/support
- Provide support to risk assessments
- Provide support to cost estimates and evaluation

A. DEPARTMENT OF DEFENSE (DOD) ACQUISITION SYSTEM

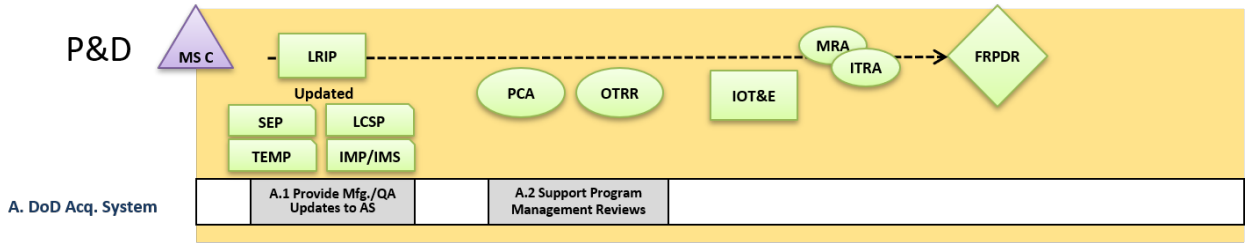


Figure 5-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

The Acquisition Process is an event-based process where a program goes thru a series of processes, milestones (five phases), and reviews where it is determined if a program will proceed into the next phase. MDAPs and major systems with production requirements should address industrial and manufacturing readiness in the Acquisition Strategy, during milestone reviews, and in various program documentation.

This thread (Acquisition) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Analysis of Alternatives (AoA)
- User Requirements
- Acquisition Strategy
- Program Documentation
- Program Support
- Milestone Decisions

The Milestone C Decision will be either an LRIP or Limited Deployment and Operational Test decision followed by an FRP or Full Deployment Decision (FDD). The initial production decision, based primarily on developmental testing results and usually also informed by an operational assessment, commits the resources (i.e., authorizes proceeding to award the contract(s)) required to enter production and begin deployment of the product. Evidence from testing that the product design is stable is the critical consideration for this decision. The commitment to enter production is expensive and difficult to reverse, thus moving forward requires a thorough examination of production risks.

Acquisition Strategy

At the end of the EMD, all the information necessary to plan the detailed manufacturing operations for the system should have been available. This information should be described in a manufacturing plan covering the issues of manufacturing organization, make or buy planning, subcontract management, resources and manufacturing capability, and the detailed fabrication and assembly planning. The plan should also describe the types of government-furnished property (GFP), or government-furnished equipment (GFE) required and the specific need dates for it. The contractor management control systems, including those for configuration management, the control of subcontractors, and

manufacturing performance evaluation should be described in enough detail for the Program Management Office to determine their expected utility.

The plan developed should also include consideration of the potential requirements for industrial preparedness planning, including surge capability during the production phase and the postproduction phase requirements for support to employment of the system in combat situations. The development of this formal manufacturing plan contributes value to the program from two standpoints. The primary benefit accrues from the fact that the contractor must crystallize the manufacturing planning to a point where it can be described in the detail required. The secondary benefit is the usability the plan provides to the Program Management Office personnel. It serves as a basis for a structured review of the contractor approach, the expected cost of the production phase effort, and a fuller assessment of manufacturing risk. Where such a plan is not developed during the EMD phase there is often unnecessarily high cost and schedule turbulence at the front end of and throughout the production phase. Also, if there is no detailed plan in place there can be no effective program office monitoring, assessing, scheduling review, testing, etc. In effect there is no production program.

Program Management Reviews

Sources of data used to inform industrial and manufacturing readiness include various technical reviews and audits, Production Readiness Reviews (PRRs), Manufacturing Readiness Assessments (MRAs), Industrial Capabilities Assessments (ICAs), Independent Technical Risk Assessments (ITRAs), pre-award surveys, trade-off studies, manufacturing plans, make-or-buy plans, facility plans, tooling plans, and bills of material (BOMs). An important output includes actions to reduce or mitigate any remaining risks.

10 USC Section 2448b requires that Independent Technical Risk Assessments (ITRAs) be conducted in support of milestone and production decisions for Major Defense Acquisition Programs (MDAPs). ITRAs will be conducted for all MDAPs prior to Milestone A, Milestone B, and Milestone C approval and before an FRP decision.

In general, technical risks are those events or conditions typically emanating from areas such as mission/requirements, technology, engineering, integration, test, software, manufacturing/quality, logistics, and system security/cybersecurity that may prevent a program from meeting cost, schedule, and/or performance objectives.

ITRAs will leverage ongoing program activities whenever practical, e.g., Technology Readiness Assessments (TRA), Manufacturing Readiness Assessments (MRA), and Systems Engineering Technical Reviews. These assessments and activities will inform the ITRA; however, the team will provide an independent assessment of any risks or maturity concerns identified. As such, there may not be a direct correlation between external assessments or measures, such as technology readiness levels, and the ITRA team's assessment."

A.1 Provide Manufacturing Updates to Acquisition Strategy

Manufacturing and Quality Tasks

- Update the Acquisition Strategy to describe the planning to assess and demonstrate that the manufacturing processes/capabilities required for production have been matured to a high enough level of confidence to ensure producing production configuration products in the production phase.
- Ensure the Acquisition Strategy reflects planned efforts that results in completion of manufacturing development and demonstrates:
    - No significant manufacturing risks
    - All manufacturing processes are under control
    - Adequate and efficient manufacturing capability
    - Produces the minimum quantity necessary to provide production or production-representative articles for Initial Operational Test and Evaluation (IOT&E)
    - Establishes an initial production baseline for the system
    - Provides for an orderly increase in the production rate for the system
    - Permits the collection of statistical process control data
- Ensure that the Systems Engineering Plan (SEP) is incorporated into the Acquisition Strategy:
    - Manufacturing Planning should be a part of the SEP
    - Quality Planning should be a part of the SEP
- Ensure the Acquisition Strategy addresses the approach to making production rate and quantity changes in response to contingency needs. Consider these items in developing the strategy:
    - Technology and Industrial Base, including small business
    - Design
    - Cost and Funding
    - Materials
    - Process Capability and Control
    - Quality Management
    - Manufacturing Personnel
    - Facilities
    - Manufacturing Management
- Update other documents with manufacturing and QA input as required:
    - Test and Engineering Master Plan (TEMP)
    - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
    - Life Cycle Sustainment Plan (LCSP)
    - Capabilities Development Document (updated-CDD)

  - Transitioning to Capabilities Production Document (CPD)

- Validate production quantities per year and the total planned production quantity.
- Finalize and validate the Production Plan.
- Ensure manufacturing risk assessments, configuration audits, production schedule reviews and production deliveries and events (including long lead, and multiple suppliers) are on the Program Schedule.
- Ensure manufacturing readiness is assessed throughout the Production and Deployment phase and Manufacturing Readiness Assessments (MRAs) are included in acquisition planning.
- Ensure all industrial base and any manufacturing/production risks and mitigation efforts are scheduled, funded, and actively worked.
- Ensure specific breakout efforts for each major component or subsystem are being worked.
- Ensure the M&Q organization or lead is being effectively utilized.
- Validate all remaining or developing IB constraints, how they are being managed, and the plan and schedule for future assessments.
- Estimate any risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule.
- Validate the Manufacturing Management System (MMS) and the Quality Management System (QMS) being used in production and ensure they are minimizing cost, schedule, and performance risks throughout the product life cycle.
- Validate the make-or-buy approach and maintain access to competitive suppliers.
- Maintain and keep current a list of critical items and their sources.
- Identify and address DMSMS/Obsolescence issues.
- Identify and address cybersecurity issues.
- Identify and address cybersecurity of manufacturing and industrial operations and processes.
- Ensure/verify all manufacturing processes have been effectively demonstrated in a manufacturing environment appropriate to the type of production that this program requires.
  - The manufacturing environment should incorporate all the key elements (manpower, machines, methods, material, measurement, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in rate production
  - To the maximum extent practical, the environment should utilize the same rate manufacturing processes scheduled to be used in production

Tools

- Acquisition Strategy Outline
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Industrial Base Assessment Survey Form Defense Contract management Agency (DCMA) Industrial Analysis Center

- Integrated Master Plan/Integrated Master Schedule: (i.e., Microsoft Project)
- Interactive MRL Users Guide (Checklist)
- ISO 9001, Quality Management System Checklist
- Risk Management Plan Template
- Life Cycle Sustainment Plan Outline
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline
    - Manufacturing Plan
    - Quality Assurance Plan
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Technology Readiness Level (TRL) Assessment Checklist
- Test and Evaluation Master Plan Outline

Resources

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Aerospace
- DoD 5000.60-H, DoD Handbook: Assessing Defense Industrial Capabilities
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE15288, System and Software Engineering
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- ISO 9001, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide
- TRA Deskbook

A.2 Support Program Management Reviews

Manufacturing and QA personnel should be actively engaged in the organization and execution of numerous formal reviews and audits during this phase, to include:

- Program offices could request an informal review Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)
- Independent Logistics Assessment (ILA)
- Industrial Capabilities Assessments (ICAs)
- Operational Test Readiness Review (OTRR)
- Full-Rate Production (FRP) Decision

Sources of data used to assess and manage industrial and manufacturing readiness include technical reviews and audits, Program Status Reviews, pre-award surveys, PRRs, MRAs, ICAs, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

Manufacturing and Quality Tasks

- Support the following reviews as required:
    - Technical Readiness Assessments (TRAs)
    - Independent Technical Risk Assessments (ITRAs)
    - Independent Logistics Assessment (ILA)
    - Industrial Capabilities Assessments (ICAs)
    - Operational Test Readiness Review (OTRR)
    - Full-Rate Production Decision Review (FRPDR)
    - Manufacturing Readiness Assessments (MRAs)
- Conduct MRL assessment using MRL 9 criteria to assess LRIP maturity.
- Conduct MRL assessment using MRL 10 criteria to assess FRP maturity.
- Identify any actual or potential producibility risks associated with the proposed design and associated manufacturing processes during any review.
- Develop mitigation plans for all quality and manufacturing risks identified during any review.
- Analyze all proposed design documentation submitted in support of reviews by applying design for manufacture and design for assembly principles to identify potential producibility risks associated with the proposed design change.
- Conduct assessment of production schedule.
- Conduct assessments of production capacity and schedule:
    - Aggregate Planning

  - Master Production Scheduling
  - Rough Cut Capacity Planning
  - Capacity Requirements Planning
- Review material sources for potential DMSMS and obsolescence issues.
- During production, assess these key manufacturing readiness considerations:
  - Industrial base viability
  - Design stability
  - Change Control
  - Manufacturing process maturity
  - Supply chain management
  - Quality management
  - Facilities (including performing capacity analyses)
  - Manufacturing skills availability
- Review these sources of industrial and manufacturing readiness data to include:
  - Technical reviews and audits
  - Program Status Reviews
  - Pre-award surveys
  - Manufacturing Readiness Level (MRL) assessments
  - Production Readiness Reviews (PRRs)
  - Industrial Capabilities Assessments (ICAs)
  - Trade-off studies
  - Tooling plans
  - Make-or-buy plans
  - Manufacturing plans
  - Bills of material

Note: An important output includes actions to reduce or address any remaining risks.

Tools

- Army Acquisition Logistician's Assessment Checklist
- Independent Technical Risk Assessments (ITRAs) Execution Guidance
- Industrial Base Capability Assessment
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Operational Test Readiness Review Checklist
- Production Readiness Review (PRR) Checklist (FRP Decision)

- Technology Readiness Assessment (TRA) Checklist
- Technology Readiness Assessment Calculator
- DCMA Post-award Orientation Checklist

Resources

- ISO 90001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Aerospace
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.7.4 Technical Reviews, and Chapter 12.5 Technical Reviews and Audits
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, IEEE Standard for Technical Reviews and Audits on Defense Programs
- Independent Logistics Assessment Guidebook
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)
- ISO 9001, Quality Management System
- Logistics Assessment Guidebook Tool
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide
- TRA Deskbook

B. DEFENSE CONTRACTING SYSTEM

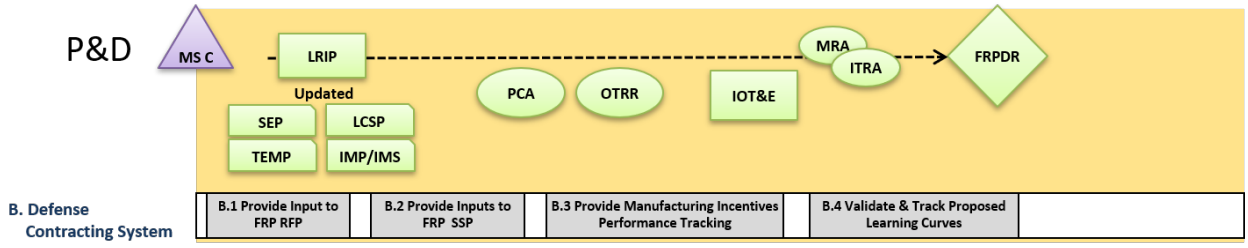


Figure 5-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

DoD contracting requirements and activities are required by various statutory and regulatory requirements to include the FAR/DFAR and by many DoD, Service and Agency regulations, policies, and guidance documents.

The contract is the vehicle used to establish the formal relationship between the government and a prime contractor. Government business processes include the business strategy or acquisition strategy, contracting approach, contracting strategies, contract language, and financial strategies. Programs that do address manufacturing considerations in their business processes will fail. M&Q personnel often are called upon to support various contracting functions and activities.

This thread (Contracting) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Market Research
- Contract Strategy
- Source Selection Plan
- Request for Proposal
- M&Q Inputs to the Contract (Section C, E, L and M) (refer to MIL-HDBK-245E)
- Contract Evaluation and Award

The purpose of the P&D phase is to produce and deliver requirements-compliant products to receiving military organizations. This requires the development of contracting strategies and other contractual documents that will drive contractor behavior. The Acquisition Strategy discussed earlier is an important document that helps to drive the Contracting Strategy. Other important documents include the Source Selection Plan (SSP), Request for Proposal (RFP), and the Contract.

Specific requirements must be identified for inclusion in the RFP/SOW for the production phase. The government procuring agency must provide specific and detailed information and guidance in Sections L and M for companies to follow when they prepare and submit their proposals.

- Section –Description/Specification/Statement of Work (SOW)
- Section E – Inspection and Acceptance
- Section L – Instructions, Conditions, and Notices to Offeror’s
- Section M – Evaluation Factors for Award (unnecessary for sole-source acquisitions)

The requirements reflect the areas that have been determined to be of importance, given the acquisition strategy of the program. Typical areas to be considered for inclusion that emphasize important M&Q considerations include:

- Manufacturing Management System (MMS)
- Quality Management System (QMS)
- Manufacturing data (including manufacturing plan updates)
- Initial production facilities
- Production and material control systems

- Production schedule assessment and control
- Manufacturing reporting systems (especially line of balance)
- Work measurement
- Control of subcontractors and vendor
- Make or Buy program
- Government Furnished Property
- System audit
- Manufacturing Readiness Assessments (MRAs)
- Technical data
- Competition

The government should provide specific areas of interest and request for data, that the contractor should include in their proposals.

When we estimate the cost or price of an item, whether it is based on a detailed cost build-up, an analogy, catalog price, or a cost estimating relationship, the cost or price may not address the effect of quantity or of learning. The learning curve (cost improvement curve, or experience curve) is a well-known approach to modeling the effect of quantity on cost.

The learning curve was adapted from the historical observation that individuals performing repetitive tasks exhibit an improvement in performance as the task is repeated several times. The current theory and practice is based:

- The time required to perform a task decreases as the task is repeated.
- The amount of improvement decreases as more units are produced.
- The rate of improvement has enough consistency to allow its use as a prediction tool.

B.1. Provide Input to Full-Rate Production Request for Proposal

Manufacturing and QA managers typically support the development of the RFP by identifying manufacturing and QA considerations for inclusion in the RFP and subsequent contract. These considerations need to ensure that there is linkage between the manufacturing and QA consideration and the warfighter requirements and evaluation factors and sub-factors. Evaluation factors often include cost or price, and Quality of product or service which includes technical, past performance and others.

Manufacturing and Quality Tasks

- Provide significant inputs into RFP documents on topics including the following:
    - Manufacturing Management Plan
    - Quality Assurance Management Plan
    - Quality Management System (QMS)

- Production schedule assessment and control
- Producibility Engineering Plan
- Manufacturing and Producibility Trade Studies
- Manufacturing Technology Investments
- Award Fee/Incentive Fee Criteria
- Make/Buy Plan
- Technical Reviews (i.e., PRR)
- Manufacturing Readiness Assessments
- Pre-award survey
- Perform or support a DCMA hosted Post-Award Orientation Conference
- Material Availability/Long-Lead Procurement Analysis
- Technical Data/Manufacturing Data
- Process Capability Study
- Capacity analysis
- Work Measurement/Learning Curve Analysis
- Manufacturing Reporting and Control Systems
- Contractor maintained cost data/libraries associated with manufacturing processes and technologies
- Contractor maintained Cost of Quality data available

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IG5315.204-5(b), Section L Guide and Template
- IG5315.204-5(c), Section M Guide and Template
- ISO 9001, Quality Management System Checklist
- DCMA Pre-award Survey System (PASS)
- DCMA Post-award Orientation Conference
- SF 1403 DCMA Pre-Award Survey General
- SF 1404 DCMA Pre-Award Survey Technical
- SF 1405 DCMA Pre-Award Survey Production
- SF 1406 DCMA Pre-Award Survey Quality Assurance
- SF1407 DCMA Pre-Award Survey Financial Capability

Resources

- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- MIL-HDBK-245E, Preparation of Statement of Work

- ISO9000, Quality Management System
- ACC Systems Engineering RFP Guide
- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288, System and Software Engineering
- IG5315.204-5(b), Section L Guide
- IG5315.204-5(c), Section M Guide
- ISO9000, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- AFMC Inst 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-award Survey Guide
- Pre-Award Survey User's Manual

B.2. Provide Inputs to Full-Rate Production Source Selection Plan

FAR 15.101, "Best Value" section, states that an agency can obtain best value in negotiated acquisitions by using any one or a combination of source selection approaches. The SSP is a key document which specifies how the source selection activities will be organized, initiated, and conducted. The SSP serves as the guide for conducting the evaluation and analysis of proposals, and the selection of contractor(s) for the acquisition. SSP must clearly and succinctly express the Government's minimum needs (evaluation factors) and their relative order of importance. Manufacturing and QA managers, as members of the technical IPT, should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Provide significant manufacturing/industrial base/quality inputs into the SSP, which could include the following topics:
    - Manufacturing Readiness
    - Investments in advanced manufacturing technology production equipment, processes, and organization of work systems that build on workers' skill and experience, and work force skill development
    - Tooling, special tooling, special test equipment
    - Material handling, management, availability
    - Production capability and efficiency

- Quality Management
- Supplier Quality History records and reports
- Subcontractor Management

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- Source Selection Plan Template (*see* applicable Service document)

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD Source Selection Procedures
- DoD Source Selection Procedures Memo
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288, System and Software Engineering
- ISO 9001, Quality Management System
- MIL-HDBK-245E, Preparation of Statement of Work
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-882, DoD System Safety
- Source Selection Plan Guide

B.3. Provide Manufacturing Incentives Performance Tracking

FAR Subpart 16.4 notes that "incentive contracts are designed to obtain specific acquisition objectives by establishing reasonable and attainable targets that are clearly communicated to the contractor; and include incentive arrangements designed to motivate the contractor to improve or discourage contractor inefficiency and waste."

Contracts should produce measurable performance outcomes that cumulatively contribute to the system Key Performance Parameters (KPP)/Key Systems Attributes (KSAs), to their threshold or objective levels. To motivate the contractor to achieve the desired behavior, appropriate contract incentives (including award fee, incentive fee, award term, and cost sharing) need to be developed to promote and facilitate contractor performance.

Manufacturing and QA managers need to support the development of Award Fee/Incentive Fee criteria in their areas. These criteria may focus on manufacturing investments and outcomes, process capability and control, reduction of waste, producibility improvements, etc.

Manufacturing and Quality Tasks

- Support the development of incentive type performance tracking measures that could include the following:
    - Organize program to ensure the incorporation of a QMS and incentives for achieving a high-functioning QMS
    - Organize program to ensure the incorporation of a Producibility Program and incentives for achieving a high producibility scores
    - Develop producibility infrastructure (software tools, training, design guides)
    - Investments in modern manufacturing methods and equipment (hardware and software)
    - Production cost reductions
    - Quality Improvement goals to include measuring and managing the cost of quality
    - Producibility packages released (#/%)
    - Materials characterized in production-representative environment (#/%)
    - Manufacturing Cost Reduction Efforts
    - Manufacturing Maturation Plan and Risks Burned Down
    - Variation/Variability Reduction efforts (initial yield rates/downward trend)
    - Manufacturing Processes defined and characterized
    - Subcontract metrics/targets (e.g., On-time Deliveries, Material Availability, Complete Kits Delivered to the Floor, etc.) developed and met
    - Quality metric/targets (e.g., Cost of Quality, Defects per Million Opportunities, Customer Complaints, Scrap Rate, etc.)
    - Schedule performance

Tools

- Award Fee Template, (see applicable service templates)

Resources

- Air Force Award Fee Guide (Army and Navy guides available)
- AS6500, Manufacturing Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD/NASA Incentive Contracting Guide
- Federal Acquisition Regulation (FAR) Subpart 16.4, Incentive Contracts
- ISO 9001, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)

B.4. Validate and Track Proposed Learning Curves

During the Production and Deployment phase manufacturing cost estimate should be based upon application of detailed manufacturing standards and learning curves to the operations being performed and adjusted, as necessary, by realization factors or actual costs. Since the program is moving into production from a pilot line, the learning curve may need to be adjusted for LRIP and FRP. By the time, the program is in FRP, learning should be relatively flat.

Cost reduction initiatives should be formally documented, and the documentation must include the baseline ("before" implementation) costs and projected ("after" implementation) costs, as well as the nonrecurring costs to implement the initiative.

It is often difficult to distinguish initiatives that are "over and above" the historical learning curves that were already used to estimate the program costs. Historical learning curves usually include some amount of cost reduction initiatives, so the challenge in documenting and estimating the impacts of new cost reduction initiatives is to determine if they are truly over and above what has been done in the past. Generally, initiatives that reduce the scope of work can be considered over and above, but ones that improve the efficiency of the work must be more carefully evaluated.

Manufacturing and Quality Tasks

- Provide significant inputs into the development and management of an appropriate learning curve for the program.
- Establish the learning curve based on appropriate factors such as:
    - Worker learning
    - Supervisor learning
    - Reductions in crowded workstation
    - Tooling improvements
    - Design producibility improvements
    - Improved work methods
    - Improved planning and scheduling
    - Increased lot sizes
    - Reduced engineering change activity
    - Reduction in scrap and rework
    - Better operation sequencing and synchronizations
- Establish the expected cost of the first items using previous cost models and actuals.

- Establish how much cost reduction is possible using expected schedule, production amounts, and process times using the learning curve formula.
- Apply the curve against the program schedule and determine the expected cost reductions.
- Manage cost reductions from the learning curve.

Tools

- Learning Curve Calculator (Estimator)
- Manufacturing Cost Estimating Worksheet
- Modeling and Simulation Software for Learning Curve Estimation
- Statistical Software for Learning Curve Estimation

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8, Learning Curve
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, System and Software Engineering
- Learning Curve Methodology for Cost Analysis
- MIL-HDBK-896, Manufacturing Management Program

C. SURVEILLANCE SYSTEM

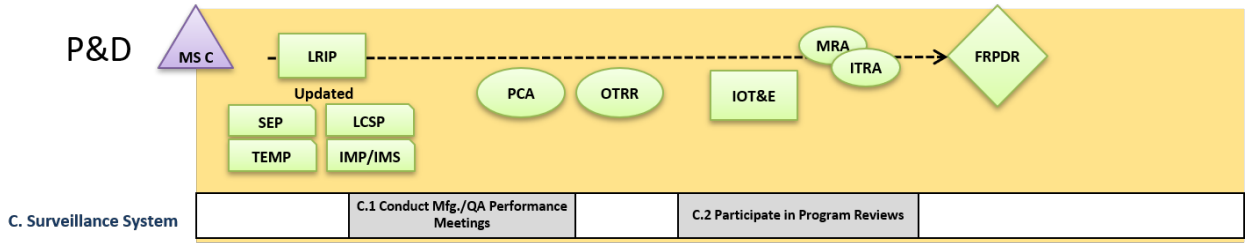


Figure 5-4. Surveillance System Manufacturing and Quality Activities

Introduction

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DoD contractor surveillance requirements and activities are required by the FAR/DFAR and by many DoD, Service and Agency regulations, policies, and guidance documents. DFAR Part 242.2 Contract Administration Services and DFAR Part 242.3, Contract Administration Office Functions, and PGI 242.3 Contract Administration Functions outlines the seventy (70) CAS functions that are required and the many that may require M&Q support in order to accomplish. M&Q personnel often are called upon to support numerous CAS functions and activities.

Often these activities may be performed under mutual agreement by the program office and the Defense Contract Management Agency. In many cases these contractor surveillance activities may be performed by on-site engineering support activity, program office contract administrators, delegated Service contract surveillance offices or a variety of engineering support activities (i.e. supervisor of shipbuilding (SUPSHIP), development command field activities). This thread (Surveillance) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Contract Administration Service (CAS) Functions
- Engineering Support Activity (ESA)
- DCMA Support
- DCMA Documentation
- Monitor and Track Risks
- Participate in Program Reviews

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DFAR subpart 242.3 identifies seventy-one (71) Contract Administration Services (CAS) functions that need to be accomplished and managed. Contractor surveillance is defined by several FAR and DFAR clauses. Many CAS activities fall under the umbrella of production or quality surveillance activities.

Contractors often depend on their own policies, procedures, processes, plans, controls, and schedules to meet government requirements. Often their plans, procedures and processes mirror government regulations, directives, instructions, and other documentation that may or may not be contractual. Government surveillance is often multifunctional requiring the support of business and technical personnel. Personnel from the program office as well as from the Defense Contract Management Agency (DCMA) may be required or asked to support surveillance functions at the prime and subcontractor facilities. Manufacturing and QA managers play an integral and vital role in the total scope of contract administration. Most program offices delegate many CAS activities to the Defense Contract Management Agency (DCMA) as a best practice.

The Program Manager should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. This may require the program office to establish a Memorandum of Agreement (MOA) or a Quality Assurance Letter of Delegation (QALI) with DCMA. DCMA may then, based on manpower availability and funding, utilize a systematic approach deploying surveillance through the supply chain to evaluate the supply chain and supplier improvement initiatives. At resident and non-resident facilities DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes. Most contractors will have implemented a higher-level quality management process IAW AS9100 or ISO 9001 as a best practice. Some contractors, but not all, may have implemented a manufacturing

management process IAW AS6500. No matter what management processes the contractor has implemented, DCMA personnel should have access to that data and should be reviewing it on a continuous basis.

C.1. Conduct Manufacturing/Quality Assurance Performance Meetings

Compliance to a standard such as AS6500, Manufacturing Management Program, or ISO 9001 Quality Management System, or AS9100 Quality Systems, does not guarantee product or service quality. These standards are management system standards that identify requirements for processes within an organization, describe expected tasks and outcomes, and explain how the processes and tasks integrate to produce required inputs and outputs. Standards are meant to enable the organization to develop a set of processes that, if done by qualified persons using appropriate tools and methods with appropriate leadership involvement, will enable a capability for delivering high quality products or services. These standards can provide a basis for developing and managing a manufacturing or quality program and for assessing compliance to those standards.

Product or service quality is achieved through the implementation of a strategic plan to integrate all business and technical functions that result in the consistent application of proven, capable processes within an organization. Managers must ensure that all management systems are working toward the same goals and are not creating conflicting or dysfunctional behavior. Implementing a standard is of little use if the financial system rewards individuals for delivering non-conforming products/services. Because everything a contractor does should be related to the quality of its products or services, a contractor's quality management system should be the basis for integrating all other management systems within an enterprise.

Manufacturing and Quality Tasks

- Ensure that manufacturing and QA personnel meet to discuss contractor performance in their respective areas. Meeting discussions should focus on and document the following elements of a Manufacturing Management System or Quality Management System:
    - Effective policies and procedures that encourage the use of the industry M&Q management systems
    - Organizations with defined authorities and responsibilities
    - Objectives to drive people, processes, and the system
    - Method to analyze and resolve M&Q problems
    - Metrics that reflect desired outcomes
    - Interacting processes to transform inputs into outputs
    - Records as evidence of what happened
- Evaluate M&Q impacts of factors such as:
    - Technical Performance
    - Production Performance

- Quality Assurance
- *Finance
- *Accounting
- Government Property Control
- Transportation and Packaging
- *Security
- Environmental/Energy Compliance
- Plant Safety
- *Flight Operations/Safety

*Other functional areas should be included in reviews. It is important to understand how these non-manufacturing areas can and will impact the manufacturing function.

Tools

- DCMA Program Assessment Report
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- ISO9001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-401, Industrial Analysis
- DD 1423, Contract Data Requirements List
- DFAR subpart 242.3, CAS Functions
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, Systems and Software Engineering
- ISO9001, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide

C.2. Participate in Program Reviews

The technical reviews and audits are necessary systems engineering (SE) activities performed to assess technical progress within a program, relative to contractual requirements and developmental maturity. Technical reviews of program progress should be event-driven and conducted when the system under development meets the review entrance criteria as documented in the SEP. The technical reviews and audits should include participation by subject matter experts who are independent of the program (i.e., peer review), unless specifically waived by the SEP approval authority as documented in the SEP. Acquisition milestones and SE technical reviews and audits serve as key points throughout the life cycle to evaluate significant achievements and assess technical maturity and risk. During the Production and Deployment phase the program will be faced with the need to conduct many program and technical reviews to include:

- Integrated Baseline Review (IBR)
- Operational Test Readiness Review (OTTR)
- Manufacturing Readiness Assessment (MRA)
- Independent Technical Risk Assessment (ITRA)
- Physical Configuration Audit (PCA)

An Integrated Baseline Review (IBR) is a joint assessment conducted by the government Program Manager (PM) and the contractor to establish a mutual understanding of the Performance Measurement Baseline (PMB).

OTRR is a multi-disciplined product and process assessment to ensure that the production configuration system can proceed into Initial Operational Test and Evaluation (IOT&E) with a high probability of success. The Program Manager certifies that all Developmental Test and Evaluation (DT&E) activities are complete and requests approval to proceed into IOT&E.

MRAs are a structured evaluation of a technology, component, manufacturing process, weapon system or subsystem using Manufacturing Readiness Levels (MRLs). It is performed to define the current level of manufacturing maturity, identify maturity shortfalls and associated costs and risks and to provide the basis for manufacturing maturation and risk management."

ITRA will assess technical risks for Major Defense Acquisition Programs as described in this framework and the Department of Defense (DoD) Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs including risks related to critical technologies and manufacturing.

The Physical Configuration Audit (PCA) formally examines the as-built configuration of each configuration item is consistent with its item detail specification and technical data package (TDP) of the final product baseline.

Each of these reviews and audits has DoD policy, guidance and direction associated with its accomplishment. Each of these reviews and audits has associated checklist that should followed and tailored as appropriate.

Manufacturing and Quality Tasks

- Conduct Production Program Assessments by reviewing the following:
  - Technical Performance
  - Production Performance
  - Quality Management System Assessment
  - Quality Assurance
  - *Finance
  - *Accounting
  - Government Property Control
  - Transportation and Packaging
  - *Security
  - Plant Safety
  - Environmental/Energy Compliance
  - *Flight Operations/Safety

    *Other functional areas should be included in the reviews. It is important to understand how these non-manufacturing areas can and will impact the manufacturing function.
  - Program assessments include:
    - Manufacturing Readiness Level (MRL) Assessment Checklist
    - Manufacturing Maturation Plan
    - Independent Technical Risk Assessment (ITRA)
- Identify, capture, and address any manufacturing concerns identified during the above assessments.

Tools

- DCMA Program Assessment Report
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning

- DCMA-INST-401, Industrial Analysis
- DFAR subpart 242.3, CAS Functions
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

D. TECHNOLOGY AND INDUSTRIAL BASE

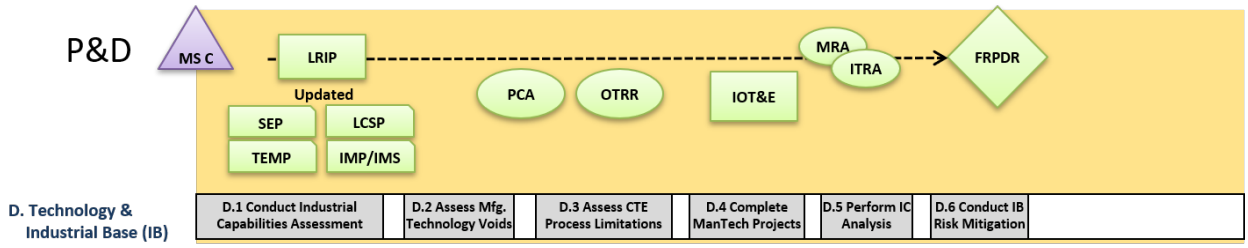


Figure 5-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC – Section 2440 requires the Secretary of Defense to consider the National Technology and Industrial Base (NTIB) in the development and implementation of acquisition plans for each MDAP. The NTIB consists of the people and organizations engaged in national security and dual-use research and development (R&D), production, maintenance, and related activities within the United States, Canada, the United Kingdom, and Australia. Acquisition planning and plans shall include considerations of the NTIB for all MDAPs. These considerations should include:

- The ability to support development and production (rates and quantities)
- The identification of IB risks in the supply chain
- The identification of single points of failure in the supply chain (sole source, foreign source, etc.)
- Support for a resilient supply base for critical defense capabilities
- Support for procurement surges and contractions

This thread (NTIB) requires an analysis of the capabilities of the national technology and industrial base to support the design, development, production, operation, uninterrupted maintenance support of

the system, and eventual disposal (including environmentally conscious manufacturing). This thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Industrial Base Assessments (IBAs)
- Industrial Base Risks
- Critical Enabling Technologies
- ManTech Projects
- Industrial Base Mitigation Plans

When acquiring material for the warfighter the DoD develops and employs strategies to effectively use the capabilities of the National Technology and Industrial Base (NTIB). Today, the U.S. Industrial Base consists of "all persons and organizations that are engaged in the Research, Development, Production, or Maintenance activities conducted with the United States, United Kingdom of Great Britain and Northern Ireland, Australia and Canada." Notice how the industrial base capabilities include research activities (technology) as well as organic capabilities.

The EMD phase activities should have highlighted the strategy for assessing the capability of emerging technologies and the industrial base to support pending production in a low-rate environment. Manufacturing processes should have been effectively demonstrated in an appropriate environment, a pilot line environment, prior to Milestone C. The manufacturing environment should incorporate key elements (Manpower, Material, Machines, Methods, Measurements, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in low-rate production. To the maximum extent practical, the environment should utilize rate production processes that are forecasted for use during LRIP.

Industrial base assessment is a continuing process with two primary components. The first gathers program specific industrial base information to help create an appropriate acquisition strategy for a program; the second engages throughout the life cycle of the program to provide feedback and updates. The objective of our NTIB is to ensure that the Department of Defense can:

- Create, expand, or preserve domestic industrial manufacturing capabilities to meet national defense requirements.
- Identify and support stable development and economical production rates.
- Identify and mitigate industrial base capabilities risks such as single points of failure and unreliable suppliers.
- Support resilience of critical defense industrial base capabilities.
- Support DoD's management of defense procurement surges and contractions.

Industrial base considerations should be documented in the Acquisition Strategy and include identification of industrial capability problems (e.g., access to raw materials, export controls,

production capabilities) that have the potential to impact the DoD near- and long-term, and identification of mitigation strategies that are within the scope of program management.

The Acquisition Strategy should strategically describe the planning required to assess and demonstrate that the manufacturing processes/capabilities, required for production will have been matured to a level of high confidence for building production configuration products in the P&D phase. Industrial Base considerations should have included:

- Industrial base sources relevant to the program, the contractor, and supply chain
- Manufacturing and quality processes and techniques
- Design producibility risks, issues, and opportunities
- Cyber risks and vulnerabilities to M&Q information and data
- Impacts of materials (e.g., critical, long-lead, etc.)
- Supply disruption risks, issues, and program impacts from critical and strategic materials
- Availability and capability of production machinery, equipment, and tooling

Industrial Capability Assessments (ICAs) is often conducted using a standardized questionnaire which is send out to companies of interest and they complete the survey. After the survey has been completed a small team visits the company to follow-up on the questions and to get a tour of the facilities. Program offices want to ensure that the contractor has the capability to produce "one" and the capacity to produce at "rate" and for the total quantity of the program.

Industrial readiness data sources could include; technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, Manufacturing Readiness Assessments, Manufacturing Readiness Assessment Maturation Plans and Risk Reduction Plans, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

For the FRP Decision Review, the Program should identify remaining risks prior to a production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. The ability of the industrial base to ramp up from LRIP to FRP is a major concern.

Manufacturing Technology (ManTech) programs are used to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. The risk assessments should identify high risk manufacturing process areas that may require investments in ManTech or other investment programs to further mature a process. These investments must be identified early so that these manufacturing capabilities will be matured on time to support rate production.

If a platform or system depends on specific technologies to meet system operational requirements in development, production, operation, and sustainment, and if the technology or its application is either new or novel, then that technology is considered a critical or enabling technology (CTE).

The ManTech program focuses on advancing state-of-the-art manufacturing technologies and processes from the research and development environment to the production and shop floor environment. Technologies with generic application required for defense systems and having high technical and financia1 risk characterize the projects with the highest priority for ManTech funding.

D.1. Conduct Industrial Capabilities Assessments

10 USC 2440 and DFAR Subpart 207.1 requires assessments of the capability of the U.S. Industrial Base to support the development, production and sustainment of weapon systems used by our defense forces." The program office as a member of the IPT should lead and support assessments of the impact of programmatic decisions on the national and international NTIB supporting U.S. weapon system programs.

Manufacturing and Quality Tasks

Industrial Capabilities Assessments (ICAs) should be conducted at critical sub-tier vendors, as well as at the prime contractor facilities.

- Ensure Industrial Base assessment looks at capabilities including the following:
    - New and unique capabilities that must be developed or used to meet program needs.
    - Identifying DoD investments needed to create new or enhance existing industrial capabilities. This includes any new capability (e.g., skills, facilities, equipment, etc.).
    - Identifying new manufacturing processes or tooling required for new technology.
    - Funding profiles must provide for up front development of manufacturing processes/tooling and verification that new components can be produced at production rates and target unit costs.
    - Identifying exceptions to FAR Part 45, which requires contractors to provide all property (equipment, etc.) necessary to perform the contract.
    - Program context in overall prime system and major subsystem level industry sector and market.
    - Strategies to address any suppliers considered to be vulnerable.
    - Risks of industry being unable to provide new program performance capabilities at planned cost and schedule.
    - Alterations in program requirements or acquisition procedures that would allow increased use of non-developmental or commercial capabilities.
    - Strategies to deal with product or component obsolescence, given DoD planned acquisition schedule and product life.
    - Strategies to utilize small business, including small-disadvantaged business, women-owned small business, veteran-owned small business, service-disabled veteran-owned small business and small businesses located in Historically Underutilized Business Zones.
    - Industrial Capability Assessment has been completed and all issues mitigated.

  - Industrial capability is in place to support LRIP.
  - Industrial capability will be in place to support Production.
- Assess the labor/facility availability by understanding labor contracts and facility leases for the production schedule.
- Industrial capability to support LRIP/Production has been analyzed. Sole/single/foreign sources stability is being assessed/monitored.
- Conduct Logistics analysis.
  - Investigate manufacturing, re-manufacturing, and overhaul opportunities which have high potential impact for reducing life cycle costs and depot operations.
- Assess the impact of programmatic decisions on the national and international technology and industrial base. Overall Industrial Capabilities Assessments (ICAs) should address critical sub-tier, as well as prime contractor capabilities and should include:
  - New and unique capabilities that must be developed or used to meet program needs.
  - Identify DoD investments needed to create new or enhance existing industrial capabilities. This includes any new capability (e.g., skills, facilities, equipment).
  - Identify new manufacturing processes or tooling required for new technology.
  - Funding profiles must provide for up front development of manufacturing processes/tooling and verification that new components can be produced at production rates and target unit costs.
- Assess the overall prime system and major subsystem level industry sector and market strategies to address any suppliers considered to be vulnerable.
- Assess risks of industry being unable to provide new program performance capabilities at planned cost and schedule.
- Assess alterations in program requirements or acquisition procedures that would allow increased use of non-developmental or commercial capabilities.
- Assess strategies to deal with product or component obsolescence, given DoD planned acquisition schedule and product life.

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- 10 USC 2440, Technology, and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base

- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60, Defense Industrial Base Assessments
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

D.2. Assess Manufacturing Technology Voids

The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. The manufacturing feasibility assessment should identify high risk manufacturing process areas that represent technology voids and may require investments in ManTech or other programs. ManTech program investments should be directed toward areas of greatest need and potential benefit. These investments must be identified early so that these manufacturing capabilities will be matured on time to support rate production.

Manufacturing and Quality Tasks

- Manufacturing and QA personnel should conduct "technology gap analysis."
- Identify new ManTech voids have surfaced.
- Evaluate ongoing ManTech efforts and determine if they can be applied to the program.
    - Assess if ManTech projects could impact projects from other Services and Agencies.

Tools

- Interactive MRL Users Guide (Checklist) Technology and Industrial Base thread
- Manufacturing Maturation Plan
- TRL Assessment Checklist

Resources

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development, and Investments
- Defense Production Act, Title III
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems

- Manufacturing Readiness Level (MRL) Deskbook
- Service ManTech guidance, e.g., Air Force Technology and Transition Strategy Guidebook
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.3. Assess CTE Process Limitations

The ManTech program focuses on advancing state-of-the-art manufacturing technologies and processes from the research and development environment (laboratory) to the production and shop floor environment. These technologies are often immature and have process limitations that need to be assessed.

Manufacturing and Quality Tasks

- Critical technology elements (CTEs) need to be evaluated to assess process maturity.
- Ensure all CTEs have been identified.
- Ensure all CTE limitations have been identified.
- Ensure all CTE risks have associated mitigation efforts.

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet (PAWs)
- Technology Readiness Assessment
- TRL Calculator

Resources

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.4. Complete ManTech Projects

ManTech projects that have been identified and implemented must be managed and completed in a timely fashion so they can be integrated into the system. ManTech projects focuses on efforts to

enhance the manufacturability and producibility of defense essential and unique processes or components.

Manufacturing and Quality Tasks

- ManTech projects should be conducted to demonstrate production application of emerging technologies.
- Ensure primary manufacturing technology efforts are maturing, and improvement efforts are continuing.
- Ensure required manufacturing technology development solutions have been demonstrated in LRIP.
- Validate required manufacturing technology solutions before the FRP decision.

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- TRL Assessment Checklist

Resources

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development, and Investments
- Defense Production Act, Title III
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook
- Service ManTech guidance, e.g., Air Force Technology and Transition Strategy Guidebook
- Technology Readiness Assessment Guidance
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.5. Perform Industrial Capabilities Assessment

An ICA is an assessment of an industry to evaluate the skills and knowledge, processes, facilities, and equipment needed to design, develop, manufacture, repair, and support DoD products. Capability Assessments (ICAs) can be performed in many ways. One way is using a standardized questionnaire which is sent out to companies and they complete the survey. After the survey has been completed a small team could visit the company to follow-up on the questions and tour of the facilities. The purpose of the assessment is to identify potential IB/program risks.

Manufacturing and Quality Tasks

- Conduct ICAs.
- Ensure the ICA questionnaire or other assessment tool addresses the following IB considerations:
    - Suppliers name, location, etc.
    - Company Ownership (public or private)
    - Facility Size and other facility information
    - Sales and sales backlog
    - Distribution or Sales Mix (% government vs commercial)
    - DoD Programs Supported
    - Significance of Current Program to overall sales
    - Maturity of product technology
    - Production Status
- Ensure the ICA addresses the following:
    - Industry status (consolidations, rising or falling market, etc.)
    - Unique or critical manufacturing processes
    - Technology issues (DMSMS, obsolescence, etc.)
    - Vendor or supply chain issues
    - Industrial base risks
    - Production rate and quantity
    - All industrial capabilities risks have been identified and all IC risks have associated mitigation efforts.

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- 10 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 2503, Analysis of the Technology and Industrial Base
- 10 USC 2440, Technology, and Industrial Base
- DCMA Industrial Analysis (DCMA-INST-401)
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

D.6. Conduct Industrial Base Risk Handling and Mitigation

Industrial base risk handling and mitigation activities may be a result of a formal study or analysis or may be a result of routine oversight that identifies risk(s) or issue(s). Manufacturing and QA managers need to assist in the development and management of risk management strategies and implementation plans that include accepting, avoiding, transferring, or mitigating the risks and issues.

Manufacturing and Quality Tasks

- Support all risk management activities:
    - Risk Planning
    - Risk Identification
    - Risk Analysis
    - Risk Handling
    - Risk Monitoring
- Support the decision to accept, avoid, transfer, or mitigate the risks.
- Support the development of risk mitigation plans to include:
    - Develop potential alternate sources, as necessary.
    - Ensure needed sources are available, multi-sourcing where cost-effective or necessary to mitigate risk.
    - Industrial capability available to support modifications, upgrades, surge, and other potential manufacturing requirements.

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing and QA Risk Mitigation Plan (no Template available)
- Manufacturing Maturation Plan

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook

- Engineering of Defense Systems Guidebook
- MRL Deskbook Chapter 5.2 Development of a Manufacturing Maturation Plan

E. DESIGN

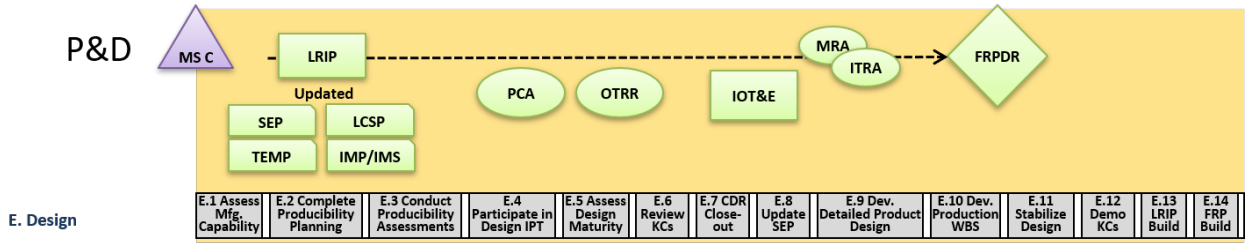


Figure 5-6. Design Manufacturing and Quality Activities

Introduction

DoD Systems Engineering (SE) is a disciplined approach for the specification, design, development, realization, technical management, operation, and retirement of a weapon system. SE is an interdisciplinary and collaborative effort requiring close interaction with many disciplines to include operations, maintenance, logistics, test, production, quality, etc. SE accomplishes these activities by focusing on eight technical processes and eight technical management processes. M&Q personnel need to support these SE activities.

This thread (Design) requires an analysis of the degree to which the identified, evolving or system design will meet user requirements and the degree to which the design is new and unproven. will focus on the following sub-threads, tasks, activities, tools, and resources:

- Systems Engineering Plan (SEP)
- Systems Engineering Integrated Product Teams (IPTs)
- Work Breakdown Structure (WBS)
- Technical Reviews and Audits
- Producibility Planning and Assessments
- Key Characteristics
- Design Maturity

The development of the Manufacturing and QA Plan and Strategy should include assessing manufacturing readiness to support the design process and should be integrated into the SEP. A robust, well characterized, and capable factory floor will help to enable the facilities ability to meet the design intent while delivering uniform, defect free product that is affordable. The first consideration is a need to understand the current manufacturing capabilities to see if they match up against the design requirements so that a plan for the enhancements of capabilities where there is a gap between the design and factory floor capabilities. Producibility is a design function aimed at achieving a design that is

relatively easy to manufacture. Producible designs are lower risk, more cost-effective and repeatable, which enhances product reliability and supportability. The Program Manager (PM) should implement Producibility Engineering and Planning (PEP) efforts early and should continuously assess the integrated processes and resources needed to successfully achieve producibility.

To assess producibility on a product level, both the product and its manufacturing processes should be measured. Manufacturing processes should be monitored and controlled, through measurement, to ensure that they can repeatedly produce accurate, high-quality products, which helps the program meet objectives for limiting process variability to a tolerable range.

Producibility assessments and engineering should be a part of the ongoing systems engineering process. DoDI 5000.02 states that "design for producibility" should be a part of the Engineering and Manufacturing Development phase. DoDD 5000.01 states that the PM should "reduce manufacturing risk and demonstrate producibility" prior to FRP.

History has demonstrated that as the complexity of systems increases, so does the acquisition cost. Therefore, producibility programs are necessary as a management means for assuring that practicality is addressed and that the cost increases associated with the growing complexity of systems are minimized. Consequently, the PMO approach to organizing for producibility is of prime importance to a successful defense system.

Major programs are organized around core design team, usually composed of 20-50 of the contractor's best engineers. This core design team makes 90-95 percent of all critical decisions. If M&Q is not one of their primary concerns, then production issues will be delegated to secondary teams, will not be addressed early, and will cause major problems. Therefore, manufacturing and QA personnel need to be assigned to the programs technical IPT and participate as appropriate in the systems engineering processes.

DoD acquisition programs face a high risk of failure at the outset of the design process. Developing and maturing a new design has a high level of risk. Historically this risk has been magnified by the misunderstanding of the industrial design disciplines necessary to turn the concept into a mature product. Assessing design maturity is one of the major activities the IPT should perform.

A mature design meets operational requirements without additional government or contractor intervention - no further field modifications or additional equipment and spares are required to overcome design shortfalls. In the factory, design maturity might be indicated by a reduction in Engineering Change Proposal (ECP) traffic. During EMD the Critical Design Review (CDR) is conducted, and the design is considered stable if 80 percent of the design has been released to manufacturing. There are not specific measures for design stability during the P&D phase, but most experts would suggest that design traffic (ECPs) should be minimal and minor in nature unless there is a major design modification going on.

A strong producibility emphasis early in design will minimize the time and cost required for successful transition to production and will ensure that production items are more reliable and dependable.

A Key Characteristic (KC) is a feature of a material, process, or part (includes assemblies) whose variation within the specified tolerance has a significant influence on product fit, performance, service life, or manufacturability. In other words, if the product deviates from the specified design (mid-tolerance dimension) then the product will experience early field failure rates and impact life cycle costs. The contractor needs to identify and manage key characteristics and demonstrate the capability to achieve these KCs.

A Critical Characteristic is any feature throughout the life cycle of a Critical Safety Item (CSI), such as dimension, tolerance, finish, material or assembly, manufacturing or inspection process, operation, field maintenance, or depot overhaul requirement that if nonconforming, missing or degraded may cause the failure or malfunction of a CSI. CSIs are parts whose failure could have catastrophic consequences. In general terms, a CSI's failure could cause loss of life, serious injury or permanent disability, loss of a weapon system, or substantial equipment damage.

DoDI 5000.02 requires that PMs and their technical staff to, “Develop an affordable and executable manufacturing process during the Engineering and Manufacturing Development (EMD) phase.” The Post-CDR assessment will include a demonstration that the “maturity of critical manufacturing processes has been accomplished. EMD should end when “manufacturing processes have been effectively demonstrated in a pilot line environment” prior to Milestone C. CDR identified risks should have been mitigated by Milestone C, but any risks that are still open and active in the Production and Deployment Phase should be managed and closed out using risk reduction techniques.

One of the most important elements of any production design is the definition of the manufacturing resources. No matter how good a design may be, it is useless if system or product cannot be built. It is therefore essential that availability and capability of manufacturing resources be a consideration during the design review process. Manufacturing engineers should be a part of each design team to assure adequate consideration of availability and capability of required manufacturing resources.

Manufacturing resources should not be limited to manufacturing methods, but should include materials, capital, manufacturing technology, facilities, qualified labor, and the management structure to effectively integrate them. The successful competitor, of the production phase will depend upon the efficient application of the full spectrum of these resources to the task of fabricating and delivering the defense system design.

The planning, execution and control of the production phase activities require that the work be divided into manageable tasks that are compatible with the existing manufacturing and performance measurement systems. Often, the work breakdown structure (WBS) used during the development phases will need to be updated for the production phase. A well-defined and documented WBS will

support the development of accurate cost and schedule models. This is critical for those programs which have utilized a design-to-unit production cost management approach during development.

The manufacturing strategy should include the criteria for determining which production processes will require proofing and the timing of such proofing activity. These processes are often identified during a manufacturing risk assessment or during the design as Key Characteristics. Process proofing can make a major contribution to risk reduction, but it may involve cost and/or potential schedule impacts during the development phase. Maturing manufacturing processes should be documented in a formal Manufacturing Maturation Plan.

The Milestone C review should provide the status of assessments of manufacturing processes and highlight the steps needed to progress from an EMD manufacturing environment to an LRIP environment. Then after the Milestone C decision to go into Low-Rate Initial Production, the program office needs to assess the LRIP process to demonstrate that manufacturing and QA processes are effective.

For the FRP Decision Review update, the program should identify remaining risks prior to a production go-ahead decision. Then after the FRP decision, the program office needs to assess production processes to demonstrate that manufacturing and QA processes are effective in achieving FRP. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, PRRs, MRAs, ICAs, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or manage remaining risks.

E.1. Assess Manufacturing Capability

As members of the technical IPT, M&Q managers should develop and integrate the M&Q Plans and Strategies into the SEP. These plans and strategies should include results of an assessment of the capability to design, develop, produce, support an acquisition program. This includes assessing manufacturing readiness and effective integration of industrial capability considerations into the design process. The first consideration is a need to understand current manufacturing capabilities to see if they match up against the design requirements so that the program can plan for the enhancements of capabilities where there is a gap between the design and factory floor capabilities. Consider these items during the capability assessment:

- Technology and Industrial Base, including small business
- Design
- Cost and Funding
- Materials
- Process Capability and Control
- Quality Management

- Manufacturing Personnel
- Facilities
- Manufacturing Management

Current "Design Best Practices" include the use of Computer-aided Design (CAD) and Computer-aided Manufacturing (CAM).

CAD (Computer Aided Design) is the use of computer software to design and document a product's design process. CAD is used to accomplish preliminary design and layouts, design details and calculations, creating 3-D models, creating, and releasing drawings, as well as interfacing with analysis, marketing, manufacturing, and end-user personnel.

Computer Aided Manufacturing (CAM) is the use of software and computer-controlled machinery to automate a manufacturing process. Based on that definition, you need three components for a CAM system to function:

- Software that tells a machine how to make a product by generating toolpaths.
- Machinery that can turn raw material into a finished product.
- Post Processing converts toolpaths into a language machines can understand.

Manufacturing and Quality Tasks

- Assess the contractors' use of best practices to manage design and manufacturing considerations
- Assess the contractors' manufacturing capability and capacity to produce an item and ensure that the assessment covers:
    - All required manufacturing processes and techniques
    - All design producibility risks
    - Manufacturing capability and capacity has a high probability of meeting delivery dates including spares and in-line repair work
    - Manufacturing capability and capacity provides for minimal impact of critical and long-lead time material
    - Manufacturing capability and capacity ensures all production equipment will be available
    - Manufacturing capability and capacity provides accurate production unit cost goals
    - Capability and capacity includes cost and production schedule estimates updated with actuals to support management reviews
    - All alternatives have adequate manufacturing feasibility and cost and schedule impact analyses that support trade-offs
    - Capability and capacity includes recommendations for anticipated production testing and demonstration efforts
    - Prior producibility improvements analyzed for effectiveness during LRIP

Tools

- Design Failure Modes and Effects Analysis (DFMEA)
- Design for Manufacturing and Assembly (DFMA) Assessment
- Design for Six Sigma
- Design of Experiments
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Fault Tree Analysis (FTA)
- Design Failure Modes and Effects Analysis (DFMEA)
- Process Failure Modes and Effects Analysis (PFMEA)
- Robust Design
- Systems Engineering Plan (SEP) Outline
- Tolerance Design

Resources

- DCMA Industrial Analysis (DCMA-INST 401)
- Design for Six Sigma Memory Jogger
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis
- Manufacturing Readiness Level (MRL) Deskbook
- Principles and Guidelines for Design for Manufacturing and Assembly
- Systems Engineering Plan (SEP) Outline
- Taguchi Robust Design/Six Sigma Guide

E.2. Complete Producibility Planning

Producibility Engineering and Planning (PEP) should be directed toward generating a design which is compatible with the current capability of the factory floor. Producibility is a major driver of product affordability because of the effect on both production and sustainment costs. The Producibility Plan should guide the design effort and describe activities that will be accomplished, the responsible organization, and the management controls that will be established to ensure successful accomplishment. Manufacturing and QA managers should review the plan with a focus on the realism, completeness and clarity of the planning accomplished by the contractor.

Producibility criteria should reflect a blending of general criteria (such as minimum parts count) and specific criteria applicable to the type of equipment being developed. The producibility program will be effective if the design engineers understand and apply the producibility design criteria. Each competing design needs to be evaluated from a producibility standpoint. Producibility evaluations will serve as a basis for estimating the likely manufacturing cost and assessing the level of manufacturing risk of the system.

Manufacturing and Quality Tasks

- Conduct regular Producibility reviews as the design evolves.
- Ensure that the contractor's detailed producibility trade studies used knowledge of key design characteristics and related manufacturing process capability.
- Ensure that producibility improvements get implemented into system design and specifications.
- Resolve all known producibility issues and ensure that they pose minimum risk for LRIP and no risk for FRP.
- Ensure that contractor producibility enhancement efforts (e.g., DFX) are completed for optimized integrated system.
- Evaluate the contractor's design producibility activities for such factors as:
    - Liberal tolerances (dimensions, mechanical, electrical).
    - Use of materials that provide optimum machinability, formability, and weldability.
    - Shapes and forms designed for castings, stampings, extrusions, etc., that provide maximum economy.
    - Inspection and test requirements that are the minimum needed to assure desired quality and maximum usage of available and standard inspection equipment.
    - Assembly by efficient, economical methods and procedures.
    - Minimized requirements for complex or expensive manufacturing tooling or special skills.

Tools

- Interactive MRL Users Guide (Checklist) Design thread
- Manufacturing Maturation Plan
- Producibility Engineering and Planning (PEP) Data Item Description (DID)
- Systems Engineering Plan (SEP) Outline

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning (PEP)
- DoD Integrated Product and Process Development Handbook
- DoD Integrated Product and Process Development Handbook

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE15288.2, System and Software Engineering
- MIL-HDBK-727, Design Guidance for Producibility
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center
- Systems Engineering Plan (SEP) Outline

E.3. Conduct Producibility Assessments

During this Phase, the PM should conduct producibility assessments to reduce manufacturing risk and demonstrate producibility prior to FRP.

Producibility engineering and producibility assessments should be a part of the ongoing systems engineering process. Producibility is directly connected to the complexity of a system. As complexity increases, so does the acquisition cost. Therefore, producibility programs are necessary as a management means for assuring that the cost increases associated with the growing complexity of systems are minimized. Producibility analysis accomplished by the PMO must be performed by a team of specialists assembled from the program office: and supporting organizations. Manufacturing and QA managers are key to the successful implementation of a producibility program.

Manufacturing and Quality Tasks

- Ongoing Producibility Assessments conducted on current efforts including additional efforts if necessary:
    - At the enterprise level (including infrastructure – software tools, design guides, training, and policies).
    - On a product-by-product level (including trade studies, and design principles – reduce part count, use of common parts, ease of assembly, and simplicity of fabrication).
    - Producibility issues/risks discovered in LRIP have been mitigated and pose no significant risk for FRP.

Tools

- CAD/CAM software
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, System and Software Engineering
- ISO 9001, Quality Management System
- MIL-HDBK-727, Design Guidance for Producibility
- MIL-HDBK-896, Manufacturing Management Program Guide
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center
- Systems Engineering Plan (SEP) Outline

E.4. Participate in Design Integrated Product Teams

Major programs are organized around core design team, usually comprised of 20-50 of the contractor's best engineers. This core design team makes 90-95 percent of all critical decisions with most design decision made prior to production. If M&Q are not one of their primary concerns, then these considerations will be delegated to secondary teams or not accomplished until late in the program causing serious problems with cost, schedule, and performance.

The PM and Technical team need to ask M&Q questions and ask them often. The contractor will follow the government's lead. If the government shows concern for these areas in the development of the design and integration with M&Q, then the contractor receives the message and will show like concern. Manufacturing and QA personnel must participate with the Design IPT in the development and review of the design and design documentation.

Manufacturing and Quality Tasks

- Support and participate in ongoing Design IPT activities that demonstrates:
    - Producibility has been assessed and integrated with other design activities.
    - Key and critical manufacturing assembly and test processes have been identified, evaluated, and matured.
    - All risks (technology, manufacturing, software development, and sustainment) have been assessed.
    - Metrics and data to assess, monitor, manage and control the transition process have been developed.

  - Manufacturing and quality engineers participate on engineering IPTs.
- Ensure the product design is stable.
  - Design change process is stable and under control and includes adequate process for identifying and approving Class 1 changes, and the classification of changes is periodically reviewed.
  - Design changes are few and generally limited to those required for continuous improvement or in reaction to obsolescence.
  - Design change process includes sign-off by contractor manufacturing or production engineer, and quality engineer.
- Ensure the production environment is robust and can be used to validate LRIP manufacturing needs.

Tools

- Design for Manufacturing and Assembly (DFMA)
- Integrated Master Plan/Integrated Master Schedule template
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- Design for Six Sigma Memory Jogger
- DoD Integrated Product and Process Development Handbook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.5. Assess Design Maturity

The design should be stable and mature by the Production and Operations phase and may be considered mature when the number and type (Class I and Class II) of engineering change traffic is tapering off and when the drawing packages have been released to manufacturing. Configuration of the item should be stable as should be the requirements.

Manufacturing and Quality Tasks

- Continue design maturity assessments. Ensure that all:
  - Product data required for pilot-line component manufacturing completed.
  - Pilot-line product requirements and features have been defined.
  - Product data essential for subsystem/system pilot line has been released.
  - All enabling/critical components have been demonstrated on the pilot line.
  - Design maturity metrics have been applied to the planned Production Line.

Tools

- Design for Six Sigma
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- DoD Integrated Product and Process Development Handbook
- DoD MIL-STD 882E, System Safety
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-727, Design Guidance for Producibility
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Systems Engineering Plan (SEP) Outline

E.6. Review Key Characteristics

AS9103 is the industry best practice of the identification and control of Key Characteristics and requires the producer to maintain documentation of Key Characteristics and control those manufacturing processes that directly influence variation of those Key Characteristics. Key Characteristics should be capable and have a Cpk of 1.33 or greater or as specified by the customer. The concept of identifying key characteristics is linked to the Pareto principle, which asserts that a relatively small number of features will have the most significant impact on performance.

Manufacturing and Quality Tasks

- Design KCs have been identified, are being tracked and managed, and mitigation plans developed.
- All KCs are controlled in LRIP to appropriate quality levels.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Critical to Quality Tree
- Failure Mode and Effects Analysis
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Process Capability Analysis Worksheet
- Process Control Document (PCD)
- Producibility Assessment Checklist
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Level Assessment Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Assurance Management
- AS9103, Variation Management of Key Characteristics
- DoD Integrated Product and Process Development Handbook
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines
- Systems Engineering Plan (SEP) Outline
- Technology Level Assessment Guidance
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

E.7 Critical Design Review Close-Out

A CDR should have been held during EMD, and any items or risk areas that were identified during that review and are still open should be monitored, managed and the risk reduced to an appropriate level and the CDR items closed out as soon as possible. The Post-CDR assessment will include a demonstration that the "maturity of critical manufacturing processes has been accomplished." EMD should end when "manufacturing processes have been effectively demonstrated in a pilot line environment" prior to Milestone C. Most CDR identified risks should have been mitigated by Milestone C, but any risks that are still open and active in the Production and Deployment Phase should be managed using risk reduction techniques.

Manufacturing and Quality Tasks

- Manufacturing and QA personnel should support the conduct of the CDR, and concerns include:
    - That the system product baseline has been established and documented to enable hardware fabrication to proceed with proper configuration management.
    - Adequate processes and metrics are in place for the program to succeed.
    - All the known risks are understood and manageable for testing in support of developmental and operational evaluation objectives.
    - The program schedule is executable (technical/cost risks).
    - The program is executable with the existing budget and the approved product baseline.
    - The detailed design is producible within the production budget.
    - The updated Cost Analysis Requirements Description (CARD) is consistent with the approved product baseline.
    - The updated cost estimate fits within the existing budget.
    - Key product characteristics that have the most impact on system performance, assembly, cost, and sustainment or safety are identified.
    - The critical manufacturing processes that affect the key characteristics have been identified and their capability to meet design tolerances determined.
    - Process control plans have been developed for critical manufacturing processes.
    - Manufacturing processes have been demonstrated in a production representative environment.
    - Detailed trade studies and system producibility assessments are complete.
    - Materials and tooling are available to meet LRIP/FRP schedule.
    - System production cost models have been updated, allocated to subsystem level, and tracked against targets.
    - Long-lead procurement plans are in place and the supply chain has been validated.
    - All product data essential for component manufacturing has been released.
    - Design change traffic does not impact LRIP.
- Ensure that major product design features and configuration are stable.
- Manufacturing and QA personnel need to support the conduct of the PCA or equivalent completed.
- Ensure that production equipment is maintained, and this translates to high overall equipment effectiveness (OEE) rate and is accounted for in determining the availability of the equipment and contingency plans.

Tools

- Critical Design Review Checklist and Assessment
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan

- Systems Engineering Plan (SEP) Outline

Resources

- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Systems Engineering Plan (SEP) Outline

E.8. Update to Systems Engineering Plan

The SEP is a living document that details the execution, management, and control of the technical aspects of an acquisition program. The SEP outlines how the systems engineering process is applied and tailored to meet objectives for the program and is updated for each acquisition phase. Manufacturing and quality managers, as members of the Technical IPT, should be providing input into the SEP.

Manufacturing and Quality Tasks

- Manufacturing and QA personnel need to support the development and update of the Systems Engineering Plan (SEP) using the following information sources provide important inputs to the Production and Deployment phase systems engineering process:
    - Acquisition Program Baseline
    - Systems Engineering Plan (SEP)
    - Test and Evaluation Master Plan (TEMP)
    - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
    - Programmatic Environmental, Safety, and Occupational Health Evaluation (PESHE)
    - Life-Cycle Sustainment Plan

- Manufacturing and quality personnel should ensure that the SEP contains the following manufacturing considerations:
    - Program Schedule (PRR/Production Lot/Phases)
    - Technical Risks and Mitigation Planning (Production/Manufacturing/Quality)
    - Manufacturing Readiness Assessment (MRA)
    - Manufacturing and Quality Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
    - Planned Activities for the Next Phase (including manufacturing maturity)

- All modifications, upgrades, Diminishing Manufacturing Sources and Material Shortages (DMSMS) and other changes assessed for producibility
- Technical Review Process (Manufacturing Purposes/Criteria)
- Manufacturing and Quality TPMs/Metrics to be used to identify and manage risks
- Manufacturing Design Considerations (Include Trade Study Criteria)
- Engineering Tools (such as Producibility/Throughput Analysis, Line of Balance, factory and process modeling and simulation tools, and quality tools) are available and in use

Tools

- Critical to Customer/Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Manufacturing Plan (included in the SEP)
- Producibility Assessment Worksheet
- Quality Assurance Plan (included in the SEP)
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DoD Integrated Product and Process Development Handbook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoDI 5000.89, Test and Evaluation
- ISO 9001, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Systems Engineering Plan (SEP) Outline

E.9 Develop Detailed Product Design

Detailed product design includes the realization (build) effort down to the lowest level system elements and includes the fabrication/production processes required to complete the build effort. As a best practice, the Systems Engineer should develop an implementation plan that includes implementation procedures, fabrication processes, tools and equipment, implementation tolerances and verification

uncertainties. Manufacturing and quality managers/engineers need to be a part of the development and assessment of detailed design efforts.

Manufacturing and Quality Tasks

- Support the development of the detailed product design.
- Ensure detailed design drawings, bills of material and product and process specifications are completed by release of design to manufacturing.
- Participate in design reviews to assure that the contractor is complying with the design requirements and meeting the cost/design goals.
- Ensure the final design definition is the result of the performance requirements, the outcomes of the testing accomplished, producibility studies and other design influences.
- Ensure that the design is specified to a low level of detail so that the required production phase processes and resources can be identified and obtained.
- Demonstrate design producibility improvements in LRIP and in FRP.

Tools

- Design for Manufacturing and Assembly (DFMA)
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- DoD Integrated Product and Process Development Handbook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.10 Develop Work Breakdown Structure

The Work Breakdown Structure (WBS) is a government approved framework that includes all program elements for which the contractor is responsible and for which they must report. The WBS is defined, developed, and maintained throughout the system life cycle based on a disciplined application of the systems engineering process. The goal is to develop a WBS that defines the logical relationship among all program elements to a specific level (typically Level 3 or 4) of indenture that does not constrain the contractor's ability to define or manage the program and resources.

Manufacturing and Quality Tasks

- Support the development the Program and Contract WBS to ensure planning, execution and control of the production phase activities are compatible with the existing manufacturing and performance measurement systems.
    - Ensure that the Program WBS is accurate down to at least three levels and includes manufacturing and quality considerations.
    - Ensure the contractor identifies the Contract WBS down to at least three levels and that production phase costs and schedule can be related to the development WBS, tracked and managed.

Tools

- Manufacturing Maturation Plan
- Manufacturing Readiness Assessment Checklist, Design thread
- Systems Engineering Plan Outline
- Work Breakdown Standard review

Resources

- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-STD-881 Work Breakdown Standard
- Systems Engineering Plan (SEP) Outline

E.11 Stabilize the Design

Product design should have been stable by the time the CDR was conducted; however, detailed design often continues well into the P&D phase. The Physical Configuration Audit (PCA) is a formal examination of the "as-built" configuration of the system or a configuration item against its technical documentation to establish or verify its product baseline. A successful PCA provides the Milestone Decision Authority with evidence that the design is stable. At the conclusion of the PCA, the final product baseline is established, and all subsequent changes are processed by a formal engineering change action and under the control of configuration management practices.

Manufacturing and Quality Tasks

- Product design and features should be assessed during the CDR to support a production decision.
    - Verify that design change traffic should be minimal
    - Verify that 80% of the drawing packages have been released to production

- Verify the detailed design of all product features and interfaces is completed.
    - All product data essential for product manufacturing has been released
- Evaluate the final material selection for completeness and for producibility.
- Evaluate the product specifications/build-to packages to ensure that they are matured to the same level as the design.
- Verify that the LRIP Build-to Packages are complete.
- Verify that the FRP Build-to Packages are complete
- Verify that the system design has been validated through operational testing of LRIP items.
- Verify that the design change traffic is now limited to Class II ECPs.
- Verify that the design efforts achieved effective and efficient manufacturing processes with the necessary process controls to satisfy requirements and minimize manufacturing costs.
- Verify that the design of the system facilitates the timely and affordable manufacture, assembly, and delivery of a quality product to the customer.

Tools

- Critical Path Template
- Design for Six Sigma
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- DoD Integrated Product and Process Development Handbook
- DoD MIL-STD 882E, System Safety
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD 4245.7-M, Transition from Development to Production, Chapter 3 – Design
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.12 Key Characteristics Demonstrated

Once a Key Characteristic has been identified, the team must determine which manufacturing processes create or significantly contribute to each KC. These processes are then termed critical processes. The contractor should maintain documentation depicting this relationship between each KC and their associated critical manufacturing processes. Then those manufacturing processes must be controlled to demonstrate that the process is stable, capable and in control. For each critical

manufacturing process, a Process Failure Modes and Effects Analysis (FMEA) should be performed, and process control plans should be developed and implemented.

Manufacturing and Quality Tasks

- Support the identification and management of Key Characteristics to ensure that they are under control.
- Manufacturing process should be identified, documented, and put under statistical control.
- Process capability (i.e., Cpk) studies should be accomplished to demonstrate process maturity.
- Key Characteristics (KC) risk issues should be identified, and mitigation plans developed and put into place.
- Key Characteristics should be assessed to ensure that they are attainable based upon production demonstrations.
- Process producibility improvements should be ongoing.
- All KCs should be controlled in FRP to appropriate quality levels.
- Manufacturing Readiness Assessment should be conducted to assess KCs.
- Manufacturing processes should be re-assessed as needed for capability to test and verify potential influence on Operations and Support.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Critical to Quality Tree
- Failure Mode and Effects Analysis
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- Systems Engineering Plan Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Assurance Management
- AS9103, Variation Management of Key Characteristics
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis

- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines
- Systems Engineering Plan (SEP) Outline

E.13 Low-Rate Initial Production Build

LRIP quantities are produced to provide production representative test articles for operational test and evaluation (OT&E) and to establish an initial production base for the system and provide efficient ramp up to FRP, and to maintain continuity in production pending completion of operational testing. The LRIP environment builds on M&Q experience gained on the pilot line prior to the Milestone C decision. The LRIP build provides M&Q managers the opportunity to prove or demonstrate the production capability and assess manufacturing readiness at the LRIP production rate and to plan for the progression to FRP.

LRIP describes the initial production effort needed to reduce the government's exposure in transitioning to FRP. It usually begins at the end of the EMD phase and often transitions from a pilot line to an LRIP then FRP production capability.

Manufacturing and Quality Tasks

- Assess LRIP to ensure that:
    - New technologies are mature and ready to transition into the production units
    - The detailed system design is complete with few engineering changes, and none that impact form, fit or function
    - All manufacturing processes are capable and under statistical control, and there are no producibility risks
    - A complete definition of the fabrication and assembly tasks and they are transferred to the general factory work force
    - Detailed work instructions exist and a controlled system for changes to the documents used in the factory, such as drawings and process specifications
    - Required production planning documentation are based on a stable design, quantity requirements and delivery schedule
    - Engineering changes are controlled to minimize disruption to production documentation and planned manufacturing schedules
    - QMS is operating effectively to produce quality systems
    - Participate in the PCA and examine the actual configuration of an item being produced and confirms that the manufacturing processes, QMS, measurement and test equipment, and training are adequately planned, tracked, and controlled and that the related design documentation matches the item as specified in the contract
- Ensure affordable and executable manufacturing process have been developed and demonstrated/proven.

- Demonstrate that the maturity of critical manufacturing processes has been accomplished.
- Ensure all manufacturing processes have been effectively demonstrated during LRIP.

Tools

- Integrated Master Plan/Integrated Master Schedule assessment
- Interactive MRL Users Guide (Checklist), Design thread
- Production Part Approval Process (PPAP) Checklist
- Production Readiness Review (PRR) checklist
- Production Verification Test
- Systems Engineering Plan Outline

Resources

- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- AS6500, Manufacturing Management System
- DCMA Instruction 302, First Article and Production Lot Testing
- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, System and Software Engineering
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.14 Full-Rate Production Build

The FRP environment builds on M&Q experience gained during LRIP and provides M&Q managers the opportunity to prove or demonstrate the production capability and manufacturing readiness at the FRP production rate and to plan for eventual shutdown and Demil/Disposal. Manufacturing assessments could include a follow-on Production Readiness Review, a Manufacturing Readiness Assessment, or other manufacturing/ quality assessment as deemed appropriate for the program and risks. FRP is the highest level of production readiness.

Manufacturing and Quality Tasks

- Manufacturing personnel must ensure that:

  - Engineering/design changes are few and generally limited to quality and cost improvements
  - System, components, or items are in FRP and meet all engineering, performance, and quality requirements
  - Manufacturing process capability is at the appropriate quality level
  - All materials, tooling, inspection and test equipment, facilities and manpower are in place and have met FRP requirements
  - Rate production unit costs meet goals, and funding is enough for production at required rates
  - Lean practices are well established, and continuous process improvements are ongoing
  - There are no significant manufacturing risks
  - Manufacturing processes should be under statistical control if quantities warrant
- Identify remaining risks prior to FRP production go-ahead decision. Key considerations should include:
  - Industrial base viability
  - Design stability
  - Process maturity
  - Supply chain management
  - Quality management
  - Facilities and manufacturing skills availability
  - Mitigation plans from the FRP MRA
- Review and assess the following sources of data to include:
  - Technical reviews and audits
  - Program Status Reviews
  - Pre-award surveys
  - Production Readiness Reviews
  - Industrial Capabilities Assessments
  - Trade-off studies
  - Tooling plans
  - Make-or-buy plans
  - Manufacturing plans
  - Bills of material
- Assess if a follow-on, tailored, PRR may be appropriate in the Production and Deployment phase for the prime contractor and major subcontractors if:
  - Changes from the EMD phase and during the production stage of the design, in either materials or manufacturing processes, occur
  - Production start-up or re-start occurs after a significant shutdown period
  - Production start-up with a new contractor, or

- Relocation of a manufacturing site

Tools

- Integrated Master Plan/Integrated Master Schedule assessment
- Interactive MRL Users Guide (Checklist), Design thread
- Production Part Approval Process (PPAP) Checklist
- Production Readiness Review Checklist
- Production Verification Test
- Systems Engineering Plan (SEP) Outline

Resources

- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- AS6500, Manufacturing Management System
- DCMA Instruction 302, First Article and Production Lot Testing
- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, System and Software Engineering
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

F. COST/FUNDING

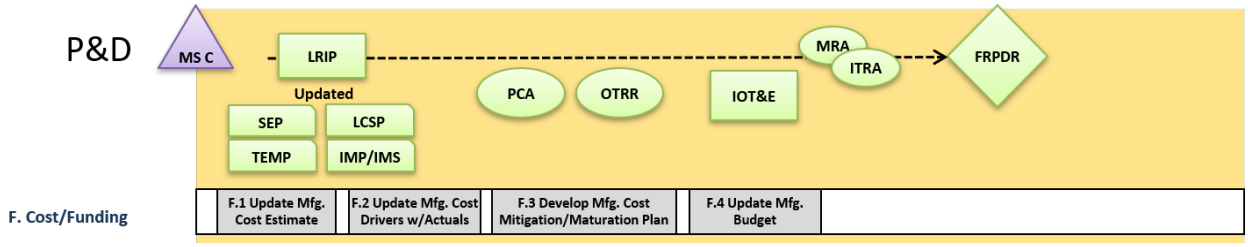


Figure 5-7. Cost and Funding Manufacturing and Quality Activities

Introduction

Services and Agencies develop Program Objective Memorandums (POMs) to identify and request resources (money) to acquire capabilities and perform operations. The POM is part of the Programming phase of the Program, Planning, Budget, and Execution (PPBE) process. The DoD combines the

various Service and Agency POM inputs and Budget Estimate Submission (BES) and submit a DoD Budget Request to the Office of Management and Budget (OMB).

Manufacturing cost estimates for the production phase are normally based on the assumption that the design is complete, that the manufacturing processes are stable and well known, and manufacturing operations will be accomplished as planned. Any deviation from these assumptions could cause a growth in cost. As such, time and conformance measures can give some indication of potential or real cost aberrations since there is normally a direct correlation between late delivery or conformance problems and cost. Historically the major cost drivers for manufacturing were direct labor and direct materials. But in today's modern industrial environment overhead to include manufacturing overhead has become the bigger cost driver. These changes makes assessing manufacturing cost much more complex. In addition, the following measures may also indicate the existence of cost problems:

- Machine set-up and tear-down
- Machine maintenance
- Production attainment
- Manufacturing cycle time
- Percentage of out-of-station work
- Scrap and rework rates
- Yield rates on manufacturing operations
- Supplier quality problems
- Engineering change volume

The cost to manufacture a weapon system or equipment results from a combination of the design, the physical facility, and the five Ms (manpower, materials, methods, measurements, and machines) used to build the design and the management efficiency of the operation. As such, the manufacturing cost for a product should be viewed within the context of the factory in which the product will be built. Three significant cost factors that need to be identified to support the estimating activity, and these are rate, quantity, and efficiency.

Production cost and production cost estimates change over time. In the early acquisition phases, cost estimating is probably based on analogy. At this point the estimate is not perfectly accurate as the basis of the estimate is may only resemble the final product and much may change as the new system is developed thus driving changes in the cost model. Then as the program matures and moves through the acquisition life cycle, more and more is learned about the final product to the point estimating may move from analogy to parametric cost estimating. Again, as the program matures and more is known about the system as it transitions from development toward production, the cost estimating methodology moves toward engineering estimates. The final and most accurate cost estimating technique is the use of actuals. Actual cost estimating method uses the actual cost of the previous production lot adjusted for inflation, labor saving, material cost, technology changes and other factors.

The problems with all cost models is that they are not perfectly accurate, and often we find programs overrunning costs for various reasons. An actual cost are calculated based on costs actually incurred

and recorded in accomplishing the work performed within a given time period, as distinguished from forecasted or estimated costs, and when costs are overrun the program may need to develop cost mitigation and maturation plans.

Budget estimates are developed to justify future production expenditures and these estimates are often abase on the rate and quantity of production units. Rate being how many a day, week, or month the contractor is planning to produce, and quantity is the grand total of units to be produced. Rate and quantity drive the process layout of a factory, and greatly impact the costs per unit. Identifying these factors will help to identify where manufacturing investments may be needed. There could be investments in facilities, capital equipment, training and certification of personnel, or money to improve current production processes and performance.

F.1 Update Manufacturing Cost Estimates

DoDI 5000.73, "Cost Analysis Guidance and Procedures" identifies Cost Estimating and Reporting requirements. Manufacturing and quality managers need to support to development and update of government cost estimates and the assessment of contractor cost estimates.

Manufacturing and Quality Tasks

- Support the development of various cost models and estimates:
  - Affordability Analysis
  - Cost Analysis Requirements Description (CARD)
  - DoD Component Cost Estimate
  - Component Cost Estimate (CCE)
  - Component Cost Position (CCP)
  - Cost Capability Analysis (CCA)
  - Should Cost Estimate
  - Sufficiency Review
  - Independent Cost Estimate (ICE)
- Update the initial manufacturing cost estimate to reflect the final definition of the system design and the completed manufacturing approach.
- Support fact finding and negotiations by collecting and analyzing cost and efficiency data from LRIP and earlier Production lots, development and application of learning curves, and development and defense of negotiation positions.
- Base manufacturing cost estimates on the application of detailed manufacturing standards to the operations to be performed and adjusted, as necessary, by realization factors and/or learning curves to develop the time phased manufacturing cost.
- Consider including a contract requirement for Work Measurement in the LRIP/FRP phase contract if the contractor does not have a system for development and application of labor standards.

- Update the FRP cost model based on the results of the LRIP build.

Tools

- Cost Analysis Requirements Description (CARD) template (*See* CAPE website)
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Interactive MRL Users Guide (Checklist), the Cost thread
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Maturation Plan

Resources

- Cost Analysis Requirements Description (CARD) website and process (*See* CAPE website)
- Defense Manufacturing Management Guide for Program Managers, Chapter 9 Manufacturing Cost Estimating
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-766 Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook
- Should-Cost and Affordability Memo

F.2 Update Manufacturing Cost Drivers with Actuals

During the Production and Deployment phase, most manufacturing costs should be based on actual cost data provided by the contractor. Cost drivers could be high-cost items, or items that have high manufacturing costs due to several factors (long processing times, low yield rates, etc.). These cost drivers need to be updated.

Manufacturing and Quality Tasks

- Manufacturing cost drivers should be identified and updated on a regular basis based on actual cost performance.
- Manufacturing costs should be rolled up to system/subsystem level and tracked against targets.
- Detailed trade studies and engineering change requests should be supported by cost estimates.
- Cost reduction and avoidance strategies should be developed and implemented.

- LRIP costs estimates should be analyzed using pilot-line actuals and updated into manufacturing cost estimates to ensure target costs are achievable.
- Manufacturing cost analysis should be conducted when there are proposed changes to requirements or configuration.
- All cost models should be updated based on the results of pilot line build.
- All cost models should be updated based on the results of LRIP build.
- LRIP cost should be monitored to ensure they meet program goals, and the learning curve should be analyzed based on actual data.

Tools

- Cost Analysis Requirements Description (CARD) template (*See* CAPE website)
- Cost/Schedule Control System Criteria (see EVM)
- Design to Cost Estimates
- Interactive MRL Users Guide (Checklist), Cost thread
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Maturation Plan

Resources

- Cost Analysis Requirements Description (CARD) website and process (*See* CAPE website)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766, Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook
- Should-cost and Affordability Memo

F.3 Develop Manufacturing Cost Mitigation/Maturation Plan

Affordability is always a concern for the DoD. Manufacturing and quality managers need to support the development and implementation of cost mitigation plans. These mitigation plans are often focus on manufacturing cost drivers and continuous improvement opportunities.

Manufacturing and Quality Tasks

- Develop and update Manufacturing cost models regularly to include:
  - The collection of actual cost data during fact finding.
  - The analysis of contractor cost and pricing data.
  - The ability to develop and defend cost estimates for future production lots.
  - The ability to be used in design trades to assess the cost impacts of specific design changes, alternative production processes or process improvements.
  - The ability to incorporate the current, actual manufacturing costs into the production cost estimate.
  - The ability to support Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs.)
- Develop Manufacturing Maturation Plans for any areas assessed that do not comply with the appropriate manufacturing readiness criteria.
- Analyze touch labor efficiency to ensure the contractor can meet production rates and elements of inefficiency identified with plans in place for reduction.

Tools

- Cost Analysis Requirements Description (CARD) (*See* CAPE website)
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Interactive MRL Users Guide (Checklist), Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan (no template available)
- Parametric, Engineering and Actual estimating

Resources

- 10 USC 2334, Independent Cost Estimation and Cost Analysis
- CARD - Cost Analysis Requirements Description Template (See CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Public Law 114-328, §807, Cost, Schedule, and performance of major defense acquisition programs

F.4 Update Manufacturing Budget

Budget estimates are developed to provide the financial resources to needed to improve affordability, reduce risks, mature emerging technologies for insertion and to help resolve several manufacturing related issues. A budget estimate was developed to take the program from EMD pilot line to low-rate production, and this budget needs to be updated to take the program from LRIP to FRP.

Manufacturing and Quality Tasks

- Support the development of a program budget estimate for achieving FRP.
    - Program estimate should support cost for achieving MRL 9 by the FRP decision point
- Identify manufacturing costs and cost drivers associated with design alternatives considered in trade-off process.
- Update manufacturing cost drivers for "Should-Cost" and other models.
- Support “Should-cost” activities.
- Develop manufacturing mitigation plans for outstanding MRL 9 risk areas that impact budget estimates and actual costs.
- Ensure that all program budget estimates includes investment for LRIP and FRP.
- Assess the affordability and executability of the manufacturing processes.
- Determine the risks to affordably to develop, manage and execute required manufacturing processes for each identified prototype.
- Analyze the identified risks.
- Integrate the individual risks identified for each prototype into a cumulative assessment of the ability to affordably install and execute the proposed manufacturing processes.
- Document and provide the cumulative assessment of the ability/risk to affordably install and execute the proposed manufacturing processes.
- Analyze of the adequacy, reasonableness and necessity of contractor-proposed manufacturing labor hours and material costs.
- Recommend quality and manufacturing cost reduction initiatives.
- Provide accurate cost performance versus target analysis and assessment of identified trends.
- Analyze the quality, manufacturing, and production cost data against cost targets, and identify trends.
- Identify and provide quality, and manufacturing cost/funding estimates and recommendations on emerging requirements.
- Identify manufacturing investment opportunities and develop investment roadmaps for achieving the manufacturing development efforts.
- Develop funding and budgeting request for quality and manufacturing initiatives.
    - Identify emerging quality and manufacturing initiatives.
    - Develop program estimates for applicable quality and manufacturing initiatives.

- Develop and manage industrial base investment programs that create, expand, or preserve assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense.
- Assess cost models and validate them based against actual FRP cost.
- FRP cost goals should be assessed.
- Production budgets should be developed that are enough for producing at the required rates and schedule.

Tools

- Interactive MRL Users Guide (Checklist), Cost thread
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Maturation Plan
- Technology Readiness Level Assessment Checklist

Resources

- Manufacturing Readiness Level (MRL) Deskbook
- Public Law 114-328, §807
- Technology Readiness Assessment Guidance
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

G. MATERIALS MANAGEMENT

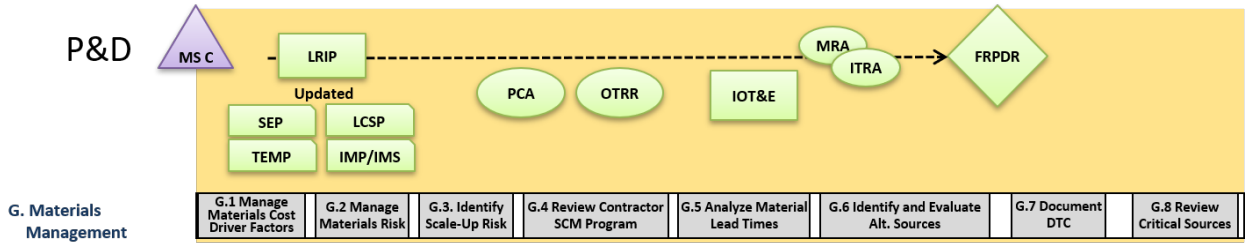


Figure 5-8. Materials Management Manufacturing and Quality Activities

Introduction

Materials is one of the 5Ms (manpower) that needs to be addressed on a regular and ongoing basis. Material Management is concerned with the ability of a program to have the right materials, at the right place, at the right time, at the right cost and quality levels. This includes raw materials, components, semi-finished parts, and subassemblies. Some major concerns that need to be assessed include:

- Material availability
- Material maturity
- Special Handling of Material
- Supply Chain Management

The DoD has many supply chains, and these chains are a multibillion- dollar business. However, many SCM best practices have not been incorporated into the DoD supply chain uniformly because the DoD supply chain is a conglomeration of different supply chains managed under different organizational structures. Some of these supply chains have a logistics view and some have an acquisition view. Because the DoD supply chain is enormous, making it even slightly more efficient could result in tremendous cost savings.

The GAO has consistently rated Supply Chain Management (SCM) as a "high-risk" area for DoD acquisition programs. This is a major concern since 60-80 percent for the material dollar value of a program exists within the supply chain, not at the prime contractors. Therefore, M&Q personnel need to be active in helping to identify and manage supply chain risks. SCM risks can include some of the following:

- Material Cost and Cost Drivers
- Scale up (Pilot Line, to LRIP, to FRP)
- Supply Chain Management (SCM)
- Lead Times (especially long lead items)
- Sourcing Issues:
    - Sole Source/Single Source
    - Foreign Source
    - Critical Sources
    - Alternate Sources

Meeting program schedules is often dependent on lead times within the supply chain. Long lead items require long lead buys. These long lead buys could include special tooling, special test equipment and special inspection equipment. The program office should maintain continuing visibility of the status of their supply chain and the forecast changes in lead times.

The impact of lead time variations on a program can be minimized but requires management attention. Tools like JIT, Supplier Partnerships, Lean, Six Sigma and Theory of Constraints can be used to minimize the cycle time.

Programs with potential supply chain risks may need to identify alternative sources of supply for several reasons:

- When the program is dependent on a sole source of supply, a single source of supply or a foreign source of supply.
- When the item being procured is a critical item.
- To encourage competition to achieve and maintain affordability.
- When faced with Diminishing Manufacturing Sources and Material Shortages (DMSMS) and Obsolescence

Diminishing Manufacturing Sources and Material Shortages (DMSMS), the loss of sources of items or material, surfaces when a source announces the actual or impending discontinuation of a product, or when procurements fail because of product unavailability. DMSMS may endanger the life-cycle support and viability of the weapon system or equipment.

There are several ways the DoD can address material needs and shortages. One is through the Defense Production Act of 1950 and the implementation of the Defense Priorities and Allocation System (DPAS) in which the government can designate programs as “high priority” and put them at the front of the contractor’s production queue. Another is the Defense Industrial Capabilities Handbook, DoD 5000.60H which identifies alternative actions the government can take when facing material shortages to include:

- Finding foreign sources of supply
- Finding alternative or substitute parts
- Making a Lifetime buy to meet all planned future needs
- Maintaining a current capability
- Developing an Alternative solution

The SEP should address the parts management strategy, including the need for a parts management plan. Parts selection should be based on trade-off and cost-benefit analyses that are conducted in accordance with the program's parts strategy and management plan, as derived from the overall acquisition and sustainment strategies. Selected parts should be documented in a parts list, which is under configuration management of the overall technical baseline.

A parts management plan typically includes the following:

- Implementation of an effective parts management program which supports acquisition strategies and systems engineering practices.
- Parts selection criteria and a parts selection baseline.
- Identification of Critical Parts/Long Lead Parts and Sole/Single/Foreign Sources of parts.
- DMSMS and Obsolescence management.
- Development of a parts list or Bill of Materials (BOM).
- Part and Supplier QA requirements and programs.
- Alternative part selection and approval procedures.

Lead times for defense materials and components can be long and volatile. There are various reasons for this situation, such as:

- Imbalances between capacity and demand.
- Imperfect forecasting of needs.
- Competition from commercial suppliers.
- Poor quality and lack of process improvement.

- Production bottlenecks.
- Long testing cycles.
- Raw materials not available.
- Long contracting process.
- Lack of funding.
- Transportation.
- Labor issues.

Supply chain management is a key driver in the ability of a program to scale up or ramp up production from a pilot line to LRIP, to FRP, and finally to slow the line down and get ready for production close out.

G.1. Manage Materials Cost Driver Factors

Production costs are driven by product complexity (design), rate of production, and total numbers produced. Direct labor and direct material cost often make up a large portion of product costs and must be assessed. Material cost drivers could include long-lead items, items that require special handling, storage, or treatment. Some materials are just more expensive (titanium versus steel), and other materials are harder to work with or have low yield rates. Manufacturing and quality managers need to pay special attention to materials that are cost drivers.

Manufacturing and Quality Tasks

- Update material cost drivers based on:
    - Design requirements
    - Material specifications and tolerances
    - Material specification is stable
    - Bill of Materials
    - Make/Buy decisions
    - Projected rates/quantities (lot buys)
    - Price stability
    - Supply Chain stability
    - Material maturities demonstrated on pilot-line build and LRIP
    - Materials proven and validated during EMD as adequate to support LRIP/FRP
- Assess and manage material risk:
    - Methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials

Tools

- Cost, Schedule Control Systems Criteria (C/SCSC)

- Earned Value Management (EVM)
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment

Resources

- DoD Cost/Schedule Control System Criteria
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Cost Estimating (*see* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687
- Strategic and Critical Materials Stock Piling Act, as amended by NDAA FY 2017 (Public Law (PL) 114-328)

G.2. Manage Materials Risk

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Material risks have been known to be risks and issues that can slow or delay a program, add additional costs to a program, or create field failures because of poor material reliability. Material risks could include availability of the material, maturity of the material, or need for special handling and control. Material risks can occur anywhere in the supply chain all the way down to the lowest level (dirt). Manufacturing and quality managers need to support the identification and management of material risks.

Manufacturing and Quality Tasks

- Identify material availability risks and minimize through mitigations.
- Assess material availability risks to meet LRIP.
- Assess material availability risks to meet FRP.
- Identify, manage, and mitigate lead procurement risk.
- Assess and initiate long-lead procurement LRIP/FRP.
- Develop and put into place an effective supply chain management process.
- Assessment of critical first tier supply chain must be completed.
- Assessment of critical second and lower tier supply chain must be conducted.
- Assess the supply chain to ensure it is adequate to support LRIP/FRP.

- Identify and manage sole source/single source items.
- Assess make/buy decisions.
- Analyze make/buy decisions for all key or critical components.
- Analyze make/buy decisions for capability of selected manufacturers, whether in factory or at vendor facility, to meet quality requirements, schedule, and cost targets.
- Develop an obsolescence plan.
- Ensure DMSMS and parts obsolescence risks are managed and mitigated.
- Ensure that counterfeit material is not finding its way into the product.
- Manage all part shortage issues to minimize impact on production line.
- Identify all special handling/storage/environmental compliance risks/issues.
- Characterize all new materials in a factory environment.
- Account for and manage all GFE, GFP, government-furnished facilities (GFF), and government-furnished materials (GFM).
- Prove and validate materials as adequate to support FRP.

Tools

- DCMA Material Management and Accounting System Audit
- DMSMS Product Life Cycle Assessment (Consult Defense Logistics Agency (DLA))
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Materials thread
- ISO 14001 Gap Analysis Toolkit
- Manufacturing Maturation Plan
- PESHE Assessment/Template
- Producibility Assessment Worksheet
- Supply Chain Management Risk Assessment Checklist
- TRL Assessment Questionnaire

Resources

- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- DMSMS Guidebook, SD-22
- DoD 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- ESOH in Acquisition Guide

- ISO 14001 Environmental Management Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687
- Technology Readiness Assessment Guidance

G.3. Identify Scale-Up Risk

As programs ramp up production from the pilot line, to low-rate, and then to FRP M&Q managers are forced to deal with issues and concerns relating to scaling up. Often companies can prove that they have the capability to build one, but can they scale up to 100 a year, a month, a week, or an hour? The entire factory floor including the 5Ms (manpower, machines, materials, methods, and measurement) must be capable of responding adequately to the requirements imposed by scaling up.

Manufacturing and Quality Tasks

- Identify any manufacturing processes and techniques that are not currently available.
- Identify any design producibility risks.
- Identify probability of meeting delivery dates.
- Identify the potential impact of critical and long-lead time material.
- Identify any production equipment availability issues.
- Verify that all production unit cost goals are realistic.
- Verify that all cost and production schedule estimates support management reviews.
- Verify that all manufacturing feasibility and cost and schedule impact analyses that supports trade-offs among alternatives.
- Verify all recommendations for anticipated production testing and demonstration efforts.
- Validate all methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials.
- Verify that all manufacturing processes and techniques are currently available and used on pilot line.
- Verify that there are no design producibility risks.
- Verify that there are no production manpower constraints.
- Verify that there are no capacity constraints.
- Verify that there is a high probability of meeting delivery dates.
- Verify that the potential impact of critical and long-lead time material is minimal.
- Verify that there are no production equipment availability issues.
- Verify production unit cost goal realism on the pilot line.
- Verify that cost and production schedule estimates support management estimates.
- Conduct manufacturing feasibility studies and analyze cost and schedule impact to support all trade-offs among alternatives.
- Verify that the supply chain is stable and adequate to support FRP.

- Verify that recommendations for anticipated production testing and demonstration efforts have been implemented.
- Develop special handling procedures and incorporate them into the production line instructions:
    - Verify that special handling procedures have been integrated into the work instructions.
    - Verify special handling procedures have been demonstrated in the LRIP and FRP environments.
    - Verify that special handling poses no significant risk for LRIP/FRP.

Tools

- Interactive MRL Users Guide (Checklist), Materials thread
- ManTech Strategic Plan
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet

Resources

- Air Force Technology Development and Transition Strategy Guidebook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- MRL Users Guide
- Producibility Systems Guidelines, NAVSO P-3687

G.4. Review Contractor Supply Chain Management Program

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then Supply Chain Management becomes a pivotal task. Often program problems originate in the supply chain but do not manifest themselves until the component is integrated into the system. Program offices and contractors often have efforts to identify and manage problems at the first tier, but do not do well below that level. Manufacturing and quality managers need to routinely review and assess contractor supply chain and procurement activities and efforts. A thorough review of the entire supply chain is needed to ensure that the contractor is can ramp up production for LRIP and FRP.

Manufacturing and Quality Tasks

- Support a review of the contractors Supply Chain Management (SCM) program for:

  - Strategic partnerships with vendors and suppliers
  - Stronger collaboration of information (especially forecasting data)
  - Reducing lead times on the critical path
  - Reducing variability
  - Supply Chain Planning
  - Demand Planning
  - Vendor Managed Inventory
  - Supplier Management
  - Procurement
  - Strategic Sourcing
  - Warehouse Management
  - Transportation Management
  - Order Fulfillment
  - Contract Management
- Review contractor's procurement system to ensure procurement packages are complete and accurate.
- Review contractor's parts management program including:
  - Management of distinct part numbers
  - Reduction in the number of distinct part numbers
- Review contractor's supplier qualification process to make sure it adequately ensures supplier's processes are capable on critical parts.
- Review contractor's supplier audit process to make sure it adequately ensures quality on critical parts.
- Participate in supplier audits and encourage other relevant organizations to participate (DCMA, etc.) to determine effectiveness of supplier qualification and auditing of supplier quality.
- Assess the supply chain management process for effectiveness.
  - Assessment of critical first tier supply chain completed.
- Ensure the supply chain is adequate to support LRIP.
  - Assessment of critical second and lower tier supply chain completed.
- Assess the supply chain to verify that it is proven and supports FRP requirements.

Tools

- AS5553, Supply Chain Assessment
- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronics Parts
- AS6500, Manufacturing Management Systems
- AS9100, Quality Management Systems
- AS9103, Variation Management of Key Characteristics
- AS9133, Qualification Procedure for Aerospace Standard Parts
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, System and Software Engineering
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- ISO 9001, Quality Management Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security

G.5. Analyze Materials Lead Time

Lead time analysis can be a trick endeavor, especially for long-lead items. Contractors and government managers have many tools available to them to support forecasting and lead time analysis, to include:

- Straight line based on historical data and constant growth rate
- Moving Average based on historical data and repeated forecast
- Simple Linear Regression based on a sample of relevant observations and comparing one independent variable with one dependent variable
- Multiple Linear Regression based on a sample of relevant observations and comparing several independent variables with one dependent variable

The contractor may go out to their suppliers and ask for lead times or delivery dates, but how accurate are those dates? What happens when there is a disruption in the supply chain caused by weather,

political unrest, change in suppliers, etc.? Forecasting and lead time assessment gets harder to do the further out the delivery date is. Furthermore, there is always a balance between the cost of holding an item and the cost of ordering. If too much is ordered or it comes in early, it could cause additional cost and risks. The same holds true if too little is ordered, or it comes in late.

Contractors must have a procurement system that ensures procurement packages are complete and accurate and are issued well in advance of lead times.

Manufacturing and Quality Tasks

- Identify potential long-lead items or issues.
- Analyze lead time fluctuations for schedule impacts.
- Ensure government funding is aligned with contractor long-lead requirements.
- Verify long-lead procurement has been initiated for LRIP.
- Verify long-lead procurement initiated for FRP.
- Verify procurement packages are complete and accurate.
- Perform material availability risk assessment.
- Develop long-lead material agreements, processes, and/or contracts.
- Verify that long-term agreements are in place where practical.

Tools

- Gantt Charts
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan
- Milestone Charts
- PERT/Network Charts

Resources

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Manufacturing Readiness Level (MRL) Deskbook

G.6. Identify and Evaluate Alternative Sources

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole source, single source, and foreign sources of supply come with a lot of risks. In addition, suppliers come and go in the marketplace. One day there may be four sources of supply and the next day one or none. Diminishing Manufacturing Sources and Obsolescence is a real problem on DoD programs, including programs that are pushing the state of the art but have

components that are past their prime. One way to mitigate those risks and to increase competition (reduce cost) is to identify and develop alternative sources of supply. This is not a quick or a cheap fix as the new supplier will probably need to go through a qualification program and prove that it has the capability to produce one, the capacity to produce all that are needed and the financial stability to be able to perform for the entire contract period of performance.

Manufacturing and Quality Tasks

- Review contractor's Bill of Materials to identify risks and potential requirements for alternative sources of supply.
- Review contractor's Parts Management Program to assess risks of not having parts when needed for production.
- Identify supply chain supplier risks.
- Identify single/sole/foreign sources of supply.
- Identify DMSMS and Obsolescence risks and plans for mitigation.
- Review contractor's use of the Government and Industry Data Exchange Program (GIDEP) database for configuration items that are susceptible to DMSMS issues.
- Identify potential alternative sources of supply.
- Identify and develop Qualification Plans for alternative sources of supply.
- Review contractor's DMSMS recommendations for the program risk management plan.
-

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit
- DMSMS Cost of Alternative Solutions Worksheet
- DMSMS Program Self-Assessment Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Interactive MRL Users Guide (Checklist), Materials thread
- Make or Buy Plans
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- Contractor Purchasing System Review (CPSR) Guidebook
- DFAR 15.407-2, Make or Buy Programs
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- MIL-STD-3018, Parts Management
- Manufacturing Readiness Level (MRL) Deskbook

- SD-22, DMSMS Guidebook

G.7. Document Design to Cost

The underlying objective of Design to Cost (DTC) is to identify cost drivers early in the system life cycle so trade-off decisions can be considered and ways to mitigate those costs identified. The program accomplishes this by making cost a design constraint with design options fixed to a cost limit.

Cost as an Independent Variable (CAIV) refocused DTC to consider cost objectives for the total life cycle of the program and to view CAIV with the understanding it may be necessary to trade-off performance to stay within cost objectives and constraints.

Manufacturing and quality personnel are still concerned in the Production and Deployment Phase with controlling cost, and as the design matures the ability to manage those costs matures. New design also can be introduced because of Pre-Planned Product Improvements (P3I) and Value Engineering Change Proposals (VECPs).

Manufacturing and Quality Tasks

- Analyze production costs using pilot-line system/subsystem actuals to ensure target costs are achievable.
- Analyze production costs using LRIP system/subsystem actuals to ensure target costs are achievable.
- Analyze production costs using FRP system/subsystem actuals to ensure target costs are achievable.
- Update cost models with design requirements, material specifications, and pilot-line results.
- Assess cost impacts from design changes due to P3I.
- Assess cost impacts from design changes due to Value Engineering Change Proposals.

Tools

- Cost Estimate (based on actuals)
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- Department of the Army Design to Cost Handbook
- DFAR 207.103(B)(i)(i), Apply design to cost principles
- DoDI 5000.85, Major Capability Acquisition
- GAO-09-3SP, GAO Cost Estimating and Assessment Guide
- MIL-HDBK-766, Design to Cost
- DoDI 5000.88, Engineering of Defense SystemsG.8. Review Critical Sources

A source is only a good source if it provides the right product, at the right time and place, at the right cost, and with the right performance. Thus, if an item is the lowest cost but is unreliable or comes in late, or comes in with quality deficiencies, then buying that item was a poor decision. Supply chain material assessments are especially needed for those items that may be considered critical sources of supply. These critical items (Pareto the vital few vs the trivial many) are often long-lead or are sole/single sources of supply. Lead times for defense materials and components can be long and volatile. There are various reasons for this situation, such as:

- Imbalances between capacity and demand
- Imperfect forecasting of needs
- Competition from commercial suppliers
- Poor quality and lack of process improvement
- Production bottlenecks
- Long testing cycles
- Raw materials not available
- Long contracting process
- Lack of funding
- Transportation
- Labor issues

Manufacturing and Quality Tasks

- Verify LRIP/FRP material availability.
- Assess the LRIP/FRP bill of materials using pilot-line activity.
    - Identify key and/or critical components in the LRIP/FRP BOM.
    - Analyze key and/or critical components in the LRIP/FRP BOM for potential issues.
- Validate material maturity based on pilot line.
    - Validate that the properties and characteristics of the material to be used for the LRIP/FRP system meet requirements.
    - Determine that the material's properties and manufacturing characteristics are predictable.
    - Assess the properties of the material for basic manufacturability.
- Develop mitigation strategies for quality and manufacturing-related supply chain counterfeit and anti-tamper and related exportability risks.
- Assess the materials planning systems. Identify materials planning systems being employed by the contractor or facility.
- Update Critical Suppliers List.
- Assess program in FRP to ensure that there are no significant material availability issues.

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- Contractor Purchasing System Review (CPSR) Guidebook
- DFAR 15.407-2 Make or Buy Programs
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328

H. PROCESS CAPABILITY/CONTROL

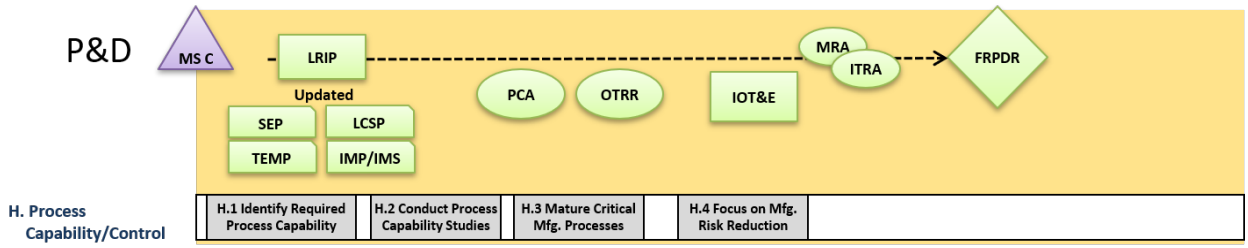


Figure 5-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with "uniform, defect free product that has consistent performance and is affordable. Product quality comes from robust product and process design and process control activities to include continuous process improvement to identify and remove sources of variation.

Process Capability and Control is a requirement of AS6500 Manufacturing Management Program standard, and ISO 9001 and AS9100 quality standards which requires a process control plan which describes the actions and activities that will demonstrate process capabilities. Process capability clarifies the inherent process variability of a given characteristic/process. Typical process capabilities measures include Cp/Cpk and Pp/Ppk A capability study is generally used to assess the ability of a

process to meet a drawing and specification requirement. Statistical Process Control tools are also used to determine if a process is in a state of statistical control (predictable). Typical process control tools generally include the X bar & R charts, control charts, plus many others.. For each concept being considered a determination of the manufacturing processes capability will be completed. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Critical and key manufacturing processes may be identified during the assessment and analysis through modelling and simulation (M&S) or experimentation.

Advances in digital engineering to include M&S along with continual improvements in computer performance have made it possible to perform comprehensive analysis of virtual parts and to test and assess the capability of processes before actual manufacturing begins. The use of solid modeling, finite element analysis, multi-paradigm numerical computing environments, and simulation software analysis tools, allows users to simulate different conditions that are likely to occur during manufacturing processes and model the behavior of systems under real-world conditions. An understanding of the capabilities to model products and processes for each of the concepts under consideration can be a valuable discriminator.

This thread (Acquisition) requires an analysis of the risk that the manufacturing processes may not be able to reflect the design intent (repeatability and affordability) of key characteristics and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Modeling and Simulation (M&S) of Processes
- Process Capability Studies
- Process Yields and Rates
- Process Demonstrations
- Statistical Process Control charts and reports

Manufacturing methods (processes) is one of the 5Ms (manpower) that needs to be addressed on a regular and ongoing basis. Three major focus areas include:

- Need for Modeling and Simulation (M&S) of the processes and production line prior to build
- Need to mature manufacturing processes so that they are ready for LRIP and FRP
- Need to measure, manage, and improve process yields and rates

The purpose of the P&D phase is to produce items for the warfighter that achieve operational capability and satisfy mission needs. Once a program passes Milestone C and goes into LRIP, there is an expectation that manufacturing processes are mature, well characterized, and controlled. The production output should be uniform and defect free.

Manufacturing process capability analysis determines the available manufacturing capacity and its capability to produce the desired end item without special controls. It is a critical activity in

producibility analysis. This normally includes analysis of the degree of process variability, the causes of variability, and the definition of methods to reduce it.

Process capability is a measure of how repeatable and consistent a manufacturing process is relative to the customer requirements in terms of specification limits of a product parameter. This measure is used to objectively measure the degree to which a process is or is not meeting the requirements.

Process capability compares the output of an in-control process to the specification limits by using capability indices. The comparison is made by forming the ratio of the spread between the process specifications (the specification "width") to the spread of the process values, as measured by six process standard deviation units (the process "width"). Process capabilities are often measured as a process capability index. Cp and Cpk are two frequently used indices and measure the short-term potential of a process. Key processes and characteristics should be controlled to a ± 3 sigma for all characteristics and ± 6 sigma for key and critical process characteristics.

Programs should be identifying all "key" and "critical" characteristics. These are the ones that really need to put under statistical process control. These are the ones that significantly impact form, fit, function, and costs. Note: There is no one standard process capability measurement for all process and product characteristics. However, key and critical characteristics should receive the most focus on development of a standard and on the management of those characteristics during the life of the product.

Once key characteristics have been identified the contractor needs to assess their current state. Are these characteristics stable (predictable) or not, and are they capable or not? This requires that the contractor conduct process capability studies. Once the studies have been completed (if required) then it is a matter of controlling those key and critical characteristics and implementing variability reduction programs to reduce costs and risks.

When associated with process capability and control, manufacturing risk reduction often focuses on the development and implementation of variability reduction programs. Variability reduction is the continuous and systematic reduction of variability in key product features and manufacturing processes. Variation reduction efforts should be applied only to those features and processes defined as key or critical based on human safety and/or mission essential performance.

Variation may be defined as any unwanted condition or as the difference between a current and a desired end-state. Both product performance and manufacturing processes exhibit variation. To manage and reduce variation, the variation must be traced back to its source. Variation occurs in all natural and man-made processes. If variation cannot be measured, it is only because the measurement systems are of insufficient precision and accuracy.

H.1. Identify Required Process Capability

One of the goals of manufacturing is to have a uniform, defect-free product. To achieve that goal, the production processes must be capable, that is, the outcome of the production process is a product that meets the specification. Manufacturing and quality managers need to be working continuously on production processes to reduce variation and to make the process robust to design requirements. Process control studies are often accomplished when the contractor finds that they are producing product that does not meet spec. But why wait for bad outcomes when the program can plan for success? Identify up-front and early what the design requirements are and ensure all processes can meet those requirements even before the start of production.

Manufacturing and Quality Tasks

- Verify and demonstrate models/simulation (M&S) of process capabilities developed earlier using the LRIP.
- Use M&S analysis to assist in the management of LRIP, and to determine that FRP requirements can be met.
- Develop manufacturing process documentation concurrently with the product specification to ensure the design is producible, supportable, and affordable.
- Conduct manufacturing assessments to determine system constraints and identify improvement opportunities.
- Conduct process capability studies to baseline the as-is process and further the development of improvement plans.
- Demonstrate manufacturing processes capability using production data:
    - Statistical analysis of current capability (Cp and Cpk, Pp and Ppk, or other appropriate metrics)
    - Results used to improve process and determine that LRIP/FRP requirements can be met
    - Continue collecting or estimating process capability data and using to improve
- Assess manufacturing processes and verified for LRIP/FRP:
    - Process Capability data from LRIP should be assessed against LRIP build target values
    - Process Capability data from FRP should be assessed against FRP Build target values
- Update and refine process capability requirements as the production environment moves from LRIP to FRP.
- Ensure continuous improvement of both LRIP and FRP are ongoing and generating positive results based on process capability models.

Tools

- AS9100 Checklist
- AS6500 Checklist

- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Capability-Based Assessment (CBA) Handbook
- Manufacturing Readiness Level (MRL) Deskbook

H.2. Conduct Process Capabilities Studies

A process capability study is a measure of the inherent process variability of a given characteristic. Process capability studies are conducted to assess the ability of a process to meet the contractual specification. Typically, a process capability study follows these steps:

1. Select a candidate for the study.
2. Define the process.
3. Procure resources for the study.
4. Evaluate the measurement system.
5. Prepare a control plan.
6. Select a method for the analysis.
7. Gather and analyze the data.
8. Track down and remove special causes.

Manufacturing and Quality Tasks

- Verify that manufacturing processes are stable, adequately controlled, capable, and have achieved program LRIP objectives.
- Evaluate manufacturing yields and rates actuals against production targets (LRIP and FRP) and use the results to feed improvement plans.
- Validate that production process capability actuals support achieving production targets.
- Verify and refine yields and rates on processes required for LRIP.
- Updated ongoing improvement plans.
- Ensure key processes are identified, and their status briefed at program meetings and reviews.

Tools

- AS9100 Checklist
- AS6500 Checklist
- First Pass Yield Estimates Worksheet
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan
- Process Capability Studies (Cp and Cpk assessment)
- Producibility Assessment Worksheet (PAW)
- Six Sigma Worksheet

Resources

- AS9100, Quality Management System – Aerospace
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687

H.3. Mature Critical Manufacturing Processes

Immature processes are a major source of risks on acquisition programs, especially during the Production and Deployment phase when most production takes place and as the program ramps up production to LRIP and FRP. As a program moves forward, process maturity takes on greater importance. According to DoDI 5000.02, the FRP decision requires that manufacturing risk be understood and that the manufacturing processes for the system be capable, in statistical control, and affordable. If these processes are not capable, in control, and affordable, the program office needs to continue to mature those processes.

Manufacturing and Quality Tasks

- Verify that manufacturing processes are stable, adequately controlled, and have the capability to achieve program LRIP and FRP objectives.

- Conduct manufacturing process demonstrations (LRIP and FRP) which includes the development of affordable and executable manufacturing processes, the completion of system fabrication, production of test articles so that system integration, interoperability, supportability, safety, and utility can be demonstrated.
- Ensure processes demonstrations include such items as cleaning, heat treatment, clean room controls, controlled testing, and special handling (i.e., personal grounding requirements for electronic components).
- Ensure processes are identified in the design and manufacturing documentation.
- Proof manufacturing processes that could contribute manufacturing risk to the program for LRIP and FRP:
    - Ensure that process can repeatedly produce conforming hardware within the cost and time constraints of the production phase.
    - Evaluate expected process yields for each critical process and indicate the statistical or other method used to maintain control of process performance.
    - Ensure proofing is accomplished in LRIP and FRP environments.
    - Assess and verify that factory floor conditions include the physical facilities, personnel, and manufacturing documentation.
    - Ensure that the contractor establishes training and certification programs for the shop personnel to ensure that process capabilities can be attained on a recurring basis for LRIP and FRP.
    - Ensure environmental and safety regulations and standards are a part of the production planning and are compliant with federal, state, and industry standards and laws.
    - Ensure that the impacts of environmental and safety regulations and standards on the cost of production operations is known.

- Tools
- ISO9001 Checklist
- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan
- Process Capability Assessment
- Production Part Approval Process (PPAP)

Resources

- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9138, Statistical Process Acceptance

- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- Manufacturing Readiness Level (MRL) Deskbook

H.4. Focus on Manufacturing Risk Reduction

According to the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs dated June 2015, the following approach should be considered to help identify risks in the production environment:

- Make-buy decisions, changes to suppliers, parts obsolescence, product delivery issues
- Manufacturing: manufacturing readiness, tooling, process maturity, etc.

Other considerations such as GFE availability, business consolidations, sole and single source suppliers, access to raw materials, export control, etc.

Manufacturing and Quality Tasks

- Conduct variability experiments to foster variability reduction and continuous improvement and to support FRP.
- Demonstrate LRIP has been achieved using production articles.
- Verify that industrial capabilities are in place and the production items have achieved their requirements as validated through testing.
- Verify that LRIP yield and rate targets have been achieved.
- Assess yields and rates required to begin FRP using LRIP results. Verify that yield improvements are ongoing.
- Demonstrate FRP has been achieved using production articles.
- Verify that FRP yield and rate targets have been achieved.
- Verify that yield improvements are ongoing.
- Ensure that process capability risk reduction efforts includes the effects of changes in:
    - workers
    - materials
    - fabrication methods
    - tooling and equipment
    - set-up, and other process conditions

Tools

- AS9100 Checklist

- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

I. QUALITY MANAGEMENT

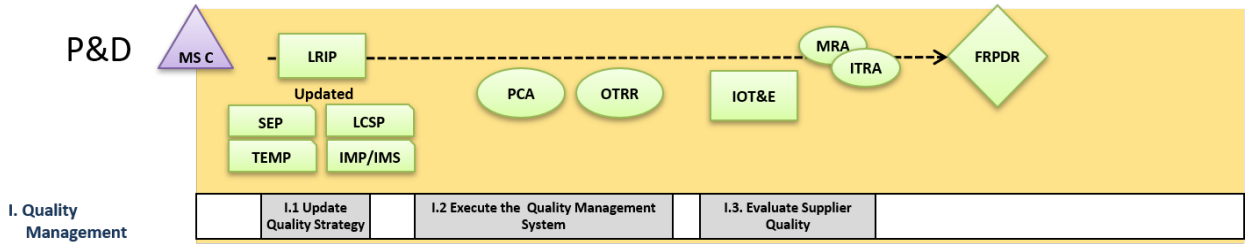


Figure 5-10. Quality Management Manufacturing and Quality Activities

Introduction

According to the Defense Manufacturing Management Guide for Program Managers, DoD Program Managers (PMs) are responsible for acquiring quality products that:

- Satisfy the needs of the warfighter.
- Provide measurable improvements in functional capabilities.
- Are affordable and arrive on schedule.

Many M&Q assurance processes, such as variability reduction, have a direct correlation to long-term performance (reliability) and to the ability to get a product back into serviceable condition after a failure (maintainability). Achieving high reliability with low maintenance costs will drive down life cycle costs and the logistics tail required by the warfighter.

An effective quality management system is required to deliver operationally safe, suitable, and effective weapon systems. The quality system assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The quality system serves as the management and control function within the systems engineering process. It requires basic controls over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. It also requires monitoring and measuring of processes and products to ensure they conform to requirements.

Compliance to a Quality Management System (QMS) standard such as ISO 9001, or AS9100, does not guarantee product or service quality. These standards are management system standards that identify requirements for processes within an organization, describe expected tasks and outcomes, and explain how the processes and tasks integrate to produce required inputs and outputs. Standards are meant to enable the organization to develop a set of processes that, if done by qualified persons using appropriate tools and methods with appropriate leadership involvement, will enable a capability for delivering high-quality products or services.

Product or service quality is achieved through the development, implementation and updating of many different plans:

- Systems Engineering Plan (SEP)
- Manufacturing Management Plan
- Quality Assurance Plan
- Supplier Quality Assurance Plan

The Program uses these plans to integrate all business and technical functions that result in the consistent application of proven, capable processes within an organization. Managers must ensure that all management systems are working toward the same goals and are not creating conflicting or dysfunctional behavior. Implementing a standard is of little use if the financial system rewards individuals for delivering non-conforming products/services. Because everything a contractor does should be related to the quality of its products or services, a contractor's quality management system should be the basis for integrating all other management systems within an enterprise.

Ramping up production to LRIP and then to FRP requires that the Program Management Office identify remaining risks prior to a production and then manage those risks during production. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality strategy/management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make- or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or manage remaining risks.

Many of the program plans and risk assessments will focus on the prime contractor, but of equal importance is the health and vitality of the supply chain. Good execution of program plans requires execution throughout the supply chain. As soon as the Make/Buy decision is made and the decision is to buy, then the Supplier QA program needs to be actively engaged to ensure that the appropriate

requirements are contractually flow down thru the supply chain, that the suppliers are actively managed and have appropriate oversight, and that product delivery supports LRIP and FRP with conforming product, at the right time and place and at the right costs. Quality requirements may reach all the way down to the component level or even the raw material level.

I.1. Update Quality Strategy

Manufacturing and quality managers support the development and updates to the Acquisition Strategy by providing their inputs into the Systems Engineering Plan (SEP). Quality managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and ultimately to the success of a program.

Manufacturing and Quality Tasks

- Ensure the following documents have been updated to support both LRIP and FRP:
  - Acquisition Strategy
  - Systems Engineering Plan (SEP)
  - Manufacturing Strategy/Plan
  - Quality Assurance Strategy/Plan
- Ensure the following quality of design attributes are represented as Key Performance Parameters:
  - Performance
  - Conformance
  - Durability
  - Serviceability
  - Safety
- Confirm that Government-furnished information (GFI) to meet system requirements and to be available, complete, and supportable.

Tools

- Acquisition Strategy Template
- AS9100 Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001 QMS Audit Checklist
- Manufacturing Maturation Plan

Resources

- AFMC Instruction 63-145 Manufacturing and Quality
- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9134, Supply Chain Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- FAR 52.246-11, Quality
- ISO 9001, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook

I.2. Execute the Quality Management System

M&Q personnel need to identify the potential product quality requirements of an identified material based on FAR 46.202, Types of Contract Quality Requirements, and FAR 52.246.1, Contractor Inspection Requirements. Best practices has contractors operating to either ISO 9001 Quality Management System or AS9100 Quality Management System. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

In addition, the organizations needs to identify the process of measuring, examining, testing, or otherwise comparing the product to the requirements for acceptance. FAR 46.291 Production Lot Testing identifies the purpose of production lot testing is to validate quality conformance of products prior to lot acceptance which usually occurs after acceptance testing.

Manufacturing and Quality Tasks

- Verify that an approved QMS is in place, operating, and is achieving desired outcomes.
- Evaluate the QMSs in use for each of the following areas:
    - Management responsibility
    - Resource management
    - Quality System
    - Contract Review
    - Product Realization
    - Design Control
    - Document Control

  - Purchasing
  - Purchaser-Supplied Product
  - Product Identification and Traceability
  - Process Control
  - Measurement, Analysis, and Improvement (metrology and calibration)
- Assess the QMS against an industry standard and the contract requirement:
  - ISO 9001
  - AS9100
  - Appropriate contractor QMS
- Establish quality targets.
- Verify quality targets on LRIP line.
- Identify and manage product quality requirements:
  - Mature new quality technologies and process state of the art into product quality requirements
  - Identify and manage product quality requirements (i.e., specific product characteristics)
  - Identify product acceptance methods and determine sampling plan as appropriate
  - Conduct First Article Inspection if required
- Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements
- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards
- Collect and analyze quality data from production and use results to feed improvement plans.
- Ensure that continuous quality improvement activities are ongoing.
- Verify quality targets on FRP line.
- Assess planned non-developmental item (NDI) or COTS items to determine that they meet program system performance and sustainment requirements through a defined acceptance process.

Tools

- AS9100 Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001 QMS Audit Checklist
- Manufacturing Maturation Plan
- Lot Acceptance Testing Calculator

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- DoD Risk, Issue, and Opportunity Management Guide
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1916 DoD Test Method Standard, Apr 1996,
- ANSI Z1.4 Sampling Procedures and Tables for Inspection by Attributes
- ANSI Z1.9 Sampling Procedure and Tables for Inspection by Variables for Percent Nonconforming
- DCMA-INST 302 First Article and Production Lot Testing
- DoD Systems Engineering Guide

I.3. Evaluate Supplier Quality

Since much (60-80%) of the program's components and subsystems comes from the supply chain, the development and execution of a Supplier QA program becomes a pivotal task. Often program problems originate in the supply chain but do not manifest themselves until the component is integrated into the system. Program offices and contractors often have efforts to identify and manage problems at the first tier but do not do well below that level. This is especially a problem as the program ramps up production from EMD into LRIP and then FRP. QA managers need to routinely review and assess contractors supply chain and procurement activities and efforts.

Manufacturing and Quality Tasks

- Ensure acceptance testing and inspection of supplier products is adequate to begin LRIP.
- Develop acceptance criteria for supplier products based on need (e.g., AQL)
- Ensure supplier products have completed qualification testing and first article inspection.
- Ensure acceptance testing and inspection of supplier products is adequate to begin FRP.
- Ensure Key Characteristics are being managed.

- Ensure continuous quality improvement is ongoing.

Tools

- AS9100 Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001 QMS Audit Checklist
- Manufacturing Maturation Plan
- Supplier QA Questionnaire

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9134, Supply Chain Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200, Contractor Material Management and Accounting
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook

J. MANUFACTURING WORKFORCE

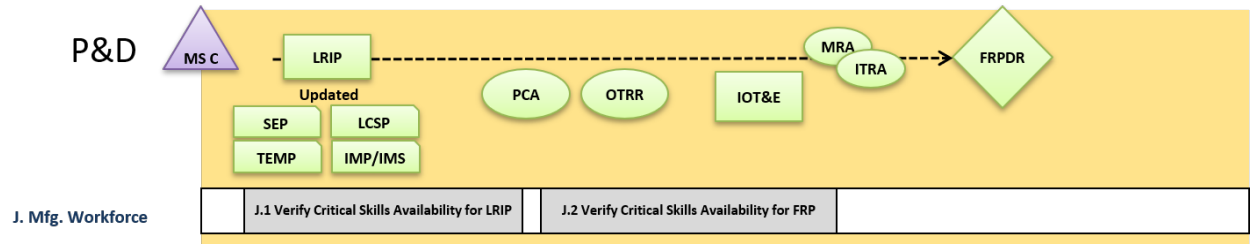


Figure 5-11. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

In developing a Workforce plan, the contractor needs to consider the number of personnel needed, the specific skills of the personnel, the phasing of the requirements, and the ability of the organization to add personnel or move personnel. The ability to meet the personnel demands should be a function of the labor pool available within the contractor's organization and the ability of the local area to provide the quantity and types of people required which may include technical schools and other sources of trained personnel.

There also needs to be a clearly defined profile of the required workforce and a plan for the acquisition and training of new personnel. While on-the-job training (OJT) may be an effective mechanism for providing the required knowledge, its effectiveness is limited. Where the skills involved are relatively complex, there should be some form of formal training and/or certification requirements and a training program provided that manages the process and keeps track of these training and certification accomplishments.

The PMO should review the adequacy of the planned personnel loadings to ensure that adequate numbers of people with the required skills are made available. When a large personnel increase is planned, the sources of those personnel should be identified early, trained, and certified prior to the execution of the planned increased and then monitored after the ramp-up has occurred.

The Program Management Office (PMO) should identify remaining risks prior to the production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Manufacturing Readiness Assessments, Industrial Capabilities Assessments, trade-off studies, tooling plans, make- or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or manage remaining risks. Provide an assessment of manufacturing processes, including critical skills availability, and highlight the steps needed to progress from an EMD manufacturing environment to an LRIP environment and to an FRP environment.

J.1. Verify Critical Skills Availability for LRIP

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on an ongoing basis. Two major focus areas are:

- Workforce skills availability
- Workforce skills capability (training and skills)

Manpower skills availability and capability should have been assessed prior to the Milestone C decision, and now that the program is ramping up production for LRIP, then manpower needs to be assessed to ensure that there is enough capability to meet the demands of LRIP.

Manufacturing and Quality Tasks

- Identify LRIP/FRP manufacturing workforce resource requirements.
- Ensure required workforce availability forecast by monthly requirement against the LRIP/FRP schedule.
- Ensure workforce training requirements forecast against the LRIP/FRP schedule.
- Review any union agreements to ensure workforce/schedule compatibility.
- Update plans to achieve LRIP workforce requirements.
- Update plans to achieve FRP workforce requirements.
- Train and certify workforce to meet LRIP and FRP requirements.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Workforce thread
- Learning Curve Calculator (Estimator)
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Systems
- AS9100, Quality Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide

J.2. Verify Critical Skills Availability for FRP

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on an ongoing basis. Two major focus areas are:

- Workforce skills availability
- Workforce skills capability

Manpower skills availability and capability should have been assessed during LRIP and an assessment made on the needs for ramping up production to FRP. Now that the program is in FRP, manpower needs to be assessed to ensure that there is enough capability to meet the demands of FRP.

Manufacturing and Quality Tasks

- Identify manufacturing workforce resource requirements for FRP:
    - Required workforce availability forecast by monthly requirement against the FRP schedule
    - Required workforce training requirements forecast against the FRP schedule
    - Union agreements must be reviewed to ensure workforce/schedule compatibility
- Develop workforce plans to achieve FRP requirements.
- Update workforce plans to achieve FRP workforce requirements.
- Ensure FRP personnel are trained on LRIP line.
- Ensure FRP personnel requirements are met.
- Implement a plan to achieve FRP workforce requirements.
- Ensure production workforce skill sets been maintained based on attrition of workforce.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Workforce thread
- Learning Curve Calculator (Estimator)
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis
- Work Measurement Analysis

- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Systems
- AS9100, Quality Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide

K. FACILITIES

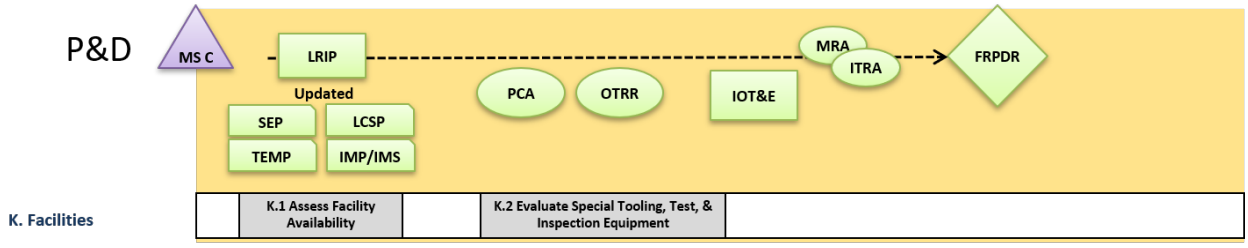


Figure 5-12. Facilities Manufacturing and Quality Activities

Introduction

Facilities management encompasses a variety of professional skills that focus on the design, construction, management, of an installation to include plant and equipment. Life cycle management includes all permanent and semipermanent real property required to support a system throughout the systems life cycle. Facility management includes studies of facility requirements to include location, environmental and security considerations, and maintenance of such property through disposal.

Industrial capability refers to all the production resources that may be required to produce an end item. This includes the 5Ms (manpower, machines, material, methods, and measurement), as well as the actual buildings that support production. Capacity is normally constrained by physical facilities, available productive equipment, tooling, and/or test equipment. In addition, special tooling, special test equipment, and special inspection equipment are often found to be a restrictor on achieving rate production. Facilities and Special Tooling need additional attention as production ramps up to LRIP and then to FRP.

Manufacturing planning begins early in acquisition and is continuously updated throughout the life of the program. Among the critical considerations that must be addressed are the manufacturing processes that will be used to build the system. The sequence of manufacturing processes begins with the receipt of the raw material, where special handling and storage may be required. Additional processes requirements may include such items as cleaning, heat treatment, clean room controls, controlled

testing, and special handling (i.e., personal grounding requirements for electronic components). Identification of all processes must be a part of the design documentation.

Where the selected processes contribute manufacturing risk to the program, the processes should be proofed during EMD. The purpose of proofing is to ensure that the process can repeatedly produce conforming hardware within the cost and time constraints of the production phase. It is important that the proofing be accomplished in an environment that simulates actual production conditions (typically a pilot line environment). These conditions include the physical facilities, personnel, and manufacturing documentation. It may also be necessary for the contractor to establish training and certification programs for the shop personnel to ensure that the process capabilities can be attained on a recurring basis.

One of the most important elements of any production design is the definition of the manufacturing resources. No matter how good a design may be, it is useless if the system or product cannot be built. It is therefore essential that availability of manufacturing resources be a consideration during the design review process. Manufacturing engineers should be a part of each design team to ensure adequate consideration of availability of required manufacturing resources.

Manufacturing resources should not be limited to manufacturing methods but should include materials, capital, manufacturing technology, facilities, qualified labor, and the management structure to effectively integrate them. The successful competitor of the production phase will depend upon the efficient application of the full spectrum of these resources to the task of fabricating and delivering the defense system design.

Special tooling and test equipment required for a program can be expensive and take a long time to develop and procure. The general guidelines for planning for tooling and test equipment need to be established and established early. The issues include contractor investment, the level of rate tooling and test equipment to be used, the transition from limited life to rate tools and the degree of similarity between production test equipment and depot test equipment to be required. Also, guidelines for calibrating and maintaining tools and test equipment need to be set forth.

K.1. Assess Facility Availability

Manufacturing facilities assessment includes an analysis of the capabilities, capacity, and availability of the key production facilities to include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities to determine if these facilities can meet the requirements of the contract. Anywhere where production may occur. This assessment is looking at the capabilities and capacity for the Pilot Line and preparations for ramping up production during LRIP.

Manufacturing and Quality Tasks

- Identify facility requirements for LRIP and FRP.

- Identify floor plan, layout, and workflow for the following:
  - Receiving and Inspection
  - Kitting
  - Fabrication and Assembly
  - In-process inspection and Test
  - Final Inspection and Shipping
- Assess machine/process availability.
- Assess machine/process floor space requirements (including feeding/storage/WIP/maintenance requirements).
- Assess surge capability/requirements.
- Assess pilot line to LRIP production ramp-up requirements.
- Assess LRIP to FRP production ramp-up requirements.
- Assess tooling/special tooling/special test equipment requirements.
- Assess soft/limited and hard/durable tooling needs.
- Assess the following against the schedule to ensure they will meet the program's needs:
  - Facilities and capability demonstrated to fulfill LRIP/FRP requirements
  - Manufacturing facilities identified and plans developed to produce LRIP build
    - Receiving and Inspection
    - Kitting
    - Fabrication and Assembly
    - In-process Inspection and Test
    - Final Inspection and Shipping
  - Manufacturing facilities adequate to begin LRIP
  - All tooling, test and inspection equipment proven in LRIP and requirements identified for FRP
  - Manufacturing equipment maintenance schedule demonstrated
  - Plans in place to support transition to FRP
  - Production facilities in place and capacity demonstrated to meet FRP requirements
  - Facilities are flexible enough to accommodate growth or surge
  - Facilities investments have factored in the impact of government changes in inventory objectives (e.g., lower rates)
  - Contingency planning is considered in the manufacturing facility planning effort
  - Production facilities physical layout has been assessed and validated including the flow of material, components, and product

Tools

- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist

- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Systems
- DCMA-INST-204, Manufacturing and Production
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

K.2. Evaluate Special Tooling, Test, and Inspection Equipment

Manufacturing and Quality Tasks

- Evaluate all documentation used to manage and account for Tooling, Special Tooling (ST), and Special Test Equipment (STE), which may include the following items:
    - Limited/Soft Tooling
    - Durable/Hard Tooling
    - ST/STE needed for development and manufacture only
    - ST/STE having possible mission support utility
    - Already available government assets
- Ensure processes for qualification of special tooling is adequate and operating effectively.
- Demonstrate and prove all tooling, test, and inspection equipment can support LRIP.
- Ensure that all tooling, test, and inspection equipment is in place to support maximum FRP.
- Ensure that adequate production test infrastructure, resources, and facilities are available.
- Assess and manage planned equipment maintenance to ensure maximum overall equipment effectiveness (OEE).
- Ensure that design and development of production tooling and STE/special inspection equipment (SIE) must be underway and can support LRIP/FRP.
- Develop, demonstrate, and manage a manufacturing equipment maintenance strategy to support both LRIP and FRP.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist

- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Material Requirements Planning
- Plant Design and Facility Layout Software Evaluation Tools
- Rough Cut Capacity Planning Spreadsheet

Resources

- AS6500, Manufacturing Management System
- DCMA-INST-204, Manufacturing and Production
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- FAR Part 2, §2.101 Definitions
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

L. MANUFACTURING MANAGEMENT/CONTROL

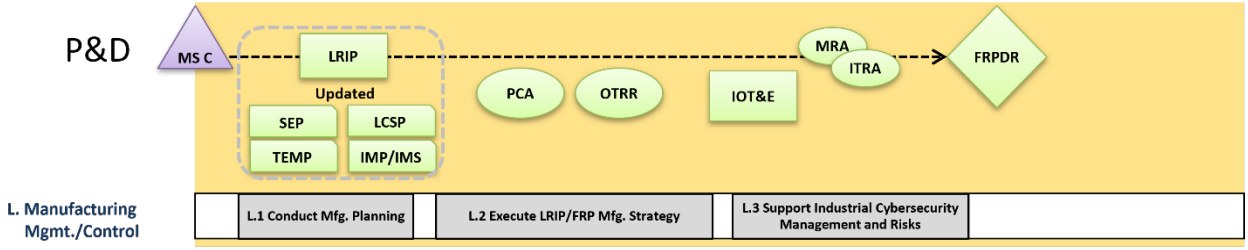


Figure 5-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

Manufacturing involves the process of transforming raw materials into finished products. This transformation is accomplished using contractor resources, which can include basic raw materials, to expensive facilities, human skills, machines, and capital investments. The purpose of manufacturing planning is the identification of these resources and their integration into a structure that provides the capability to achieve production objectives. This is especially true as the program ramps up production from the pilot line, to LRIP and then to FRP.

Manufacturing planning is primarily a contractor function though there are some DoD organizations that do accomplish manufacturing tasks and as such must plan for those activities. Planning is a complex task that includes long-range plans, medium-range plans, and short-range plans.

- Long-range manufacturing or production plans (2-5 years) takes into consideration Corporate Strategic Plans and long-range business forecasts to leverage core capabilities in the achievement of corporate goals.
- Medium-range manufacturing plans (6-18 months), sometimes referred to as the Master Production Scheduling (MPS), breaks down a business plan and aggregate production plan into product plans or families of products.
- Short-range manufacturing plans are the day-to-day plans and activities. This could include capacity planning and scheduling; materials requirements planning; production planning which includes detailed workflow analysis from procurement to receiving through fabrication; sub-assembly; assembly; inspection/test; and packaging and shipping.

Planning is carried out to ensure that activities and resources are coordinated over time to achieve production goals. Planning must be done so the progress of the plan can be monitored at regular intervals and control over operations can be maintained. Planning in the manufacturing environment involves many elements: scheduling, labor planning, equipment planning, process planning, materials planning, quality planning, and cost planning.

- Scheduling involves specifying the start, duration, and sequencing of operations.
- Labor planning involves the training and allocation of qualified personnel, distribution of responsibilities and resources.
- Equipment planning involves identification, purchasing, installation, and proofing.
- Process planning involves the identification, maturing, and continuous improvement of processes, especially key and critical processes, so that cost and performance are managed.
- Materials planning involves identifying and coordinating the supply chain and at a minimum should include key and critical suppliers and vendors.
- Quality planning involves the identification of methods to manage product quality (measurement) and the purchasing and proofing of inspection equipment.

Detailed Manufacturing Plans are often reflected in the use of an MRP II system and includes the ability to create:

- Rough Cut Capacity Plan
- Capacity Requirements Plan
- Production Schedule
- Labor Reports
- Quality Reports
- Cost Reports

SAE's AS6500 requires a manufacturing management system to be documented. The contractor should be able to provide examples of the analyses, work instructions, process control plans, and metrics that are required by AS6500. Government personnel can examine these products to determine if the processes and procedures are being implemented in accordance with the standard.

Work instructions are a basic manufacturing tool, developed to assist a worker in accomplishing a task. A work instruction details the sequence of steps that an employee must follow every time they perform a task. The work instruction organizes the work into logical steps so that an employee can easily follow it independently. Planning for this phase includes the planning for LRIP and the transition from LRIP to FRP, and then FRP demonstration.

L.1. Conduct Manufacturing Planning

Manufacturing planning is about understanding everything it takes to produce all the items required by the contract, on time, on budget, and with the right performance features. It includes considerations of all the 5Ms, at the prime contractor and throughout the supply chain. It is also concerned with contingency planning for surge and slow-down environments.

Manufacturing and Quality Tasks

- Update manufacturing planning for FRP and ensure the planning covers the following items:
    - Ensure that all the information necessary to plan the detailed manufacturing operations for the system should be available to the contractor
    - Ensure that this information described in a contractor's manufacturing plan covers:
        - Manufacturing organization including who is responsible, organization charts, points of contact.
        - Manufacturing Management System including how materials and parts are ordered, structure order for parts and components, and track a project to produce the end item.
        - How all manufacturing risks are being tracked and mitigated.
    - Ensure that the Manufacturing Management Program describing manufacturing strategy includes:
        - Program manufacturing time-phased schedule,
        - Manpower Plan,
        - Industrial facilities capacity assessment,
        - Surge and Mobilization capacity assessment,
        - Manufacturing risk assessment,
        - Capital investment commitment,
    - Ensure that the Manufacturing Program Planning including:
        - Producibility Program Plan,
        - Make-or-Buy Criteria including considerations used in making decisions
    - Ensure the conservation of critical/strategic materials
    - Ensure the reduction of critical components and parts (reducing foreign dependency)
    - Ensure that there is the capacity to support normal production needs, surge, mobilization
    - Ensure risk reduction efforts are ongoing

- Ensure that there is a second sourcing of critical components including critical safety items as appropriate
- Ensure the standardization of components and parts
- Ensure that there is a trade-off analyses that documents and provides an optimized solution that is the basis for the production planning effort
    - The analyses are based on established modeling tools and factor in the current capabilities and experience of the contractor
    - Cost optimization is a significant factor
    - The production plan provides for scheduled and unscheduled maintenance with little disruption to the production schedule
- Ensure subcontractor/Supplier Management includes:
    - List of proposed major/critical subs and suppliers including products
    - Locations
    - Make/Buy decisions and BOM complete to support FRP
- Ensure that the Make/Buy decisions are consistent with contractor policy and reflect a rationale that meets the planned schedule and offers the best value to the government.
    - Data used to determine supplier capacity and capability to meet program needs
    - Data used to support second sourcing decisions and to define supplier risk
    - Supplier management methodology/process/tracking
- Ensure that Manufacturing Methods and Production Flow includes:
    - Advanced or unique manufacturing technology required to produce components or end items including tools and processes requiring proofing or demonstration to minimize high risk or critical operations
    - Effective production control system in place to support FRP
    - Production flow utilizing a “goes-into” chart, tree chart, to portray the planned process of fabrication and assembly in terms of key operational points; this includes lead times from procurement of raw material to delivery of product
    - The acquisition of production tooling and equipment is based on a schedule that represents reasonable acquisition lead times, installation and setup, training, etc., that is coordinated with the overall schedule and presents contingency plans that address any schedule risks
    - Identify production, test, or inspection stations which have bottleneck potential and identify corrective action
    - Plant flow of major in-plant manufacturing operations including operation, equipment, and location
    - Identify expected process yields for each process and indicate statistical or other method used to maintain control

- During LRIP or Production obtain and evaluate processes using process control system
- A detailed allocation of production space and equipment is described, along with the factors used in developing the plan
- The status of design and acquisition of production equipment is tracked in the schedule; equipment cost, efficiency, and availability are reflected in the planning process

- Ensure that the Tooling, ST, and STE program verifies procedures for ensuring functional compliance and calibration of all tooling and test equipment
- Ensure that a Productivity Improvement program is reducing manufacturing risks and the risks are being mitigated
- Ensure that Industrial Materials Management includes:
  - Critical forms and parts
  - Strategic and critical materials
  - Diminishing Manufacturing Sources and Materials Shortages
  - Material planning systems proven in LRIP and enough for FRP.
  - Requests for Special Priorities Assistance
  - Scrap management and reclamation
  - Material planning systems validated on FRP build
- Ensure that Manufacturing Management Data includes:
  - Cost of work scheduled, cost of work performed, and the actual cost of work performed in hours
  - Cause, corrective action, and means of follow-up to attain planned performance
- Ensure that manufacturing audits including checklists and other criteria used by the prime to conduct audits of the contractor and supplier operations
  - Include audit summaries and corrective actions
- Ensure a review and assessment of Labor Relations includes:
  - Location of facilities performing program work
  - Each union representing workers at the facility locations, type, and number of workers
  - Expiration date of union’s labor management agreement.
  - History of last 3 negotiations
- Ensure that the Facility plan describes:
  - All GFP required and specific need dates.
  - Components supplied by each facility location
  - Contingency plan listing possible alternate suppliers

- Ensure the contractor has procedures for management of company and GFI assets that support the needs of the program
- Ensure that contractor management control systems, including those for configuration management and the control of subcontractors and manufacturing performance evaluation are evaluated for risks
- Ensure that contractor assets and government-owned resources are identified and are supported by the confirmed availability of the resources. Resource sharing between programs is on a non-competing basis
    - The plan should also include industrial preparedness planning, including surge capability during the production phase and the postproduction phase requirements for support to employment of the system in combat situations

Tools

- Acquisition Strategy Template
- AS6500, Assessment
- Interactive MRL Users Guide (Checklist), Management/Control thread
- Manufacturing Maturation Plan

Resources

- Acquisition Plan Preparation Guide
- AS6500, Manufacturing Management System
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- IEEE 15288, Systems and Software Engineering
- MIL-HDBK-896, Manufacturing Management Program Guide,
- Manufacturing Readiness Level (MRL) Deskbook
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- Service-specific policies and regulations (i.e., AFI 63-145)

L.2. Execute LRIP/FRP Manufacturing Strategy

Developing a manufacturing plan is the first half of a great challenge. Now M&Q managers need to execute the plan. This requires constant management attention as production and deployment could

last for many years, and along the way change will happen. There may be a change in the design due to upgrade opportunities, there will probably be a change in the 5Ms as manpower changes due to retirement and personnel changes, there may be a change to material as subcontractors and vendors change. Risks and opportunities are constantly evolving, and M&Q managers need to be on top of these changes.

Manufacturing and Quality Tasks

- Develop Manufacturing Plans to support LRIP Manufacturing Strategy and risk reduction efforts.
- Develop Manufacturing Plans to support FRP Manufacturing Strategy and risk reduction efforts.
- Update the LRIP Manufacturing Plans needs to incorporate actual production results.
- Update the FRP Manufacturing Plans needs to incorporate LRIP actual results.
- Ensure that manufacturing planning is include in the Initial Manufacturing Planning Strategy.
- Identify and assess manufacturing risks and develop approved mitigation plans in place.
- Integrate manufacturing risks into risk mitigation plans.
- Track and mitigate manufacturing risks for LRIP.
- Track and mitigate manufacturing risks for FRP.
- Ensure that production control systems are in place to support LRIP.
- Ensure that production control systems are in place to support FRP.
- Ensure material planning systems are in place and proven to support LRIP build.
- Ensure material planning systems are in place and proven to support FRP build.
- Complete Make/Buy decisions and develop a BOM to support LRIP.
- Complete Make/Buy decisions and develop a BOM to support FRP.
- Finalize production work instructions:
    - Labor standards should be developed and are considered a key aspect of production planning and important in workforce projection. These standards also are considered when planning facilities and equipment to ensure efficient utilization rates and overall productivity of the workforce.
- Develop LRIP work instructions and validate with actual experience.
- Develop FRP work instructions and validate with actual experience.
- Ensure that the Manufacturing Strategy addresses production and rate issues such as process capabilities and proofing, factory layout, availability of tooling, lead-times, etc.

Tools

- AS6500, Manufacturing Management Program Assessment
- Interactive MRL Users Guide (Checklist), Management, Control thread
- Manufacturing Maturation Plan

- Material Management and Accounting System Audit

Resources

- AS6500, Manufacturing Management Program
- DFAR 242.72, Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

L.3 Support Industrial Cybersecurity Management and Risk Assessment

Industrial cybersecurity is concerned with the ability of organizations to share information digitally (government to industry, prime contractor to subs, labs to program offices, etc.). While the sharing of information is critical, it is equally important to do so in a safe and secure environment. Industrial cybersecurity is concerned with the transfer of digital data via Operational Technologies (OT) inside a facility and through the cloud to other organizations and facilities.

NIST standard NIST SP 800-37, 'Risk Management Framework for Information Systems and Organizations' defines Operational Technology as:

> *Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems/devices detect or cause a direct change through the monitoring and/or control of devices, processes, and events. Examples include industrial control systems, building management systems, fire control systems, and physical access control mechanisms.*

There are three main types of operational technologies of concern:

- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution system (MES) support the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers
- Enterprise resource planning (ERP) system supports functional management resources within an enterprise, and control process performance.
- These data systems are often digital and shared across multiple functions and organizations.

DFARS 252.204-7012 requires contractors to follow NIST SP 800-171 and to:

- Provide adequate security to safeguard covered defense information that resides on or is transiting through a contractor's internal information system or network
- Report cyber incidents that affect a covered contractor information system or the covered defense information residing therein

- Submit malicious software discovered and isolated in connection with a reported cyber incident to the DoD Cyber Crime Center
- Submit media/information as requested to support damage assessment activities
- Flow down the contract clause in subcontracts for operationally critical support, or for which subcontract performance will involve covered defense information

Manufacturing, as an industry, is the most targeted industry for cyber-attacks. DoD policy and best business practices require that data be protected from attack. This includes classified data, controlled unclassified data (CUI), personal data, financial data, etc.

This thread (Industrial Cybersecurity) requires an analysis of the risk that the manufacturing environment may not be able to protect digital and other forms of data from cyber risks and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Identification of Cybersecurity Risks
- Cybersecurity Planning and Management (Execution)

M&Q personnel need to identify and manage Industrial Cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the AAF.

M&Q personnel need to develop and execute Industrial Cybersecurity planning for system concepts identified and execute the management of those plans. Programs will employ system security engineering methods and practices, including cybersecurity, cyber resilience, and cyber survivability in design, test, manufacture, and sustainment. Such methods and practices will ensure that systems function as intended, mitigating risks associated with known and exploitable vulnerabilities to provide a level of assurance commensurate with technology, program, system, and mission objectives.

Manufacturing and Quality Tasks

- Assess supply chain OT cybersecurity and vulnerability risks, and develop risk management plans
- Implement supply chain OT cybersecurity and vulnerability risk mitigation plans
- Demonstrate OT cybersecurity solutions in an LRIP environment
- Demonstrate OT cybersecurity solutions in an FRP environment
- Assess the design of OT systems for facilities and equipment (i.e., in-house factory systems, production equipment, STE/SIE, and tooling) to ensure they include cybersecurity and physical/digital controls and access requirements
- Plan for and document that LRIP facilities and equipment OT systems include cybersecurity and physical/digital controls, and access requirements
- Identify and assess OT cyber incidents throughout the supply chain

- Ensure that OT cybersecurity Incident Reporting procedures are in-place, including reporting, tracking, and corrective actions
- Train the workforce in current cybersecurity procedures for production environment

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (DAU)
- Cybersecurity Strategy ADDM Template
- Interactive MRL Users Guide (Checklist), Cybersecurity thread
- USMC Cybersecurity Management Checklist

Resources

- FAR 52.202.21 Basic Safeguarding of Covered Contractor Information Systems
- DFAR 252.7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.83 Technology and Program Protection
- DoDI 8500.01 Cybersecurity
- DoDI 5000.90 Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoD 5220.22-M National Industrial Security Program
- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle
- NIST SP 800-171 Protecting Controlled Unclassified Information in Nonfederal Systems and Organization
- NIST Special Publication 800-82 Guide to Industrial Control Systems (ICS) Security

Department of Defense
Manufacturing and Quality Body of Knowledge
(M&Q BoK)

Chapter 6
Operations and Support (O&S) Phase

November 2022
Version 1.1

Office of the Under Secretary of Defense
Research and Engineering

Washington, D.C.

Approved for public release.

The appearance of external hyperlinks does not constitute endorsement by the United States Department of Defense (DoD) of the linked websites, or the information, products, or services contained therein. The DoD does not exercise any editorial, security, or other control over the information you may find at these locations.

Department of Defense Manufacturing and Quality Body of Knowledge (M&Q BoK)

Office of the Under Secretary of Defense for Research and Engineering
Executive Director, Systems Engineering and Architecture 3030 Defense Pentagon
Washington, DC 20301-3030
Email: osd.r-e.comm@mail.mil | Attention: SE&A
https://ac.cto.mil/engineering

Approved for public release. DOPSR Case # 23-S-0359.

Contents

Figures

This page is intentionally blank.

Introduction: How to Use the M&Q BoK

The Department of Defense (DoD) Manufacturing and Quality (M&Q) Body of Knowledge (BoK) is a compilation of best practices and lessons learned for completing M&Q activities across the DoD system acquisition life cycle. The office of the Executive Director, Systems Engineering and Architecture (ED, SE&A) prepared the BoK and will update the work periodically to reflect current policy, guidance, tools, and best practices. This document does not supersede DoD policy, guidance, or law.

The BoK details M&Q activities throughout the system life cycle but is not intended to be read from end to end. DoD Engineering and Technical Management (ETM) practitioners and managers may refer to the BoK to find information relevant to the phase of the program they are working on. Within a specific phase, the user may focus on the section and tasks that apply (with appropriate tailoring) for the M&Q activities the program is conducting.

The BoK chapters cover recommended M&Q activities and tasks during each acquisition life cycle phase to meet DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework.

The BoK includes 6 chapters:

- Chapter 1: Pre-Materiel Development Decision (Pre-MDD)
- Chapter 2: Materiel Solution Analysis (MSA)
- Chapter 3: Technology Maturation and Risk Reduction (TMRR)
- Chapter 4: Engineering and Manufacturing Development (EMD)
- Chapter 5: Production and Deployment (P&D)
- Chapter 6: Operations and Support (O&S)

Each chapter focuses on the DoDI 5000.02 activities and program documentation required for that phase. Each chapter uses the following format:

- **Introduction:** Discusses the objectives of that phase to allow the user to understand the environment and requirements.
- **Manufacturing and Quality Objectives:** Discusses roles, goals, and objectives of program M&Q during this phase.
- **Threads:** Twelve threads or topic areas include discussions of major M&Q functions based on the "5 Ms" (Manpower, Machines, Materials, Methods, Measurement); Manufacturing Readiness Level (MRL) criteria; and DoD-unique M&Q-related functions not found in industry (i.e., DoD acquisition system, defense contracting system, and surveillance system). The 12 threads are labeled with letters A through L as follows:

  A. DoD Acquisition System
  B. Defense Contracting System
  C. Surveillance System
  D. Technology and Industrial Base

E. Design
F. Cost and Funding
G. Materials Management
H. Process Capability and Control
I. Quality Management
J. Manufacturing Workforce
K. Facilities
L. Manufacturing Management and Control

Each thread includes several **Activities** represented by gray boxes in the corresponding chapter figure (Figure 1). Activities are numbered A.1, A.2, A.3 . . . B.1, B.2, B.3, etc. The BoK includes the following for each activity:

- Activity overview description
- **Tasks** that M&Q personnel could be expected to support or lead.
- **Tools** such as checklists, templates, and samples available to M&Q personnel intended to help them to accomplish these tasks.
- **Resources** including guidance documents, handbooks, manuals, instructions, memos, etc., that provide direction to M&Q personnel for tasks identified in the gray box.

Example: Figure 1 shows Threads, Documents, Activities, and Reviews for the EMD Phase.

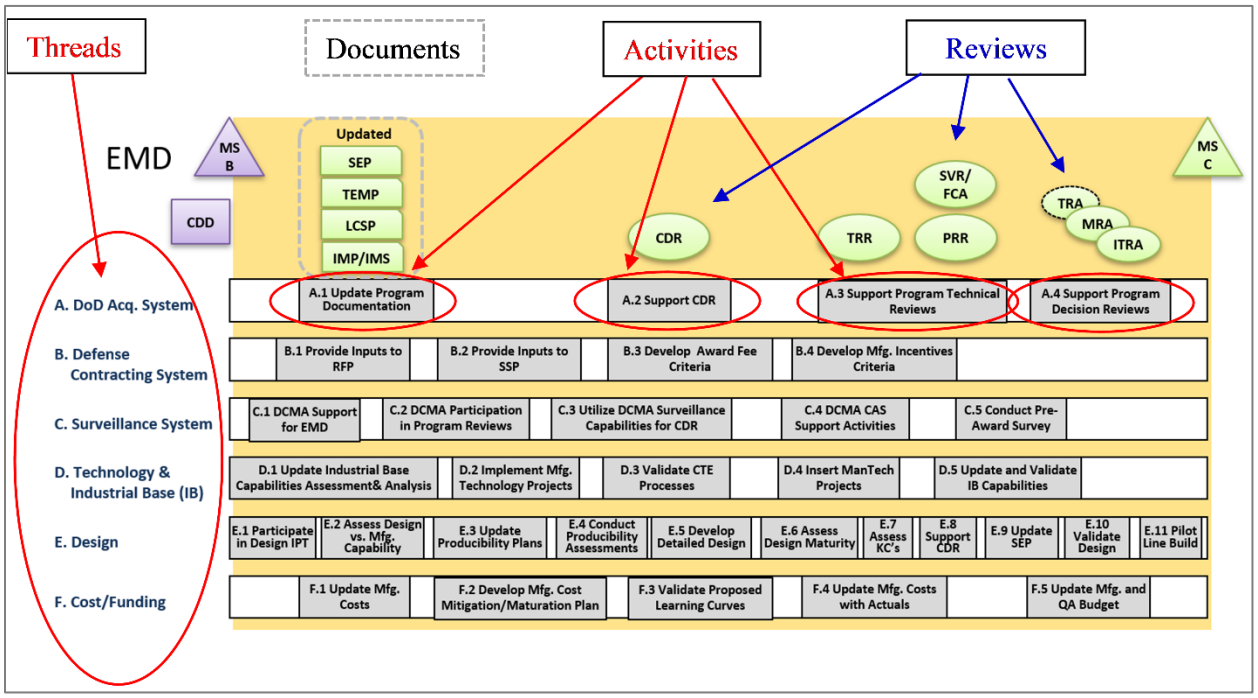
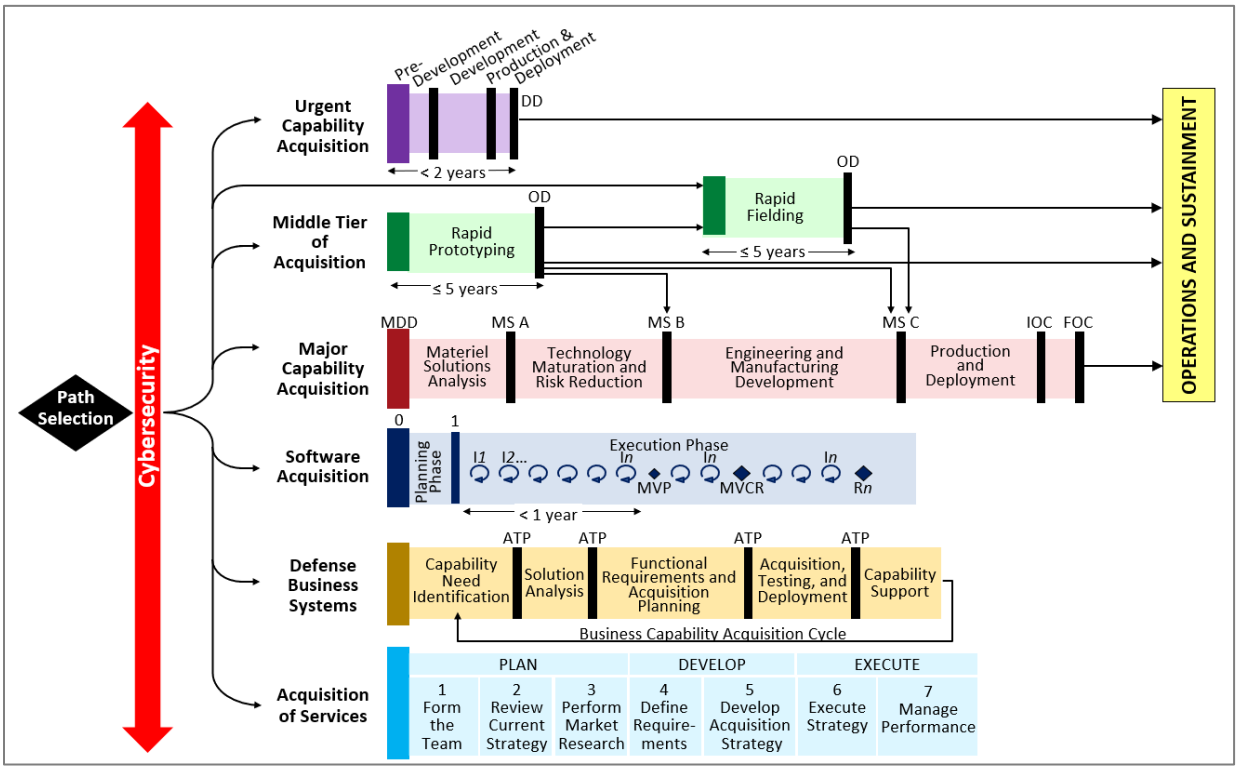


Figure 1. Sample Activity Chart

Adaptive Acquisition Framework (www.aaf.dau.edu)

This BoK follows DoDI 5000.02, Operation of the Adaptive Acquisition Framework (AAF), and for the most part will describe M&Q activities for the path labeled Major Capability Acquisition (MCA). This path includes a comprehensive and systematic approach for applying M&Q best practices; however, the M&Q BoK best practices are applicable to the alternative AAF pathways as well. AAF pathways are depicted in Figure 2.



Source: DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework, January 23, 2020

Figure 2. Adaptive Acquisition Framework Paths

For example, under the AAF, a program may have an Urgent Capability Acquisition (UCA) and may have less than 2 years to provide a solution to the Warfighter, or the program may be involved in a Middle Tier of Acquisition (MTA) approach focused on rapid prototyping or rapid fielding. If so, users can see how these efforts are aligned with the MCA process in Figure 2 and use those BoK chapters to identify and accomplish required tasks and activities.

In addition to DoDI 5000.02, the following associated policies provide information for the paths:

- DoD Instruction 5000.74, Defense Acquisition of Services
- DoD Instruction 5000.75, Business Systems Requirements and Acquisition
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.85, Major Capability Acquisition

- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation

With any acquisition model, the program office should include M&Q personnel on the technical Integrated Product Team (IPT) and to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

M&Q planning, control, and management activities represent an important and central effort that begins early in the life cycle (Pre-Materiel Development Decision (MDD) and/or Materiel Solution Analysis (MSA) phases) and continues throughout the life of a program though Operations and Support. Although planning is discussed in detail in each chapter, Figure 3 provides key elements of M&Q planning activities in relation to overall program life cycle activities.

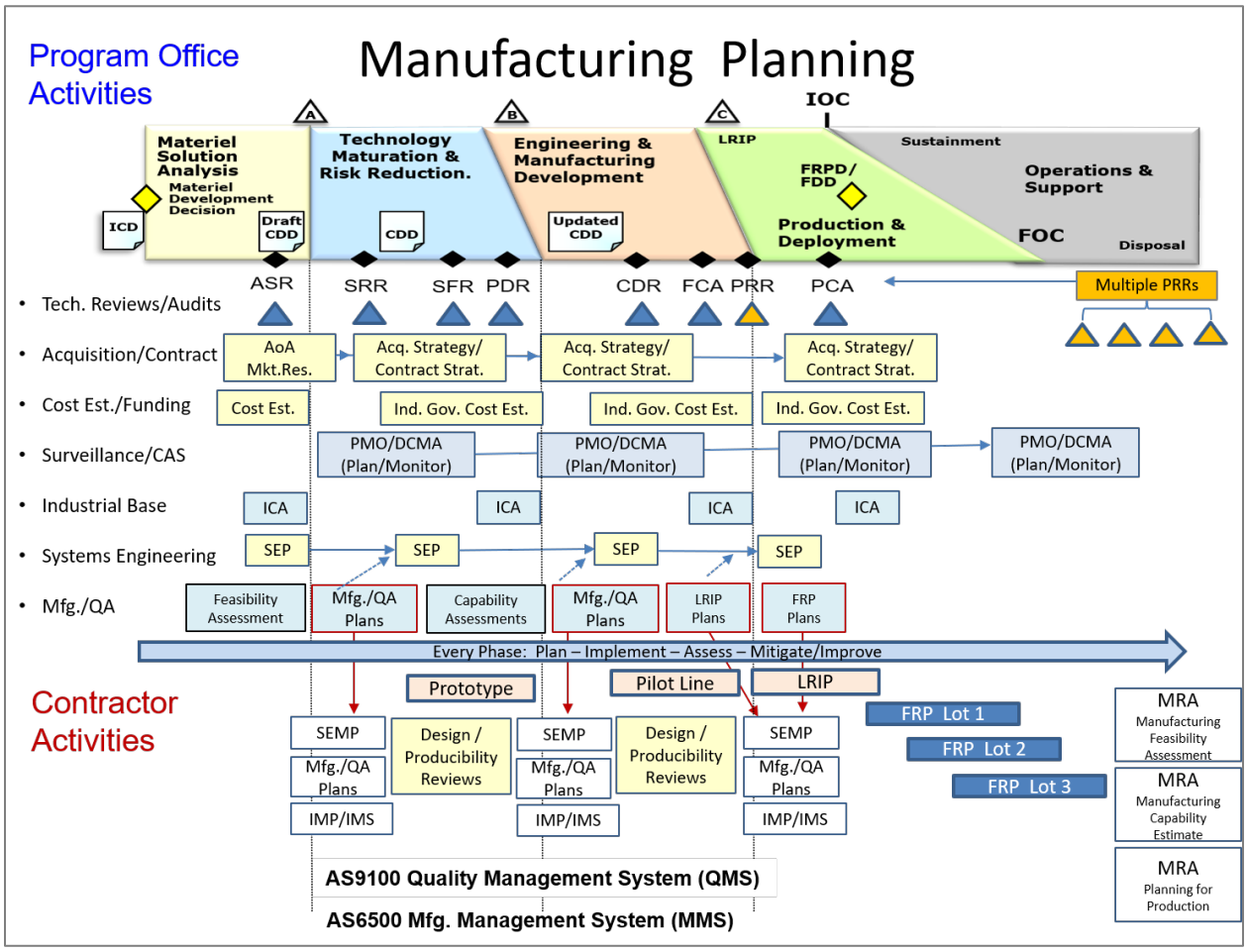


Figure 3. Typical Manufacturing and Quality Planning Activities

Most activities begin with the need to identify requirements, risks, and gaps, followed by planning activities. The top-most planning document is the Acquisition Strategy, and numerous documents feed into the Acquisition Strategy to include the Contracting Strategy and the Systems Engineering Plan (SEP). M&Q strategies should be a component of the SEP. Plans are then evaluated and updated on a recurring basis, usually just before a milestone decision.

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occur. The contractor is responsible for the execution of the program and in planning for success. The government Program Management Office (PMO), along with the Defense Contract Management Agency (DCMA) or other contract surveillance organizations and engineering support activities, is responsible for oversight and management of the acquisition. Risk assessment and mitigation is an ongoing effort that should be conducted throughout the system life cycle. Key references for DoD M&Q planning and management approaches include: MIL-HDBK-896, Manufacturing Management Program Guide; SAE Standard AS6500, Manufacturing Management Program; and Quality Management Systems standards ISO 9100 and/or AS9100. In addition, MRL criteria and assessments are a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

DoD tools and resources are available from many sources. Most should be available through open web-based links, but some may require a ".mil" address or a Common Access Card (CAC), or they may be available only to users in a specific community. Commercial tools and resources should be available to everyone but may require the organization to purchase a user's license/rights (e.g., ISO 9001 Quality Management System industry standard). In many cases, commercial resources and tools have been identified as a best practice. The M&Q BoK lists these tools for reference only; DoD does not necessarily endorse these resources or the publishing organizations. In addition, this document may reference a source for a specific tool (i.e., Pareto Chart), but there may be other widely available sources for this tool or for similar tools.

Sections labeled "Tools and Resources" are provided throughout the document chapters. The following section includes a summary of key references and links by publisher or topic. A more comprehensive list of references is included in Appendix B.

Key Manufacturing and Quality Body of Knowledge References and Resources
Department of Defense (DoD) Issuances, Directives Division https://esd.whs.mil/DD/

- DoD Directive 5000.01, The Defense Acquisition System
- DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.84, Analysis of Alternatives

- DoD Instruction 5000.85, Major Capability Acquisition
- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation
- DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD
- DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD
- DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
- DoD Directive 4400.01E, Defense Production Act Programs
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures

Defense Acquisition University (DAU) www.dau.edu

- DAU Guidebooks and References https://aaf.dau.edu/guidebooks/
- Acquisition Notes (AcqNotes) www.acqnotes.com
- Adaptive Acquisition Framework (AAF) https://aaf.dau.edu
- Analysis of Alternatives (AoA) www.acqnote/acquisitions/analsis-of-alternatives
- Market Research www.acqnotes/acqnote/acquisitions/market-research
- Acquisition Strategy (AS) Process/Guidance https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf
- Systems Engineering Plan (SEP) Outline https://ac.cto.mil/erpo/ (Engineering Guidance tab)
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

Defense Contract Management Agency (DCMA) www.dcma.mil

- DCMA Policies https://www.dcma.mil/Policy/
- DCMA Instructions https://www.dcma.mil/Policy/
- DCMA-INST 204, Manufacturing and Production
- DMCA-INST 205, Program Support
- DMCA-INST 207, Engineering Surveillance
- DMCA-INST 309, Government Contract QA Surveillance Planning
- DCMA-INST 401, Industrial Analysis
- DCMA-INST 3401, Defense Industrial Base Mission Assistance

Defense Federal Acquisition Regulation (DFAR) Supplement https://www.acquisition.gov/dfars

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System

- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS Subpart 242.7200, Contractor Material Management and Accounting

Defense Logistics Agency (DLA) Website www.dla.mil

- DMSMS Guidebook, SD-22 https://www.dsp.dla.mil/Programs/DMSMS
- ASSIST (Database of specifications and standards) https://assist.dla.mil
- ASSIST Quick search https://quicksearch.dla.mil/qsSearch.aspx
- DoD 4140.01, Supply Chain Materiel Management Regulation www.dla.mil

Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
Manufacturing Readiness Levels (MRLs) www.dodmrl.org

- MRL Assessment Criteria Matrix www.dodmrl.org
- Interactive MRL Users Guide (MRL Assessment Criteria) www.dodmrl.org
- MRL Deskbook www.dodmrl.org
- MIL-HDBK-896, Manufacturing Management Program Guide www.dodmrl.org

National Institute of Standards and Technology (NIST) www.nist.gov

- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST Manufacturing https://www.manufacturing.gov

Office of the Director, Cost Assessment and Program Evaluation (CAPE) www.cape.osd.mil
OSD Manufacturing Technology (ManTech) Program Office https://www.dodmantech.mil
OUSD(R&E) Systems Engineering and Architecture (SE&A) https://ac.cto.mil/engineering
Relevant Government Publications (Available via Web/Internet Search)

- DoD 4245.7-M Manual, Transition from Development to Production, 1985
- NAVSO P-3687, Producibility Systems Guidelines, 1999
- MIL-HDBK-766, Design to Cost
- MIL-HDBK-727, Design Guidance for Producibility, 1984

Standards, Specifications, and Standards Organizations

- ASSIST (Defense Logistics Agency Database of Specifications and standards) https://assist.dla.mil
- ASSIST Quick Search https://quicksearch.dla.mil/qsSearch.aspx
- SAE International www.sae.org
- International Organization for Standards (ISO) www.iso.org
- Institute of Electrical and Electronics Engineers (IEEE) www.ieee.org
- *Note:* Many specifications and standards can be accessed at http://everyspec.com/

Technology Readiness Levels (TRLs)

- Technology Readiness Assessment Deskbook www.acqnotes.com
- Technology Readiness Assessment Calculator www.acqnotes.com
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

6. Operations and Support (O&S) Phase

Introduction

During the Operations and Support (O&S) phase, the Department of Defense (DoD) Program Manager (PM) executes the Life Cycle Sustainment Plan (LCSP)/Product Support Strategy to satisfy materiel readiness and provide operational support. The O&S phase includes two major efforts: Sustainment (of operational systems) and Disposal. The LCSP, prepared by the PM and approved by the Milestone Decision Authority, is the basis for the activities conducted during this phase. Following the Production and Deployment (P&D) phase, production operations may shift from the prime contractor to government owned and operated facilities such as depots; arsenals; shipyards; maintenance, repair, and overhaul (MRO) facilities; or other industrial operations. In some cases, system sustainment activities are accomplished at contractor facilities.

Many manufacturing and quality (M&Q) activities in this phase have a logistics focus such as supply, inventory, transportation, or maintenance and repair. This Body of Knowledge (BoK) focuses on DoD program office O&S activities such as management of system upgrades and modification as part of DoD Directive 5000.01, The Defense Acquisition System, as opposed to logistics "shop floor" functions such as Figure 6-1 illustrates typical program office M&Q activities of the O&S phase.

Sustainment

During this phase, the PM will deploy the product support package and monitor its performance according to the LCSP, which may include time-phased transitions between commercial, organic, and partnered product support providers. The PM will ensure the program has appropriate resources; will acquire the necessary intellectual property (IP) deliverables and associated license rights, tools, equipment, and facilities to support each level of maintenance; and will establish necessary organic depot maintenance capability in compliance with statute and the LCSP.

- A successful program meets the sustainment performance requirements, remains affordable, and continues to seek cost reductions by applying should-cost management and other techniques throughout this phase. Doing so requires close coordination with the warfighting sponsor (i.e., user), resource sponsors, and materiel enterprise stakeholders, along with effective management of support arrangements and contracts. During O&S, the PM will measure, assess, and report system readiness using sustainment metrics and will implement corrective actions for trends diverging from the required performance outcomes defined in the Acquisition Program Baseline (APB) and LCSP.
- Over the system life cycle, operational needs, technology advances, evolving threats, process improvements, fiscal constraints, plans for follow-on systems, or a combination of these influences and others may warrant revisions to the LCSP. When revising the LCSP, the PM will revalidate the supportability analyses and review the most current product support requirements, senior leader guidance, and fiscal assumptions to evaluate product support changes or alternatives and determine best value.

Disposal/Demilitarization (DeMil)

- The O&S phase ends when the program is at the end of its useful life. The system will be demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment.

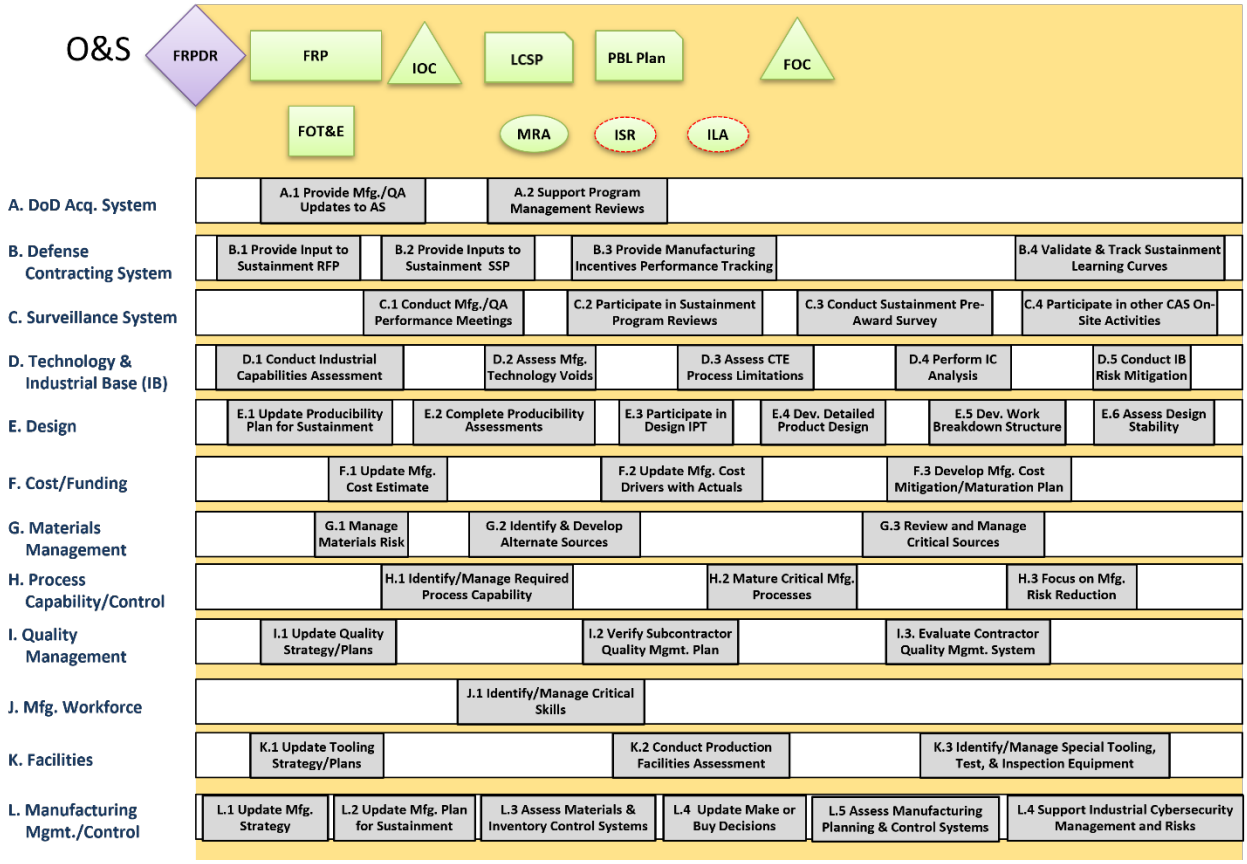


Figure 6-1. O&S Phase Manufacturing and Quality Activities

Key Program Phase Reviews, Documentation, and Activities

The O&S phase begins after the Production and Deployment milestone decision supported by the program's LCSP. Life cycle sustainment planning begins as early as the Materiel Solution Analysis (MSA) phase and is updated in every phase all the way through the O&S phase. The LCSP helps the PM develop a complete and detailed product support package, resulting in product support arrangements. The package consists of product support elements needed to achieve sustainment requirements and the set of arrangements that programs establish with organic and commercial sustainment providers. The backbone of the product support package is the Integrated Product Support (IPS) Elements as detailed in the IPS Element Guidebook. These 12 elements can be grouped into three areas that cover the full range of life cycle functions:

- Life cycle management
  - Product Support Management
  - Supply Support
  - Packing, Handling, Storage, and Transportation (PHST)
  - Maintenance Planning and Management
- Technical management
  - Design Interface
  - Sustaining Engineering
  - Technical Data
  - Computer Resources
- Infrastructure management
  - Support Equipment
  - Training and Training Support
  - Manpower and Personnel
  - Facilities and Infrastructure

A major focus during the sustainment effort of the O&S phase is identifying root causes and resolutions for safety and critical readiness degrading issues. These efforts include participating in trade studies and decision making relative to changes to the product support package, process improvements, modifications, upgrades, and future increments of the system. All these changes need to consider the operational needs and the remaining expected service life, interoperability or technology improvements, parts or manufacturing obsolescence, aging system issues, premature failures, changes in fuel or lubricants, and Joint or Service commonality.

- Key Program Documentation
  - System Safety Analysis (MIL-STD-882E)
  - Programmatic Environmental, Safety and Occupational Health Evaluation (PESHE)
  - National Environmental Policy Act (NEPA) and NEPA Compliance Schedule
  - Systems Engineering Plan (SEP)
  - Life Cycle Sustainment Plan (LCSP)
  - Reliability Centered Maintenance Analysis
  - Requests for Proposals (RFPs)
  - Source Selection Plans (SSPs)
- Key Program Reviews
  - Independent Logistics Assessment (ILA)
  - Manufacturing Readiness Assessment (MRA)
  - In-Service Review (ISR)

Manufacturing and Quality O&S Objectives

During the O&S phase, program offices collect service use data, user feedback, failure reports, and discrepancy reports to assess sustainment performance. The program often will define and execute a series of improvements because of a Preplanned Product Improvement, a value engineering proposal, or modifications/upgrades to meet warfighter needs. When the product is competitive with similar products, these improvements are often driven by the action of competitors. The challenge in this phase is to integrate these changes into the production system with minimal disruption and cost. The changes introduced reflect both improvements in the ability of the product to meet the original design objective and extensions of capability to meet increased performance objectives.

Manufacturing considerations during the O&S phase should include the following:

- Continued production of units being fielded
- Updates/product improvements often tied to block upgrades
- Changes to the supply chain
- Items maturing (Diminishing Manufacturing Sources and Material Shortages (DMSMS)/ Obsolescence/Counterfeit Parts)
- Changes to rate and quantity of items being produced; need to ensure a source of supply
- Items manufactured for spare parts (different configurations)
- Improvements to a contractor's Manufacturing Management System or Quality Management System (QMS)
- Impacts of Continuous Process Improvement (CPI) due to Lean Six Sigma/total ownership cost or other improvement activities
- Environmental considerations (environment, safety, and occupational health (ESOH)/Occupational Safety and Health Administration (OSHA)/National Environmental Policy Act (NEPA) and Programmatic Environmental, Safety and Occupational Evaluation (PESHE)), requirements and risks
- Need to be able to maintain fielded items (data/technical information availability)
- Manage total life cycle costs/affordability (M&Q elements)
- End of life management (demil and disposal)

The O&S phase often overlaps with the P&D phase for many years, since O&S activities begin when the first system is fielded, and production can run for many years after Initial Operational Capability (IOC). O&S ends when a system is demilitarized and disposed of. Manufacturing and QA activities often change as production sometimes moves from a prime contractor to government owned and operated facilities, such as depots and MRO facilities. Key activities during this phase include:

- Continuation of Full-Rate Production (FRP)
- Performance-Based Logistics (PBL) implementation continues
- Updates to the Sustainment contract

- Updates to intelligence/counterintelligence products
- Disposal and demil at the end of its useful life

A. DOD ACQUISITION SYSTEM

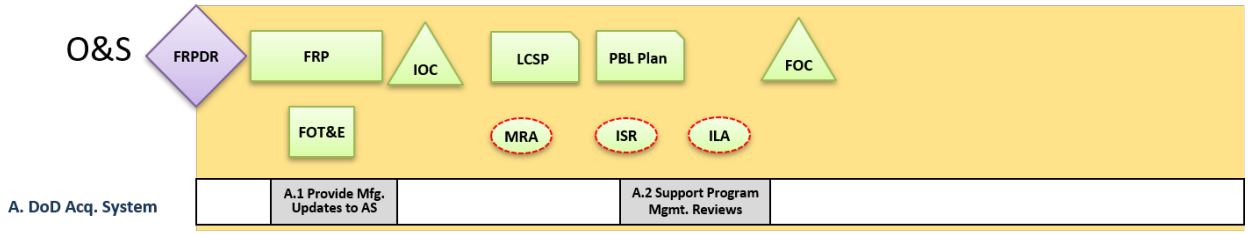


Figure 6-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

Sustainment planning, including the requirements in 10 USC 2337, must be an integral element of the capability requirements and acquisition process from inception. The PM, with the support of the Product Support Manager (PSM), will:

- Develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and will lead to a product support package to achieve and sustain warfighter requirements.
- Initiate system modifications, as necessary, to improve performance and reduce ownership costs, consistent with the limitations prescribed in 10 USC 2244a.
- Begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components, as required by DoDM 4160.28, Defense Demilitarization: Program Administration, with sufficient lead-time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.

The LCSP is updated at each milestone and specified decision points to reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

The PM will integrate the product support design into the overall design process and will assess enablers that improve supportability, such as diagnostics and prognostics, for inclusion in the system performance specification. As the design matures, the PM will ensure that life cycle affordability is a factor in engineering and sustainment trades.

The following information sources provide important inputs to the O&S phase systems engineering process and should contain manufacturing considerations:

- Systems Engineering Plan (SEP)
- Programmatic Environmental, Safety and Occupational Evaluation (PESHE)
- Life Cycle Sustainment Plan (LCSP)

Manufacturing and quality tasks during the O&S phase generally focus on producing spare parts/ subsystems/systems to keep the production articles operating and initiating system modifications to improve performance and reduce ownership costs.

Manufacturing should help develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and leads to a product support package that will achieve and sustain warfighter requirements.

- Manufacturing should begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components with enough lead-time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.
- Manufacturing should initiate/support system modifications, as necessary, to improve performance and reduce ownership costs.
- Manufacturing will also be concerned with several related issues to include:
    - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
    - Obsolescence
    - Counterfeit parts
    - Corrosion prevention and control
- Manufacturing should provide updates that reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

Several technical reviews could occur during this phase:

- Independent Logistics Assessment (ILA)
- Manufacturing Readiness Assessment (MRA)
- In-Service Review (ISR)

The Independent Logistics Assessment (ILA) is a multi-disciplined product and process assessment to ensure that the fielded system is operationally employed with well-understood and managed risk. This review is intended to characterize in-service technical and operational health of the fielded system by providing an assessment of risk, readiness, technical status, and trends in a measurable form that will substantiate in-service support budget priorities. Normally ISRs occur at numerous points in the O&S phase. They are typically initiated before, and in support of, the initiation of the following fiscal year(s) O&S budget requirements determination process.

During the sustainment effort of the O&S phase, systems engineering processes support ISRs including identifying root causes and resolutions for safety and critical readiness degrading issues. This effort includes participating in trade studies and decision making relative to the best resolution (e.g., changes to the product support package, manufacturing process improvements, modifications, upgrades, and future increments of the system), considering the operational needs and the remaining expected service life.

There may be a need to conduct a Manufacturing Readiness Assessment (MRA) to support ongoing risk assessment activities.

Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, joint or Service commonality, etc., may all indicate the need for a system upgrade(s) or process improvements.

- The program should measure, assess, and report manufacturing readiness.
    - The major review during the O&S phase is the ISR
    - During O&S reviews, the manufacturing team should measure, assess, and report manufacturing readiness using metrics and should implement corrective actions for trends diverging from the required performance outcomes
    - The manufacturing team should provide information on quality, manufacturing/ production, engineering, and software-related issues, deficiencies, or risks
- Manufacturing analysis supports the depot source of repair decision and must include detailed requirements for core depot-level maintenance and repair capabilities, and associated sustaining workloads required to support such requirements.

During O&S, the PM will measure, assess, and report system readiness using sustainment metrics and will implement corrective actions for trends diverging from the required performance outcomes defined in the Acquisition Program Baseline and LCSP.

The PM will ensure sustainment factors are fully considered at all key life cycle management decision points, and that appropriate measures are taken to reduce O&S costs by influencing system design early in development, developing sound product support strategies, and addressing key drivers of cost.

The PM should be aware of changing production capability as the transition from production to spare parts provisioning will severely reduce opportunities for future spares procurement if production facilities are changed to accommodate a new product line, material needs change, or new tooling for special purpose machines is installed. If extended production runs did not provide a spare parts inventory, the cost of parts produced later can be significantly higher than the original procurement. Conditions that drive up spare parts prices include:

- Smaller order quantity requirements
- Orders for earlier configuration units that require special documentation

- Parts requiring special purpose tooling
- Unique or scarce material requirements
- Lack of production capability due to several factors: Out of business, discontinued facilities, lack of available production capacity, etc.
- Special handling, packaging, and shipping requirements

A.1 Provide Manufacturing and QA Updates to the Acquisition Strategy

Manufacturing and QA personnel need to be actively engaged in the development and update of numerous documents, to include:

- **Acquisition Strategy (AS)**
  - Product Support Strategy
  - Manufacturing Strategy
  - Quality Strategy
- **Systems Engineering Plan (SEP)**
  - Manufacturing Plan
  - Quality Plan
- Test and Engineering Master Plan (TEMP)
- Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
- Life Cycle Sustainment Plan (LCSP)
- Capability Development Document (CDD)
- Requests for Proposals (RFP)
- Source Selection Plan (SSP)

PMs should develop a Systems Engineering Plan (SEP) for Milestone Decision Authority approval in conjunction with each milestone review and integrated with the Acquisition Strategy. This plan should describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It should also detail the timing, conduct, and success criteria of technical reviews.

Manufacturing and Quality Tasks

- Support updates to the Acquisition Strategy and other program documentation, as necessary.
- Support the development and implementation of the Product Support Strategy (PSS) as detailed in the 12 step Product Support Model
- Ensure M&Q inputs for the O&S phase documents and activities evolve from the P&D phase to include:
  - Manufacturing Strategy and Plan
  - Quality Strategy and Plan
  - Test and Engineering Master Plan (TEMP)

  - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
  - Life Cycle Sustainment Plan (LCSP)
  - Capability Development Document (CDD)
  - Requests for Proposals (RFP)
  - Source Selection Plans (SSP)

- Sustainment requirements should be finalized to support sustainment contracts and the LCSP.
- Support the development of the Product Support Package (PSP) to include the following 12 elements:
  - Product Support Management
  - Design Interface
  - Sustaining Engineering
  - Maintenance Planning and Management
  - Supply Support
  - Support Equipment
  - Technical Data
  - Training and Training Support
  - Manpower and Personnel
  - Facilities and Infrastructure
  - Packaging, Handling, Storage, and Transportation (PHS&T)
  - Computer Resources
- Support the development of the Product Support Strategy.
- Support the development of the Product Support Requirements.
- Prepare the M&Q inputs to the Product Support Strategy and Requirements:
  - Manufacturing support to system and product support package design trades
  - Manufacturing support to test and evaluation (T&E) planning
  - Manufacturing support in defining performance metrics for product support contracts and organic support requirements
  - Manufacturing support to logistics requirements, workload estimates, and logistics risk assessment
  - Manufacturing support to integrate the product support design into the overall design process, and assess enablers that improve supportability, such as diagnostics and prognostics, for inclusion in the system performance specification
  - Manufacturing support that helps ensure life cycle affordability is a factor in engineering and sustainment trades
  - Produce spare parts/subsystems/systems to keep the production articles operating and initiating system modifications, to improve performance and reduce ownership costs.
  - Manufacturing should initiate/support system modifications, as necessary, to improve performance and reduce ownership costs
  - Manufacturing should support cost estimating associated with system modifications

- Manufacturing should help develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and leads to a product support package that will achieve and sustain warfighter requirements
- Manufacturing should help to assess field R&M data to evaluate the impact of M&Q activities on field failures. Assess using Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA) and Process Failure Modes and Effects Analysis (PFMEA)
- Manufacturing should begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components with enough lead time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements
- Monitor related issues including the following:
    - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
    - Obsolescence
    - Counterfeit Parts
    - Corrosion Prevention and Control
- Provide updates that reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Industrial Base Assessment Survey Form Defense Contract Management Agency (DCMA) Industrial Analysis Center
- Interactive MRL Users Guide (Checklist)
- ISO 9001, Quality Management System Checklist
- Life Cycle Sustainment Plan Outline
- Manufacturing Maturation Plan
- Product Support Strategy Development Tool, Defense Acquisition University (DAU)
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- 10 USC 2337, Life-Cycle Management and Product Support
- DoD Product Support Managers Handbook
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems–Aerospace
- CJS JCIDS 3170.01, JCIDS System

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities
- DoD HCI Style Guide, Human Computer Interaction (HCI)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDM 4160.28, Defense Demilitarization: Program Administration
- Guide to Environment, Safety, and Occupational Health (ESOH) in the Systems Engineering Plan (SEP)
- ISO 9001, Quality Management System
- DoD Systems Engineering Guidebook
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- MIL-STD-1472, DoD Design Criteria Standard: Human Engineering
- NIST 800-171, Controls for Controlled Unclassified information
- Performance-Based Logistics (PBL) Guidance
- Product Support Manager Guidebook
- Technology Readiness Assessment Guidance

A.2 Support Program Management Reviews

Manufacturing and QA personnel should be actively engaged in the organization and execution of numerous formal reviews and audits during this phase to include:

- Manufacturing Readiness Assessments (MRAs)
- In-Service Reviews (ISRs)
- Independent Logistics Assessments (ILAs)
- Industrial Base Assessments

Program offices could request an informal review at any time and M&Q managers need to be prepared to support such reviews.

Sources of data used to assess and manage industrial and manufacturing readiness include technical reviews and audits, Program Status Reviews, pre-award surveys, Manufacturing Readiness Assessments, Industrial Base Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

Manufacturing and Quality Tasks

- Provide M&Q assessments in support of the Independent Logistics Assessment (ILA) by assessing:

  - Product Support Management
  - Design Interface
  - Sustaining Engineering
  - Supply Support
  - Maintenance Planning and Management
  - Packaging, Handling, Storage, and Transportation (PHS&T)
  - Technical Data
  - Support Equipment
  - Training and Training Support
  - Manpower and Personnel
  - Facilities and Infrastructure
  - Computer Resources
  - Environment, Safety, and Occupational Health (ESOH)
- Provide M&Q assessments in support of the ISR:
  - System Hazard Risk Assessment
  - Operational Readiness assessment of system impacts from M&Q risks
  - Cost, schedule, and budget assessments from M&Q risks
  - Budget estimates in support of future M&Q activities
  - Current and Future Operational Risk and Systems Assessment of the impact of M&Q on reliability, maintainability, and operational readiness
- Support Follow-on Test and Evaluations (FOT&E) and review test reports
- Provide M&Q assessments in support of Manufacturing Readiness Assessments (MRA):
  - Assessments of the 12 threads
- Provide M&Q assessments in support of Industrial Base Assessments.

Tools

- Army Acquisition Logistician's Assessment Checklist
- DoD In-Service Review (Checklist)
- Independent Logistics Assessment Checklist (DLA)
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Independent Logistics Assessment Guidebook
- ISO 9001, Quality Management System
- Logistics Assessment Guidebook Tool
- DoD Product Support Managers Handbook

B. DEFENSE CONTRACTING SYSTEM

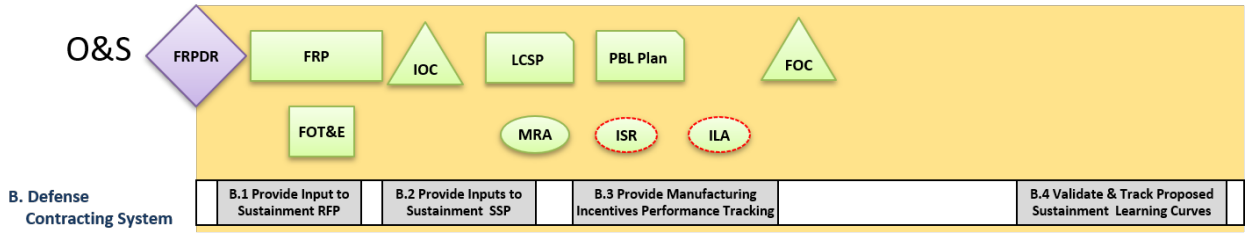


Figure 6-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

DoD contracting requirements and activities are required by the FAR/DFAR and by many DoD, Service and Agency regulations, policies, and guidance documents.

The Request for Proposal (RFP) is the primary opportunity for M&Q personnel to make inputs and should be based on M&Q risks, issues, and opportunities discovered during the O&S phase. Typical areas to be included in the proposal include industry best practices for manufacturing management, quality management, and systems engineering. Other areas to be addressed by M&Q include design and producibility, trade studies, M&Q technology investments, competition, materials (availability, counterfeit, and/or long-lead), data management, quality processes (capability studies), and M&Q reporting and control. This list and other details should be addressed in the Statement of Work (SOW) and/or the Statement of Objectives (SOO).

Market Research is a pre-solicitation activity that involves the evaluation of the market's ability to satisfy the user needs. M&Q personnel need to support market research to identify suppliers and evaluate potential sources and opportunities to assess the risks associated with these opportunities. During this phase, programs are often faced with Diminishing Manufacturing Sources and Material Shortages (DMSMS), obsolescence, counterfeit and other supply chain issues, making the finding of alternative sources a priority. Market Research can be conducted at the weapon system, subsystem, component, or part level and during any phase,

A well-written RFP is critical to the success of the source selection. There should be consistency between the requirements documents, Source Selection Plan (SSP), and RFP. The acquisition team

must ensure a clear linkage between the requirements and evaluation factors to maximize the accuracy and clarity of the RFP.

Manufacturing and quality personnel should support the PM in the development of an RFP based on the supportability analyses contained in the LCSP and review of the most current product support requirements, senior leader guidance, and fiscal assumptions to evaluate product support changes or alternatives and determine best value.

After the Full-Rate Production decision, the LCSP will focus on finalizing the sustainment metrics, integrating sustainment considerations with design and risk management activities, and refining the execution plan for the design, acquisition, fielding, and competition of sustainment activities.

The RFP needs to consider that at the end of a system's useful life, that system may need to be demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment.

Life cycle sustainment for information systems may be provided via multiple approaches, including Service-level agreements, support agreements, performance work statements, and enterprise services. Where feasible and as approved by the MDA, programs may employ portfolio-level documents to satisfy their LCSP requirements. COTS and GOTS products used as intended will normally be supported via standard warranties and support agreements. Effective life cycle sustainment requires continuous monitoring to ensure investments are maintained at the right size, cost, and condition, to include vulnerability management, to support warfighter and business missions and objectives.

The necessary intellectual property (IP) deliverables and associated license rights, consistent with and integrated with the program IP Strategy.

COTS and GOTS products used as intended will normally be supported via standard warranties and support agreements. Effective life cycle sustainment requires continuous monitoring to ensure investments are maintained at the right size, cost, and condition, to include vulnerability management, to support warfighter and business missions and objectives.

The relationship between government and contractor is a critical area. The Program Management Office (PMO) and M&Q managers should strive to create and maintain close teaming arrangements with their counterparts. This will enable better communications and enhanced respect between both parties.

Performance tracking within the SOO/SOW and RFP should focus on technical and business measures that will help to assure program success (cost, schedule, and performance). Cost performance measures should focus on affordability and total life cycle costs, schedule performance measures should focus on the Integrated Master Plan/Schedule. Adherence to both may be found in an Earned Value Management (EVM) if required. Technical performance should be assessed using technical measures

that are derived from the Measures of Effectiveness (MOEs), Key Performance Parameters (KPPs), Measures of Performance, and Technical Performance Measures (TPMs). Manufacturing and QA-related TPMs should support the achievement of Sustainment Supportability Measures.

Manufacturing and quality personnel should support an integrated product support capability implementing the program's mix of government and industry providers supported by appropriate analyses as included in 10 USC 2337 – Life-cycle management that focuses on:

- Maximize competition to make the best possible use of available DoD and industry resources at the system, subsystem, and component levels; and
- Maximize value to the DoD by providing the best possible product support outcomes at the lowest operations and support cost.

Manufacturing and QA personnel should be working to identify cost, schedule, and TPMs. TPMs are often derived from mission needs or MOEs, KPPs, and Measures of Performance. These measures can then be related to and tracked by an Earned Value Management System (if applicable), and the Integrated Master Plan/Schedule.

A successful program meets the sustainment performance requirements, remains affordable, and continues to seek cost reductions by applying should-cost management and other techniques throughout the O&S phase. Doing so requires close coordination with the warfighting sponsor (i.e., user), resource sponsors, and materiel enterprise stake holders, along with effective management of support arrangements and contracts.

During Full-Rate Production, manufacturing should focus on how sustainment performance will be measured, managed, assessed, and reported; and the necessary actions to adjust the product support package to ensure continued competition and cost control while meeting warfighter mission requirements. After Initial Operational Capability (IOC), the LCSP is the principal document governing the system's sustainment. Programs will update the plan whenever there are changes to the product support strategy, or every 5 years, whichever occurs first, supported by appropriate analyses, sustainment metrics, sustainment costs, system components or configuration (hardware and software), environmental requirements, and disposal plans or costs.

Manufacturing and QA should support programs to update the plan whenever there are changes to the product support strategy, or every 5 years, whichever occurs first, supported by appropriate analyses, sustainment metrics, sustainment costs, system components or configuration (hardware and software), environmental requirements, and disposal plans or costs. Performance-based payment events should be used as effective M&Q measures. This activity involves the assessment of how efficiently the contractor is producing products, primarily through the evaluation of work measurement data. It also includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.

During production and into sustainment, manufacturing should support performance-based payment events such as award fees, manufacturing/production incentives, and learning curve analysis.

B.1 Provide Input to Sustainment Request for Proposal

M&Q managers typically support the development of the RFP by identifying M&Q considerations for inclusion in the REP and subsequent contract. M&Q should consider the warfighter requirements and evaluation factors and sub-factors with an emphasis on Sustainment. Evaluation factors often include cost or price, and quality of product or service, which includes technical, past performance and others.

Manufacturing and Quality Tasks

- Ensure that M&Q personnel are included in the Sustainment RFP writing and review teams.
- Review the RFP to ensure it contains the following item:
    - Content for SOW, SOO
    - Contract sections C, L, M, and H
    - System Performance Specification
    - Top-level Schedule
    - Preliminary Work Breakdown Structure (PWBS)
    - Contract Data Requirements List (CDRLs) (M&Q)
    - Contract Line Items (CLINs)
- Ensure Sustainment RFPs and contracts contain the following if appropriate:
    - Higher-Level Contract Quality Requirement per Federal Acquisition Regulation (FAR) Part 52
        - ISO 9001, AS9100, etc.
    - Manufacturing Management Program
        - AS6500, Manufacturing Management Systems
    - Identify Sustainment requirements to include a Life Cycle Sustainment Plan and Product Support Strategy
    - Failure Modes, Effects, and Criticality Analysis (FMECA)
    - System Safety Military Standard (MIL-STD-882)
    - Material Management and Accounting System (MMAS)
    - Software QA Plan
    - Other (Parts Management Program, Counterfeit Management Program, Configuration Management Program, Integrated Product Support Plan, etc.)
- Ensure that a Failure Reporting, Analysis, and Corrective Action System (FRACAS) has been established and is operating effectively.
- Analyze the RFP Sustainment requirements and inputs from a M&Q perspective for the following:
    - Risk, Issue, and Opportunity Management System and processes
    - Design producibility, feasibility, and manufacturability studies and analyses
    - Tooling, facility, and workforce analyses

  - Prototype demonstrations and development tests
  - Materials analyses
  - Make/buy processes and analyses
  - Costs and budget analyses
  - Market research and analyses
  - Pre-award survey
  - Modeling and simulation analyses
  - Process Capability Studies
  - Environmental studies and risks (PESHE)
  - Manufacturing and quality processes and data
  - Work measurement/learning curve analyses
  - Industrial base studies
- Specify contractual M&Q requirements for:
  - Content for SOW/SOO and contract sections C, L, M, and H
- Review RFP and contract for Defense Priorities and Allocation System (DPAS) applicability in obtaining priority support from contractors and subcontractors.
- Review RFP and contract for eventual Demilitarization and Disposal.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IG5315.204-5(b) Section L Guide and Template
- IG5315.204-5(c) Section M Guide and Template
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- ISO 9001, Quality Management System Checklist
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- DCMA Pre-Award Survey System (PASS)
- SF 1403 DCMA Pre-Award Survey General
- SF 1404 DCMA Pre-Award Survey Technical
- SF 1405 DCMA Pre-Award Survey Production
- SF 1406 DCMA Pre-Award Survey Quality Assurance
- SF 1407 DCMA Pre-Award Survey Financial Capability

Resources

- Air Force Contract Sustainment Support Guide
- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DoD 5000.60-H, DoD Handbook: Assessing Defense Industrial Capabilities

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- IG5315.204-5(c) Section M Guide
- ISO 9000, Quality Management System
- ISO/IEC/IEEE 15288, System and Software Engineering IG5315.204-5(b) Section L Guide
- MIL-HDBK-29612-1A Guidance for Acquisition of Training Data Products and Services
- AFMC Inst 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-Award Survey Guide
- Pre-Award Survey User's Manual

B.2 Provide Inputs to Sustainment Source Selection Plan

FAR 15.101, in the Best Value section, states that an agency can obtain best value in negotiated acquisitions by using any one or a combination of source selection approaches. The Source Selection Plan (SSP) is a key document that specifies how the source selection activities will be organized, initiated, and conducted. The SSP serves as the guide for conducting the evaluation and analysis of proposals, and the selection of contractor(s) for the acquisition. The SSP must clearly and succinctly express the government's minimum needs (evaluation factors) and their relative order of importance. M&Q managers, as members of the technical Integrated Product Team (IPT), should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Support the development of the SSP. The Source Selection Authority should approve the SSP before the final solicitation is issued. The SSP should include the following as a minimum:
    - Introduction: Background and Objectives
    - Source Selection Process
    - Source Selection Organization (source selection team should include M&Q)
    - Security (data, communications and personnel)
    - Pre-solicitation Activities
    - Major Source Selection Events including Visits
    - Evaluation Factors and Sub-factors (should include some M&Q)
    - Evaluation Procedures
- Review the SSP against the Acquisition Strategy.
- Ensure manufacturing inputs to the Sustainment SSP include:
    - Manufacturing and QA evaluation criteria,
    - Technical Data Rights and Manufacturing Process Data Rights,
    - Intellectual property (IP) deliverables and associated license rights.
- Ensure the SSP describes the following data requirements:

- The management approach to managing data acquired with other than unlimited rights.
- The management approach for management data (i.e., data that is not software or technical data). It should include how contractor data needing protection will be identified, marked, and managed.
- How the data deliverables will be reviewed for unjustified or non-conforming markings. It should include the process the program will follow to question or challenge contractor assertions or markings
- The data deliverables specified in the RFP or contract, including the technical data, computer software documentation, and management data items.
- The approach for maintaining the software and its documentation once software maintenance is transferred from the Original Equipment Manufacturer. It should include the contract provisions being put into place that will allow for a cost-effective migration.
- The degree to which data will be acquired to support future competitions. It should include the logic by which these elements were selected; the alternative solutions considered; and the criteria by which the decision to procure technical data was made.
- The extent to which priced options and associated source selection criteria will be used to acquire additional licenses.
- The intended use of other mechanisms such as deferred ordering, deferred delivery, and the use of withholding or incentives specific to performance in data management.
- How the use of an integrated digital environment and the repository system factors into the data strategy.
- Any required interfaces to government data systems or repositories, and how those requirements will be satisfied.
- The digital format standards to be used and why they were selected. The process (i.e., business case analysis, adherence to DoD Component policy, etc.) used to determine the deliverable form/format for all deliverables should be included.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- ISO 9001, Quality Management System Checklist
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- Source Selection Plan Template

Resources

- DoD Product Support Managers Handbook
- Air Force Contract Sustainment Support Guide
- AS6500, Manufacturing Management System
- AS9100, Quality Management System

- DoD Systems Engineering Guidebook
- DAU AcqNotes website
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities
- DoD Source Selection Procedures
- FAR Subpart 15.3 Source Selection
- IG5315.303 Source Selection Plan Guide
- ISO 9000, Quality Management System

B.3 Provide Manufacturing Incentive Performance Tracking

FAR Subpart 16.4 notes that *"incentive contracts are designed to obtain specific acquisition objectives by establishing reasonable and attainable targets that are clearly communicated to the contractor; and include incentive arrangements designed to motivate the contractor to improve or discourage contractor inefficiency and waste."*

Contracts should produce measurable performance outcomes that cumulatively contribute to the system KPP/Key System Attributes (KSAs), to their threshold or objective levels. To motivate the contractor to achieve the desired behavior, appropriate contract incentives (including award fee, incentive fee, award term, and cost sharing) need to be developed to promote and facilitate contractor performance.

Manufacturing and QA managers need to support the development of Award Fee/Incentive Fee criteria in their areas. These criteria may focus on manufacturing investments and outcomes, process capability and control, reduction of waste, producibility improvements, etc.

Manufacturing and Quality Tasks

- Support the development of the Acquisition Strategy, which promotes program stability and encourages industry to invest, plan, and bear their share of the risk.
- Support the development of award fee, incentive fee language for performance tracking to include incentive clauses, incentive metrics, and contractual strategies that promote competition, or the option of competition, at the prime and subcontract levels for large and small businesses and at system and subsystem levels.
    - Materiel Availability (Am)
    - Operational Availability (Ao)
    - Material Reliability
    - Mean Down Time
    - Ownership Cost
    - Customer Fulfillment Rate (on time/schedule)
    - Throughput Time
    - Manufacturing Cycle Time

- Quality:
  - First Pass Yield/Scrap/Rework and Repair Rates
  - Supplier Quality Yield Rates
  - Field Data (Warranty/Mean Time Between Failure) (Technical performance)
  - Cost of Quality (affordability)
- In-Plant:
  - OSHA Compliance
  - Inventory Reduction
  - Overall Equipment Effectiveness (OEE)

Tools

- Award Fee Template, Annex B of the Air Force Award Fee Guide
- Life Cycle Sustainment Plan (LCSP) Outline
- Quality Function Deployment Excel template
- Requirements Roadmap worksheet

Resources

- Air Force Contract Sustainment Support Guide
- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DoD Systems Engineering Guidebook
- Award Fee Guide, various Army, Navy, and Air Force
- Guidebook for the Acquisition of Services
- ISO 9000, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- Quality Function Deployment Models
- Supply Chain Metrics Guide

B.4 Validate and Track Sustainment Learning Curves

During the O&S phase, the manufacturing cost estimate should be based upon application of detailed manufacturing standards and learning curves to the operations being performed and adjusted, as necessary, by realization factors or actual costs. By this phase learning should be flat and may even go up as rates and quantities may go down or as system updates are being made.

Cost reduction initiatives should be formally documented, and the documentation must include the baseline ("before" implementation) costs and projected ("after" implementation) costs, as well as the nonrecurring costs to implement the initiative.

It is often difficult to distinguish initiatives that are "over and above" the historical learning curves that were already used to estimate the program costs. Historical learning curves usually include some amount of cost reduction initiatives, so the challenge in documenting and estimating the impacts of new cost reduction initiatives is to determine if they are truly over and above what has been done in the past. Generally, initiatives that reduce the scope of work can be considered over and above, but ones that improve the efficiency of the work must be more carefully evaluated.

Manufacturing and Quality Tasks

- Help develop sustainment performance requirements to include metrics such as:
    - Learning Curves
    - Work Measurement
    - Line of Balance
    - Manufacturing Cycle Times
- Cost/Schedule Control Systems Criteria (C/SCSC) or Earned Value Management (EVM). This includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.
- Assess contractor performance where progress or performance-based payments are in effect.
    - During production and into sustainment, manufacturing should support performance-based payment events such as award fees, manufacturing/production incentives, and learning curve analysis.
- Encourage contractors to continually improve their processes and products during regular program meetings, formal program reviews, fact-finding activities, etc.

Tools

- Application of Learning Curve Theory, DAU
- Cash Flow Tool for Evaluating Alternative Finance Arrangement
- DFAR Subpart 232.10, Performance-Based Payments
- DoD Progress-Based Payments Tool
- Learning Curve Calculator (Estimator)
- Performance-Based Payments Guide
- Resources
- Work Measurement Time Study Worksheet

Resources

- 10 USC 2337, Life-cycle management and product support (b)(2)
- Application of Learning Curve Theory, DAU Teaching Note
- CJCSM 3170M, Manual for the Operation of the Joint Capabilities Integration and Development System

- DFAR Subpart 232.10, Performance-Based Payments
- DoD Systems Engineering Guidebook
- DMMG for PMs, Chapter 9 – Work Measurement
- Life-Cycle Sustainment Plan Outline
- MIL-HDBK-502A, Product Support Analysis
- Performance-Based Payments Guide
- RA-C Report Manual

C. SURVEILLANCE SYSTEM

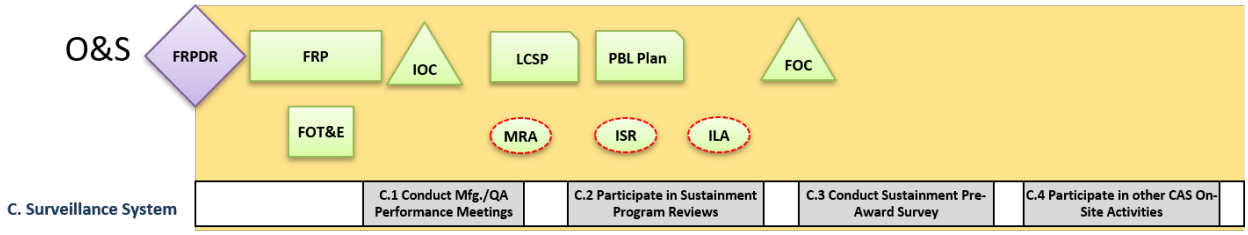


Figure 6-4. Surveillance System Manufacturing and Quality Activities

Introduction

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DoD contractor surveillance requirements and activities are required by the FAR/DFAR and by many DoD, Service and Agency regulations, policies, and guidance documents. DFAR Part 242.2 Contract Administration Services and DFAR Part 242.3, Contract Administration Office Functions, and PGI 242.3 Contract Administration Functions outlines the 70 CAS functions that are required and the many that may require M&Q support in order to accomplish. M&Q personnel often are called upon to support numerous CAS functions and activities.

Often these activities may be performed under mutual agreement by the program office and DCMA. In many cases these contractor surveillance activities may be performed by on-site program office contract administrators, delegated Service contract surveillance offices, or a variety of engineering support activities (i.e., supervisor of shipbuilding (SUPSHIP), development command field activities).

The PM and PMO should use to the extent possible available personnel from DCMA to provide onsite contract administration services (CAS) and functions in accordance with FAR 42.302(a) or DFAR subpart 242.3. Typical CAS functions involving engineering, M&Q can provide program offices with timely, value-added analysis, acquisition insight, and early confirmation of progress and risk reporting. CAS functions include but are not limited to:

- Pre- and Post-award contract actions
- Cost and financial surveillance

- Property administration
- Supply chain management
- Safety and Environmental Health
- Engineering
- Production
- Quality

CAS functions may be delegated to the DCMA using a Memorandum of Agreement (MOA) or Letter of Delegation (LOD). DCMA-INST-205, Major Program Support and FAR 42.302(a) Contract Administration Functions outlines how DCMA personnel can be used to support program office request. Their support may be dependent upon manpower availability and funding.

Many M&Q functions may have moved from prime contractor facilities to government owned and operated facilities such as depots and MROs where CAS surveillance may not be available. This does not mean that oversight functions as outlined in the FAR/DFAR are not still appropriated.

Oversight of contracting actions will continue during the O&S phase. Sometimes contractors go out of business or for other reasons the program changes contractors. If so, it is important to gain a thorough understanding of their capability, capacity, and financial stability using a pre-award survey.

Major oversight functions include the need for regular status meetings, program reviews, the need for pre-award surveys (as appropriate) and other CAS oversight functions and activities. Manufacturing and QA oversight should be based on contract requirements (AS6500, AS9100, etc.).

Over the system life cycle, operational needs, technology advances, evolving threats, process improvements, fiscal constraints, plans for follow-on systems, or a combination of these influences and others may warrant revisions to the LCSP.

Major Defense Acquisition Programs (MDAPs) undergo Independent Logistics Assessments (ILAs) before Milestones B and C and the Full-Rate Production Decision to assess the adequacy of the product support strategy and to identify features likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs. The reviews focus on sustainment planning and execution, including the core logistics analyses and establishment of organic capabilities.

After IOC, the DoD Components will continue to conduct ILAs at a minimum interval of every 5 years. Assessments will focus on the weapon system-level product support performance in satisfying warfighter needs, meeting sustainment metrics, and providing best-value outcomes. They must specifically assess O&S costs to identify and address factors resulting in growth in O&S costs and adapt strategies to reduce such costs. Results will inform LCSP and analyses updates.

Each DoD Component will establish its criteria for independence and will provide (1) guidance to ensure consistency within the respective Component and (2) the scope of the assessment for key acquisition decision points. At a minimum, these reviews will be chartered by the Component Acquisition Executive (CAE) and conducted by logistics, program management, and business experts from outside the program office. Each DoD Component will establish its criteria for independence and will provide guidance to ensure consistency within the respective Component and the scope of the assessment for key acquisition decision points. At a minimum, these reviews will be chartered by the CAE and conducted by logistics, program management, and business experts from outside the program office M&Q experts should participate in this activity.

The In-Service Review (ISR) is a multidisciplined product and process assessment to ensure that the fielded system is operationally employed with well-understood and managed risk. This review is intended to characterize in-service technical and operational health of the fielded system by providing an assessment of risk, readiness, technical status, and trends in a measurable form that will substantiate in-service support budget priorities.

C.1 Conduct Manufacturing and QA Performance Meetings

Compliance to a standard such as AS6500 Manufacturing Management Program, or ISO 9001 Quality Management System, or AS9100 Quality Systems, does not guarantee product or service quality. These standards are management system standards that identify requirements for processes within an organization, describe expected tasks and outcomes, and explain how the processes and tasks integrate to produce required inputs and outputs. Standards are meant to enable the organization to develop a set of processes that, if done by qualified persons using appropriate tools and methods with appropriate leadership involvement, will enable a capability for delivering high quality products or services. These standards can provide a basis for developing and managing a manufacturing or quality program and for assessing compliance to those standards.

Programs achieve product or service quality by implementing a strategic plan to integrate all business and technical functions, resulting in the consistent application of proven, capable processes within an organization. Managers must ensure that all management systems are working toward the same goals and are not creating conflicting or dysfunctional behavior. Implementing a standard is of little use if the financial system rewards delivery of non-conforming products and services. Because everything a contractor does should be related to the quality of its products or services, a contractor's quality management system should be the basis for integrating all other management systems within an enterprise.

Manufacturing and Quality Tasks

- Support the contractor's government/contractor status meetings to ensure the contractor is performing according to contract requirements:
    - At the prime contractor facility

  - At key/critical subcontractors and suppliers
- Ensure the contractor has established and implemented a Material Management and Audit System (MMAS).
- Ensure the contractor has established and implemented a Government Property Control System.
- Support regular (weekly/monthly) contractor status meetings.
  - Manufacturing management concerns per contract requirements (AS6500).
  - Quality concerns per contract requirements (AS9100, ISO 9001, etc.).

Tools

- Army Acquisition Logistician Assessment Checklist
- DAU Logistics Assessment Guidebook, Appendix A: Integrated Product Support Element Assessment Criteria (checklist)
- Interactive MRL Users Guide (Checklist
- Manufacturing Maturation Plan
- Material Management and Accounting System checklist
- Navy Government Property Compliance Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program
- ASA(ALT) Independent Logistics Assessments (ILA) Policy Memorandum
- DoD Systems Engineering Guidebook
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-309, Government QA Surveillance Planning
- DFARS 245, Government-Furnished Property
- DoD Logistics Assessment Guidebook
- DoDI 4161.02, Accountability and Management of Government Contract Property
- FAR Part 46 Government Property
- Guidebook for Contract Property Administration,
- Independent Logistics Assessment
- Independent Logistics Assessment Handbook (Navy)
- ISO 9001, Quality Management System
- Material Management and Accounting System (MMAS) Audit Program
- SECNAVINST4105.1C, Independent Logistics Assessment and Certification Requirements
- DoD Product Support Managers Handbook

C.2 Participate in Sustainment Program Reviews

The technical reviews and audits are necessary systems engineering (SE) activities performed to assess technical progress within a program, relative to contractual requirements and developmental maturity. Technical reviews of program progress should be event-driven and conducted when the system under development meets the review entrance criteria as documented in the Systems Engineering Plan (SEP). The technical reviews and audits should include participation by subject matter experts who are independent of the program (i.e., peer review), unless specifically waived by the SEP approval authority as documented in the SEP. Acquisition milestones and SE technical reviews and audits serve as key points throughout the life cycle to evaluate significant achievements and assess technical maturity and risk. During the O&S phase the program will be faced with the need to conduct many program and technical reviews to include:

- Independent Logistics Assessment (ILA)
- In-Service Review (ISR)
- Manufacturing Readiness Assessment (MRA)

Manufacturing and Quality Tasks

- Support Independent Logistics Assessments (ILAs) at a minimum of every 5 years:
    - Assess O&S costs and address factors resulting in growth in O&S costs and adapt strategies to reduce such costs
    - Assess M&Q considerations that might impact sustainment activities
        - Assessments at prime and subcontractor levels
- Support the ISR to ensure the fielded system is operationally employed with well-understood and managed risk. The ISR should include the following considerations as appropriate:
    - Review quality, manufacturing, engineering, and software-related issues, deficiencies, and/or risks during program reviews
    - Assess System Operational Risk and System Readiness have been quantified and related to current O&M and procurement budgets
    - Review any time-phased transitions between commercial, organic, and partnered product support providers
    - Ensure data rights and IP deliverables and associated license rights, tools, equipment, and facilities are acquired to support each of the levels of maintenance that will provide product support; and will help establish necessary organic depot maintenance capability
    - Identify features that are likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs
    - Assess sustainment planning and execution, to include the core logistics analyses and establishment of organic capabilities
    - Review and assess Performance-Based Logistics (PBL) planning, development, implementation, and management during Sustainment

  - Review and assess product obsolescence and the likelihood of future redesign to upgrade system capability to include Diminishing Manufacturing Sources and Material Shortages (DMSMS) and obsolescence
  - Review and assess program office shutdown activities as needed
  - DCMA should be used to support sustainment reviews
- Conduct a Manufacturing Readiness Assessment as appropriate.

Tools

- Army Acquisition Logistician's Assessment Checklist
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DoD Systems Engineering Guidebook
- DoD Product Support Managers Handbook
- DoD Independent Logistics Assessment Guidebook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Independent Logistics Assessment Handbook
- ISO 9001, Quality Management System
- NAVSO P-3692, ILA Handbook

C.3 Conduct Sustainment Pre-Award Survey

A pre-award survey may be required per FAR 9.106 and is an evaluation of a prospective contractor's capability to perform under the terms of a proposed contract. During the O&S phase some subcontractors may leave the business and a new subcontractor may be validated, or there may be a significant system update that may require a pre-award survey and a first article inspection. It typically requires an on-site visit to the prospective contractor's facility and could be an assessment of their technical, production, quality, and financial capabilities. Manufacturing and QA managers need to support assessments at the contractors' facilities and should involve the support by DCMA personnel stationed at the facility.

Manufacturing and Quality Tasks

- Support the evaluation of a proposed contractor's capability and capacity by performing a pre-award survey.

- Support DCMA personnel on the following surveys:
  - Technical (SF 1404)
  - Production (SF 1405)
  - Quality (SF 1406)
  - Financial (SF 1407)
- Support the evaluation of Technical Capability; Production Capability; Quality; Packaging; Flight Operations/Safety; Technical documentation; Configuration Management; and Software Capability.
- Support revisions and system modifications over the system life cycle, as may be driven by operational needs, technology advances, evolving threats, process improvements, fiscal constraints, and plans for follow-on systems.
- Support taking appropriate measures to reduce operating and support costs by influencing system design early in development, developing sound product support strategies, and addressing key drivers of cost.
- Support independent logistics assessments to assess the adequacy of the product support strategy, and to identify features that are likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs.
- Support sustainment planning and execution, to include the core logistics analyses and establishment of organic capabilities.

Tools

- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- SF 1404 Pre-Award Survey – Technical
- SF 1405 Pre-Award Survey – Production
- SF 1406 Pre-Award Survey – Quality Assurance
- SF 1407 Pre-Award Survey – Financial Capability

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DCMA Pre-Award Survey Guide
- ISO 9001, Quality Management System

C.4 Participate in Other CAS On-Site Activities

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DFAR subpart 242.3 identifies 71

Contract Administration Services (CAS) functions that need to be accomplished and managed. Contractor surveillance is defined by several FAR and DFAR clauses. Many CAS activities fall under the umbrella of production or quality surveillance activities. Manufacturing and QA managers play an integral and vital role in the total scope of contract administration. Most program offices delegate many CAS activities to the DCMA as a best practice.

Manufacturing and Quality Tasks

Manufacturing and QA personnel may be called out to perform some or all the following functions:

- Provide input to the development of a Memorandum of Agreement (MOA) between with program office and the government contract administration activity.
- Attend/participate in Post-Award Orientation Conference (PAOC).
- Provide independent program status of cost, schedule, and technical performance.
- Conduct Flight Operations, if applicable.
- Support Requests for Variation (RFVs) Material Review Board (MRB) proposals for Use-As-Is (UAI) and repair non-conformances.
- Verify supplier complies with contractual Special Packaging Instructions (SPIs) for end item systems and spares.
- Perform Government Contract Quality Assurance (GCQA), to include Inspection and Acceptance, of production quantities.
- Verify Surveillance Critical Designator (SCD) (FAR 42.11) applied to the contract is the correct designator.
- Perform government surveillance of the supplier's Material Management and Accounting System (MMAS).
- Verify Beyond Economical Repair (BER) requests.
- Perform evaluation of Over and Above (O&A) requests.
- Perform Physical Progress Reviews (PPRs) to support Progress Payments.
- Perform Estimates to Completion (EAC) when requested.
- Provide delivery delay notices to the customer.
- Validate/verify Performance Base Payment requests.
- Provide support to customer priority delivery requests.
- Support of Failure Reporting, Analysis and Corrective Action System (FRACAS).
- Support assessment of field failures.

Tools

- DCMA Manufacturing and Production Surveillance Plan
- DMCA Engineering Surveillance Plan
- DMCA Program Support Plan
- DMCA QA Surveillance Plan

- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DCMA-INST-204, Manufacturing and Production
- DMCA-INST-205, Program Support
- DMCA-INST-207, Engineering Surveillance
- DMCA-INST-309, Government Contract QA Surveillance Planning
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- ISO 9001, Quality Management System

D. TECHNOLOGY AND INDUSTRIAL BASE

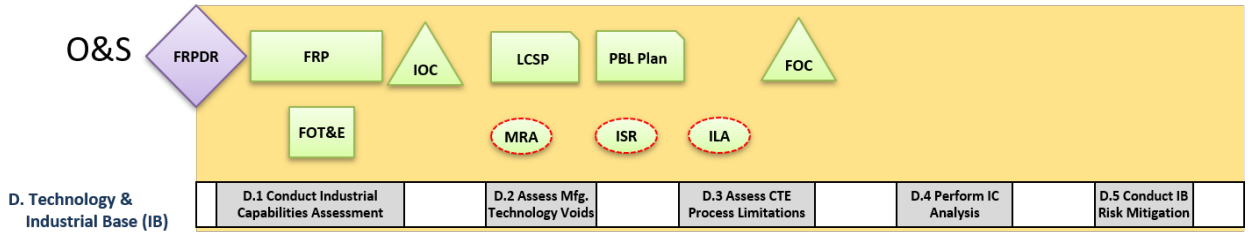


Figure 6-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC 2440 requires the Secretary of Defense to consider the National Technology and Industrial Base (NTIB) in the development and implementation of acquisition plans for each MDAP. The NTIB consists of the people and organizations engaged in national security and dual-use research and development (R&D), production, maintenance, and related activities within the United States, Canada, the United Kingdom, and Australia. Acquisition planning and plans must include considerations of the NTIB for all MDAPs, for example:

- The ability to support development and production (rates and quantities)
- The identification of IB risks in the supply chain
- The identification of single points of failure in the supply chain (sole source, foreign source, etc.)
- Support for a resilient supply base for critical defense capabilities
- Support for procurement surges and contractions

This thread (Technology and Industrial Base) requires an analysis of the capabilities of the NTIB to support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal (including environmentally conscious manufacturing). This thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Industrial Base Assessments (IBAs)
- Industrial Base Risks
- Critical Enabling Technologies
- ManTech Projects
- Industrial Base Mitigation Plans

The O&S phase is characterized by ongoing production and sustainment operations. The PM should evaluate the industrial base to ensure there will be a source of material for future development, production, and sustainment. The potential loss of design or manufacturing capabilities at planned cost and schedule is the major program risk during the O&S phase.

Industrial Base Assessments are required by law:

- 10 USC 2440: Technology and Industrial Base
- 10 USC 2503: Analysis of the Technology and Industrial Base
- 10 USC 2504: Annual Report to Congress
- 10 USC 2525: Periodic Defense Capabilities Assessments

When there is an indication that industrial capabilities needed by DoD are endangered, an additional analysis is required as the basis for determining what if any DoD action is required to preserve an industrial capability (*see* DoDD 5000.60 and DoD 5000.60H). Along with this analysis come the identification of risks and the development and implementation of risk mitigation activities.

The risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule is a major risk during this phase.

- Manufacturing and QA personnel should consider industrial surge requirements and capability for operationally expendable items such as munitions, spares, and troop support items. These are likely surge candidates and should receive close attention and specific planning, to include use of contract options.
- Manufacturing and QA personnel should identify production bottlenecks at both the prime and sub tier supplier levels for high use/high volume programs in an asymmetric warfare construct. Consider surge capability in evaluation criteria for contract award.
- If M&Q analysis indicates that industrial capabilities are in danger of being lost to include DMSMS and Obsolescence, the DoD Components should determine whether government action is required to preserve the industrial capability.
- Conduct industrial base risk handling.

During the O&S phase the industrial base may include depots, MROs, and other organic activities. There are several manufacturing concerns for the PM during the O&S phase to include:

- Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Obsolescence
- Counterfeit parts
- Insertion of new technology
- Smart shutdown
- Demilitarization and disposal

Typically, the program is very mature in the O&S phase but may still require R&D of new technologies to keep weapon systems current with new threats. As a result, the program is constantly looking at emerging threats and emerging capabilities. If there is a gap between requirements and capabilities, then the program may initiate a manufacturing technology (ManTech) development effort to close that gap.

DoD investments may be needed to create and maintain access to competitive suppliers for critical areas at the system, subsystem, and component level. When the analysis indicates that industrial capabilities needed by DoD are in danger of being lost, the Components should determine whether government action is required to preserve the industrial capability. They should address product technology obsolescence, replacement of limited-life items, regeneration options for unique manufacturing processes, and conversion to performance specifications at the subsystem, component, and spares levels.

D.1 Conduct Industrial Capabilities Assessment

10 USC 2440 and DFAR Subpart 207.1 require assessments of the capability of the U.S. industrial base to support the development, production, and sustainment of weapon systems used by U.S. defense forces. As a member of the IPT, the program office should lead and support assessments of the impact of programmatic decisions on the national and international NTIB supporting U.S. weapon system programs. These assessments should include DCMA and program office personnel.

Manufacturing and Quality Tasks

- Support assessments of the capabilities of the industrial base to support the development, production and sustainment of weapon systems used by U.S. defense forces.
- Support industrial base assessments, which could include the following concerns:
    - Capability to develop, produce, and sustain a capability
    - Capacity to develop, produce, and sustain a capability
    - Financial stability to develop, produce, and sustain a capability
- Support assessments of the ability to meet post-production operational needs (spares, etc.).

- Support assessments related to:
  - Technology obsolescence
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
  - Counterfeit parts
  - Replacement of limited-life items
  - Regeneration options for unique manufacturing processes
  - Conversion to performance specifications at the subsystems, component, and spares levels

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base
- DCMA Industrial Analysis (DCMA-INST 401)
- DCMA Instruction 3401, Defense Industrial Base Mission Assistance
- DoDI 5-000.60, Defense Industrial Base Assessments
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- MRL Deskbook

D.2 Assess Manufacturing Technology Voids

The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. During the O&S phase, programs may be working on additional capabilities and block upgrades to programs. Manufacturing assessments should identify high-risk manufacturing process areas that represent technology voids and may require investments in ManTech or other programs. ManTech program investments should be directed toward areas of greatest need and potential benefit. These investments must be identified early so that these manufacturing capabilities will be matured on time to support rate production.

Manufacturing and Quality Tasks

- Support the identification and assessment of technology voids:

    - Update assessments of emerging technologies needed to upgrade existing weapon systems

- Perform manufacturing trade studies on potential technologies to solve the requirements gap.
- Identify costs and risks associated with these new technologies.
- Update current ManTech and other technology development plans and roadmaps.
- Ensure ManTech programs and other technology programs target the risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule following production.
- Ensure manufacturing analysis addresses product technology obsolescence, replacement of limited-life items, regeneration options for unique manufacturing processes, and conversion to performance specifications at the subsystem, component, and spares levels.
- Assess lab resources that could be used to help contractors solve technical problems.

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- ManTech or other Technology Roadmap
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Pugh Matrix
- Technology Readiness Assessment

Resources

- Defense Production Act, Title III
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- MRL Deskbook
- NAVSO P-3687Producibility Systems Guidelines
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Technology Transition Managers Guide
- TRA Deskbook

D.3 Assess CTE Product and Process Limitations

The ManTech program focuses on advancing state-of-the-art manufacturing technologies and processes from the R&D environment (laboratory) to the production and shop floor environment. These technologies are often immature and have process limitations that need to be assessed. Manufacturing and quality managers need to be on the IPT assessing these product and process limitations.

Manufacturing and Quality Tasks

- Assess critical processes that may be difficult to provide on a limited production basis.
- Manufacturing and QA personnel should assess Critical Technology Element (CTE) Process Limitations.
- Assess CTE for impacts to feasibility, affordability, producibility, and supportability.
- Assess maturity of the technology and manufacturing processes.
- Participate in product and process assessments.

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Technology Readiness Assessment
- TRL Calculator

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- MRL Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.4 Perform Industrial Capability Analysis

An Industrial Base Assessment is an assessment of an industry to evaluate the skills and knowledge, processes, facilities, and equipment needed to design, develop, manufacture, repair, and support DoD products. ICAs can be performed in many ways. One way is to send a standardized questionnaire to companies. After they complete the survey a small team could visit the company to follow up on the questions and tour of the facilities. The purpose of the assessment is to identify potential industrial base/program risks.

Manufacturing and Quality Tasks

- Conduct industrial base assessments as needed, or when they are in danger of being lost.
- Address product and process technology obsolescence, replacement of limited-life items, regeneration options for unique manufacturing processes, and conversion to performance specifications at the subsystem, component, and spares levels.

- Determine whether government alternative action is required to preserve the industrial capability per DoD Handbook 5000.60H, which could include:
    - Take no action
    - Buy from a foreign source
    - Find/develop an alternative source
    - Lifetime buy
    - Smart Shutdown
    - Maintain the current capability
- Identify DoD investments needed to create and maintain access to competitive suppliers for critical areas at the system, subsystem, and component level.
    - Identify ManTech projects
    - Initiate ManTech projects

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- TRL Assessment Checklist

Resources

- DoD 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5-000.60, Defense Industrial Base Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- MRL Deskbook

D.5 Conduct Industrial Base Risk Mitigation

Industrial base risk mitigation activities may be a result of a formal study or analysis or may be a result of routine oversight that identifies a risk or an issue. Manufacturing and QA managers need to assist in the development and management of risk management strategies and implementation plans.

Manufacturing and Quality Tasks

- Develop and implement Industrial Base risk mitigation activities per DoD 5000.60H, Chapter 5, Identify and Evaluate Alternative Actions. These risk mitigation plans should address the following:
    - Identify which M&Q capabilities should be maintained throughout the life of the program.

- Mitigate product or process technology obsolescence, lifetime replacement, or regeneration of items projected to go out of production.
- Address the approach to making production rate and quantity changes that support a response to contingency and support requirements including surges.
- Mitigate the vulnerability of the supply chain (to include sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources).
- Address the availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment (required to include the availability of alternatives for obtaining such items from within the NTIB.
- Address the risks introduced by new and unique capabilities and processes.

- Support the development of Acquisition Strategies that consider industrial surge requirements and capability for operationally expendable items such as munitions, spares, and troop support items.

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing and QA Risk Mitigation Plan (no Template available)
- Manufacturing Maturation Plan

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and Evaluate Alternative Actions
- DoDI 5-000.60, Defense Industrial Base Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- DoD Product Support Managers Handbook
- MRL Deskbook, Chapter 5.2 Development of a Manufacturing Maturation Plan

E. DESIGN

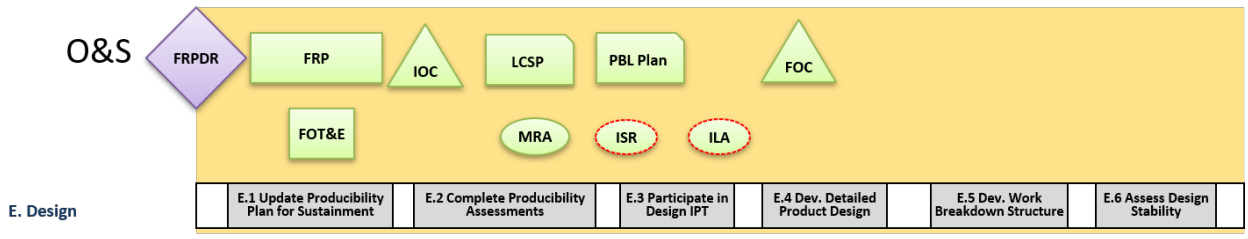


Figure 6-6. Design Manufacturing and Quality Activities

Introduction

DoD Systems Engineering (SE) is a disciplined approach for the specification, design, development, realization, technical management, operation, and retirement of a weapon system. SE is an interdisciplinary and collaborative effort requiring close interaction with many disciplines to include operations, maintenance, logistics, test, production, quality, etc. SE accomplishes these activities by focusing on eight technical processes and eight technical management processes. M&Q personnel need to support these SE activities. M&Q personnel need to support these SE activities.

Manufacturing and quality personnel participation in the program's systems engineering process as a part of the IPTs is critical to succeeding in producibility and affordable system with acceptable risks. Manufacturing and quality industry best practices are integral to design and development efforts in both Manufacturing Management System (MMS) and Quality Management System (QMS) requirements (e.g., AS6500, ISO 9001, AS9100, etc.). The program should integrate M&Q into the product design and development process and engage M&Q expertise throughout the entire life cycle of a system to include the O&S phase. Analyses of design alternatives through trade studies, producibility analyses, and manufacturing feasibility based on program requirements needs to be conducted, with results incorporated into the design.

During the O&S phase, M&Q should be assessed to support all sustainment activities and concerns. Sustainment activities supporting system operations should address two major efforts: life cycle sustainment and disposal. This includes continued production and design activities associated with technology refresh, life-extension modifications, value engineering activities, Preplanned Product Improvements (P3I), and capability enhancements. It should be noted that during the O&S phase design, M&Q activities can be taking place at contractor facilities or at government depots, MRO facilities, or other forms of government facilities.

The producibility engineering and planning (PEP) program should be defined contractually and contain specific tasks and measurable performance that will support an orderly transition. PEP progress should be tracked by means of production readiness reviews required before initial or full production decisions. The objective of a transition plan is to provide visibility of how well each activity is being executed. Progress should be regularly compared against the transition plan.

One of the roles of M&Q personnel is to "influence the design." It must be noted that M&Q personnel are not design engineers and thus their role is a supporting role. They need to assess the design to ensure that the design is manufacturable and inspectable/testable. The existing factory floor is a "capability," and a design that cannot be produced on the existing factory floor either requires a design change to match the existing factory floor capability or M&Q personnel must develop new processes that will ensure that the design can be build that results in uniform, defect-free products that are affordable.

Manufacturing must assess the detailed production designs, processes, WBS, and schedules must be transitioned from Full-Rate Production to a schedule and rate that can be used to produce spares during sustainment. In addition:

- Manufacturing and QA personnel must assess new analytical methods, tools, and processes for analyzing production schedules against spare parts manufacturing.
- Manufacturing should support developing an overarching WBS framework to identify "smart shutdown" tasks. This would stop Full-Rate Production efforts and change over to a limited spares production capability.
- The planning, execution, and control of the production phase activities require that the work be divided into manageable tasks that are compatible with the existing manufacturing and performance measurement systems. Often, the WBS used during the development phases will not be appropriate for the production phase or for sustainment. Consequently, the contractor should, as a basis for production planning, identify and develop the WBS to be used. While this may differ from the EMD structure, the two should be such that production phase costs can be related to the development WBS, and the sustainment costs can be related to the production costs. This is critical for those programs that have used a design-to-unit production cost management approach during development.
- The objective of the O&S phase is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. When the system reaches the end of its useful life, the department should dispose of it.
- During the O&S phase, systems engineering processes support sustainment efforts using In-Service Reviews (ISRs). ISRs include the identification of root causes of field and other problems, and the development of mitigation strategies for safety and critical readiness on these problems that are degrading performance. Mitigation activities could include the participation in trade studies and decisions making (e.g., changes to the product support package, manufacturing process improvements, modifications, upgrades, and future increments of the system), considering the operational needs and the remaining service life. Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, Joint or Service commonality, etc. may all indicate the need for a system upgrade(s) or process improvements.
- During the sustainment effort of the O&S phase, systems engineering processes support
- The last activity associated with the operations and support acquisition phase is disposal. Early systems engineering processes should include and inject disposal requirements and considerations into the design processes that facilitate disposal.

Designs should be stable and mature prior to going into production, with design changes limited to those required for continuous improvement. All Key Characteristics should be stable and under control per appropriate quality standards. Any significant design changes should be assessed for maturity prior to release to production.

Contractors and production organizations during the O&S phase may be experiencing the following:

- Ongoing production (no design impact)
- Ramp up or ramp down in production (no design impact)
- Production of spares (no design impact)
- Design changes to meet changing requirements or for continuous improvement
- Changing requirement could indicate a significant design change
- Continuous improvement may involve "tweaking" of the design or manufacturing processes

Manufacturing and QA personnel should advocate continuous improvement. They have numerous opportunities to do so, such as during teleconferences, Program Management Reviews, and fact findings. The effort is not confined to contractors, as personnel can encourage internal improvements at depots and within the program office.

E.1 Update Producibility Plan for Sustainment

PEP should be directed toward generating a robust design that is compatible with the current capability of the factory floor. Producibility is a major driver of product affordability because of the effect on both production and sustainment costs. The producibility plan should guide the design effort and describe activities that will be accomplished, the responsible organization, and the management controls that will be established to ensure successful accomplishment. Manufacturing and QA managers should review and update the plan with a focus on the realism, completeness, and clarity of the planning accomplished by the contractor.

Manufacturing and Quality Tasks

- Provide input into the Life Cycle Sustainment Plan (LCSP).
    - The LCSP should contain requirements for a Producibility Plan
- Provide input to the Product Support Strategy (PSS)
- Provide input into producibility/design reviews, systems engineering, and trade studies for Sustainment planning.
- Review contractor/governments plans for producibility planning.
- Ensure the producibility plan describes how the design engineers will apply producibility principles.
- Identify specific producibility engineering techniques (Design for Manufacturing and Assembly (DFMA), Design for Reliability and Maintainability, Design for Six Sigma (DFSS), DfX, etc.) that the contractor could use to enhance producibility outcomes.
- Support the identification and management of key characteristics (KCs).
- Support the identification of producibility risks and issues.

Metrics

- Life Cycle Sustainment Plan has been updated.
    - Life Cycle Sustainment Plan includes requirements for Producibility Planning.
- Product Support Strategy has been updated
- Sustainment planning includes inputs for producibility during design reviews, systems engineering processes and trade studies.
- Manufacturing and QA personnel reviewed contractor/governments plans for producibility planning.
- Manufacturing and QA personnel ensured the producibility plan describes how the design engineers will apply producibility principles.
- The contractor used specific producibility engineering techniques to enhance producibility outcomes.
- Key characteristics (KCs) were identified and managed.
- Manufacturing and QA personnel supported the identification of producibility risks and issues.

Tools

- DoD Life Cycle Sustainment Plan Content Guide
- DoD Life Cycle Sustainment Plan Outline
- DoD PBL Guidebook
- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Producibility Engineering and Planning (PEP) Data Item Description

Resources

- 10 USC 2441 Sustainment Reviews
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program
- AS9103, Variation Management of Key Characteristics
- DCMA-INST-204 Manufacturing and Production
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning
- DoDI 5000.88, Engineering of Defense Systems
- IEEE15288.2, System and Software Engineering, Standard for Technical Reviews and Audits on Defense Program
- DoD Systems Engineering Guidebook

- DoD Product Support Managers Handbook
- MRL Deskbook
- NAVSO P-3687 Producibility System Guidelines
- Producibility System Guidelines, Missile Defense Agency

E.2 Complete Producibility Assessments

Producibility engineering and producibility assessments should be a part of the ongoing systems engineering process. Producibility is directly connected to the complexity of a system. As complexity increases, so does the acquisition cost. Therefore, producibility programs are necessary as a management means to minimize the cost increases associated with the growing complexity of systems. Producibility analysis accomplished by the PMO must be performed by a team of specialists assembled from the program office and supporting organizations. Manufacturing and QA managers are key to the successful implementation of a producibility program.

Manufacturing and Quality Tasks

- Complete producibility assessments.

Metrics

- Producibility Assessment completed.
- Producibility Rating established.

Tools

- AS9100 Checklist
- AS6500 Checklist
- CAD/CAM software
- Producibility Assessment Worksheet
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan

Resources

- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- NAVSO P-3687, Producibility System Guidelines
- AS6500, Manufacturing Management Program
- DCMA-INST-204, Manufacturing and Production
- AS9100, Quality Management Program
- AS9103, Variation Management of Key Characteristics
- MRL Deskbook

E.3 Participate in Design Integrated Product Team

Major design updates can occur during the O&S phase as programs bring on new capabilities and technologies. Programs are organized around a core design team, usually composed of 20-50 engineers. This core design team makes 90-95 percent of all critical decisions with most design decision made prior to production. If M&Q are not one of their primary concerns, these considerations will be delegated to secondary teams or not accomplished until late in the program, causing serious problems with cost, schedule, and performance.

The PM and technical team need to ask M&Q questions and ask them often. The contractor will follow the government's lead. If the government shows concern for these areas in the development of the design and integration with M&Q, then the contractor receives the message and will show like concern. Manufacturing and QA personnel must participate with the Design IPT in the development and review of the design and design documentation.

Manufacturing and Quality Tasks

- Participate in the Systems Engineering process along with other members of the Design Integrated Product Team (IPT).
- Ensure adherence to appropriate M&Q requirements and best practices.
- Provide inputs to any design trade studies.
- Provide inputs to any engineering trouble analysis on factory floor problems (FTA, FMEA, PFMEA, etc.) or on field failures (FRACAS, etc.).

Tools

- Interactive MRL Users Guide (Checklist) for the Design thread
- Life Cycle Sustainment Plan outline
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program
- AS9103, Variation Management of Key Characteristics
- DCMA-INST-204, Manufacturing and Production
- Defense Acquisition Guidebook, Chapter 4 – Life Cycle Sustainment
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- LCSP memo, Sep 2011, and DAG Chapter 4-3.1
- MRL Deskbook

- Systems Engineering Plan (SEP) Outline

E.4 Develop Detailed Product Design

Detailed product design includes the realization (build) effort down to the lowest level system elements and includes the fabrication/production processes required to complete the build effort. As a best practice, the systems engineer should develop an implementation plan that includes implementation procedures, fabrication processes, tools and equipment, implementation tolerances, and verification uncertainties. Manufacturing and QA managers/engineers need to be a part of the development and assessment of detailed design efforts.

Manufacturing and Quality Tasks

- Support the detailed design process with M&Q inputs.
- Assess proposed design changes for producibility and manufacturability.
- Assess proposed design changes for inspectability and high levels of quality (yields).

Tools

- Design for Performance
- Design for Manufacturing and Assembly (DFMA)
- Design for Six Sigma
- Design for Producibility
- Design for Affordability
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE15288.2, Systems and Software Engineering, Standard for Technical Reviews and Audits on Defense Programs
- AS6500, Manufacturing Management Program
- DCMA-INST-204, Manufacturing and Production
- AS9100, Quality Management Program
- AS9103, Variation Management of Key Characteristics
- MRL Deskbook

E.5 Develop Work Breakdown Structure

The Work Breakdown Structure (WBS) is a government-approved framework that includes all program elements for which the contractor is responsible and for which they must report. The WBS is

defined, developed, and maintained throughout the system life cycle based on a disciplined application of the systems engineering process. The goal is to develop a WBS that defines the logical relationship among all program elements to a specific level (typically Level 3 or 4) of indenture that does not constrain the contractor's ability to define or manage the program and resources.

Manufacturing and Quality Tasks

- Support the development and/or review of the WBS:
  - Program WBS (government owned usually)
  - Contract WBS (contractor owned usually)

Tools

- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- WBS Template

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program
- DCMA-INST-204, Manufacturing and Production
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- MIL-STD-881 – Work Breakdown Structure for Defense Materiel Items
- MRL Deskbook

E.6 Assess Design Stability

The design should be stable and mature as the product moves into the O&S phase and may be considered mature when the number and type (Class I and Class II) of engineering change traffic is tapering off and when the drawing packages have been released to manufacturing. Configuration of the item should be stable as should be the requirements.

Manufacturing and Quality Tasks

- Support the assessment of the design's stability.
- Encourage contractors to continually improve their processes and products and change from rate production to limited production of spares.
- Monitor field failures and the potential for design changes due to a variety of problems (Field Failure Reports, etc.).

Tools

- Design for Performance

- Design for Six Sigma
- Design for Producibility
- Design for Affordability
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- AS6500, Manufacturing Management Program
- DCMA-INST-204, Manufacturing and Production
- AS9100, Quality Management Program
- AS9103, Variation Management of Key Characteristics
- MRL Deskbook

F. COST AND FUNDING

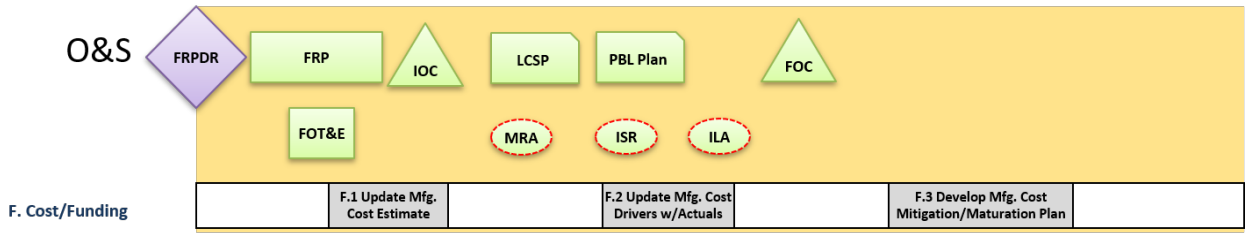


Figure 6-7. Cost and Funding Manufacturing and Quality Activities

Introduction

Services and Agencies develop Program Objective Memorandums (POMs) to identify and request resources (money) to acquire capabilities and perform operations. The POM is part of the Programming Phase of the Program, Planning, Budget, and Execution (PPBE) process. The DoD combines the various Service and Agency POM inputs and Budget Estimate Submission (BES) and submit a DoD Budget Request to the Office of Management and Budget (OMB).

Cost and funding are mainly concerned with having cost models to initially estimate costs, then validating the cost models by collecting and analyzing actual cost against cost targets or budget goals, and finally, establishing a budget to support future M&Q efforts.

Manufacturing cost estimates for the production phase are normally based on the assumption that the design is complete, that the manufacturing processes are known, stable and in control, and manufacturing operations will be accomplished as planned. The same hold true for the O&S phase. However, the O&S phase may see several changes to the P&D model.

- Full-Rate Production may not continue, and if it stops and the contractor is only producing spares, then the unit cost may go up.
- Work may be done at a public or private

Typically, in any industry, materials and labor are the two biggest manufacturing cost drives. Another major factor is rate and quantity. During the O&S phase several changes often take place that impact costs, such as changes to rate and quantity as the contractor's original rate from Full-Rate Production goes down, and most of their production is in support of spares. There may also be changes to the supply chain as contractors either move in and out of a business or contractors look for lower prices and higher quality.

During this phase should-cost management and other techniques will be used continuously to control and reduce cost. Employ a should-cost management and analysis approach to identify and implement system and enterprise sustainment cost reduction initiatives. Should-cost targets will be established and reviewed periodically based on analysis of acquisition sustainment costs and O&S cost element drivers. PMs will capture product support metrics and cost data in DoD Component- and DoD-level information systems, and track performance against should-cost targets.

Any deviation from these assumptions could cause a growth in cost. As such, time and conformance measures can give some indication of potential or real cost aberrations since there is normally a direct correlation between late delivery or conformance problems and cost.

Support Earned Value Management System analysis, or its predecessor Cost/Schedule Control System Criteria (C/SCSC). This will help in updating manufacturing costs using production phase actuals when developing cost estimates for the O&S phase to ensure that the government receives the full benefit of the contractor's production learning curve.

Manufacturing and QA cost estimates for the O&S phase are normally often based on actual costs that were experienced during the Production and Operations phase, the costs associated with Full-Rate Production (FRP). Cost associated with FRP should be well known, however, during the O&S phase, the contractor may not be producing product or spares at the same rate and the contractor may not be in Full-Rate Production, so the cost may be higher. Or the O&S costs are now associated to depot-level work, and because the throughput is lower and thus the cost per unit to remanufacture may be higher.

Detailed cost estimates need to be established or updated. Costs could be related to contractor or depot/MRO activities and products. Historical cost estimates based on Full-Rate Production quantities may not be appropriate for the O&S phase.

F.1 Update Manufacturing Cost Estimate

DoDI 5000.02, Operation of the Adaptive Acquisition Framework, Enclosure 10 identifies Cost Estimating and Reporting requirements. M&Q managers need to support the development and update of government cost estimates and the assessment of contractor cost estimates.

Manufacturing and Quality Tasks

- Establish cost models for the O&S phase based on the planned rates and quantities.
    - Cost Analysis Requirements Description (CARD)
    - Total Ownership Costs (TOC) or Life-Cycle Cost Estimate (LCCE)
    - Program Office Estimate (POE)
    - Independent Cost Estimate (ICE)
    - Independent Government Cost Estimate (IGCE)
    - Component Cost Estimate (CCE)
    - Component Cost Position (CCP)
    - Cost Capability Analysis (CCA)
    - Should Cost Estimate (SCE)
    - Sufficiency Review
- Review and assess the work allocation by a contractor or the government, and at a production facility or at an organic activity (depot, arsenal, shipyard, fleet readiness center, or MRO).
- Assess whether DoD investments are going to be needed to create or enhance certain critical industrial capabilities.
- Track expenditures and estimate to complete using approved techniques such as Earned Value Management System analysis, or its predecessor Cost/Schedule Control System (C/SCS) during sustainment operations.

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Design to Cost Estimates
- Interactive MRL Users Guide (Checklist), Cost thread
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Maturation Plan
- *See* CAPE website for tools

Resources

- C/SCSC Reference Guide
- CAIG website and processes
- DCAPE website and processes
- DoDD 5000.04, DoD Cost Analysis Improvement Group (CAIG)
- DoDI 5000.73 Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems

- DoD Systems Engineering Guidebook
- Earned Value Management Guide
- GAO Cost Estimating and Assessment Guide
- Manufacturing Cost Estimating (*see* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- MIL-HDBK-766, Design to Cost
- MRL Deskbook
- OSD O&S Cost Estimating Guide
- Should-cost and affordability memo

F.2 Update Manufacturing Cost Drivers with Actuals

During the O&S phase, most manufacturing costs should be based on actual cost data provided by the contractor. Cost drivers could be high-cost items, or items that have high manufacturing costs due to several factors (long processing times, low yield rates, etc.). These cost drivers need to be updated.

Manufacturing and Quality Tasks

- Identify manufacturing cost and cost drivers, and then continuously control and reduce cost.
- Use the actuals generated to update Sustainment costs to determine new cost drivers and to validate funding estimates.
- Assess risks and the costs associated with those risks.
- Employ should-cost management and analysis approach to identify and implement system and enterprise sustainment cost reduction initiatives.
    - Employ other cost reduction initiatives (Lean/Six Sigma, etc.)
- Periodically establish, and review cost targets based on analysis of acquisition sustainment costs and O&S cost element drivers.
- Support the PM to capture product support metrics and cost data and track performance against should-cost targets.
- Conduct cost analysis and cost reduction programs on subcontractors and vendors.

Tools

- Cost Analysis Requirements Description template
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Design to Cost Estimates
- Interactive MRL Users Guide (Checklist), Cost thread
- Manufacturing Cost Estimating Spreadsheet
- Manufacturing Maturation Plan
- *See* CAPE website for tools

Resources

- DoDI 5000.73 Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Manufacturing Cost Estimating (*see* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- MIL-HDBK-766, Design to Cost
- MRL Deskbook
- O&S Cost Estimating Guide, CAPE
- O&S Cost Management Guide
- Should-cost and Affordability Memo

F.3 Develop Manufacturing Cost Mitigation/Maturation Plan

Affordability is always a concern for the DoD. Manufacturing and quality managers need to support the development and implementation of cost mitigation plans. These plans often focus on manufacturing cost drivers and continuous improvement opportunities.

Manufacturing and Quality Tasks

- Manufacturing and QA personnel should be engaged in the development of a Cost Mitigation/ Maturation Plan.
    - Prime Contractor
    - Key and critical subcontractors and vendors.
- Support the development of the Cost Mitigation/Maturation Plan (refer to the Independent Logistics Assessment).
- Track cost and cost trends using Earned Value Management (EVM) or Cost, Schedule Control Systems Criteria (C/SCSC).
- Assess if DoD investments will be needed to create or enhance certain critical industrial capabilities.
- Monitor product support performance and correct trends that could negatively impact availability and cost.
- Develop Manufacturing Cost Risk Handling/Maturation Plans:
    - Prime Contractor
    - Key and critical subcontractors and vendors.
- Use field data and failure reports to update cost models and help ensure that Sustainability targets are being met.
- Identify and account for demil. and disposal cost.

- Review reliability and maintainability data from operational testing and fielding in developing the Cost Mitigation/Maturation Plan.

Tools

- EVM and C/SCSC software tools or in excel
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Maturation Plan
- Manufacturing Readiness Assessment Cost and Funding thread

Resources

- 10 USC 2334, Independent Cost Estimation and Cost Analysis
- Cost Analysis Requirements Description (CARD) Template (*see* CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- MRL Deskbook
- O&S Cost Estimating Guide, CAPE
- O&S Cost Management Guide
- Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide for Defense Acquisition Process

G. MATERIALS MANAGEMENT

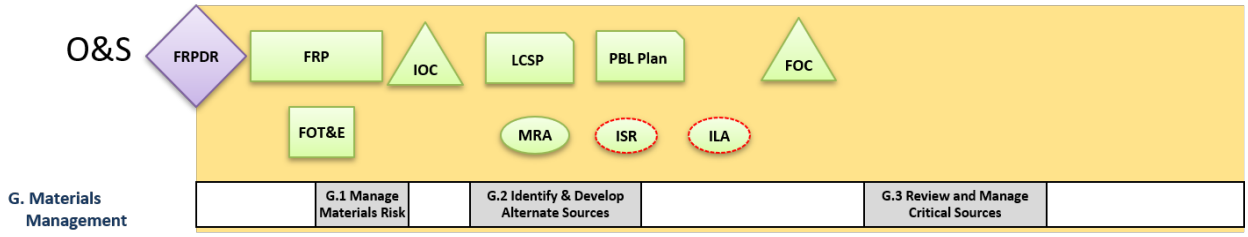


Figure 6-8. Materials Management Manufacturing and Quality Activities

Introduction

The acquisition community generally refers to material management as being concerned with the identification and management of materials required for manufacturing or production during operations and sustainment. Materiel management is different. The logistics or sustainment community refers to materiel management as being concerned with management activities involved in developing,

operating, implementing, and analyzing manual and automated integrated logistics systems to support various weapons systems, while simultaneously providing customer service to combat support. This section is about managing materials and includes concerns about:

- Availability (is readily available to support production)
- Maturity (has been characterized for manufacturability)
- Supply chain (for the buy items in the Bill of Materials)
- Special handling requirements (toxic materials or chemicals used in the product or production process, or special handling from a perspective of moving the item around the production facility)

Material management is concerned with the entire supply chain and is driven by several specifications and standards to include:

- DoDM 4140.01, DoD Supply Chain Materiel Management Procedures
- DoDM 4140.01, Volumes 1-11, DoD SCM Management Procedures
- Supply Chain Operations Reference (SCOR) Model
- MIL-STD-3018 Parts Management
- SD-22, Diminishing Manufacturing Sources and Material Shortages
- DoDM 4160.21, Volumes 1-4, Defense Materiel Disposition: Disposal Guidance and Procedures

During the sustainment phase, programs face unique challenges as they attempt to manage their military supply chains, especially during wartime.

At the strategic level, military and private organizations must address the logistics issues of acquisition, distribution, sustainment, and disposition and disposal. As the program matures and moves from production to spares production, and ongoing maintenance and sustainment activities, the nature of the business arrangement often changes as DoD contractors get out of the business and DoD MRO activities take on increasingly more responsibilities.

As the program matures and transitions to the O&S phase, Sustainment managers should be concerned about:

- Material availability and in particularly DMSMS, obsolescence, and counterfeit parts
- Material maturity
- Supply chain management
- Special handling

The objective of this phase is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. When the system reaches the end of its useful life, the department should dispose of it.

During sustainment, M&Q managers should support in-service reviews to identify material risks including identifying root causes of risks, corrective action, and continuous improvement. Sustainment activities include participating in trade studies and decision making that may impact the product

support package, manufacturing process improvements, modifications, upgrades, and future increments of the system while considering the operational needs and expected service life.

DoD Supply Chain Material Management Regulation directs DoD Components to use the supply chain operational reference processes of Plan, Source, Make/Maintain, Deliver, and Return as a framework for developing, improving, and conducting material management activities. Most of the DoD supply chain focus is on operations and logistics.

Sustainment Material Risks often include such concerns as:

- Diminishing Manufacturing Sources and Material Shortages (DMSMS) and Obsolescence
- Corrosion Control
- Counterfeit Parts

DMSMS, the loss of sources of items or material, surfaces when a source announces the actual or impending discontinuation of a product, or when procurements fail because of product unavailability. DMSMS may endanger the life cycle support and viability of the weapon system or equipment.

Counterfeiting of parts and materials, especially in the electronic business segment, is growing at an alarming rate. In addition, there are unique conditions that make aerospace and defense products susceptible to counterfeiting, including a long-life cycle and DMSMS issues. Therefore, supporting aerospace and defense products throughout their life cycle sometimes requires the use of parts that may no longer be available from the Original Equipment Manufacturer, authorized aftermarket manufacturer or through franchised or authorized distributors or resellers.

There are several ways the DoD can address material needs and shortages. One is through the Defense Production Act of 1950 and the implementation of the Defense Priorities and Allocation System (DPAS) in which the government can designate programs as “high priority” and put them at the front of the contractor’s production queue. Another is the Defense Industrial Capabilities Handbook, DoD 5000.60H, which identifies alternative actions the government can take when facing material shortages to include:

- Finding foreign sources of supply
- Finding alternative or substitute parts
- Making a Lifetime buy to meet all planned future needs
- Maintaining a current capability
- Developing an Alternative solution

Many DoD systems require maintenance long beyond the useful life initially anticipated. Extending the service life of military systems increases the costs of ownership. One way to reduce O&S costs is to take advantage of the commercial sector's technological innovations by inserting commercial technology into fielded weapon systems.

One of the major challenges facing DoD is modernizing legacy systems using state-of-the-art technology. Therefore, from the start of an acquisition program, DoD must consider not only how to field a useful military capability quickly, but also how it can upgrade a system later. Considerations include the latest technology, increasing mission performance, reducing O&S costs, and enhancing

supportability. Modernizing legacy systems requires the identification of potential replacement parts, components, and even subsystems requiring the validation and acceptance of alternative materials.

Where and how the contractor gets sources of material can be a vital concern for PMs. Having just one sole source, single source or foreign source in supply chain could be a showstopper, especially if that item is a critical item that significantly impacts the capability of the system to perform its mission.

- A sole source is one in which there is only one source for that item. There are no other alternatives.
- A single source is one in which there is only one "qualified" source. Qualification can be an expensive and time-consuming process.
- A foreign source is one that is outside of the U.S. industrial base

If the contractor is in a sole source, single source, or a foreign source situation, it may want to consider an investment strategy to qualify a second source. Now the contractor has competition in addition to a second source.

Foreign sources carry with them many problems. The transfer of some intellectual information to companies outside of the United States can be restricted by International Traffic in Arms Regulations (ITAR). In addition, some countries restrict the types of items their companies can sell to the United States. For example, items that go into nuclear programs are often restricted by countries with strong nuclear concerns. Sometimes politics can play a role and an item that is available this week may not be available next week due to political pressures. If the contractor has a foreign sources item that is critical to the program, they might want to consider funding a second source, a U.S. source.

G.1 Manage Materials Risk

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Material risks may slow or delay a program, add additional costs to a program, or create field failures because of poor material reliability. Material risks could include availability of the material, maturity of the material, or need for special handling and control. Material risks can occur anywhere in the supply chain all the way down to the lowest level (dirt). Manufacturing and QA managers need to support the identification and management of material risks.

Manufacturing and Quality Tasks

- Help identify material availability risks to include:
  - DMSMS/obsolete parts and develop plans for suitable replacements
  - Sole Source, Single Source or Foreign Sourced items
  - Counterfeit parts
- Help identify material maturity risks or materials that have not been fully characterized.
- Help identify supply chain risks at the prime, subcontractors, and vendors.
- Help identify special handling risks.
  - Move safe

  - ESOH
- Periodically assess product support performance and take corrective action to prevent degraded materiel readiness or O&S cost growth.

Tools

- DMSMS Product Life Cycle Assessment
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan
- Market Research
- Supply Chain Management Risk Assessment Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Audit Checklist
- AS9103, Variation Management of Key Characteristics
- AS9134, Supply Chain Risk Management Guidelines
- DMSMS Guidebook, SD-22
- DoD Market Research Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- DoD Product Support Managers Handbook
- DoDM 4140.01, DoD Supply Chain Materiel Management Procedures
- DoDM 4140.01, Volumes 1-11, DoD SCM Management Procedures
- DoDM 4160.21, Volumes 1-4, Defense Materiel Disposition: Disposal Guidance and Procedures
- MIL-STD-3018, Parts Management
- MRL Deskbook
- SD-22 Diminishing Manufacturing Sources and Material Shortages
- Supply Chain Operations Reference (SCOR) Model

G.2 Identify and Develop Alternate Sources

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole source, single source, and foreign sources of supply come with a lot of risks. In addition, suppliers come and go in the marketplace. One day there might be four sources of supply and the next day one or none. DMSMS and obsolescence are two very real problems on DoD programs, especially programs that are past their prime and well into the operations and support activities. One way to mitigate those risks and to increase competition (reduce cost) is to identify and

develop alternative sources of supply. But this is not a quick or a cheap fix as the new supplier will probably need to go through a qualification program and prove that they have the capability to produce one, the capacity to produce all that is needed, and the financial stability to be able to perform for the entire contract period of performance.

Manufacturing and Quality Tasks

- Identify potential parts problems and help to identify and develop alternative sources of supply as appropriate.
- Work with product support integrators and product support providers to investigate alternate source options.
    - Sources may be organic, commercial, or a combination.
- Verify the prime supplier has validated alternate sources are capability of meeting quality, manufacturing, engineering, and software requirements.
- Periodically assess product support performance and assist PMs, users, resource sponsors, and materiel enterprise stakeholders to take corrective action to prevent degraded materiel readiness or O&S cost growth.

Tools

- DMSMS Product Life Cycle Assessment
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan
- Market Research
- Supply Chain Management Risk Assessment Checklist

Resources

- DoD Product Support Managers Handbook
- DoDM 4140.01, DoD Supply Chain Materiel Management Procedures
- Supply Chain Operations Reference (SCOR) Model
- MIL-STD-3018, Parts Management
- SD-22 Diminishing Manufacturing Sources and Material Shortages
- DLA DMSMS Acquisition Guidelines
- DoD Market Research Guide
- AS9134, Supply Chain Risk Management Guidelines
- AS9100, Quality Audit Checklist
- AS9103, Variation Management of Key Characteristics
- AS6500, Manufacturing Management Program
- MRL Deskbook
- SCM: A Recommended Performance Measurement Scorecard

- DoDM 4160.21, Volumes 1-4, Defense Materiel Disposition: Disposal Guidance and Procedures
- DoDM 4140.01, Volumes 1-11

G.3 Review and Manage Critical Sources

A source is only a good source if it provides the right product, at the right time and place, at the right cost and with the right performance. Thus, if an item is the lowest cost but is unreliable or comes in late, or comes in with quality deficiencies, then buying that item was a poor decision. Supply chain material assessments are especially needed for those items that may be considered critical sources of supply. These critical items (Pareto the vital few vs the trivial many) are often long-lead or are sole/single sources of supply. Lead times for defense materials and components can be long and volatile. There are various reasons for this situation, such as:

1. Imbalances between capacity and demand
2. Imperfect forecasting of needs
3. Competition from commercial suppliers
4. Poor quality and lack of process improvement
5. Production bottlenecks
6. Long testing cycles
7. Raw materials not available
8. Long contracting process
9. Lack of funding
10. Transportation
11. Labor issues

Manufacturing and Quality Tasks

- Help identify and assess materials risks, especially critical materials, and sources of supply that should include the assessment of:
    - Material Availability: Concerned primarily about sole source and foreign source but could also include limited sourcing and long lead sourcing. In the O&S phase there will be growing concerns about DMSMS and obsolescence. Along with that will be concerns about counterfeit parts.
    - Material Maturity: Concerned about the introduction on new parts, especially electronic parts that are replacing parts that are old and no longer being produced. This is usually concerned with having complete material knowledge at the time of production.

  - Material Supply Chain Management (SCM): Concerned about SCM since 60-80 percent of the fabricated and assembled items come from subcontractors and vendors and this is often where we have problems. Often the design occurs at the supplier level. The supply chain for the O&S phase often shifts from the prime and subcontractors to Maintenance Activities, Inventory Control Points, depots, MRO facilities, and installation support activities.
  - Material Special Handling: Concerned about the movement of material to and within the plant and any ESOH concerns.

- Review critical sources of supply, including contractor's technical capabilities in engineering, configuration management, and quality.
- Analyze and encourage sources to continually improve their processes and products. Encourage internal improvements at depots and within the support facilities.
- Review and analyze a contractor's parts program for the identification and elimination of counterfeit parts and materials.
- Ensure the prime contractor has delegated all technical requirements to include quality requirements.
- Ensure that DCMA at the prime contractor is reviewing the flow-down of requirements and oversight to their counterparts at subcontractor and vendor organizations.

Tools

- AS6500, Manufacturing Management Program
- AS9100, Quality Audit Checklist
- AS9134, Supply Chain Risk Management Guidelines
- Interactive MRL Users Guide (Checklist) for the Materials thread
- ISO 9001, Quality Audit Checklist
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Management System – Aerospace
- AS9103, Variation Management of Key Characteristics
- DAU DMSMS Acquisition Guidelines
- DoD Market Research Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDM 4140.01, DoD Supply Chain Materiel Management Procedures
- DoDM 4140.01, Volumes 1-11
- DoDM 4160.21, Volumes 1-4, Defense Materiel Disposition: Disposal Guidance and Procedures
- ISO 9001, Quality Management System

- MIL-STD-3018 Parts Management
- MRL Deskbook
- SD-22 Diminishing Manufacturing Sources and Material Shortages
- Supply Chain Operations Reference (SCOR) Model

H. PROCESS CABABILITY AND CONTROL

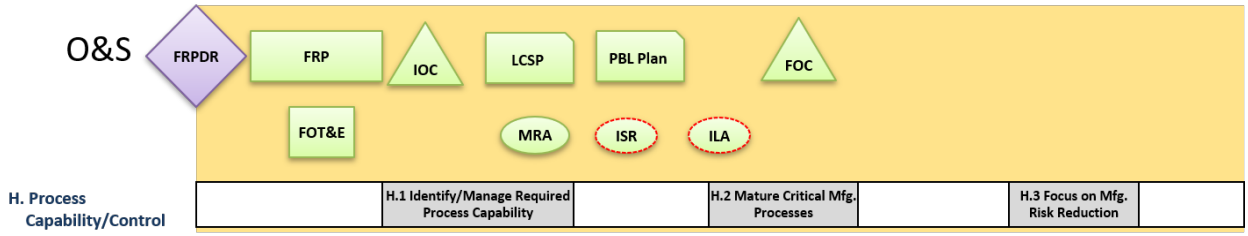


Figure 6-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with "uniform, defect free product that has consistent performance and is affordable. Product quality comes from robust product and process design and process control activities to include continuous process improvement to identify and remove sources of variation.

Process Capability and Control is a requirement of both ISO 9001 and AS9100 quality standards and requires a process control plan, which describes the actions and activities that will demonstrate process capabilities. Process capability is used to determine if a process is stable (predictable) and in a state of control. Typical process control measures include Cp/Cpk and Pp/Ppk. For each concept being considered, a determination of the manufacturing processes capability will be completed. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Critical and key manufacturing processes can also be identified during the assessment and analysis either through M&S or experimentation.

Advances in digital engineering to include modeling and simulation along with continual improvements in computer performance have made it possible to perform comprehensive analysis of virtual parts and to test and assess the capability of processes before actual manufacturing begins. The use of solid modeling, finite element analysis, multi-paradigm numerical computing environments, and simulation software analysis tools, allows users to simulate different conditions that are likely to occur during manufacturing processes and model the behavior of systems under real-world conditions. An understanding of the capabilities to model products and processes for each of the concepts under consideration can be a valuable discriminator.

This thread (Acquisition) requires an analysis of the risk that the manufacturing processes may not be able to reflect the design intent (repeatability and affordability) of key characteristics and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Modeling and Simulation (M&S) of Processes
- Process Capability Studies
- Process Yields and Rates
- Process Demonstrations

During the sustainment phase, Process Capability and Control should be well understood, based on knowledge and experience during the P&D phase. However, production operations may shift from the prime contractor to government owned and operated facilities such as depots, MROs, and other industrial operations. Moving from one facility to another, with a different workforce, machines and other factory floor considerations may cause the process capability and control to slip below levels required to satisfy the warfighter.

Product quality, and effective operations and sustainment results, are a product of the feedback of M&Q data during production and after the item has been fielded and is in use. The results of the design and manufacturing efforts receive their real test when the item or system is placed in use under rigorous field conditions. If all the prior efforts have been adequately performed, the resulting product should meet the user's needs.

The goal is to strive for no failures and full user satisfaction. If this is not achieved, then corrective action must be taken, and taken quickly to remove the cause of failure and of the user discontent. Of course, this is more difficult at this late stage of the acquisition cycle then if action were taken to identify and correct the root cause of the problem early in design or production. If the root cause of the problem requires a design change then engineering changes after this point cost more to implement than those discovered during initial design; therefore, it is important that all quality actions take place during design, development, and manufacture of the product. It is essential that M&Q personnel are involved in all aspects of any program and are involved early in the process. If the problem is in the production or MRO/depot facility, then root cause corrective action must be taken on the industrial facilities that caused the defect or problem.

If AS6500, Manufacturing Management Program is invoked on contract, verify the supplier has conducted a PFMEA of critical manufacturing processes. This may also be required to be accomplished by the supplier when required by contract requirements language.

- Review supplier process yields and PFMEA conducted on critical manufacturing processes to identify possible government surveillance.

Studies have shown that by the time a Preliminary Design Review (PDR) is held, around 80 percent of a program's life cycle costs are locked in even though only a small percentage of the program's cumulative costs have been expended. It is also the time when a program or contractor has the most opportunity to impact life cycle cost savings. By the time, the Critical Design Review (CDR) is held, the LCC commitment is around 90 percent. Manufacturing, logistics, and other considerations must be taken seriously early, or the program is doomed to becoming unaffordable. All manufacturing processes should have been demonstrated and those processes, especially the key processes, should be stable and in control. However, there may have been changes to manufacturing due to engineering changes (Value Engineering Change Proposals, etc.), or to changes in manufacturing facilities as

production of items and spares moves from the prime contractor to subcontractors, vendors, or government facilities.

The program should employ effective performance-based logistics (PBL) planning, development, implementation, and management in developing a system's product support arrangements. PBL is performance-based product support, where outcomes are acquired through performance-based arrangements that deliver warfighter requirements and incentivize product support providers to reduce costs through innovation

During the P&D phase the contractor will produce and deliver requirements-compliant products to receiving military organizations. During the O&S phase, they will have to supply compliant sustainment products, parts, and limited-life supplies to maintain the systems they have produced.

Continually assess and refine the product support strategy based on projected and actual performance.

The Sustainment KPP (Availability) is as critical to a program's success as cost, schedule, and performance. Acquisition Category I and II PMs will use availability and sustainment cost metrics as triggers to conduct further investigation and analysis into drivers of those metrics. Manufacturing and quality managers need to assess and improve specific process capabilities that can have a negative impact on reliability, availability, and maintainability to help reduce cost. The materiel availability portion of the KPP will be based on the entire system inventory and supported by the following sustainment metrics.

The EMD Acquisition Strategy should have highlighted the strategy for assessing the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a pilot line environment, before Milestone C.

To the maximum extent practical, the environment should use rate production processes forecasted to be used in LRIP. The Acquisition Strategy should strategically describe the planning to assess and demonstrate that the manufacturing processes/capabilities, required for production will have been matured to a level of high confidence for building production configuration products in the P&D phase and spares during sustainment.

H.1. Identify/Manage Required Process Capability

One of the goals of manufacturing is to have a uniform, defect-free product. To achieve that goal, the production processes must be capable, that is, the outcome of the production process is a product that meets spec. Manufacturing and QA managers need to be working continuously on production processes to reduce variation and make the process robust to design requirements. Process control studies are often accomplished when the contractor finds they are producing product that does not meet spec. But why wait for bad outcomes when the program can plan for success. Identify upfront and early what the design requirements are and make all processes capable of meeting those requirements even before the start of production. Note: There is no one standard process capability measurement for all process and product characteristics. However, key and critical characteristics should receive the most focus on development of a standard and on the management of those characteristics during the life of the product.

Manufacturing and Quality Tasks

- Support the identification and management of key/critical characteristics.
- Identify opportunities for government surveillance of key/critical characteristics.
    - At prime contractor, subcontractor, or government facility.
- Review process control plans for management and control of key/critical characteristics and identify possible government surveillance.
- Review key/critical process capability performance measures (Cp and Cpk, Pp and Ppk, or other appropriate measure) to identify possible government surveillance and flow-down requirements, and to determine process stability and capability.
- Review process yields and Process Failure Modes and Effects Analysis (PFMEA) conducted on key/critical manufacturing processes to identify possible government surveillance and continuous improvement opportunities.
- Manage sustainment performance by using sustainment metrics mapped to the Sustainment KPP and KSAs.
- Conduct a PRR or MRA to assess risk in standing up a new spare parts line or conducting work at a repair facility.

Tools

- AS9100 Checklist
- AS6500 Checklist
- FMEA Template
- Interactive MRL Users Guide (Checklist) for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Studies (Cp and Cpk assessment)
- Producibility Assessment Worksheet (PAWs)
- Six Sigma Worksheet

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9134, Supply Chain Risk Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook

- Capability-Based Assessment (CBA) Handbook
- DCMA-INST 323, Data Collection and Analysis
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program
- MRL Deskbook

H.2. Mature Critical Manufacturing Processes

Immature processes are a major source of risks on acquisition programs, especially during the P&D phase when most production takes place. As a program moves forward, process maturity takes on greater importance. According to DoDI 5000.85, Major Capability Acquisition, the FRP decision requires the control of manufacturing processes. If these processes are not capable, in control, and affordable, then the program office needs to continue to mature those processes.

Manufacturing and Quality Tasks

- Support the maturation of critical manufacturing processes.
- Promote standard and stable manufacturing/factory floor processes that could be used in a depot as well as production activities:
    - Utilize SPC or other appropriate controls
- Support performance-based logistics (PBL) planning, development, implementation, and management at contractor and government facilities to mature critical manufacturing processes.
- Identify outcomes for critical manufacturing processes and incentivize product support providers to reduce costs through innovation.
- Support the assessment and refinement of the product support strategy based on projected and actual factory floor performance.
- Assess key/critical manufacturing processes to ensure that they are stable and in control.

Tools

- AS9100 Checklist
- AS6500 Checklist
- AS6500, Manufacturing Management Program
- Interactive MRL Users Guide (Checklist) for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Study (Cp and Cpk assessments)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program

  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS913,3, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Risk Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- DCMA-INST 323, Data Collection and Analysis
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program
- MRL Deskbook
- PBL Guidebook

H.3. Focus on Manufacturing Risk Reduction

According to the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, the following approach should be considered to help identify risks in the production environment:

- Make-buy decisions, changes to suppliers, parts obsolescence, product delivery issues
- Manufacturing: manufacturing readiness, tooling, process maturity, etc.
- Other considerations such as government-furnished equipment availability, business consolidations, sole and single source suppliers, access to raw materials, export control, etc.

The risk mitigation option seeks to actively reduce risk to an acceptable level. Mitigation generally entails taking action to reduce the likelihood, and on occasion the consequence, of a risk to as low as possible to minimize potential program impacts.

Manufacturing and Quality Tasks

- Review manufacturing risks at contractor and DoD facilities to ensure compliant products are produced and delivered to the warfighter.
- Assess manufacturing risks and develop a manufacturing maturity program.
- Track cost, schedule, and performance using the sustainment KPP (Availability) as a critical metric.
- Identify, track, and manage sustainment metrics (availability and sustainment cost), and act when metrics exceed goals or targets.
  - KPPSs, KSAs, MOEs, TPMs, etc.
- Develop Should Cost targets, and to develop strategies for improving reliability, availability, and maintainability (R&M) while reducing cost.

- Ensure that the materiel availability portion of the KPP is be based on the entire system inventory.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Risk Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- DCMA-INST 323 Data Collection and Analysis
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program
- MRL Deskbook

I. QUALITY MANAGEMENT

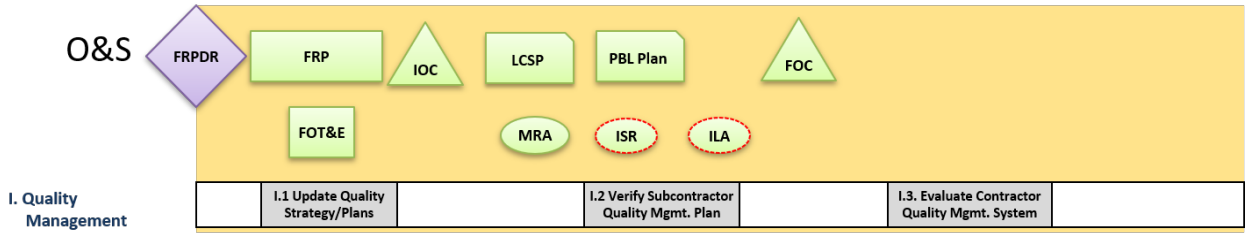


Figure 6-10. Quality Management Manufacturing and Quality Activities

Introduction

DoD has increased management focus on M&Q management during early program phases. Quality is the degree to which material attributes, performance features, and characteristics of a product satisfy a

given need. Quality may apply to a product, process, or system and may be physical, sensory, behavioral, temporal, ergonomic, or functional.

Quality management is an integral part of design and development efforts. QMS standards include industry best practices such as ISO 9001, Quality Management Systems–Requirements; and AS9100, Quality Management Systems - Requirements for Aviation, Space and Defense Organizations, Product Realization (clause 7) includes typical systems engineering tasks under sub-clause 7.3, Design and Development. The typical systems engineering processes included in the QMS are:

- Design and Development Planning – SE Management, Failure Modes, Effects, and Criticality Analysis (FMECA), System Safety, etc.
- Design and Development Inputs/Outputs – T&E, Reviews, and Audits.
- Design and Development Review, Verification and Validation.
- Control of Design and Development Changes – hardware and software Configuration Management.
- Hardware and Software Configuration Management.
- Risk, Issue, and Opportunity Management.
- Corrective Action System.

The requirements for Quality Assurance and Control come from the FAR/DFAR and general industry guidance comes from ISO 9001 and AS9100 quality standards. These standards require that organizations establish a formal quality policy and submit documentation on internal processes, procedures, and standards. The following are mandatory requirements of ISO 9001:

- Monitoring and measuring equipment calibration records
- Records of training, skills, experience and qualifications
- Product/service requirements review records
- Record about design and development outputs review
- Record about design and development inputs
- Records of design and development controls
- Records of design and development outputs
- Design and development changes records
- Characteristics of product to be produced and service to be provided
- Records about customer property
- Production/service provision change control records
- Record of conformity of product/service with acceptance criteria
- Record of nonconforming outputs
- Monitoring measurement results
- Internal audit program
- Results of internal audits
- Results of the management review

- Results of corrective actions

Note: AS9100 standards includes all of the above, and more.

This thread (Quality) requires an analysis of the risk and management efforts to control quality, and foster continuous quality improvement and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Quality Management System (QMS)
- Quality Strategy and Plan
- Product Quality
- Supply Chain Quality
- Quality Risk

An effective QMS is required to produce operationally safe, suitable, and effective weapon systems. A QMS should be compliant with industry standards such as ISO 9001 or AS9100 and is foundational to producing products that meet contractual requirements. The QMS ensures the as-delivered configuration is the same as the as-designed and as-tested configuration. The QMS serves as the management and control function, requiring controls over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. It also requires monitoring and measuring of processes and products to ensure they conform to requirements.

Quality Assurance focuses on having a:

- Quality Management System (QMS)
- Product Quality Focus
- Supplier Quality Program

A program should ensure that the Acquisition Strategy incorporated a Quality Strategy that supports and aligns with the program strategy, objectives, goals, and the contract. This will involve the use of process audits as to whether the contractor's and supply chain activities, resources, and behaviors are being managed efficiently and effectively including participation of DCMA, Key Characteristic control and management, use of acceptance testing, application of Statistical Process Controls (SPC), etc. Similarly, these audits should be conducted on the supply chain, as necessary.

The initial quality strategy should have been developed during the MSA phase and updated in every phase in support of the Systems Engineering Plan (SEP) to include the O&S phase.

During the sustainment phase, a contractor, or a government owned or operated remanufacturing facility (depot/MRO, etc.) should have implemented an effective QMS in accordance with FAR 46.202-4 Higher-level Contract Quality Requirements.

The Contractor Quality Control Plan (QCP) is the contractor's management plan for executing the contract. The Contractor QCP describes the way in which the contractor will produce the deliverables, and the step-by-step approach that will be taken to ensure the quality of the engineering and design

services and the products derived from those services. The contractor is required to submit a Contractor QCP as the first item of work in each delivery order or may submit a Contractor QCP as the first item of work in his contract and, at a minimum, a quality control supplement for each delivery order for an indefinite delivery contract. Subcontractors make up 60-80 percent of the material content on many programs, thus prime control of subcontractors' Quality Management System and Plan are essential to the success of any program.

The intent of verifying supplier quality programs is to draw attention to troubled suppliers or critical processes needing corrective action by on-site visits/reviews. The contractor will usually respond by sending his own representative to the site when the program office outlines their reasoning. Consider inviting the program chief engineer or even the program director if the situation warrants their attention. The contractor will usually respond with equal high-level attention.

Primes and suppliers conduct training in counterfeit parts avoidance for inspectors, operators, auditors, and lower tier suppliers to include awareness of AS5553. Training should discuss how to inspect parts and identify possible counterfeits (e.g., non-conforming part markings).

As MDAPs become more complex and supply chains become longer, more obscure, and prone to unforeseen quality breakdowns, program risk associated with supplier processes has increased exponentially. Since the issues surrounding the supply chain typically impact program quality, cost, and schedule, the M&Q personnel at DCMA can be key contributors in addressing this type of risk and providing visibility into potential future suppliers' problems/ issues.

The Quality Surveillance Plan (QSP) is a government document that establishes the methodology that the government will use to monitor and evaluate contractor performance and to ensure that the contract objectives are being met. A properly developed QSP provides guidance to all government contract oversight personnel on their contract surveillance roles and responsibilities.

A QMS is a formal system that documents policies, processes, and procedures that may be required to achieve specific quality goals and objectives. The intent is to use the QMS to meet or exceed customer expectations and improve overall efficiency and effectiveness. The two dominant QMS programs currently available are ISO 9001 and AS9100. A QMS should be in place at all contractor facilities with a higher-level quality requirement per FAR/DFAR or at any government owned and operated facility doing production type work.

I.1 Update Quality Strategy/Plans

M&Q managers support the development and updates to the Acquisition Strategy by providing their inputs into the Systems Engineering Plan (SEP). Quality managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and ultimately for the success of a program.

Manufacturing and Quality Tasks

- Review and update the program's Quality Strategy.
    - The Quality Strategy should be updated based on performance results, sustainment metrics mapped to the Sustainment Key Performance Parameter and Key System Attributes, to manage sustainment performance.
- Continually monitor product support performance using field data and correct trends that could negatively impact availability and cost.
- Review factory floor department status (schedule, work measurement, Scrap, Rework, and Repair, yields, etc.).
- Review and improve M&Q processes to reinforce the need for process improvement efforts.
- Review and assess problem/failure reports (Failure Reporting, Analysis and Corrective Action System) as appropriate.
- Determine the root cause of problems, identify corrective actions, and manage continuous improvement activities to completion.
- Ensure quality strategies address the following areas:
    - Process and analyze mission data
    - Manage Preplanned Product Improvements
    - Develop and implement technology refresh schedules
    - Conduct technology insertion efforts as needed to maintain or improve system performance
    - Update system safety assessments
    - Perform engineering analysis to investigate the impact of DMSMS issues
    - Work with vendors and the general technical community to determine opportunities for technology incursion to increase reliability and affordability
    - Support demilitarizing and disposing of the system; in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment

Tools

- Acquisition Strategy Template
- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Requirements Analysis Roadmap

Resources

- AFMC Instruction 63-145, Manufacturing and Quality

- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Risk Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- FAR 46.202 Types of Contract Quality Requirements
- FAR 52.246-11, Quality
- ISO 9001, Quality Management System
- MRL Deskbook

I.2 Verify Subcontractor Quality Management Plan

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then the development, execution, and verification of a supplier QA program becomes a pivotal task. Often program problems originate in the supply chain, but do not manifest themselves until the component is integrated into the system. Program offices and contractors often have efforts to identify and manage problems at the first tier, but may not do well below that level. QA managers need to routinely review and assess contractors supply chain and procurement activities and efforts.

Manufacturing and Quality Tasks

- Review and verify the Subcontractor Quality Management Plan
- Ensure that the appropriate quality clauses are flowed down into the supply chain.
- Ensure that subcontractor quality requirements to include quality management plans are reviewed and managed at depots and MRO activities.
- Establish supply chain quality management metrics for each of the concepts being considered for incoming quality inspection to include the identification of acceptable quality levels (AQLs)
  - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Assess how efficiently the subcontractor or vendor is producing products, primarily through on-site quality assessments and the evaluation of work measurement data.
- Analyze the causes of variances, their root causes, and championing and motivating contractor improvements.

- Verify the supplier is conducting a Corrective Action Board (CAB) and/or Material Review Board (MRB), or similar meetings, to discuss quality, manufacturing/production, supply chain, engineering and software deficiencies/issues and proposed/status corrective actions, at a minimum.
- Draw management attention to troubled suppliers or critical processes needing corrective action by on-site visits/reviews.
- Perform government surveillance of supplier's compliance to software quality assurance, configuration management, and testing contract requirements
- Review how primes and suppliers conduct training in counterfeit parts avoidance for inspectors, operators, auditors, and lower tier suppliers.
- Ensure that training discusses how to inspect parts and identify possible counterfeits (e.g., non-conforming part markings).

Tools

- AS9100, Audit Checklist
- AS9134, Supply Chain Risk Management Guidelines
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Supplier QA Questionnaire

Resources

- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9134, Supply Chain Risk Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- DAG Chapter 14.3.1.3.6 Quality Plans
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- MRL Deskbook

I.3. Evaluate Contractor and Organic Facility Quality Management System

The following applies to either contractor or organic (i.e., depot, arsenal, shipyard) manufacturing operations. M&Q personnel need to identify the potential product quality requirements of an identified

material based on FAR 46.202, Types of Contract Quality Requirements, and FAR 52.246.1, Contractor Inspection Requirements. In addition, the organizations needs to identify the process of measuring, examining, testing, or otherwise comparing the product to the requirements for acceptance. FAR 46.291 Production Lot Testing identifies the purpose of production lot testing is to validate quality conformance of products prior to lot acceptance, which usually occurs after acceptance testing. Best practices has contractors operating to either ISO 9001 Quality Management System or AS9100 Quality Management System. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

Manufacturing and Quality Tasks

- Ensure the prime contractor or organic has implemented a Quality Management System Based on Best Practices (AS9100 or ISO 9001 as appropriate).
- The QMS should include:
    - Management responsibility
    - Resource management
    - Quality System
    - Contract Review
    - Product Realization
    - Design Control
    - Document Control
    - Purchasing
    - Purchaser-Supplied Product
    - Product Identification and Traceability
    - Process Control
    - Measurement, Analysis, and Improvement (metrology and calibration)
- Ensure the requirement for a QMS is flowed down throughout the supply chain as appropriate.
- Ensure the depots and MRO activities have implemented a Quality Management System Based on Best Practices (AS9100 or ISO 9001 as appropriate).
- Ensure that quality audits of the QMS and product take place at regular intervals and at the Prime, subcontractor, depot, and MRO activities.
- Ensure product quality requirements have been identified and are being managed:
    - Identify product acceptance methods and determine sampling plans as appropriate
    - Mature new quality technologies and process state of the art into product quality requirements
    - Identify and manage product quality requirements (i.e., specific product characteristics)
    - Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks

  - Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements
  - Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards

- Ensure the following:
  - Primes and suppliers have implemented a strong incoming quality review on all parts, and visually inspect for defects.
  - Organizations implement root cause corrective action for all defects.
  - Prime contractors require certificates of conformance, testing certification, and procedures for managing any counterfeit parts that might slip through the system.
  - First Article Inspection (FAI) and First Article Testing (FAT) are conducted, as necessary.
  - They determine the need for delegated government surveillance on critical products, configuration items, critical product characteristics and critical manufacturing processes that are produced at a sub tier supplier, especially those that have been designated high or moderate risk and those that impact KSA/KPP compliance.
  - Review the implementation of a reliability improvement program based on Failure Modes and Effects Criticality Analysis (FMECA).
  - Continually assess and refine the product support strategy based on projected and actual performance.
  - Conduct benchmarking to survey outside organizations that perform similar processes.
  - Support shutdown activities at all levels (Prime contractor, depot, MRO, etc.).

Tools

- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Lot Acceptance Testing Calculator

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Risk Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- MRL Deskbook
- MIL-STD-1916 DoD Test Method Standard, Apr 1996,
- ANSI Z1.4 Sampling Procedures and Tables for Inspection by Attributes
- ANSI Z1.9 Sampling Procedure and Tables for Inspection by Variables for Percent Nonconforming
- DCMA-INST 302 First Article and Production Lot Testing
- DoD Systems Engineering Guidebook

J. MANUFACTURING WORKFORCE

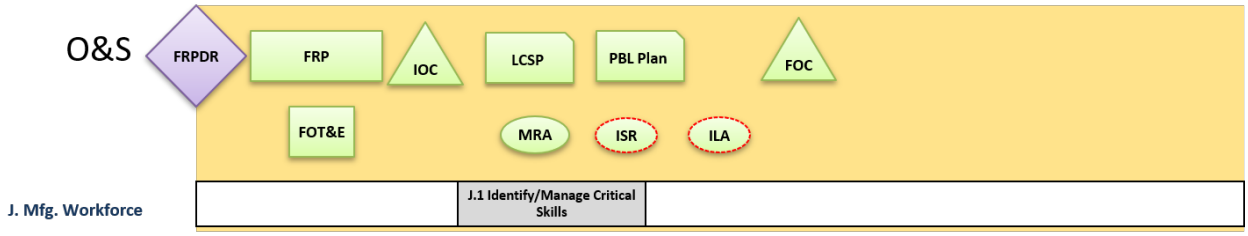


Figure 6-11. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

During the sustainment phase, workforce management is concerned about the availability of workers and skill levels required to perform the production and quality operations. Workforce planning should align the skills required to the scope of the effort required to develop, field, and sustain the system. A comprehensive assessment of contractor manufacturing plans for system development is necessary to understand the requirements for workforce skills, capabilities, training, and certifications.

Operations and support workforce requirements and contractor plans should be assessed for human resource policies, processes, and procedures, forecasts for the number of workers, skills, and capabilities, etc. In addition, the current training, certifications, and education, sourcing availability and stability, demographics of the contractor and supply chain should be evaluated for adequacy, as well as their capability and capacity to maintain the workforce as the program moves from Full-Rate Production to Operations and Support.

These production and quality operations may move from a prime or subcontractor facility to a depot or MRO. Problems may occur when the prime contractor cuts back from Full-Rate Production to supporting production for spares and sustainment operations. This lower level of production may cause the contractor to lose sight of important functions while they put their resources into higher rate production programs.

J.1. Identify/Manage Critical Skills

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on a regular and ongoing basis. Two major focus areas are:

- Workforce sills availability
- Workforce skills capability

Manpower skills availability and capability should have been assessed on a regular basis. Now that the program is in the O&S phase, manpower assessments need to identify critical skills and ensure that they will be available for the duration of the program.

Manufacturing and Quality Tasks

- Review and assess the contractor's manufacturing plans to identify workforce requirements for skills, capabilities, training, and certification requirements:
    - Contractor's make/buy processes for factors that determine the outsourcing of workforce skills
    - Scale-up or scale down of materials, subsystems, items, and components
    - Contractor's labor market (availability, stability, capabilities, training, etc.)
    - Potential ManTech changes, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
    - Potential facilities changes (e.g., location, improvements and expansion, lay-out changes, etc.)
    - Materials handling (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
    - Environment, safety, and occupational health
    - Manufacturing machinery and equipment (e.g., programming and operation, maintenance, calibration, and repair, etc.)
    - Facilities and tooling (e.g., operation and maintenance, safety, security, cleanliness, acoustics, Heating, Ventilation, Air Conditioning (HVAC) and environmental controls, etc.)
    - Quality (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- Assess the factory floor environment (union contract status, earthquakes, power outages, etc.) to determine potential impacts to program performance and sustainability goals.
- Assess factory efficiency and utilization. This activity involves the assessment of how efficiently the contractor is producing products, primarily through the evaluation of work measurement data. It also includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Workforce thread
- Learning Curve Calculator (Estimator)
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis
- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Resource Planning (MRP II) software
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook

K. FACILITIES

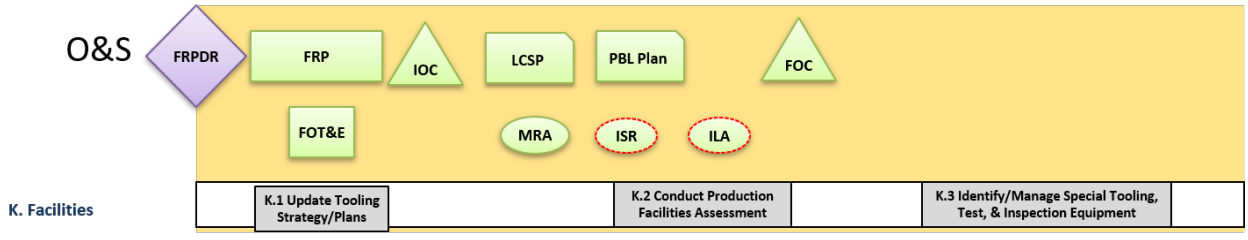


Figure 6-12. Facilities Manufacturing and Quality Activities

Introduction

During the sustainment phase, M&Q personnel should update the facility and tooling strategies and plans developed and used during production and operations. In addition, they should conduct

assessments of proposed production facilities and update and finalize the tooling plan for the O&S phases and then plan for smart shutdown.

During the sustainment phase, a contractor, or a government owned or operated remanufacturing facility (depot/MRO, etc.) should have implemented an effective facilities management plan along with a tooling plan.

Manufacturing tooling, to include special tooling (ST), special test equipment (STE), and special inspection equipment (SIE) should be assessed for its ability to support sustainment production and operations. Current special tooling strategies favor condition-based maintenance or total productive maintenance (also known as total preventive maintenance). Often special tools, test, and inspection equipment have been in use in the production environment for a long time and may face the need for refurbishment or purchasing of new tools and test equipment. But as production rates and quantities go down, the budget for special tools and test equipment may also go down. In addition, the manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as depots, MROs, etc.

K.1. Update Tooling Strategy/Plans

Tooling (special tooling, special test equipment and special inspection equipment) is often a significant cost and schedule driver. The B1 program for example had over $1 billion in tooling, and the lead times for facility and tooling development can be years. Often one risk reduction strategy is to begin development of facilities and long-lead tooling well in advance of the contract for the next phase. During the O&S phase M&Q managers need to be considering what their strategy is for reducing risk in the implementation of a tooling program.

Manufacturing and Quality Tasks

- Ensure that updated Tooling Strategy and Plans include:
    - Identify special tooling, special test, and special inspection equipment
    - Update the manufacturing plan (tooling section)
    - Identify smart shutdown conditions and operations with respect to special tooling, test, and inspection equipment
    - Implement preservation and storage of unique tooling plan once shutdown is accomplished
    - Identify ST, STE, and SIE risk areas
    - Identify ST, STE, and SIE requirements to maintain equipment for the life of the program
- Review the use of existing government owned inventory prior to use of product support arrangements.
    - The government accountable property system that documents all government owned property whether it is held and managed by the government, contractor, or third party

- The government accountable property system that documents all government-owned property whether it is held and managed by the government, contractor, or third party, in accordance with 40 USC 524

Tools

- Acquisition Strategy Template
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Strategy (no template available)

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management Program
- Condition-Based Maintenance Plus DoD Guidebook
- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5, Elements of a Manufacturing Strategy
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 4151.22, Condition Based Maintenance Plus for Material Management
- DoDI 5000.88, Engineering of Defense Systems
- FAR/DFAR 52.245.17, Special Tooling
- FAR/DFAR 52.245.18, Special Test Equipment
- MRL Deskbook
- P.L. 110-417, Section 815, program documentation must include the review cycle for assessing tool retention across the life of the system.

K.2. Conduct Production Facilities Assessment

Manufacturing facilities assessment includes an analysis if the capabilities and capacity of the production facilities to continue production through the O&S phase and prepare for a smart shut-down. Facilities assessments should include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities anywhere production may occur.

Manufacturing and Quality Tasks

- Conduct production facilities assessments to ensure that:
  - Facilities had the capability and capacity to produce items needed during the O&S phase
  - Facilities assessments consider the impact of a program winding down production and producing only to support spares.
  - Facilities should plan for a smart shut down at the end of the program.
  - The contractor's manufacturing plan has been updated to include facilities management.
  - That the current usage and utilization rates are cost effective and affordable.

  - Product support integrators and product support providers identify future production or remanufacturing as organic, commercial, or a combination.

- Prepare an assessment of facility capacity to include:
  - General knowledge of factory and environment (union contract status, earthquakes, power outages, etc.)
  - Identify schedule, key milestones, decision points, risks, and long lead items
  - Delineate between shutdown tasks to be charged directly to the shutdown effort, tasks covered by existing contracts including postproduction planning, and tasks to be otherwise allocated to overhead/indirect expenses
  - Assess any impact to the last production contract due to Ramp-Down. There may be a loss of efficiency due in part to employee morale unless the workforce moves to another program immediately
  - Process to include government personnel in the preliminary planning phases to identify items to be retained, disposed, and/or stored for sustainment or production restart
  - Union termination agreements
  - Shutdown of subcontractor activities and contract close-out
  - Cessation of production, disposal, and other related activities unless initially negotiated for the government to pay certain costs

Tools

- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management Program
- DCMA-INST-204, Manufacturing and Production
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook

K.3. Identify/Manage Special Tooling, Test, and Inspection Equipment

DoD often permits contractors to acquire Special Tooling, Special Test Equipment, and Special Inspection Equipment (ST/STE/SIE) as government-furnished property to be used in the development

or manufacturing of a product. Special tooling can include jigs, dies, fixtures, molds, patterns, taps, and gauges of a specialized nature intended for the development or production of specific DoD products. Special test equipment can be single or multi-purpose test units to accomplish special purpose testing in the performance of a DoD contract. Special inspection equipment can be single or multipurpose equipment used in the inspection and acceptance of DoD products

Manufacturing and Quality Tasks

- Identify unique tooling associated with the production of hardware to facilitate its protection and storage through the end of the program's service life.
- Review the contractor's or government's tooling plan and inventory.
- Review movement of special tooling and special test equipment.
- Review the use of existing government owned inventory prior to use of product support arrangements.
- Minimize the need for unique automatic test equipment (ATE) by using designated DoD automatic test system families for all ATE hardware in DoD field and depot operations.
- Review the Preservation and Storage of Unique Tooling Plan and ensure that it includes the review cycle for assessing tool retention across the life of the system.
- Review and assess all STE whether single or multipurpose integrated test units engineered, designed, fabricated, or modified to accomplish special purpose testing in performing a contract.

Tools

- Interactive MRL Users Guide (Checklist), Facilities thread
- Life Cycle Sustainment Plan Outline, Tooling Plan
- Manufacturing Maturation Plan

Resources

- DCMA Instruction 124, Contract Property Administration
- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5, Elements of a Manufacturing Strategy
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- FAR 45 Government Property
- FAR 52.245-1 Government Property
- Guidebook for Contract Property Administration
- MRL Deskbook
- USD(AT&L) Memo, Preservation, and Storage of Tooling for MDAPs

L. MANUFACTURING MANAGEMENT AND CONTROL

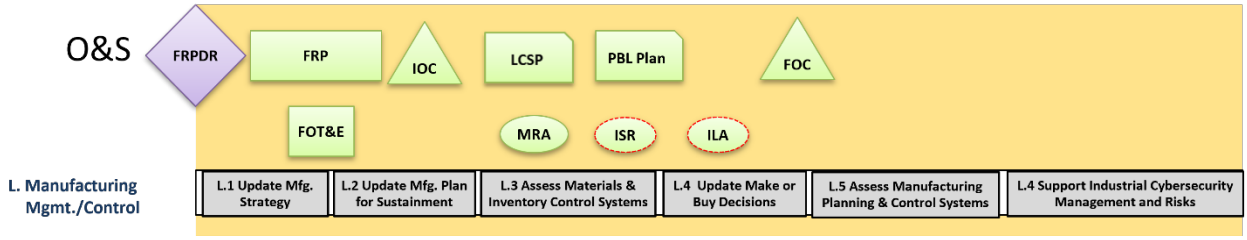


Figure 6-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

During the sustainment phase, Manufacturing Management/Control includes Materials Planning (MRP) and Manufacturing Planning (MRP II).

MRP is a production control system that integrates production requirements (rates and quantities) with the Bill of Material and inventories to calculate shipping schedules for parts and components and initiate the purchasing or subcontracting activities to support production. The primary functions of an MRP system is to ensure that the right materials are at the right place and at the right time to support production operations. A secondary function is to reduce waste by maintaining the lowest possible levels of materials and stock (inventory) while still meeting customer demand.

Manufacturing management is generally concerned with three types of material inventories:

- Raw Materials: Raw materials are the basic building blocks for the company. Often this is in the form of raw materials and components.
- Work-in-Progress (WIP): WIP is made up of materials, components, subassemblies, and assemblies that are in the process of being produced. That is, they have been released from material stores and have not yet been through final inspection and acceptance.
- Finished Goods: Finished goods have been inspected and accepted and are awaiting delivery to the customer.

Manufacturing Resource Planning (MRPII) is a planning control system that addresses factory floor planning from rough cut capacity planning, capacity requirements planning, cost reporting and control, and down to the execution of shop floor activities to meet daily demand. An MRP II system:

- Integrates Operational Planning and Execution with Financial Planning and Execution.
- Predicts production outcomes using simulation before the start of production.
- Involves every facet of the factory floor from planning to execution.

MRP II software auxiliary systems include:

- Lot traceability
- Contract management
- Tool management
- Configuration management

- Engineering change control

Manufacturing plans should have been developed in support of the O&S phase and sustainment operations. The manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as depots, MROs, etc.

Manufacturing resources consist of facilities, materials, machines, manpower, methods, measurement systems, and capital that are used to convert or transform raw materials and component parts into end items. Contractors must have an effective combination of people and systems to plan for, monitor, and control these manufacturing resources. A well-structured manufacturing management system generally employs the use of industry best practices. Assessment of the contractor's manufacturing management and quality systems should be performed against the recognized industry best practices such as AS6500, ISO 9000, AS9100, etc.

During the system Sustainment, the PM will deploy the product support package and monitor its performance according to the Life Cycle Sustainment Plan (LCSP). PMs are responsible for developing and maintaining an LCSP consistent with the product support strategy. The LCSP describes how sustainment influences the technical, business, and management activities that help to implement a product support package that maintains affordable system operational effectiveness over the system life cycle. The Acquisition Strategy will also include an overview of the product support strategy and sustainment-related contracts.

DMSMS, obsolescence, and counterfeiting of parts and materials, especially in the electronic segment, are growing at an alarming rate. A large network of suppliers in an increasingly global supply chain creates limited visibility into these sources, leading to a greater risk of procuring counterfeit parts. In addition, there are unique conditions that make aerospace and defense products susceptible to counterfeiting, including a long-life cycle and DMSMS issues. Therefore, supporting aerospace and defense programs require increased vigilance and oversight.

During the O&S phase, M&Q personnel will be involved in the following:

- Conduct Environment, Safety and Occupational Health risk assessments and maintain oversight of critical safety item supply chain management.
- Conduct analysis to identify and mitigate potential obsolescence impacts (i.e., DMSMS).
- Support implementation of follow-on development efforts in response to formal decisions to extend the weapon system's service life extension program (SLEP), or to initiate a major modification (may be treated as a stand-alone acquisition program).

L.1. Update Manufacturing Strategy

A manufacturing strategy is developed as part of the program acquisition strategy and often includes considerations such as competition. Manufacturing voids, deficiencies, and dependencies on critical foreign source materials should also be addressed. The producibility of each system design concept should be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and industrial base goals and thresholds.

Manufacturing and Quality Tasks

- Support the development of a Manufacturing Strategy to include the following items:
  - Should be included in the Systems Engineering Plan (SEP) and/or the Life Cycle Sustainment Plan (LCSP)
  - Should include Make/Buy decisions and the decision to have either organic or contractor sustainment support.
  - Should support the PMs in developing and maintaining an LCSP consistent with the product support strategy.
  - Should describe sustainment influences on system design and the technical, business, and management activities to develop, implement, and deliver a product support package that maintains affordable system operational effectiveness over the system life cycle and seeks to reduce cost without sacrificing necessary levels of program support.
  - Should specify Manufacturing Management System requirements (e.g., AS6500), if applicable to be met by the prime contractor and flowed down to suppliers, as appropriate.
- Review the following sources of industrial and manufacturing readiness data to develop the Manufacturing Strategy:
  - Program Status Reviews
  - Pre-Award Surveys
  - Production Readiness Reviews
  - Industrial Base Assessments
  - Trade-off studies, tooling plans
  - Make-or-buy plans
  - Manufacturing plans
  - Bills of material
- Identify risks and actions to reduce or address any remaining risks to include:
  - Manufacturing should review foreign sources and international cooperative development should be used where advantageous.
  - Manufacturing should provide inputs to support production surge capability and what-if exercises.
  - Manufacturing should provide inputs to program cuts and smart shutdown once a program has concluded.
  - Manufacturing should review priorities of competing programs (commercial and military).
  - Manufacturing should review production shutdown planning efforts.

Tools

- Acquisition Strategy Template

- Interactive MRL Users Guide (Checklist), 2018 for the Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management System
- ASD(LM&R) Life-Cycle Sustainment Plan memo
- DAG Chapter 4-3.5 Operating and Support Phase
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- Systems Engineering Plan (SEP) Outline

L.2. Update Manufacturing Plan for Sustainment

Manufacturing planning is about understanding everything it takes to produce the items required by the contract, on time, on budget, and with the right performance features. It includes considerations of all the 5Ms (manpower, machines, materials, methods, and measurements), at the prime contractor and throughout the supply chain. During the O&S phase, there may be manufacturing processes and requirements (5Ms) that will require planning for sustaining these capabilities through the duration of this phase.

Manufacturing and Quality Tasks

- Support development of Manufacturing Plans in support of the O&S phase and sustainment operations.
- Review the Manufacturing Plan to ensure it will provide the resources needed for sustainment operations as outlined in the LCSP.
- Assess the Manufacturing Plan for impact to the ‘5Ms’ (Manpower, Material, Methods, Measurement and Machinery).
- Assess the Manufacturing Plan for Risks, Issues and Opportunities.
- Ensure that Defense acquisition programs minimize the need for new defense-unique industrial capabilities.
- Support the development a Smart Shutdown plan.
- Ensure the contractor is conducting First Article Inspections on the hardware being produced from any new facility.

- The manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as depots, MROs, etc.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Material Management and Accounting System (MMAS) audit
- Risk, Issue, and Opportunity assessment
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis

Resources

- AS6500, Manufacturing Management Program
- DFARS 252.72 Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.88, Engineering of Defense Systems
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- Systems Engineering Plan (SEP) Outline

L.3. Assess Materials and Inventory Control Systems

Manufacturing and QA managers should be actively involved in the evaluation of a contractor's material management and control systems and with Material Resource Planning activities. DFAR 242.72 outlines the requirement for the Contractor Material Management and Accounting System (MMAS). An evaluation of the contractor's MMAS should include a review of the contractor's system for planning, management, and costing of materials used in the production of the DoD system.

Manufacturing and Quality Tasks

- Evaluate Material and Inventory Control Systems such as Material Requirements Planning.

  - Determine material requirements and components to support the manufacturing rate and determination of manufacturing lot quantities.
  - Minimize the total cost of inventory, which includes raw materials, work-in-progress, and finished goods.
    - Minimize buffer and supermarket inventories (identify and mitigate bottlenecks)
    - Implement Lean manufacturing and sustainment practices
    - Minimize setup times and batch sizes that lead to excess inventory
- Periodically assess product support performance and take corrective action to prevent degraded materiel readiness or O&S cost growth.
- Support DCMA in their assessment of contractor Production Planning and Control systems.
- Support the use of DCAA material management audit program.
- MSRA Production Planning and Control (PPC), Material Requirement Planning Checklist can be used to assess Material Requirements Planning.

Tools

- AS6500, Assessment
- AS9100, Assessment
- DCAA Materials Management Audit Program and Checklist
- DCMA MSRA Production Planning and Control (PPC), Material Requirement Planning Checklist
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- ISO 9001, Assessment
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronic Parts
- AS6174, Counterfeit Material
- AS6500, Manufacturing Management System
- AS9100, Quality Management System – Aerospace
- DCMA, Audit Policies, Procedures and Internal Controls Relative to Accounting and Management Systems
- DFAR Subpart 242.72 – Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- Material Management and Accounting System – Audit Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook

L.4. Update Make/Buy Decisions

The Make/Buy decision, sometimes called outsourcing, is a common practice, with the prime contractor often outsourcing 60-80 percent of the material costs of the system. The decision to make or buy should be based on the capability to produce, the capacity to produce, the availability of resources to produce, and the cost to produce.

Manufacturing and Quality Tasks

- Review and assess the contractor's Make/Buy plan identifying those items to be produced (make) or work that will be subcontracted (buy).
- Support the assessment of Make/Buy decision factors such as lowest overall cost or technical risk.
    - At the prime contractor's facility, subcontractors, vendors, depot, or MRO facility

Tools

- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- Product Support Business Case Analysis Guidebook Appendix A BCA Checklist
- Weapon System Acquisition Reform Product Assessment report requirements tool

Resources

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- MRL Deskbook
- Product Support Business Case Analysis Guidebook

L.5 Assess Manufacturing Planning and Control Systems

Manufacturing and quality managers need to be actively involved in the evaluation of a contractor's Manufacturing Resource Planning system. This includes the evaluation of the system's ability to collect, integrate, and process factory floor information to support manufacturing planning and execution activities. This includes capacity planning, production scheduling, manufacturing cost reporting, performance measurement, quality, and labor reporting.

Manufacturing and Quality Tasks

- Support the evaluation of Manufacturing Planning and Control systems (MRP II) to include:
    - Long-Term Planning
    - Medium-term planning
    - Short-term planning

- Support the following Long-term Planning requirements:
    - Demand Management (Customer requirements, how many and when)
    - Sales and Operations Planning
    - Resource/Production Planning (Rough Cut Capacity Planning)
    - Master Production Scheduling
    - Medium-term planning is the “engine” of an MRP II system and includes:
    - Detailed Material Planning
    - Demand Capacity Planning (Capacity Requirements Planning)
    - Material and Capacity Plans
- Support planning and implementation activities associated with the “back-end” of an MRP II system and includes:
    - Supplier Systems (Purchase Order Release)
    - Shop-Floor Systems (Work Order Release)
    - Shop Floor Activities
- Periodically assess manufacturing plans along with the LCSP to identify risks and develop risk mitigation measures.
- Review the Manufacturing Plan to ensure it will provide the resources needed for sustainment operations as outlined in the LCSP.
- Assess the Manufacturing Plan for impact to the “5Ms” (Manpower, Material, Methods, Measurement and Machinery).
- Assess the Manufacturing Plan for Risks, Issues, and Opportunities.
- Identify any assumptions made in developing the shutdown plan.
- Ensure the contractor is conducting First Article Inspections on the hardware being produced from the new facility.
- The DCMA MSRA Production Planning and Control, Material Requirement Planning Checklist can be used to assess:
    - Resource Requirements Planning
    - Aggregate Planning
    - Master Production Schedule
    - Rough Cut Capacity Planning
    - Capacity Requirements Planning
    - Shop Floor Controls

Tools

- AS6500, Assessment
- DCMA Production Planning and Control Checklist
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- Manufacturing Maturation Plan

- Material Management and Accounting System Audit

Resources

- AS6500, Manufacturing Management System
- DCMA MSRA Production Planning and Control (PPC), Material Requirement Planning Checklist
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook

L.6 Support Industrial Cybersecurity Management and Risk Assessment

Industrial cybersecurity is concerned with the ability of organizations to share information digitally (government to industry, prime contractor to subs, labs to program offices, etc.). While the sharing of information is critical, it is equally important to do so in a safe and secure environment. Industrial cybersecurity is concerned with the transfer of digital data via Operational Technologies (OT) inside a facility and through the cloud to other organizations and facilities.

NIST standard NIST SP 800-37, 'Risk Management Framework for Information Systems and Organizations' defines Operational Technology as:

> *Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems/devices detect or cause a direct change through the monitoring and/or control of devices, processes, and events. Examples include industrial control systems, building management systems, fire control systems, and physical access control mechanisms.*

There are three main types of operational technologies of concern:

- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution system (MES) support the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers
- Enterprise resource planning (ERP) system supports functional management resources within an enterprise, and control process performance.
- These data systems are often digital and shared across multiple functions and organizations.

DFARS 252.204-7012 requires contractors to follow NIST SP 800-171 and to:

- Provide adequate security to safeguard covered defense information that resides on or is transiting through a contractor's internal information system or network
- Report cyber incidents that affect a covered contractor information system or the covered defense information residing therein

- Submit malicious software discovered and isolated in connection with a reported cyber incident to the DoD Cyber Crime Center
- Submit media/information as requested to support damage assessment activities
- Flow down the contract clause in subcontracts for operationally critical support, or for which subcontract performance will involve covered defense information

Manufacturing, as an industry, is the most targeted industry for cyber-attacks. DoD policy and best business practices require that data be protected from attack. This includes classified data, controlled unclassified data (CUI), personal data, financial data, etc.

This thread (Industrial Cybersecurity) requires an analysis of the risk that the manufacturing environment may not be able to protect digital and other forms of data from cyber risks and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Identification of Cybersecurity Risks
- Cybersecurity Planning and Management (Execution)

M&Q personnel need to identify and manage industrial cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the AAF.

M&Q personnel need to develop and execute industrial cybersecurity planning for system concepts identified and execute the management of those plans. Programs will employ system security engineering methods and practices, including cybersecurity, cyber resilience, and cyber survivability in design, test, manufacture, and sustainment. Such methods and practices will ensure that systems function as intended, mitigating risks associated with known and exploitable vulnerabilities to provide a level of assurance commensurate with technology, program, system, and mission objectives.

Manufacturing and Quality Tasks

- Assess supply chain OT cybersecurity and vulnerability risks, and develop risk management plans
- Implement supply chain OT cybersecurity and vulnerability risk mitigation plans
- Demonstrate OT cybersecurity solutions in an LRIP environment
- Demonstrate OT cybersecurity solutions in an FRP environment
- Assess the design of OT systems for facilities and equipment (i.e., in-house factory systems, production equipment, STE/SIE, and tooling) to ensure they include cybersecurity and physical/digital controls and access requirements
- Plan for and document that LRIP facilities and equipment OT systems include cybersecurity and physical/digital controls, and access requirements
- Identify and assess OT cyber incidents throughout the supply chain

- Ensure that OT cybersecurity Incident Reporting procedures are in-place, including reporting, tracking, and corrective actions
- Train the workforce in current cybersecurity procedures for production environment

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (DAU)
- Cybersecurity Strategy ADDM Template
- Interactive MRL Users Guide (Checklist), Cybersecurity thread
- USMC Cybersecurity Management Checklist

Resources

- FAR 52.202.21 Basic Safeguarding of Covered Contractor Information Systems
- DFAR 252.7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.83 Technology and Program Protection
- DoDI 8500.01 Cybersecurity
- DoDI 5000.90 Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoD 5220.22-M National Industrial Security Program
- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle
- NIST SP 800-171 Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations
- NIST Special Publication 800-82 Guide to Industrial Control Systems (ICS) Security

Appendix A: Abbreviations and Acronyms

A_m	Materiel Availability
A_o	Operational Availability
AAF	Adaptive Acquisition Framework
ADM	Acquisition Decision Memorandum
AFRL	Air Force Research Laboratory
AM	Additive Manufacturing
ANSI	American National Standards Institute
AoA	Analysis of Alternatives
APA	Additional Performance Attributes
APB	Acquisition Program Baseline
AQAP	Advanced Product Quality Planning
AQL	Acceptable Quality Level
ARL	Army Research Laboratory
AS	Acquisition Strategy
ASME	American Society of Mechanical Engineers
ASR	Alternative Systems Review
AT	Anti-Tamper
ATE	Automatic Test Equipment
AUPC	Average Unit Procurement Cost
BCA	Business Case Analysis
BER	Beyond Economical Repair
BES	Budget Estimate Submission
BoK	Body of Knowledge
BOM	Bill of Materials
C/SCSC	Cost/Schedule Control Systems Criteria
C4I	Command, Control, Communications, Computers, and Intelligence
CAB	Corrective Action Board
CAD	Computer-Aided Design
CAE	Component Acquisition Executive
CAI	Critical Application Item
CAIG	Cost Analysis Improvement Group
CAIV	Cost as an Independent Variable

CAM	Computer-Aided Manufacturing
CAPE	Cost Assessment and Program Evaluation
CARD	Cost Analysis Requirements Description
CAS	Contract Administration Services
CBA	Capabilities-Based Assessment
CCA	Cost Capability Analysis
CCB	Configuration Control Board
CCE	Component Cost Estimate
CDD	Capability Development Document
CDRL	Contract Data Requirements List
CI	Configuration Item
CI	Critical Item
CJCS	Chairman of the Joint Chiefs of Staff
CLIN	Contract Line Item Number
CM	Configuration Management
CMO	Contract Management Office
CMP	Configuration Management Plan
CMP	Critical Manufacturing Process
COE	Center of Excellence
COMSEC	Communications Security
CONOPS	Concept of Operations
COSSI	Commercial Operations and Support Savings Initiative
COTS	Commercial Off-the-Shelf
CPAR	Contractor Performance Assessment Report
CPC	Corrosion Prevention and Control
CPI	Continuous Process Improvement
Cp/Cpk	Process Capability/Process Capability Index
CRI	Cost Reduction Initiative
C/SCSC	Cost and Schedule Control Systems Criteria
CSI	Critical Safety Item
CTC	Critical to Customer
CTE	Critical Technology Element
CTQ	Critical to Quality
CUI	Controlled Unclassified Information

DAE	Defense Acquisition Executive
DAG	Defense Acquisition Guidebook
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University
DCMA	Defense Contract Management Agency
DPM	Defective Parts Per Million
DFA	Design for Assembly
DFARS	Defense Federal Acquisition Regulation Supplement
DFM	Design for Manufacturability
DFMA	Design for Manufacture and Assembly
DFMEA	Design Failure Modes and Effects Analysis
DFSS	Design for Six Sigma
DIB	Defense Industrial Base
DID	Data Item Description
DLA	Defense Logistics Agency
DMS	Diminishing Manufacturing Sources
DMMG	Defense Manufacturing Management Guide
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoD	Department of Defense
DoDD	DoD Directive
DoDI	DoD Instruction
DoDM	DoD Manual
DOE	Design of Experiments
DPAS	Defense Priorities and Allocation System
DSS	Design for Six Sigma
DTRAM	Defense Technical Risk Assessment Methodology
DTC	Design to Cost
DT&E	Developmental Test and Evaluation
EAC	Estimate at Completion
ECP	Engineering Change Proposal
ED, SE&A	Executive Director, Systems Engineering and Architecture
EMC	Electromagnetic Compatibility
EMD	Engineering and Manufacturing Development
EMI	Electromagnetic Interference

EOQ	Economic Order Quantity
ERP	Enterprise Resource Plan
ESA	Engineering Support Activity
ESOH	Environment, Safety, and Occupational Health
ESS	Environmental Stress Screening
EVMS	Earned Value Management System
FA	First Article
FAI	First Article Inspection
FAR	Federal Acquisition Regulation
FAT	First Article Test
FCA	Functional Configuration Audit
FDD	Full Deployment Decision
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOD	Foreign Object Damage
FOT&E	Follow-on Test and Evaluation
FPAF	Fixed Price Award Fee
FRACAS	Failure Reporting, Analysis, and Corrective Action System
FRP	Full-Rate Production
FRPDR	Full-Rate Production Decision Review
FTA	Fault Tree Analysis
FYDP	Future Years Defense Program
GAO	Government Accountability Office
GCQA	Government Contract Quality Assurance
GFE	Government-Furnished Equipment
GFM	Government-Furnished Material
GFP	Government-Furnished Property
GIDEP	Government and Industry Data Exchange Program
GOTS	Government Off-the-Shelf
HAZMAT	Hazardous Material
HSI	Human Systems Integration
HVAC	Heating, Ventilation, and Air Conditioning
HWCIs	Hardware Configuration Items
IB	Industrial Base

ICA	Industrial Capabilities Assessments
ICD	Initial Capabilities Document
ICE	Independent Cost Estimate
ICS	Industrial Control Systems
IEEE	Institute of Electrical and Electronics Engineers
IG	Inspector General
IGCE	Independent Government Cost Estimate
IPT	Integrated Product Team
ILA	Independent Logistics Assessment
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOC	Initial Operational Capability
IP	Intellectual Property
IPS	Integrated Product Support
IPT	Integrated Product Team
IRAD	Independent Research and Development
ISO	International Organization for Standardization
ISR	In-Service Review
ITAR	International Trafficking in Arms Regulation
ITRA	Independent Technical Risk Assessment
JCIDS	Joint Capabilities Integration and Development System
JROC	Joint Requirements Oversight Council
KC	Key Characteristics
KLP	Key Leadership Position
KPP	Key Performance Parameter
KSA	Key System Attribute
LCC	Life Cycle Cost
LCSP	Life Cycle Sustainment Plan
LOD	Letter of Delegation
LFT&E	Live-Fire Test and Evaluation
LRIP	Low-Rate Initial Production
5Ms	Manpower, Machines, Materials, Methods, Measurement
M&S	Modeling and Simulation
ManTech	Manufacturing Technology

MATE	Multi-Attribute Trade Space Exploration
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDD	Milestone Development Decision
MEP	Manufacturing Extension Program
MES	Manufacturing Execution System
MIL-STD	Military Standard
MMAS	Material Management and Accounting System
MMP	Manufacturing Maturation Plan
MMS	Manufacturing Management System
MOA	Memorandum of Agreement
MOE	Measure of Effectiveness
MOSA	Modular Open Systems Approach
MP	Mission Profile
MRO	Maintenance, Repair, and Overhaul
MMP	Manufacturing Maturation Plan
M&Q	Manufacturing and Quality
MRA	Manufacturing Readiness Assessment
MRB	Material Review Board
MRL	Manufacturing Readiness Level
MRO	Maintenance, Repair, and Overhaul
MRP	Material Requirements Planning
MRP II	Manufacturing Resource Planning
MS A	Milestone A
MS B	Milestone B
MS C	Milestone C
MSA	Materiel Solution Analysis
MSRA	Manufacturing Systems Risk Assessment
MTA	Middle Tier Acquisition
MTTR	Mean Time to Repair
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
NAVSO-P	Navy Standard Operating Procedure
NDAA	National Defense Authorization Act

NDI	Non-Developmental Item
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NRL	Naval Research Laboratory
NSPAR	Non-Standard Parts Approval Request
NTIB	National Technology Industrial Base
O&A	Over and Above
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
OIPT	Overarching Integrated Product Team
O&M	Operations and Maintenance
OMB	Office of Management and Budget
OMS/MP	Operational Mode Summary/Mission Profile
O&S	Operations and Support
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
OT	Operational Technology
OTRR	Operational Test Readiness Review
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
P3I/P^3I	Preplanned Product Improvement
PAOC	Post-Award Orientation Conference
PAW	Producibility Assessment Worksheet
PBL	Performance-Based Logistics
PCA	Physical Configuration Audit
PCO	Procurement Contracting Officer
P&D	Production and Deployment
PDR	Preliminary Design Review
PEP	Producibility Engineering and Planning
PESHE	Programmatic Environmental, Safety, and Occupational Health Evaluation
PFMEA	Process Failure Modes and Effects Analysis
PHL	Preliminary Hazard List
PHST	Packing, Handling, Storage, and Transportation
PLM	Product Lifecycle Management
PM	Program Manager

PMP	Parts, Materials, and Processes
PMR	Program Management Review
PMO	Program Management Office
POE	Program Office Estimate
POM	Program Objective Memorandum
Pp / Ppk	Process Performance/Process Performance Index
PPAP	Production Part Approval Process
PPBE	Program, Planning, Budget, and Execution
PPC	Production Planning and Control
PPP	Program Protection Plan
PPV	Production Part Verification
PQM	Production, Quality, and Manufacturing
Pre-MDD	Pre-Materiel Development Decision
PRR	Production Readiness Review
PSA	Program Support Assessment
PSM	Product Support Manager
PSS	Product Support Strategy
PTAC	Procurement Technical Assistance Center
PWBS	Program Work Breakdown Structure
QA	Quality Assurance
QALI	Quality Assurance Letter of Instruction
QDR	Quality Deficiency Report
QFD	Quality Function Deployment
QMS	Quality Management System
QSP	Quality Surveillance Plan
R&D	Research and Development
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RIO	Risk, Issues and Opportunities
RFI	Request for Information
RFP	Request for Proposal
RFP DP	Request for Proposal Release Decision Point
RFV	Request for Variation
R&M	Reliability and Maintainability
RMBoK	Reliability and Maintainability Body of Knowledge

SAE	Society of Automotive Engineers
SAR	Safety Assessment Report
SAT	Software Acceptance Test
SCE	Should Cost Estimate
SCM	Supply Chain Management
SCMP	Software Configuration Management Plan
SCOR	Supply Chain Operations Reference
SCRM	Supply Chain Risk Management
SDP	Software Development Plan
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SEP	Systems Engineering Plan
SF	Standard Form
SFMEA	System Failure Modes and Effects Analysis
SFQT	Software Formal Qualification Testing
SFR	System Functional Review
SIE	Special Inspection Equipment
SLEP	Service Life Extension Program
SME	Society of Manufacturing Engineers
SOO	Statement of Objectives
SOW	Statement of Work
SPC	Statistical Process Control
SPI	Special Packaging Instructions
SQAP	Software Quality Assurance Plan
SRR	System Requirements Review
SSA	System Safety Assessment
SSE	Systems Security Engineering
SSP	Source Selection Plan
ST	Special Tooling
S&T	Science and Technology
STE	Special Test Equipment
STEM	Science, Technology, Engineering, and Math
SUPSHIP	Supervisor of Shipbuilding
SVR	System Verification Review

SWOT	Strengths, Weaknesses, Opportunities, and Threats
TAPP	Technology Area Protection Plan
TBD	To Be Determined
TDP	Technical Data Package
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TMRR	Technology Maturation and Risk Reduction
TO	Technical Order
TOC	Total Ownership Cost
TOC	Theory of Constraints
TPM	Technical Performance Measure
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
TRR	Test Readiness Review
USD(R&E)	Under Secretary of Defense for Research and Engineering
USC	United States Code
VCRM	Verification Cross-Reference Matrix
VOLT	Validated Online Lifecycle Threat
VR	Variability Reduction
VSM	Value Stream Mapping
V&V	Verification and Validation
WBS	Work Breakdown Structure
WIP	Work in Progress

Appendix B: References

Resources identified in the Manufacturing and Quality Body of Knowledge (M&Q BoK) are listed below alphabetically and contain links to the referenced document or website. As many of these resources are revised frequently, readers are advised the documents may change or be updated, replaced, or cancelled between editions of this BoK. Readers may need to conduct an Internet search to find the most recent version.

10 USC 144B, Weapon Systems Development and Related Matters
https://uscode.house.gov/view.xhtml?path=/prelim@title10/subtitleA/part4/chapter144B&edition=prelim

10 USC 2304, Contracts: Competition Requirements
https://www.govinfo.gov/content/pkg/USCODE-1995-title10/pdf/USCODE-1995-title10-subtitleA-partIV-chap137-sec2304.pdf

10 USC 2305, Contracts: Planning, Solicitation, Evaluation and Award Procedures
https://www.govinfo.gov/content/pkg/USCODE-2012-title10/pdf/USCODE-2012-title10-subtitleA-partIV-chap137-sec2305.pdf

10 USC 2334, Independent Cost Estimate and Cost Analysis
https://www.law.cornell.edu/uscode/text/10/2334

10 USC 2337, Life-cycle Management and Product Support
https://www.govinfo.gov/content/pkg/USCODE-2015-title10/pdf/USCODE-2015-title10-subtitleA-partIV-chap137-sec2337.pdf

10 USC 2430, Major Defense Acquisition Program Defined
https://www.law.cornell.edu/uscode/text/10/2430

10 USC 2431a. Acquisition Strategy
https://www.law.cornell.edu/uscode/text/10/2431a

10 USC 2431b, Risk Management
https://www.govinfo.gov/content/pkg/USCODE-2015-title10/pdf/USCODE-2015-title10-subtitleA-partIV-chap144-sec2431b.pdf

10 USC 2435, Acquisition Program Baseline
https://www.govinfo.gov/content/pkg/USCODE-2010-title10/pdf/USCODE-2010-title10-subtitleA-partIV-chap144-sec2435.pdf

10 USC 2438, Performance Assessments
https://www.govinfo.gov/content/pkg/USCODE-2010-title10/pdf/USCODE-2010-title10-subtitleA-partIV-chap144-sec2438.pdf

10 USC 2440, Technology and Industrial Base Plans
https://www.govinfo.gov/app/details/USCODE-2011-title10/USCODE-2011-title10-subtitleA-partIV-chap144-sec2440

10 USC 2445b, Cost, Schedule, and Performance Information
https://www.govinfo.gov/content/pkg/USCODE-2011-title10/pdf/USCODE-2011-title10-subtitleA-partIV-chap144A-sec2445b.pdf

10 USC 2448b, Independent Technical Risk Assessments
https://www.govinfo.gov/content/pkg/USCODE-2016-title10/html/USCODE-2016-title10-subtitleA-partIV-chap144B-subchapIII.htm

10 USC 2501, National Security Strategy for NTIB
https://www.govinfo.gov/app/details/USCODE-2015-title10/USCODE-2015-title10-subtitleA-partIV-chap148-subchapII-sec2501

10 USC 2502, National Defense Technology and Industrial Base Council
https://www.govinfo.gov/app/details/USCODE-2010-title10/USCODE-2010-title10-subtitleA-partIV-chap148-subchapII-sec2502

10 USC 2503, Analysis of the Technology and Industrial Base
https://www.govinfo.gov/app/details/USCODE-2011-title10/USCODE-2011-title10-subtitleA-partIV-chap148-subchapII-sec2503

10 USC 2504, Annual Report to Congress
https://www.govinfo.gov/app/details/USCODE-2010-title10/USCODE-2010-title10-subtitleA-partIV-chap148-subchapII-sec2504

10 USC 2505, NTIB Periodic Defense Capability Assessments
https://www.govinfo.gov/app/details/USCODE-2006-title10/USCODE-2006-title10-subtitleA-partIV-chap148-subchapII-sec2505

10 USC 2521, Manufacturing Technology Program
https://www.govinfo.gov/content/pkg/USCODE-2010-title10/pdf/USCODE-2010-title10-subtitleA-partIV-chap148-subchapIV-sec2521.pdf

48 CFR 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
https://www.law.cornell.edu/cfr/text/48/252.204-7012

Acquisition Process/Acquisition Strategy
www.acqnote/acquisitions/acquisition-strategy

Acquisition Strategy Guide, 4th Edition, DSMC, Dec 1999
http://www.acqnotes.com/Attachments/DSMC%20Acquisition%20Strategy%20Guide.pdf

Adaptive Acquisition Framework
https://aaf.dau.edu

AFI 10-601, Operational Capability Requirements Development
https://static.e-publishing.af.mil/production/1/af_a3_5/publication/afi10-601/afi10-601.pdf

AFI 63-145, Manufacturing and Quality Management, Dec 2020
https://static.e-publishing.af.mil/production/1/saf_aq/publication/afi63-145/afi63-145.pdf

Air Force Technology Development and Transition Strategy Guidebook, Jul 2010
http://acqnotes.com/dod-guides-handbooks

Analysis of Alternatives
www.acqnote/acquisitions/analsis-of-alternatives

Analysis of Alternative (AoA) Handbook, Office of Aerospace Studies, Aug 2017
https://afacpo.com/AQDocs/AoAHandbook.pdf

Application of Learning Curve Theory to Systems Acquisition, Defense Acquisition University (DAU) Teaching Note, Feb 2011
https://www.dau.edu/cop/ce/DAU%20Sponsored%20Documents/B5%20Application%20of%20Learning%20Curve%20Theory%20Feb%2011.pdf

AR 700-90 Army Industrial Base Process, Feb 2020
https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN20450_AR_700-90_FINAL.pdf

AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition, Mar 2019, SAE International
https://www.sae.org/standards/content/as5553/

AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel, Jul 2014, SAE International
https://www.sae.org/standards/content/as6174/

S6500A, Manufacturing Management Program, Jul 2021, SAE International
https://www.sae.org/standards/content/as6500/

AS9100D: 2016, Quality Management Systems - Requirements for Aviation, Space and Defense Organizations, Sep 2016. SAE International
https://www.sae.org/standards/content/as9100d/

AS9102, First Article Inspection Requirement, Oct 2014, SAE International
https://www.sae.org/standards/content/as9102/

AS9103, Variation Management of Key Characteristics, Oct 2001, SAE International
https://www.sae.org/standards/content/as9103/

AS9133, Qualification Procedure for Aerospace Standard Products, Jul 2002, SAE International
https://www.sae.org/standards/content/as9133/

AS9134, Supply Chain Risk Management Guidelines, Feb 2014, SAE International
https://www.sae.org/standards/content/arp9134/

AS9136, Root Cause Analysis and Problem Solving, Nov 2016, SAE International
https://www.sae.org/standards/content/arp9136/

AS9138, Quality Management Systems Statistical Product Acceptance, Jan 2018, SAE International
https://www.sae.org/standards/content/as9138/

Award Fee Board Member Guide, Army, Sep 2003
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjSk43F8aLsAhVkmuAKHftkBLAQFjAAegQIBBAC&url=https%3A%2F%2Fwww.acq.osd.mil%2Fdpap%2Fccap%2Fcc%2Fjcchb%2FFiles%2FTopical%2FSource_Selection%2Fguides%2Faca_award_fee_board_member_guide.docx&usg=AOvVaw3UXncnSQOnEdnZS5sssBBs

Award Fee Guide, Air Force, Oct 2008
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Award Fee Guide, Navy/Marine Corps, Jul 2004
http://acqnotes.com/acqnote/careerfields/award-fee-contracts

Capability-Based Assessment (CBA) Handbook, Office of Aerospace Studies, Mar 2014
https://daytonaero.com/wp-content/uploads/USAF-Capabilities-Based-Assessment-CBA-Handbook-10-Mar-2014.pdf

Capability Development Document (CDD) Writer's Guide, Army Training and Doctrine Command, Jun 2009
http://www.acqnotes.com/Attachments/CDD%20Writers%20Guide.pdf

CJCS Instruction 5123.01, JROC and Implementation of JCIDS
CJCS Instruction 5123.01 JROC & Implementation of JCIDS - AcqNotes

Condition Based Maintenance Plus DoD Guidebook, May 2008
https://www.dau.edu/guidebooks/Shared%20Documents/Condition%20Based%20Maintenance%20Plus%20(CBM+)%20Guidebook.pdf

Cost Analysis Requirements Description (CARD) Guidance (See CAPE website for 897 guidance)
https://cade.osd.mil/policy/card

Cost Analysis Requirements Description (CARD) Template, Oct 2009
http://acqnotes.com/acqnote/careerfields/cost-analysis-requirements-description

Cost/Schedule Control System Criteria Reference Guide, Sep 1991
https://www.secnav.navy.mil/rda/OneSource/Documents/CEVM/Tools%20and%20Examples/DOD%20Guides/BowmanInterpretiveGuide1.pdf

Defense Acquisition University Guidebooks and References
https://aaf.dau.edu/guidebooks
Cost Estimating
Cybersecurity
Engineering
Human Systems Integration
Intellectual Property
Intelligence
International Acquisition
IT and Business Systems
Program Management
Program Protection
Sustainment
Test and Evaluation

DCMA (Defense Contract Management Agency) Instructions/Policies
https://www.dcma.mil/Policy/

DCMA-INST 204, Manufacturing and Production
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-204.pdf

DMCA-INST 205, Major Program Support, Dec 2013
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-205.pdf

DMCA-INST 207, Engineering Surveillance, Dec 2014
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-207.pdf

DCMA-INST-209, Pre-award Surveys
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-209.pdf

DCMA-INST-219, Supplier Risk Management Through Standard Contract Surveillance, May 2013
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-219.pdf

DCMA-INST-221, Integrated Surveillance Plan, Apr 2014
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-221.pdf

DCMA-INST-302, First Article and Production Lot Testing, Jan 2015
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-302.pdf

DCMA-INST-309, Government Contract Quality Assurance Surveillance Planning, Mar 2015
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-309.pdf

DCMA-INST-311, Process Review -QA, Aug 2014
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-311.pdf

DCMA-INST-322, Quality System Audit, Sep 2015
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-322.pdf

DCMA-INST-323, Data Collection and Analysis
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-323.pdf

DCMA-INST-324, Product Examination, Aug 2014
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-324.pdf

DCMA-INST-325, Technical Reviews
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-325.pdf

DCMA-INST 401, Industrial Analysis
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-401.pdf

DCMA-INST-1201, Corrective Action
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-1201.pdf

DCMA-INST 3401, Defense Industrial Base Mission Assistance
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-3401.pdf

Defense Manufacturing Management Guide for Program Managers (DMMG for PMs), Defense Acquisition University (DAU)
https://www.dau.edu/tools/t/Defense-Manufacturing-Management-Guide-for-Program-Managers-(PQM-for-PMs)
DMMG for PMs Chapter 1, Overview of DOD Manufacturing Management
DMMG for PMs Chapter 2, Industrial Base
DMMG for PMs Chapter 3, Acquisition Environment for Manufacturing
DMMG for PMs Chapter 4, Manufacturing Strategy
DMMG for PMs Chapter 5, CPI/Lean Six Sigma
DMMG for PMs Chapter 6, Manufacturing Planning
DMMG for PMs Chapter 7, Producibility
DMMG for PMs Chapter 8, Technology Development and Investments
DMMG for PMs Chapter 9, Manufacturing Cost Estimating
DMMG for PMs Chapter 10, Contracting Issues in Manufacturing
DMMG for PMs Chapter 11, Transition for Development to Production
DMMG for PMs Chapter 12, Technical Reviews and Audits
DMMG for PMs Chapter 13, Manufacturing Controls
DMMG for PMs Chapter 14, Factory of the Future
DMMG for PMs Chapter 15, Supply Chain Management and Sustainable Manufacturing
DMMG for PMs Chapter 16, Manufacturing Problems and Organic Capabilities
DMMG for PMs Chapter 17, Manufacturing Readiness

Defense Production Act, Title III
https://www.businessdefense.gov/Programs/DPA-Title-III/

Defense Technical Risk Assessment Methodology (DTRAM) Tier 0-1 Criteria, Sep 2021
https;//ac.cto.mil/wp-content/uploads/DTRAM-0-1.pdf

Design for Manufacturing and Assembly (DFMA)
https://www.dau.mil/cop/pqm/DAU%20Sponsored%20Documents/DFMA%20new.doc

DFARS 15.407-2, Make or Buy Programs
https://www.acquisition.gov/content/15407-2-make-or-buy-programs#:~:text=When%20make%2Dor%2Dbuy%20programs,or%20implementation%20of%20socioeconomic%20policies.

DFARS 246 – Quality Assurance
https://www.acquisition.gov/dfars/part-246-quality-assurance

DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
https://www.acquisition.gov/dfars/part-246-quality-assurance

DFARS 252 – Solicitation Provisions and Contract Clauses
https://www.acquisition.gov/dfars/part-252-clauses

DFARS 252.72, Contractor Material Management and Accounting System
https://www.acquisition.gov/dfars/part-252-clauses

DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
https://www.acquisition.gov/dfars/part-252-clauses

DFARS 252.228-7001, Ground and Flight Risk
https://www.acquisition.gov/dfars/part-252-clauses

DFARS 252.242-7004, Material Management and Accounting System (MMAS)
https://www.acquisition.gov/dfars/part-252-clauses

DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
https://www.acquisition.gov/dfars/part-252-clauses

DFARS 252.246-7008, Sources of Electronic Parts
https://www.acquisition.gov/dfars/part-252-clauses

Diminishing Manufacturing and Materials Shortages (DMSMS) Guidebook, SD-22, Sep 2009
https://www.dsp.dla.mil/Programs/DMSMS

DMSMS Acquisition Guidelines, Rev 3, Defense MicroElectronics Agency (DMEA), 2007
https://apps.dtic.mil/sti/citations/ADA518172

DoD Continuous Process Improvement Transformation Guide, May 2006
https://www.dau.edu/cop/se/DAU%20Sponsored%20Documents/DoD%20Continuous%20Process%20Improvement%20CPI%20Guidebook%20May%202006.pdf

DoD Directives
https://www.esd.whs.mil/Directives/issuances/dodd/

DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
https://www.esd.whs.mil/Directives/issuances/dodd/

DoD Directive 4400.01E, Defense Production Act Programs
https://www.esd.whs.mil/Directives/issuances/dodd/

DoD Directive 5000.01, The Defense Acquisition System
https://www.esd.whs.mil/Directives/issuances/dodd/

DoD Directive 5105.84, Cost Analysis Guidance and Procedures, May 2020
https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/510584p.pdf

DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
https://www.esd.whs.mil/Directives/issuances/dodd/

DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
https://esd.whs.mil/DD/

DoD Human Computer Interface (HCI) Style Guide, Apr 1996
http://everyspec.com/DoD/DOD-General/download.php?spec=DISA_TAFIM_VOL8.007545.pdf

DoD Instructions
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 4140.01, Supply Chain Materiel Management Policy
https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/414001p.pdf

DoD Instruction 4275.5, Acquisition and Management of Industrial Resources, Mar 2005
https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/427505p.pdf?ver=2018-11-08-122537-997

DoD Instruction 5000.01, The Defense Acquisition System, 2020
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.81, Urgent Capability Acquisition
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.83, Technology and Program Protection, May 2021
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.84, Analysis of Alternatives, Aug 2020
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.85, Major Capability Acquisition, Aug 2020
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.88, Engineering of Defense Systems, Nov 2020
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.90, Cybersecurity for Acquisition Decision Authorities and Program Managers
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.92, Innovation and Technology to Sustain Materiel Readiness, May 2021
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD, Jul 2021
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD, Mar 2022
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Instruction 5105.84, Director of Cost Assessment and Program Evaluation
https://www.esd.whs.mil/Directives/issuances/dodi/

DoD Integrated Product and Process Development Handbook, 1998
http://www.acqnotes.com/Attachments/DoD%20Integrated%20Product%20and%20Process%20Development%20Handbook,%20Aug%2098.pdf

DoD Manuals
https://www.esd.whs.mil/Directives/issuances/dodm/

DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures (Volumes 1-12)
https://www.esd.whs.mil/Directives/issuances/dodm/

DoD Manual 4160.21, Defense Materiel Disposition: Disposal Guidance and Procedures
Volume 1
https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodm/416021_vol1.pdf?ver=2019-10-02-080613-750
Volume 2, Sep 2019
https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodm/416021m_vol2.PDF
Volume 3, Sep 2019
https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodm/416021_vol3.PDF?ver=2019-09-30-130146-047
Volume 4, Sep 2019
https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodm/416021_vol4.PDF?ver=2019-09-30-130144-453

DoD Manual 4245.7 Transition from Development to Production, Sep 1985
http://everyspec.com/DoD/DoD-PUBLICATIONS/DoD_4245--7-M_3692/

DoD Manual 4245.7-M Transition from Development to Production, Sep 1985
https://apps.dtic.mil/dtic/tr/fulltext/u2/a303209.pdf

DoD Manufacturing Technology (ManTech) Program
https://www.dodmantech.mil/

DoD Market Research Guide, May 2012
http://acqnotes.com/acqnote/acquisitions/market-research

DoD Market Research Report Guide, Mar 2017
https://www.acq.osd.mil/dpap/cpic/cp/docs/2017_Market_Research_Guide_(Final).pdf

DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, Jan 2017
https://www.dau.edu/tools/t/DoD-Risk,-Issue,-and-Opportunity-Management-Guide-for-Defense-Acquisition-Programs

DoD Source Selection Procedures Memo, Apr 2016
https://www.acq.osd.mil/dpap/policy/policyvault/USA004370-14-DPAP.pdf

DoD Supply Chain Management Implementation Guide, 2000
https://apps.dtic.mil/dtic/tr/fulltext/u2/a387934.pdf

DoD Supply Chain Metrics Handbook, Sep 2021
https://www.acq.osd.mil/log/LOG_SD/.policy_vault.html/Supply_Chain_Metrics_Guide_22Sep2021.pdf

DoD-Wide Continuous Process Improvement (CPI/Lean Six Sigma) Program, May 2008
file:///C:/Users/ganoy/Documents/George/DAU/Guidance%20Docs/Quality/QA%20Guides/DOD%20CPI%20Memo%20501042p,%20May%202008.pdf

Early Manufacturing and Quality Engineering Guide, Jul 2022
https://ac.cto.mil/maq/
https://ac.cto.mil/erpo/

Engineering of Defense Systems Guidebook, Feb 2022
https://ac.cto.mil/wp-content/uploads/2022/02/Eng-Defense-Systems_Feb2022-Cleared-slp.pdf

Environmental Safety and Occupational Health (ESOH) in Acquisition Guide, Apr 2009
https://safety.army.mil/Portals/0/Documents/ON-DUTY/ARMYSYSTEMS/Standard/Independent_Safety_Assessments.pdf

FAR (Federal Acquisition Regulation) Homepage
https://www.acquisition.gov/browse/index/far

FAR Part 2, Definitions of Words and Terms
https://www.acquisition.gov/content/part-2-definitions-words-and-terms

FAR Subpart 7.1 Acquisition Plans
https://www.acquisition.gov/content/subpart-71-acquisition-plans

FAR Subpart 9.1 Responsible Prospective Contractors
https://www.acquisition.gov/content/part-9-contractor-qualifications#i1116049

FAR Subpart 9.2 Qualification Requirements
https://www.acquisition.gov/content/part-9-contractor-qualifications#i1115819

FAR Subpart 9.3 First Article Inspection
https://www.acquisition.gov/content/part-9-contractor-qualifications#i1115649

FAR Part 10 - Market Research
https://www.acquisition.gov/content/part-10-market-research

FAR Subpart 15.1 Source Selection Processes and Techniques
https://www.acquisition.gov/content/part-15-contracting-negotiation

FAR Subpart 15.2 Solicitation and Receipt of Proposals and Information
https://www.acquisition.gov/content/part-15-contracting-negotiation

FAR Subpart 15.3 Source Selection
https://www.acquisition.gov/content/part-15-contracting-negotiation

FAR Subpart 15.4 Contract Pricing
https://www.acquisition.gov/content/part-15-contracting-negotiation

FAR Subpart 15.5 Pre-award, Award and Post-award Notifications
https://www.acquisition.gov/content/part-15-contracting-negotiation

FAR Subpart 16 Types of Contracts
https://www.acquisition.gov/content/part-16-types-contracts

FAR Subpart 16.4 Incentive Contracts
https://www.acquisition.gov/content/part-16-types-contracts

FAR Subpart 30.6 Contract Administration Service (CAS) Administration
https://www.acquisition.gov/content/subpart-306-cas-administration#

FAR Subpart 31 Contract Cost Principles
https://www.acquisition.gov/content/part-31-contract-cost-principles-and-procedures

FAR Subpart 32.5 Progress Payments Based on Cost
https://www.acquisition.gov/content/part-32-contract-financing#i1082047

FAR Subpart 37.6 Performance Based Acquisition
https://www.acquisition.gov/content/part-37-service-contracting#i1077388

FAR Subpart 42.3 Contract Administration Service (CAS) Functions
https://www.acquisition.gov/content/part-42-contract-administration-and-audit-services

FAR Subpart 42.11 Production surveillance and Reporting
https://www.acquisition.gov/content/part-42-contract-administration-and-audit-services

FAR Subpart 42.15 Contractor Performance Information
https://www.acquisition.gov/content/part-42-contract-administration-and-audit-services

FAR Subpart 44.3 Contractors Purchasing System Reviews
https://www.acquisition.gov/content/part-44-subcontracting-policies-and-procedures#i1073426

FAR Subpart 45.1 Government Property
https://www.acquisition.gov/content/part-45-government-property

FAR Subpart 46 Quality Assurance
https://www.acquisition.gov/content/part-46-quality-assurance

FAR Subpart 48 Value Engineering
https://www.acquisition.gov/content/part-48-value-engineering

FAR Subpart 52 Solicitation Provisions and Contract Clauses
https://www.acquisition.gov/content/part-52-solicitation-provisions-and-contract-clauses

Guidance on Using Incentive and Other Contract Types, Apr 2016
https://www.acq.osd.mil/dpap/policy/policyvault/USA001270-16-DPAP.pdf

Guide to Environment, Safety, and Occupational Health (ESOH) in the Systems Engineering Plan
http://www.acqnotes.com/Attachments/Guide%20PESHE.pdf

IEEE Standards Association Homepage
https://standards.ieee.org/

IEEE 15288, Systems and Software Engineering – System Life Cycle Processes, ISO/IEC/IEEE document, 2015
https://www.iso.org/obp/ui/#iso:std:iso-iec-ieee:15288:ed-1:en

IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs, May 2015, ASO/IEC/IEEE Document
https://ieeexplore.ieee.org/document/7105318

IEEE 15288.2-2014, Application of Systems Engineering on Defense Programs, May 2015, ASO/IEC/IEEE Document
https://ieeexplore.ieee.org/document/7105321

Incentive Contracting Guide, DoD/NASA, Oct 1969
https://www.dau.edu/tools/t/Department-of-Defense-(DoD)-and-National-Aeronautics-and-Space-Administration-(NASA)-Incentive-Contracting-Guide,-1969

Independent Logistics Assessment Guidebook, DAU, Jul 2011
https://www.dau.edu/tools/t/Logistics-Assessment-Guidebook

Independent Technical Risk Assessment (ITRA) Resources
https://ac.cto.mil/itra/

Initial Capabilities Document (ICD) Writer's Guide, TRADOC, Aug 2009
http://www.acqnotes.com/Attachments/Initial%20Capabilities%20Document%20(ICD)%20Writers%20Guide.pdf

Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide, DOD, Oct 2005
https://www.dau.edu/cop/pm/DAU%20Sponsored%20Documents/Integrated%20Master%20Plan%20and%20Integrated%20Master%20Schedule%20Prep%20and%20Use%20Guide.pdf

Integrated Product Support (IPS) Element Guide, Chapter 2.1.1.3 FMECA, Apr 2017
https://www.dau.edu/guidebooks/Shared%20Documents/IPS_Element_Guidebook.pdf

ISO 9000:2015 Quality Management Systems, International Organization for Standardization (ISO)
https://www.iso.org/iso-9001-quality-management.html

ISO 14001:2015, Environmental Management Systems, International Organization for Standardization (ISO)
https://www.iso.org/standard/60857.html

JCIDS Process: CJCS Instruction 5123.01 JROC and Implementation of JCIDS
http://acqnotes.com/acqnote/acquisitions/cjcsi-5123-01-jroc-and-implementation-of-jcids

JCIDS Manual, Feb 2015 was replaced by CJCS Instruction 5123.01 above
http://acqnotes.com/wp-content/uploads/2014/09/Manual-for-the-Operation-of-the-Joint-Capabilities-Integration-and-Development-System-JCIDS-12-Feb-2015.pdf

Life Cycle Sustainment Plan Content Guide, Apr 2010, DAU AcqNotes
http://acqnotes.com/acqnote/careerfields/life-cycle-sustainment-plan-lcsp

Life-Cycle Sustainment Plan Outline, Aug 2019
www.dau.edu/tools/t/Life-Cycle-Sustainment-Plan-(LCSP)-Outline

Logistics Assessment Guidebook, DAU, Jul 2011
www.dau.edu/tools/t/logistics-assessment-guidebook

ManTech, DoD (DoD Manufacturing Technology Program)
https://www.dodmantech.mil/

ManTech Guidance, Air Force
https://www.dodmantech.com/ManTechPrograms/AirForce

ManTech Guidance, Army
https://www.dodmantech.com/ManTechPrograms/Army

ManTech Guidance, Navy
https://www.dodmantech.com/ManTechPrograms/Navy

ManTech Strategic Plan, Mar 2012-2019
https://www.dodmantech.com/About/files/FINAL_DoD_ManTech_Pgm_2012_Strat_Plan.pdf

Manufacturing.gov: A National Advanced Manufacturing Portal
https://www.manufacturing.gov

Manufacturing Maturation Plan (see MRL Deskbook, Chapter 5), 2022
http://www.dodmrl.com/MRL_Deskbook_2018.pdf

Manufacturing Readiness Level (MRL) Deskbook, 2022
http://www.dodmrl.com/MRL_Deskbook_2018.pdf

Manufacturing Resource Planning (MRP II)
Internet Search

Market Research
http://acqnotes.com/acqnote/acquisitions/market-research

Market Research Report Guide for Improving the Tradecraft in Services Acquisition, DoD, Oct 2014
www.acqnotes/acqnote/acquisitions/market-research

Material Management and Accounting System – Audit Program, Jul 2020
https://www.dcaa.mil/Portals/88/Documents/Guidance/Directory%20of%20Audit%20Programs/12500%20Material%20Management%20and%20Accounting%20System%20(MMAS)%20AP.pdf?ver=2020-07-01-133628-443

Material Requirements Planning (MRP)
Internet Search

Materiel Solution Analysis (MSA) Guide, DAG Chapter 3-3.2.2 Materiel Solution Analysis Phase
https://aaf.dau.edu/aaf/mca/msa

The Memory Jogger, Goal/QPC
https://goalqpc.com/product/memory-jogger/

The Memory Jogger, Design for Six Sigma, Goal/QPC
https://goalqpc.com/product/design-for-six-sigma-mem-jogger/

MIL-HDBK-245E, Preparation of Statement of Work
https://quicksearch.dla.mil/

MIL-HDBK-727, Design Guidance for Producibility
https://quicksearch.dla.mil/

MIL-HDBK-766, Design to Cost
https://quicksearch.dla.mil/

MIL-HDBK-896, Manufacturing Management Program Guide
https://quicksearch.dla.mil/

MIL-HDBK-29612-1A, Guidance for Acquisition of Training Data Products and Services
https://quicksearch.dla.mil/

MIL-STD-882E, System Safety
https://quicksearch.dla.mil/

MIL-STD-1472H, Human Engineering
https://quicksearch.dla.mil/

MIL-STD-11991A, General Standard for Parts, Materials, and Processes
https://quicksearch.dla.mil/

MIL-STD-1521B, Technical Reviews and Audits for Systems, Equipments, and Computer Software
https://quicksearch.dla.mil/

Mission Engineering Guide, Nov 2020
https://ac.cto.mil/erpo

Modeling and Simulation (M&S) Guidance for the Acquisition Workforce, Oct 2008
http://www.acqnotes.com/Attachments/Modeling%20&%20Simulation%20Guidance%20for%20the%20Acquisition%20Workforce.pdf

Modeling and Simulation (M&S) Management, DODD 5000.59, Oct 2018
https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/500059p.pdf

MSA Guide, DAG Chapter 3-3.2.2 Materiel Solution Analysis Phase
https://dau.edu/tools/dag

National Defense Authorization Act (NDAA) for Fiscal Year 2017. Public Law 114-238. 114th Congress, Dec 23, 2016.
https://www.congress.gov/bill/114th-congress/senate-bill/2943/text

NDAA – National Defense Authorization Act, FY 2017 Section 807, Sect 2448b. Independent Technical Risk Assessments
https://uscode.house.gov/statutes/pl/114/328.pdf

NDAA – National Defense Authorization Act, FY 2017 Section 807 (Public Law 114-328), Cost, Schedule, and Performance of Major Defense Acquisition Programs
https://uscode.house.gov/statutes/pl/114/328.pdf

NAVSO P-3687 Producibility Systems Guidelines
http://everyspec.com/USN/NAVY-General/NAVSO_P-3687_8510/

NIST Documents, National Institutes of Standards and Technology
https://csrc.nist.gov/publications

NIST 800-82, Guide to Industrial Control Systems Security, May 2015
https://csrc.nist.gov/publications/detail/sp/800-82/rev-2/final

NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations, Rev 2, Feb 2020
https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-171r2.pdf

O&S Cost Estimating Guide, CAPE, Mar 2014
https://www.cape.osd.mil/files/OS_Guide_v9_March_2014.pdf

O&S Cost Management Guide, DAU, Mar 2016
https://www.dau.edu/tools/t/Operating-and-Support-(OandS)-Cost-Management-Guidebook

OUSD(R&E) Systems Engineering and Architecture (SE&A)
https://ac.cto.mil/engineering/

OUSD(R&E) Manufacturing and Quality
https://ac.cto.mil/maq/

Parametric Estimating Handbook, DAU, Apr 2008
https://www.dau.edu/tools/Lists/DAUTools/Attachments/112/Parametric%20Handbook%204th%20Edition.pdf

Performance-Based Logistics (PBL) Guidebook, DAU Apr 2016
https://www.dau.edu/tools/t/Performance-Based-Logistics-(PBL)-Guidebook

Pre-Materiel Development Decision (MDD) Analysis Handbook, Jul 2010, Office of Aerospace Studies, Kirtland AFB, NM. ***Note:*** *This document was replaced with The Measures Handbook, Aug 2014, Office of Aerospace Studies, Kirtland AFB*
https://daytonaero.com/wp-content/uploads/USAF_The-Measures-Handbook_6Aug2014.pdf

Preservation and Storage of Tooling for MDAPs, DUSD Memo, Aug 2009
https://www.acq.osd.mil/dpap/pdi/uid/docs/DrCarterSignedMemo.pdf

Process Capability Control and Improvement Requirements – Process Control Plan Reference Guide, Picatinny Arsenal
https://ac.ccdc.army.mil/organizations/QESA/_files/PCCI_Review_Guide_Rev-1.pdf

Producibility Engineering and Planning (PEP) Program Management Guide, Jan 1985
https://apps.dtic.mil/sti/citations/ADA153730

Producibility Engineering Standard Practice Manual, US Army Belvoir, R&D Center, Sep 1993
http://everyspec.com/ARMY/ARMY-General/PRODUCIBILITY_STD_PRACTICE_MANUAL_SEP1993_34552/

Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
http://everyspec.com/USN/NAVY-General/NAVSO_P-3687_8510/

Product Support Manager Guidebook, May 2022
https://www.dau.edu/tools/t/Product-Support-Manager-(PSM)-Guidebook

Public Law 114-328, §807, Cost, Schedule and Performance of Major Defense Acquisition Programs
https://www.govinfo.gov/content/pkg/PLAW-114publ328/html/PLAW-114publ328.htm

Quality Function Deployment, IEEE article, Kenneth Crow, DRM Associates, Los Angeles, CA
https://www.ieee.li/tmc/quality_function_deployment.pdf

Regulation EC 1907/2006. Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)
Regulation (EC) No 1907/2006 - Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) | Safety and health at work EU-OSHA (europa.eu)

Request for Proposal Evaluation Guide, Reform Support Network, no date, used by state and local education agencies to evaluate proposals
https://www2.ed.gov/about/inits/ed/implementation-support-unit/tech-assist/request-proposals-evaluation-guide.pdf

Requirements Traceability Matrix Guide, Jan 2012
https://www.dau.edu/cop/pqm/_layouts/15/WopiFrame.aspx?sourcedoc=/cop/pqm/DAU%20Sponsored%20Documents/CDD-CPD%20Writing%20Guide,%20Feb%202015.pptx&action=default

Requirements Traceability Matrix Tool (excel), DAU
https://www.dau.edu/tools/Documents/SAM/resources/RTM_Risk_Register.html

Risk, Issues and Opportunity Management Guide for Defense Acquisition Systems, DoD, Jan 2017
http://acqnotes.com/wp-content/uploads/2017/07/DoD-Risk-Issue-and-Opportunity-Management-Guide-Jan-2017.pdf
https://ac.cto.mil/erpo

Robust Design and Taguchi Methods
https://www.dau.edu/cop/risk/DAU%20Sponsored%20Documents/Robust%20Design%20and%20Taguchi%20Methods.pdf

R&M Body of Knowledge (BoK), Aug 2018
https://ac.cto.mil/wp-content/uploads/2020/10/RMBoK-2018-s.pdf

SAE EIA 649B-2011, Configuration Management Standard
https://webstore.ansi.org/Standards/SAE/SAEEIA649B2011EIA649B?gclid=EAIaIQobChMI6NS4yPOL6wIVxf7jBx0qGQxrEAAYAiAAEgLSmPD_BwE

SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA) and Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA) Reference Manual, SAE International, Jan 2009
https://www.sae.org/standards/content/j1739_200006/

SD-5 Market Research, Defense Standardization Program, Jan 2008
http://acqnotes.com/wp-content/uploads/2014/09/SD-5-Market-Research.pdf

SD-22, DMSMS Guidebook
https://www.dsp.dla.mil/Programs/DMSMS

Section L Guide - IG5315,204-5(b)
https://far.affinitext.com/public/book?id=18966&toc_id=5280626#PG_5280185_60384008

Section M Guide - IG5315,204-5(c)
https://far.affinitext.com/public/book?id=18966&toc_id=5280626#PG_5280775_60387757

SF 1403 Preaward Survey of Prospective Contractor
http://www.acqnotes.com/Attachments/Standard%20Form%201403.pdf

SF 1404 Preaward Survey of Prospective Contractor – Technical
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-technical

SF 1405 Preaward Survey of Prospective Contractor – Production
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-technical

SF 1406 Preaward Survey of Prospective Contractor – Quality Assurance
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-quality-assurance

SF 1407 Preaward Survey of Prospective Contractor – Financial Capability
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-financial-capability

SF 1408 Preaward Survey of Prospective Contractor – Contractor Accounting System
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-financial-capability

Should Cost Affordability Memo, Aug 2011
https://www.acq.osd.mil/fo/docs/Should-cost%20and%20Affordability.pdf

Source Selection Procedure, DoD Memo, Apr 2016
http://acqnotes.com/wp-content/uploads/2014/09/DoD-Source-Selection-Procedures-31-Mar-2016.pdf

Strategic and Critical Materials Stockpiling Act, 1939
https://uscode.house.gov/view.xhtml?req=(title:50%20section:98%20edition:prelim)

Supply Chain Metrics Guide, Sep 2021
https://www.acq.osd.mil/log/LOG_SD/.policy_vault.html/Supply_Chain_Metrics_Guide_22Sep2021.pdf

Supply Chain Operations Reference (SCOR) Model, Association for Supply Chain Management
https://www.apics.org/apics-for-business/frameworks/scor

Sustainability Analysis Guidance: Integrating Sustainability into Acquisition Life Cycle Assessment
https://www.denix.osd.mil/esohacq/home/dod-guidance/dod-sustainability-analysis-guidance/OSD-ATL%20SA%20Guidance%20v5%20508%20Additions.pdf

Systems Engineering Guidebook, Feb 2022
https://ac.cto.mil/wp-content/uploads/2022/02/Systems-Eng-Guidebook_Feb2022-Cleared-slp.pdf

Technology Readiness Assessment (TRA) Deskbook, Jul 2009 (update forthcoming)
http://www.acqnotes.com/Attachments/Technology%20Readiness%20Assessment%20Deskbook.pdf

Technology Readiness Assessment Guide, GAO Report: GAO-20-48G, Jan 2020
https://www.gao.gov/assets/710/703694.pdf

Technology Transition Managers Guide, Real title is Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment, DAU Press, Jun 2005
https://apps.dtic.mil/dtic/tr/fulltext/u2/a484102.pdf

Test and Evaluation Management Guide (TEMG), DAU, Aug 2016
https://www.dau.edu/tools/t/Test-and-Evaluation-Management-Guide-(TEMG)

Appendix C: Manufacturing and Quality Tools

Tools identified in the M&Q BoK are listed below alphabetically and many contain a link to the referenced tools that are published by a U.S. Government entity and available in the public domain. If the tool is commercially available either for free or for a charge, the entry will direct the reader to *Internet Search*. Individual publishers may provide a short video on how to use the tool.

Acquisition Decision Memorandum (ADM) MDD Template
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-Materiel-Development-Decision-(MDD)-Template-v1-4

Acquisition Decision Memorandum (ADM) MDD Template, Milestone A
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-MS-A-Template-v1-4

Acquisition Decision Memorandum (ADM) MDD Template, Milestone B
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-MS-B-Template-v1-4

Acquisition Decision Memorandum (ADM) MDD Template, Milestone C
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-MS-C-Template-v1-4

Acquisition Logistician's Assessment Checklist (Army)
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiRsPqKmdXtAhULlKwKHZ_lBX4QFjAAegQIAxAC&url=https%3A%2F%2Fwww.dau.edu%2Fcop%2Flog%2FDAU%2520Sponsored%2520Documents%2FArmy%2520Acquisition%2520Logistician%2520s%2520Assessment%2520Checklist%2520V5.0.doc&usg=AOvVaw2wved2qLjb0ZMNM6cyiBzL

Acquisition Logistics: An Assessment Tool (NAVSO P-3690)
https://www.dau.edu/cop/log/DAU%20Sponsored%20Documents/NAVSO%20P%203690%20ILA%20Asess%20Tool%20Sep%2001.pdf

Acquisition Plan Preparation Guide template
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjYzKf-p7TsAhVIT6wKHYfvA8oQFjAAegQIBBAC&url=http%3A%2F%2Fwww.acqnotes.com%2FAttachments%2FAcquisition%2520Plan%2520Preparation%2520Guide.doc&usg=AOvVaw1yKslG_VAKiWoUuIxnBO2C

Acquisition Strategy (AS) Outline
https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf

Acquisition Strategy Template
https://www.dau.edu/tools/t/Acquisition-Strategy-Template-v2-4

Alternative System Review (ASR) Checklist
http://acqnotes.com/acqnote/tasks/alternative-systems-review-2

Analysis of Alternatives (AoA) Study Plan Template
https://www.dau.edu/tools/t/Analysis-or-Alternatives-(AoA)-Study-Plan-Template-v2-0

AoA Study Guidance Template
https://www.dau.edu/tools/t/Analysis-or-Alternatives-(AoA)-Study-Guidance-Template-v1-0

AoA Study Plan Template
https://www.dau.edu/tools/t/Analysis-or-Alternatives-(AoA)-Study-Plan-Template-v2-0

AS5553 Counterfeit Electronic Parts: Avoidance, Detection, Mitigation, and Disposition
Internet Search

AS6500 Manufacturing Management Program Checklist
Internet Search

AS9100 Quality Management System Checklist
Internet Search

AS9100 Quality Audit Checklist
Internet Search

AS9103 Variation Management of Key Characteristics Assessment
Internet Search

AS9133 Qualification Procedure for Standard Products (Supplier Audit) Checklist
Internet Search

AS9134 Supply Chain Risk Management Guidelines
Internet Search

AS9137 Advanced Quality Assurance Procedure (AQAP) Checklist
Internet Search

AS9145 Requirements for Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP) Checklist
Internet Search

Assembly Chart
Internet Search

Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
http://www.dodmrl.com/DI-SESS-81974.pdf

Automated Requirements Roadmap Tool (ARRT) Suite, DAU
https://www.dau.edu/tools/t/Acquisition-Requirements-Roadmap-Tool-(ARRT)-Suite

Award Fee Plan Checklist
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Award Fee Plan Template
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Award Fee Sample Rating Definitions
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Award Fee Sample Evaluation Criteria
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Benchmarking
Internet Search

Bill of Material Assessment
Internet Search

Bill of Material Data Item Description - DI-PSSS-81656B
https://www.dau.edu/cop/dmsms/Lists/Tools/DispForm.aspx?ID=48&ContentTypeId=0x0100AE321BA2819FFD499A441F9A8F574C1600A3866BA66DC4B546AF0E2614A20E809A

Bottleneck Analysis (Theory of Constraints)
Internet Search

Capability Development Document (CDD) Template
http://acqnotes.com/acqnote/acquisitions/capability-development-document-cdd

Capabilities-Based Assessment (CBA) Tool, DAU
https://www.dau.edu/tools/t/CBA-Tool

Capability Development Document (CDD) Template
http://acqnotes.com/acqnote/acquisitions/capability-development-document-cdd

Capacity Assessment Worksheet
Internet Search

Cash Flow Tool for Evaluating Alternative Finance Arrangement
https://www.acq.osd.mil/dpap/policy/policyvault/USA005332-10-DPAP.pdf

Cause and Effect Diagram
Internet Search

Contractor Purchasing System Review (CPSR)
Note: User must register on the DCMA 360 portal to get access

Cost Analysis Requirements Description (CARD) Guidance (see CAPE website for tools)
http://acqnotes.com/acqnote/careerfields/cost-analysis-requirements-description

Cost Analysis Requirements Description (CARD) Template
https://www.dau.edu/tools/t/Cost-Analysis-Requirements-Description-(CARD)-Template-v1-3

Cost Estimating Technique – Analogy
http://acqnotes.com/acqnote/careerfields/cost-estimating-methods

Cost Estimating Technique – Parametric
http://acqnotes.com/acqnote/careerfields/cost-estimating-methods

Cost Estimating Technique – Engineering
http://acqnotes.com/acqnote/careerfields/cost-estimating-methods

Cost Estimating Technique – Actuals
http://acqnotes.com/acqnote/careerfields/cost-estimating-methods

Cost/Schedule Control System Criteria (C/SCSC) Reference Guide – DTIC
https://apps.dtic.mil/dtic/tr/fulltext/u2/a258445.pdf

Cost/Schedule Control System Criteria (C/SCSC) Guide and Checklist – DTIC
https://www.secnav.navy.mil/rda/OneSource/Documents/CEVM/Tools%20and%20Examples/DOD%20Guides/BowmanInterpretiveGuide1.pdf

Cost of Quality (CoQ) Estimates
Internet Search

Critical Chain Project Management
Internet Search

Critical Design Review (CDR) Checklist
http://acqnotes.com/acqnote/acquisitions/critical-design-review

Critical Path Template
Internet Search

Critical to Customer Template
Internet Search

Critical to Quality Tree Template
Internet Search

Cyber Security Assessment see Cyber Security Assessment see Cybersecurity & The Acquisition Lifecycle Integration Tool (CALIT)
https://www.dau.edu/tools/t/Cybersecurity-and-Acquisition-Lifecycle-Integration-Tool-(CALIT)

DMCA Engineering Surveillance Plan
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-207.pdf

DCMA Industrial Capability Assessment Survey
Note: User must register on the DCMA 360 portal

DCMA Manufacturing and Production Surveillance Plan
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-204.pdf

DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
Note: User must register on the DCMA 360 portal

DCMA Material Management and Accounting System (MMAS) Audit
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-211.pdf

DCMA Pre-Award Survey System (PASS) review
https://www.dcma.mil/WBT/pass/

DCMA Pre-Award Survey (SF 1403)
https://www.gsa.gov/reference/forms?search_keyword=SF%201403

DCMA Pre-Award Survey – Technical (SF 1404)
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-technical

DCMA Pre-Award Survey – Production (SF 1405)
https://www.gsa.gov/reference/forms?search_keyword=SF%201405

DCMA Pre-Award Survey – Quality Assurance (SF 1406)
https://www.gsa.gov/reference/forms?search_keyword=SF%201406

DCMA Pre-Award Survey – Financial Capability (SF 1407)
https://www.gsa.gov/reference/forms?search_keyword=SF%201407

DCMA Pre-Award Survey – Contractor Accounting System (SF 1408)
https://www.gsa.gov/reference/forms?search_keyword=SF%201407

DCMA Production Planning and Control Risk Assessment Checklist
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-204.pdf

DCMA Program Assessment Report
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-MAN-3101-02.pdf

DCMA Program Support Plan (DCMA-ANX 205-02)
Note: *User must register on the DCMA 360 portal*

DMCA QA Surveillance Plan
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-309.pdf

Design Failure Modes and Effects Analysis (DFMEA)
Internet Search

Design for Affordability
Internet Search

Design for Manufacture and Assembly (DFMA)
Internet Search

Design for Performance
Internet Search

Design for Producibility
Internet Search

Design for Six Sigma (DFSS)
Internet Search

Design of Experiments (DoE)
Internet Search

Design of Experiments (DoE) Analysis
Internet Search

DFAR Subpart 232.10 Performance-Based Payments
https://www.acq.osd.mil/dpap/dars/dfars/html/current/232_10.htm

DMSMS Cost of Alternative Solutions Worksheet (see SD-22)
https://www.dau.edu/tools/t/SD-22-Diminishing-Manufacturing-Sources-and-Material-Shortages-(DMSMS)-Guidebook

DMSMS Implementation Plan - DI-MGMT-81949
https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=280073

DMSMS Health Assessment Report
https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=283247

Earned Value Management
https://www.dau.edu/tools/t/EVM-General-Reference-(Gold-Card)

Failure Mode and Effects Analysis (FMEA)
Internet Search

Failure Modes, Effects, and Criticality Analysis (FMECA)
Internet Search

First Pass Yield Estimates Worksheet
Internet Search

First Article Inspection (FAI) Checklist, AFMC Form 260, First Article Requirements
https://www.e-publishing.af.mil/Product-Index/#/?view=form&orgID=4&catID=9&low=200&high=299&modID=449&tabID=131

First Article Test (FAT) Checklist
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-302.pdf

Functional Configuration Audit (FCA) Checklist (Air Force)
Templates – USAF Acquisition Process Model (afacpo.com)

Gantt Charts
Internet Search

Government Property Compliance Checklist (Navy)
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiyivT-sbnsAhVHuVkKHaU5Di0QFjAAegQIAhAC&url=http%3A%2F%2Fwww.secnav.navy.mil%2Frda%2FDocuments%2FCompliance%2520Checklist.xlsx&usg=AOvVaw0Jec3r4-gNaxYYoLYbcDLM

Histograms
Internet Search

IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
Internet Search

IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
Internet Search

IG5315.204-5(b) Section L Guide and Template
https://far.affinitext.com/public/book?id=18966&toc_id=5280626#PG_5280626_60386996

IG5315.204-5(c) Section M Guide and Template
https://far.affinitext.com/public/book?id=18966&toc_id=5280779#PG_5280779_60387780

Incentive Fee Template
https://www.dau.edu/tools/t/FPIF-CPIF

Independent Logistics Assessment Checklist (MCSC)
https://www.dau.edu/cop/log/_layouts/15/WopiFrame.aspx?sourcedoc=/cop/log/DAU%20Sponsored%20Documents/MCSC%20ILA%20Checklist%20v3%206AUG09.xls&action=default

Independent Technical Risk Assessments (ITRAs) Execution Guidance
https:ac.cto.mil/wp-content/uploads/2020/12/DoD-ITRA-ExecGuide-2020s.pdf

Industrial Base Assessment Survey Form (DCMA Industrial Analysis Group)
Internet Search

Industrial Base Sector Plans (no specific tool)
Internet Search

Initial Capabilities Document (ICD) Template (on page 2 of ICD Writers Guide
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiz0K6U09XtAhUNWq0KHYuuAMEQFjABegQIARAC&url=http%3A%2F%2Fwww.acqnotes.com%2FAttachments%2FCapability%2520Development%2520Document%2520Template%252030%2520Oct%252012.doc&usg=AOvVaw167Ffrt1uVVB8BdH4AjRAj

In-Service Review (Checklist)
In-Service Review - AcqNotes

Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
Internet Search MS Project

Interactive MRL Users Guide (Checklist), all threads
http://www.dodmrl.com/

Initial Capabilities Document (ICD) Template
http://acqnotes.com/acqnote/acquisitions/initial-capabilities-document-icd

ISO 9001, Quality Management Systems, Quality Audit Checklist
Internet Search

ISO 14001 Environmental Management System (EMS) Gap Analysis Checklist
Internet Search

ITAR Compliance Checklist
Internet Search

Lead Time Estimator
Internet Search

Learning Curve Calculator (Estimator)
https://www.dau.edu/tools/t/Learning-Curve-QuickCalc

Learning Curve Estimation (M&S Software)
Internet Search

Learning Curve Worksheet (in Excel)
Internet Search

Life Cycle Sustainment Plan outline
https://www.dau.mil/tools/t/Life-Cycle-Sustainment-Plan-(LCSP)-Outline

Life Cycle Sustainment Plan template (AFLCMC)
https://www.dau.mil/tools/Lists/DAUTools/Attachments/56/Life%20Cycle%20Sustainment%20Plan%20(LCSP)%20%20Outline%20AFLCMC%20ADDM%20Template%20v2.docx

Line of Balance Template
Internet Search

Logistics Assessment Guidebook (DAU), Appendix A: Integrated Product Support Element
https://www.dau.edu/tools/t/Logistics-Assessment-Guidebook

Long Lead Times Material Report, DI-PSSS-82201
https://standards.globalspec.com/std/10291122/di-psss-82201

Make/Buy Plans/Decision
Internet Search

ManTech Roadmap
Internet Search

ManTech Strategic Plan
Internet Search

Manufacturing Capability Assessment Worksheet
Internet Search

Manufacturing Cost Estimating Worksheet (commercial)
Internet Search

Manufacturing Maturation Plan (see MRL Deskbook)
http://www.dodmrl.com/

Manufacturing Plan, DI-MGMT-81889A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-MGMT/DI-MGMT-81889A_55798/

Manufacturing Resource Planning (MRP II)
Internet Search

Manufacturing Resource Planning (MRPII) Assessment
Internet Search

Manufacturing Technology (ManTech) Report, DI-MISC-81176A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-MISC/DI-MISC-81176A_13522/

Manufacturing Strategy (no template available)
Internet Search

Market Research (DAU)
https://www.dau.edu/tools/t/Market-Research-Methods

Market Research Report Template
https://www.dau.edu/tools/t/Market-Research-Report-Template-v1-1
Material Forecasting Models
Qualitative Forecasting
Executive Opinion
Sales Forecast Composite
Consumer Market Survey
Delphi
Group Discussion
Quantitative Forecasting
Time Series
Regression Modeling
Internet Search

Material Management and Accounting System (MMAS) Audit
https://www.dcaa.mil/Portals/88/Documents/Guidance/Directory%20of%20Audit%20Programs/12500%20Material%20Management%20and%20Accounting%20System%20(MMAS)%20AP.pdf?ver=2020-07-01-133628-443

Material Requirements Planning (MRP I)
Internet Search

Materials Requirements Planning (MRP) Assessment
Internet Search

Materiel Development Decision (MDD) ADM Template
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-Materiel-Development-Decision-(MDD)-Template-v1-4

Materiel Development Decision (MDD) ADM Template (Air Force)
https://www.afacpo.com/apm/core-documents/templates/

Materiel Development Decision (MDD) Development Planning Templates
https://www.afacpo.com/apm/core-documents/templates/

Milestone Charts (Program)
Internet Search

Multi-Attribute Tradespace Exploration (MATE) (see MIT Thesis)
Internet Search

Operational Test Readiness Review (OTRR) Checklist
http://acqnotes.com/acqnote/acquisitions/operational-test-readiness-review

Operations Process Chart
Internet Search

Pareto Analysis
Internet Search

Parts List
Internet Search

Performance-Based Payments Guide
https://www.acq.osd.mil/dpap/cpic/cp/docs/Performance_Based_Payment_(PBP)_Guide.pdf

PERT/Network Charts
Internet Search

Pilot Line Demonstration and Assessment
Internet Search

Plant Design and Facility Layout Software Evaluation Tools
Internet Search

Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)
Internet Search

Pre-award Survey – Technical (SF 1404)
http://www.acqnotes.com/Attachments/SF%201404%20Preaward%20Survey%20of%20Prospective%20Contractor%20-%20Technical.pdf

Pre-award Survey – Production (sf 1405)
http://www.acqnotes.com/Attachments/SF%201405%20Preaward%20Survey%20of%20Prospective%20Contractor%20-%20Production.pdf

Pre-award Survey – Quality Assurance (SF 1406)
http://www.acqnotes.com/Attachments/SF%201406%20Preaward%20Survey%20of%20Prospective%20Contractor%20-%20Quality%20Assurance.pdf

Pre-award Survey – Financial Capability (SF 1407)
http://www.acqnotes.com/Attachments/SF%201407%20Preaward%20Survey%20of%20Prospective%20Contractor%20-%20Financial%20Capability.pdf

Preliminary Hazard List (PHL) (*See* MIL-STD-882E, Task 201)
https://www.dau.edu/cop/armyesoh/DAU%20Sponsored%20Documents/MIL-STD-882E.pdf

Preliminary Hazards Analysis (PHA) (*See* MIL-STD-882E, Task 202)
https://www.dau.edu/cop/armyesoh/DAU%20Sponsored%20Documents/MIL-STD-882E.pdf

Preservation, Handling, Storage, Packaging and Delivery (PHSPD) Checklist
Internet Search

Process Capability Studies (Cp and Cpk assessment)
Internet Search

Process Capability Study Worksheet (Cp and Cpk Assessment)
Internet Search

Process Control Document (PCD)
Internet Search

Process Control Plan Worksheet
Internet Search

Process Failure Modes and Effects Analysis (PFMEA)
Internet Search

Process Modeling Tools (Siemens PLM, Delmia)
Internet Search

Producibility Assessment Worksheet (PAW) (see NAVSO P-3687, page F-20)
https://www.dau.edu/cop/pqm/DAU%20Sponsored%20Documents/NAVSO%20P%203687.PDF

Producibility Engineering and Planning (PEP) Data Item Description – DI- MGMT-80797A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-MGMT/DI-MGMT-80797_4277/

Production Part Approval Process (PPAP), see AS9137 Advanced Quality Assurance Procedure (AQAP)
Internet Search

Production Part Approval Process (PPAP) Checklist
Internet Search

Production Plan (schedule)
Internet Search

Production Readiness Review (PRR) Checklist
Internet Search

Production Verification Test
Internet Search

Product Support Business Case Analysis Guidebook Appendix A BCA Checklist
https://www.dau.edu/tools/t/Product-Support-Business-Case-Analysis-(BCA)-Guidebook

Product Support Strategy Development Tool, Defense Acquisition University (DAU)
https://www.dau.edu/guidebooks/Shared%20Documents/Product%20Support%20Strategy%20Development%20Tool.pdf

Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) Template
https://www.dau.mil/cop/pm/DAU%20Sponsored%20Documents/PESHE%20AFLCMC%20ADDM%20Template%20v2.1.docx

Progress-Based Payments Tool (recommend changing to Performance Based Payments Analysis Tool (DAU)
https://www.dau.edu/tools/t/Performance-Based-Payments-Analysis-Tool

Pugh Matrix Template
Internet Search

Quality Assurance Program Plan, DI-QCIC-81794
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-QCIC/DI-QCIC-81794_20418/

Quality Assurance Provisions, DI-SESS-80789A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-QCIC/DI-QCIC-81794_20418/

Quality Function Deployment (QFD) or House of Quality Matrix
Internet Search

Quality Function Deployment (QFD) Excel Spreadsheet
Internet Search

Quality Management Plan (Sample)
Internet Search

Quality Management System (QMS), DI-MGMT-82184
https://quicksearch.dla.mil/qaDocDetails.aspx?ident_number=282795

Quality Program Plan, DI-QCIC-81722
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-QCIC/DI-QCIC-81722_43871/

Quality Status Report, DI-MGMT-82186
https://quicksearch.dla.mil/qaDocDetails.aspx?ident_number=282783

Requirements Roadmap Worksheet, DAU
https://www.dau.edu/tools/Documents/SAM/resources/Requirements_Roadmap.html

Requirements Traceability Matrix Template, DAU
https://www.dau.edu/tools/Documents/SAM/resources/RTM_Risk_Register.html

Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs (DoD)
http://acqnotes.com/wp-content/uploads/2017/07/DoD-Risk-Issue-and-Opportunity-Management-Guide-Jan-2017.pdf

Risk, Issue, and Opportunity (RIO) assessment
Internet Search

Risk Management Plan Template – DAU
https://www.dau.edu/tools/t/Risk-Management-Plan-Template-2017

Robust Design (Taguchi)
Internet Search

Rough Cut Capacity Planning Spreadsheet
Internet Search

Route Sheet
Internet Search

Route Sheet Analysis
Internet Search

Safety and Industrial Hygiene Hazard Assessment Checklist
https://www.dla.mil/Portals/104/Documents/Strategic%20Materials/IATK/Copy%20of%20Safety%20and%20health%20checklist%20Strategic%20Materials.pdf?ver=2015-09-23-114310-987

Shop Floor Manufacturing Plan Analysis
Internet Search

Six Sigma Worksheet
Internet Search

Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins)
Internet Search

Source Selection Plan Template (USMC)
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiOiba-i8bsAhUCR6wKHfTRAGsQFjAAegQIBRAC&url=https%3A%2F%2Fwww.quantico.marines.mil%2FPortals%2F147%2FDocs%2FRCO%2FSource%2520Selection%2520Plan%2520Template.doc&usg=AOvVaw0v19l6mRlO1PqWG6r6zOWY

Supplier Quality Questionnaire
Internet Search

Supply Chain Management Risk Assessment Checklist
Internet Search

Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis
Internet Search

System Capabilities Analytic Process (SCAP)
https://apps.dtic.mil/dtic/tr/fulltext/u2/a539905.pdf

Systems Engineering Management Plan, DI-SESS-81785A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-SESS/DI-SESS-81785A_53778/

Systems Engineering Plan (SEP) Outline
http://acqnotes.com/acqnote/acquisitions/systems-engineering-plan

Systems and Software Engineering–System Life Cycle Processes, ISO/IEC/IEEE 15288
Internet Search

System Verification Review (SVR) Checklist
http://acqnotes.com/acqnote/acquisitions/system-verification-review-svr#:~:text=The%20System%20Verification%20Review%20(SVR,and%20Development%20(EMD)%20Phase.

Taguchi Loss Function Analysis
Internet Search

Technology Readiness Assessment Calculator
https://www.dau.edu/cop/stm/Lists/Tools/AllItems.aspx

Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
https://www.gao.gov/products/GAO-20-48G

Technology Readiness Level (TRL) Assessment Checklist
Internet Search

Test and Evaluation Master Plan (TEMP) Guidebook
http://www.acqnotes.com/Attachments/DOT&E%20and%20TEMP%20Guidebook%20-%2028%20Mar%2013.pdf

Test and Evaluation Master Plan (TEMP) template
https://www.dau.edu/tools/t/Test-and-Evaluation-Master-Plan-(TEMP)-Template--v3-0

Test Readiness Review (TRR) Checklist
http://acqnotes.com/acqnote/careerfields/test-readiness-review-te

Theory of Inventive Problem Solving (TRIZ) Matrix
Internet Search

Tolerance Design
Internet Search

Transition from Development to Production, DoD 4245.7-M
https://apps.dtic.mil/dtic/tr/fulltext/u2/a303209.pdf

TRIZ Matrix Template
Internet Search

Work Breakdown Structure (Template)
Internet Search

Work Measurement Analysis
Internet Search

Work Measurement Time Study Worksheet (DD Form 2042-1)
https://www.esd.whs.mil/Portals/54/Documents/DD/forms/dd/dd2042-1.pdf

Workforce Planning Tools (SAP/Oracle/MRP II)
Internet Search

Yield Rate Assessment
Internet Search

Appendix D: Sample Manufacturing and Quality Assurance Request for Proposal Input

Sample Manufacturing and Quality Assurance Request for Proposal Input

Office of the Under Secretary of Defense for Research and Engineering

2021

Developed in coordination with Air Force Life Cycle Management Center and industry representatives following the 2017 Defense Manufacturing Conference Manufacturing and Quality Roundtable, which identified the need for more consistent manufacturing and quality contracting approaches across the Department of Defense.

Contents

Introduction

This document provides examples for Manufacturing and Quality Request for Proposal (RFP) inputs, including the Statement of Work (SOW), Sections L and M for competitive acquisitions, and Federal Acquisition Regulation (FAR)/Defense Federal Acquisition Regulation (DFAR) requirements.

The Core SOW requirements should be used on all Acquisition Category (ACAT) I programs. They may be used on other programs but should be tailored as needed to match the scope and needs of each program. For all of the requirements and other inputs in this guide, program team with input from manufacturing and quality specialist should conduct specific tailoring to ensure requirements are appropriate to meeting the unique needs and circumstances of each program.

If possible, developing contractual requirements should be a collaborative process between the government program office and the prime contractor.

Data Item Descriptions (DIDs):

- Prior to using a DID, ensure the most current version is being referenced.
- Use caution when calling out DIDs: Some requirements in the SOW do not have DIDs that directly correspond to them. In those cases, the closest, related DID is suggested. In other cases, some DIDs may be significantly outdated. They were provided to serve as a potential starting point and may need to be tailored. These will be discussed in each section, if applicable.

Manufacturing and Quality RFP Guide Summary Applicability Matrix

The following table is provided for general guidance only. Specific determinations of program and contract applicability should be made on a case-by-case basis.

All requirements are applicable to land, sea, air, and space-based systems. The only exception is for Aviation Critical Safety Items, which are applicable only to air and space systems.

Where checkmarks are shown, that requirement should be considered for inclusion in a SOW. Requirements may still be tailored to meet program needs.

Manufacturing and Quality Input to RFP

Manufacturing/Quality RFP Inputs	MSA	TMRR	EMD	P&D	O&S	Design Change	NDI/COTS
Core SOW Inputs							
Manufacturing Management Program		✓	✓	✓	✓	✓	
Quality Management System Requirements		✓	✓	✓	✓	✓	✓
Manufacturing Readiness Levels and Assessments (MRLs)	✓	✓	✓	✓	✓	✓	✓
Quality and Manufacturing Metrics		✓	✓	✓	✓	✓	✓
Counterfeit Parts Prevention		✓	✓	✓	✓	✓	✓
First Article Inspections/First Article Tests			✓	✓	✓	✓	✓
GIDEP Participation			✓	✓	✓	✓	
Production Readiness Review			✓	✓		✓	✓
Other SOW requirements to consider							
Aviation Critical Safety Items		✓	✓	✓	✓	✓	
Manufacturing Modeling and Simulation		✓	✓	✓	✓	✓	
Calibration			✓	✓	✓	✓	
Configuration Management		✓	✓	✓	✓	✓	
Risk Management		✓	✓	✓	✓	✓	
Parts, Materials, and Processes Control Program		✓	✓	✓	✓	✓	
Environmental Stress Screening		✓	✓	✓	✓	✓	
Key Characteristics and Variation Reduction		✓	✓	✓	✓	✓	
Advanced Product Quality Planning (APQP) & Production Part Approval Process (PPAP)			✓	✓	✓	✓	

1. Core SOW Inputs

1.1. Manufacturing Management Program

The contractor shall establish and maintain a Manufacturing Management Program that meets the requirements of SAE AS6500A and flow this requirement down to major/critical suppliers. The contractor shall document this program as part of their Manufacturing Plan. The contractor shall include its plans for Production Readiness Reviews (PRRs) and Manufacturing Readiness Level (MRL) Assessments in the Manufacturing Plan.

Suggested Data Item Description (DID):

- DI-MGMT-81889B, Manufacturing Plan

Guidance:

1. Major and critical suppliers are defined in AS6500A:

Critical Supplier: A contractor whose performance could seriously jeopardize the successful achievement of a program's cost, schedule, technical, or supportability requirements if not satisfactorily managed (e.g., a sole source supplier or supplier of critical parts, strategic and critical materials, or unique or special processes.)

Major Supplier: A supplier, distributor, vendor, or firm that furnishes supplies or services to or for the prime contractor whose total costs are a significant portion of the total purchased value for the program.

2. While the requirement for a manufacturing management system is applicable during the TMRR phase, it may be too early to require a deliverable manufacturing plan.

3. The DID for a Manufacturing Plan, DI-MGMT-81889B, was updated to be consistent with AS6500A.

1.2. Quality Management System Requirements

The contractor shall establish and maintain a Quality Management System (QMS) that meets the requirements of AS9100. The quality system shall ensure delivery of product that complies with all technical requirements. The Contractor shall document how the QMS is implemented with any unique requirements within the Quality Assurance Program Plan. Major/critical suppliers and suppliers with design authority shall be required to establish and maintain a Quality Management System (QMS) in accordance with requirements of AS9100. Suppliers without design authority shall be compliant to SAE AS9003, Inspection and Test Quality System, as a minimum.

Suggested DID:

- DI-QCIC-81794A, Quality Assurance Program Plan, contractor format acceptable

Guidance:

1. AS9100 is the preferred requirement for a Quality Management System for ACAT I programs in Aviation, Space, and Defense Organizations. The Federal Acquisition Regulation, Part 46, also recognizes overarching quality management system standards such as ISO 9001, ASQ/ANSI E4; ASME NQA-1, SAE AS9003, and ISO/TS 16949. If applying any of these other standards, ensure they are appropriate to the complexity and criticality of the product.

2. The most recent version of AS9100 (or equivalent standard) shall be specified.

3. While the requirement for a quality management system is applicable during the TMRR phase, it may be too early to require a deliverable quality plan.

1.3. Manufacturing Readiness Levels and Assessments (MRLs)

The contractor shall conduct assessments of manufacturing readiness in accordance with AS6500A and use the definitions, criteria, and processes defined in the Manufacturing Readiness Level Deskbook as a guide. Assessments will be conducted at the locations and frequencies specified in Appendix TBD. They will be led by the government program office at the prime contractor's facilities. The prime contractor shall lead the assessments at suppliers and include government participants. The selection of supplier assessments should be determined by the government and prime contractor using the MRL Deskbook, Section 4.3 as a guide. The contractor shall develop and implement Manufacturing Maturation Plans or their equivalent for criteria in which the MRL is lower than the target MRL. The contractor shall monitor and provide status at all program reviews for in-house and supplier MRLs and shall re-assess MRLs in areas for which design, process, source of supply, or facility location changes have occurred that could impact the MRL.

Suggested DIDs:

- DI-SESS-81974, Assessment of Manufacturing Risk and Readiness
- DI-ADMIN-81249B, Conference Agendas
- DI-ADMIN-81250B, Conference Minutes
- DI-MISC-80508B, Technical Report – Study/Services

Guidance:

1. Ensure DIDs are current and appropriate.

1.4. Quality and Manufacturing Metrics

In accordance with AS6500A, the contractor shall maintain a manufacturing surveillance process. The contractor shall submit quality and manufacturing metrics at the agreed upon frequency that report the contractor's and major/critical suppliers' performance and progress. Metrics shall include cost, schedule, and quality metrics to monitor the effectiveness of the contractor's manufacturing, quality, and supplier management programs. Metrics shall be

presented at design, technical, and program management reviews. The contractor shall provide on-line access of these metrics to the government.

Suggested DIDs:

- DI-QCIC-82323, Manufacturing and Quality Assurance Status Report

Guidance:

1. Tailor the list of metrics in the DID to meet your specific program needs.

2. On-line access to contractor metrics may be desired, but not feasible. Discuss this with the prime contractor before including this as a requirement.

1.5. Counterfeit Parts Prevention

The contractor shall develop and implement a Counterfeit Parts Prevention (CPP) program in compliance with SAE AS5553 and AS6174 to prevent the inclusion of counterfeit parts or parts embedded with malicious logic into products intended for sale to the Government. These requirements shall be flowed to suppliers to ensure requirements are met. As part of CPP, the contractor shall make available to the government Certificates of Conformance (CoC) as well as supply chain traceability for all electronic part purchases.

Suggested DID:

- DI-MISC-81832, Counterfeit Prevention Plan

Guidance:

1. The RFP could request the elements of DI-MISC-81832 be included in the contractor's Program Protection Implementation Plan (PPIP), DI-ADMN-81306. Another good reference source is SAE-AS6081; Parts, Electronic, Fraudulent/Counterfeit: Avoidance, Detection, Mitigation, and Disposition.

2. The DID may be significantly out of date. Review for appropriateness prior to use.

1.6. First Article Inspections (FAI)/First Article Tests (FAT)

The contractor shall establish an FAI/FAT process and perform FAIs/FATs on new and modified product in accordance with AS9102, "Aerospace First Article Inspection Requirement." First article inspections shall be conducted on new products representative of the first production run and when changes occur that invalidate the original results (e.g., engineering changes, manufacturing process changes, tooling changes). The contractor shall notify the Government program office, and designated representative(s) of first article inspection events to allow for participation. An FAI/FAT report shall be generated for each product as evidence that the engineering requirements have been met.

Suggested DIDs:

- DI-NDTI-81307A, First Article Qualification Test Plan and Procedures
- DI-NDTI-80809, Test/Inspection Report

Guidance:

1. The DIDs may be out of date or not related exactly to the SOW requirement. Review for appropriateness prior to use.

2. Applicability to O&S phase is based on new designs, suppliers, or other changes.

1.7. Government Industry Data Exchange Program (GIDEP) Participation

The contractor shall implement procedures and processes for their participation in GIDEP, including the submission of alerts/advisories to GIDEP when warranted. The processes and procedures shall describe how the contractor (a) receives alerts and advisories from GIDEP and other sources, (b) determines any impact to their product design and already manufactured hardware, (c) implements corrective action procedures when design and/or produced hardware are affected, and (d) includes supplier participation.

Suggested DID:

- DI-QCIC-80125B, Government Industry Data Exchange Program (GIDEP) Alert/Safe-Alert Report
- DI-QCIC-80126B, Government Industry Data Exchange Program (GIDEP) Alert Response

1.8. Production Readiness Review (PRR)

The contractor shall perform PRRs in support of the Milestone C/FRP Decision in accordance with IEEE 15288.2. These requirements shall be flowed to the contractor's major and critical suppliers.

Suggested DIDs:

- DI-ADMIN-81249B, Conference Agendas
- DI-ADMIN-81250B, Conference Minutes
- DI-MISC-80508B, Technical Report – Study/Services

Guidance:

1. The requirement for a PRR is a Core requirement for contracts that will result in a Milestone C or FRP Decision

2. Ensure deliverable plans, minutes, etc., are not already required in another section of the SOW for technical reviews and audits. Ensure DIDs are compatible with IEEE 15288.2 requirements, if imposed.

2. Other SOW Requirements to Consider

2.1. Aviation Critical Safety Items (CSIs)

The contractor shall identify, establish and manage aviation CSIs using the Joint Aeronautical Logistics Commanders (JALC) Critical Safety Item Management Handbook and SAE AS9017, "Control of Aviation Critical Safety Items," as guides. The contractor shall develop a list of Critical Safety Items, their Key or Critical Characteristics (KCs/CCs), and associated Critical Manufacturing Processes. The contractor shall identify, measure and reduce variability of KCs/CCs and provide a formal method to manage and monitor all critical processes associated with CSIs. The contractor shall flow requirements to the lowest level of the supply chain.

Suggested DIDs:

- DI-SAFT-81932, Critical Safety Item (CSI) / Critical Application Item (CAI) List
- DI-SAFT-80970A, Critical Safety Item, Characteristic and Critical Defect Report

Guidance:

1. Requirements for CSI management should be balanced against the costs.

2. The DIDs may be out of date. Review for appropriateness prior to use.

2.2. Manufacturing Modeling and Simulation

The contractor shall analyze manufacturing processes using Modeling & Simulation (M&S) techniques to identify potential bottlenecks or constraints and confirm the achievability of planned cycle times, etc., and provide the government access to the model and data. The model should use commercially available simulation software used to evaluate scenarios and impacts of process variabilities, plant optimizations, production rate changes, capacity planning, and estimate required quantities of tooling, personnel, and inventory. The contractor shall update the production simulation model for facility modifications and other significant changes.

Suggested DID:

DI-MISC-80508B, Technical Report – Study/Services

Guidance:

1. While AS6500A requires the use of Modeling & Simulation, this additional requirement should be imposed if the government program office needs to obtain the contractor's manufacturing model(s) as a deliverable item. This would enable the program office to conduct independent capacity and schedule assessments and to better identify risks independently from the contractor.

2. The DID may be out of date. Review for appropriateness prior to use.

2.3. Calibration

The contractor shall maintain a calibration system in accordance with ANSI/NCSL Z540.3. The calibration system shall control the accuracy of measuring and test equipment, and measurement standards, used to ensure that products delivered to the Government comply with all contract technical specifications. The calibration system shall prevent inaccuracy by ready detection of deficiencies and timely positive action for their correction. Contractors who operate and maintain calibration laboratories or subcontract to outside calibration laboratories shall ensure compliance with requirements of ISO/IEC 17025:2017, General Requirements for the Competence of Testing and Calibration Laboratories.

2.4. Configuration Management

The contractor shall establish, document, and maintain a Configuration Management (CM) system for control of all configuration documentation, physical media, and physical parts representing or comprising the product, which includes all hardware, software, and firmware. The contractor's configuration management system shall consist of these elements:

a. Configuration management and planning.
b. Configuration identification.
c. Configuration change management.
d. Configuration status accounting.
e. Configuration audit.
f. Configuration management of digital data.

The contractor may use MIL-HDBK-61A as additional guidance for CM.

Guidance:

1. Applicability during TMRR should be determined on a case-by-case basis. Consult Configuration Management Subject Matter Experts for guidance.

2.5. Risk Management

The contractor shall establish and maintain a risk management program to continuously identify, analyze, mitigate, monitor, and report systems engineering process, product, technology, cost, schedule, and other program risks. Risk management process results shall be used for continual improvement and risk reduction. Program risks must be assessed and managed at the appropriate level. The contractor shall establish and maintain risk management programs consistent with the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs.

2.6. Parts, Materials, and Processes Control Program

The contractor shall establish, document, and maintain a Parts, Materials, and Processes Control Program (PMPCP) to ensure selection and use of parts, devices, and materials, including commercial and non-developmental items, meet specified performance, quality, reliability, safety, supportability, and configuration management requirements throughout the life cycle of

the system. The program shall include provisions for mitigating the impact of counterfeit parts and parts obsolescence on product integrity.

The contractor shall flow down applicable PMPCP requirements to applicable lower-tier suppliers.

The contractor may use SD-22, MDA-QS-003-PMAP, MIL-STD-3018, or SMC Standard SMC-S-009 as additional guidance for control of Parts, Materials, and Processes.

Suggested DID:

- DI-MGMT-81949, DMSMS Implementation Plan

2.7. Environmental Stress Screening

The contractor shall implement an Environmental Stress Screening (ESS) program to surface defects by stressing the item without degrading its inherent reliability. Environmental stresses (i.e., thermal cycling and random vibration) may be applied in sequence or in combination, with the intent of stimulating hardware defects. The ESS program should not be used to simulate an operational environment. Results of ESS shall be used to continually improve manufacturing processes. The contractor may use MIL-HDBK-344 as additional guidance for planning, controlling, and measuring the effectiveness of the ESS program.

Guidance:

1. Imposing ESS requirements should be a joint determination by engineering, manufacturing, Quality, and Reliability functional experts. Consider using ESS on major and critical suppliers of electrical, electronic, electro-optical, electromechanical or electrochemical components in demonstration & validation, engineering & manufacturing development and production phases.

2.8. Key Characteristics and Variation Reduction

The contractor shall identify Key Characteristics and implement a Variation Reduction program in accordance with AS9103.

2.9. Advanced Product Quality Planning (APQP) & Production Part Approval Process (PPAP)

The contractor shall implement APQP and PPAP programs in accordance with AS9145.

3. Suggested Section L and M inputs

3.1. Instructions to Offerors Guidance (Section L):

1. Manufacturing Readiness Level Demonstration. The offeror's proposal shall identify those elements (systems, subsystems, suppliers, and/or processes) being assessed for manufacturing risk and their current Manufacturing Readiness Levels using the criteria and process identified in the Manufacturing Readiness Level Deskbook (Link http://www.dodmrl.com). The contractor shall describe the approach used to assess the MRLs. For any element that is assessed to be below the target MRL of 'X', the offeror shall identify the current MRL and the plan to achieve the target MRL.

(Note: DFARS Subpart 215.304 requires that the manufacturing readiness of offerors be considered during source selection for ACAT I programs.)

2. Manufacturing Plan. The offeror shall describe:

a. How their manufacturing management system meets the requirements of AS6500A.
b. The major assembly sequence chart and anticipated manufacturing process flow.
c. The manufacturing build schedule, including drawing release; tooling design, build, and proofing; key supplier deliveries; and fabrication, assembly, and delivery schedules.
d. Facility requirements and layouts.
e. The offeror's plans to provide the needed manpower, facilities, and equipment for expected delivery rates.

3. Quality Systems. The offeror shall describe how their quality system assures product quality; achieves stable, capable processes; prevents defects; and employs effective methods for conducting root cause analyses and implementation of corrective actions.

4. Supplier Management. The offeror shall describe their:

a. Approach to selecting and managing key suppliers.
b. Processes for integration of key supplier activities into the overall program plan to assure that supplier activities support the overall program performance.
c. Specific supplier risks to the program and plans for mitigating those risks.
d. Plan for preventing the intrusion of counterfeit parts in factory equipment and delivered products.

3.2. Evaluation Criteria Guidance (Section M):

1. Manufacturing Readiness Level Demonstration. The offeror's proposal will be evaluated on the maturity of their proposed manufacturing capability, the adequacy of their supporting documentation to justify this capability, and the adequacy of the offeror's process and plans to achieve the target MRL as described in the Manufacturing Readiness Level Deskbook.

This sub-factor is met when the offeror's proposal identifies the elements being assessed for manufacturing readiness and their current MRLs. As described in the proposal, the offeror's

MRL assessment process is consistent with the MRL Deskbook. For elements that are below the target MRL, the proposal describes an achievable plan to meet the target MRL.

2. Manufacturing Plan. This sub-factor evaluates the proposed methods, schedules, and resources for producing the required products. This sub-factor is met when the offeror's proposal:

a. Describes how their manufacturing management system meets the requirements of AS6500A.
b. Describes the major assembly sequence and manufacturing process flows.
c. Includes an integrated, achievable schedule incorporating design, tooling, supplier, fabrication, assembly, and delivery milestones.
d. Describes facility requirements and layouts.
e. Describes achievable plans to provide the needed manpower, facilities, and equipment for expected delivery rates.

3. Quality Systems. This sub-factor evaluates the offeror's planned quality assurance system. This sub-factor is met when the offeror's proposal describes policies and practices that will:

a. Assure product quality.
b. Achieve stable, capable processes.
c. Prevent defects.
d. Result in effective root cause analyses and corrective actions.

4. Supplier Management. This sub-factor evaluates the offeror's proposed supplier management program. This sub-factor is met when the offeror's proposal:

a. Describes how key suppliers are selected and managed.
b. Describes how supplier activities will be integrated into the overall program plan.
c. Lists specific supplier risks and achievable plans for mitigating those risks.
d. Describes effective plans for preventing the intrusion of counterfeit parts in factory equipment and delivered products.

4. FAR/DFARS Clauses

Although the Contracting Officer is ultimately responsible for applying the appropriate FAR and DFARS clauses to the contract, the following sections address topics relevant to the Manufacturing and Quality function. Manufacturing and Quality Subject Matter Experts should be familiar with the requirements of these sections and offer their support and recommendations to the Contracting Officer.

4.1. Higher Level Quality Requirements

FAR Part 46, "Quality Assurance," prescribes the use of various FAR clauses that address quality and inspection requirements, depending upon the nature of the contract. For critical or complex items, clause 52.246-11 must be included in the contract. This clause requires the identification of a specific higher-level contract quality standard. Section 46.202-4 lists examples, such as ISO 9001 and AS9100. The Manufacturing/Quality Subject Matter Expert should work with the Contracting Officer to ensure the appropriate clause is included in the contract and the appropriate higher-level quality requirement is included in 52.246-11.

4.2. Counterfeit Parts Prevention

DFARS 246.870-3 prescribes the use of clauses 252.246-7007, "Contractor Counterfeit Electronic Part Detection and Avoidance System," and 252.246-7008, "Sources of Electronic Parts" when procuring electronic parts or end items that contain electronic parts.

4.3. First Article Approvals

FAR Subpart 9.3 governs First Article Testing and Approval and describes when this testing is required. When it is required, Subpart 9.3 requires either FAR clause 52.209-3 for contractor testing or 52.209-4 for government testing.

4.4. Contract Administration Functions

FAR Subpart 42.302, "Contract Administration functions," lists the activities performed by the Contract Administration Office (typically DCMA.) Manufacturing & Quality-related functions include activities such as performing production surveillance and status reporting, conducting pre-award surveys, monitoring industrial labor relations, ensuring contractor compliance with contractual quality assurance requirements, and reviewing waivers and deviations.

4.5. Labor Relationships

FAR Part 22 describes the government's policies and practices regarding labor relations at contractor facilities. Subpart 22.103-5 prescribes the use of Clause 52.222-1 to require the contractor to notify the government of labor disputes.

4.6. Government Property

FAR Part 45 governs the use of government property. Subpart 45.107 prescribes the use of Clause 52.245-1 when government property is being used.

4.7. Records Retention

FAR Subpart 4.7 governs records retention. Many Manufacturing and Quality-related items, such as receiving and inspection reports, purchase orders, and quality control and inspection records must be retained for four years.

4.8. Contractor Debarment, Suspension, and Ineligibility

FAR Subpart 9.4 discusses reasons that contractors may not be allowed to obtain government contracts. This includes limitations on subcontracting (Subpart 9.405-2). Most contracts must include Clause 52.209-6 that protects the government's interests when subcontracting with debarred (or soon to be debarred) or suspended suppliers.

Acronyms

3D	Three-Dimensional
A_o	Operational Availability
AAF	Adaptive Acquisition Framework
AFRL	Air Force Research Laboratory
AM	Additive Manufacturing
AoA	Analysis of Alternatives
ASR	Alternative Systems Review
CARD	Cost Analysis Requirements Description
CBA	Capabilities-Based Assessment
CCTD	Concept Characterization and Technical Description
CDD	Capability Development Document
CoI	Community of Interest
CONOPS	Concept of Operations
COTS	Commercial Off-the-Shelf
Cpk	Process Capability
CSI	Critical Safety Item
CTE	Critical Technology Element
DARPA	Defense Advanced Research Projects Agency
DID	Data Item Description
DCMA	Defense Contact Management Agency
DTIC	Defense Technical Information Center
DE	Digital Engineering
DFARS	Defense Federal Acquisition Regulation Supplement
DFMA	Design for Manufacturing and Assembly
DFMEA	Design Failure Modes and Effects Analysis
DIU	Defense Innovation Unit
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoD	Department of Defense
DoDD	DoD Directive
DoDI	DoD Instruction
DP	Development Planning
DTRAM	Defense Technical Risk Assessment Methodology
EMD	Engineering and Manufacturing Development
ESOH	Environment, Safety, and Occupational Health
FFRDC	Federally Funded Research and Development Center
FMEA	Failure Modes and Effects Analysis
FOC	Full Operational Capability
FRP	Full-Rate Production
GAO	Government Accountability Office

GFE	Government Furnished Equipment
GOTS	Government off-the-shelf
IB	Industrial Base
IBA	Industrial Base Assessment or Industrial Base Analysis
ICA	Industrial Capability Assessment
ICD	Initial Capabilities Document
IMP/IMS	Integrated Master Plan/Integrated Master Schedule
IoT	Internet of Things
IIOT	Industrial Internet of Things
IOC	Initial Operational Capability
IPT	Integrated Product Team
ISO	International Organization for Standardization
IT	Information Technology
ITRA	Independent Technical Risk Assessment
JCIDS	Joint Capabilities Integration and Development System
KC	Key Characteristic
KPP	Key Performance Parameter
KSA	Key System Attribute
LCSP	Life Cycle Sustainment Plan
LRIP	Low-Rate Initial Production
M&S	Modeling and Simulation
M&Q	Manufacturing and Quality
ManTech	Manufacturing Technology
MBE	Model-Based Engineering
MBSE	Model-Based Systems Engineering
MCA	Major Capability Acquisition
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDD	Materiel Development Decision
ME	Mission Engineering
MFA	Manufacturing Feasibility Assessment
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOS	Measure of Suitability
MOSA	Modular Open Systems Approach
MTBF	Mean Time Between Repair
MTTR	Mean Time To Repair
MMP	Manufacturing Maturation Plan
MRA	Manufacturing Readiness Assessment
MRL	Manufacturing Readiness Level

MS A	Milestone A
MS B	Milestone B
MS C	Milestone C
MSA	Materiel Solution Analysis
MS&T	Manufacturing Science and Technology
MTA	Middle Tier of Acquisition
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NRL	Naval Research Laboratory
NTIB	National Technology and Industrial Base
O&S	Operations and Support
OT	Operational Technology
OT&E	Operational Test and Evaluation
PDR	Preliminary Design Review
PESHE	Programmatic Environmental, Safety, and Occupational Health Evaluation
PFMEA	Process Failure Modes and Effects Analysis
PM	Program Manager or Program Management
Ppk	Process Performance
PPP	Program Protection Plan
Pre-MDD	Pre-Materiel Development Decision
P&D	Production and Deployment
PRR	Production Readiness Review
QA	Quality Assurance
QMS	Quality Management System
R&D	Research and Development
RAM	Reliability, Availability and Maintainability
RCO	Rapid Capability Office
RCT	Requirements Correlation Table
RFP	Request for Proposal
RIO	Risk, Issue, and Opportunity
ROI	Return on Investment
SBIR	Small Business Innovation Research
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SEP	Systems Engineering Plan
SETR	Systems Engineering Technical Review
SFR	System Functional Review
SME	Subject Matter Expert
SRD	System Requirements Document

SRR	System Requirements Review
STTR	Small Business Technology Transfer
S&T	Science and Technology
TAPP	Technology Area Protection Plan
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TMRR	Technology Maturation and Risk Reduction
TPM	Technical Performance Measure
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
UCA	Urgent Capability Acquisition
WBS	Work Breakdown Structure

Bibliography

Resources related to the guide are listed below and contain links to the referenced document. As many of these resources are revised frequently, readers are advised the documents may change or may be updated, replaced, or cancelled. Readers may need to conduct an Internet search to find the most recent version.

10 USC 2440, DFARS Subpart 207.1, Technology and Industrial Base Plans.
https://www.govinfo.gov/app/details/USCODE-2011-title10/USCODE-2011-title10-subtitleA-partIV-chap144-sec2440

10 USC 2448b, Independent Technical Risk Assessments.
https://www.govinfo.gov/content/pkg/USCODE-2016-title10/html/USCODE-2016-title10-subtitleA-partIV-chap144B-subchapIII.htm

10 USC 2503, Analysis of the Technology and Industrial Base.
https://www.govinfo.gov/app/details/USCODE-2011-title10/USCODE-2011-title10-subtitleA-partIV-chap148-subchapII-sec2503

10 USC 2521, Manufacturing Technology Program.
https://www.govinfo.gov/content/pkg/USCODE-2010-title10/pdf/USCODE-2010-title10-subtitleA-partIV-chap148-subchapIV-sec2521.pdf

48 CFR 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting.
https://www.law.cornell.edu/cfr/text/48/252.204-7012

Acquisition Process/Acquisition Strategy, Defense Acquisition University.
www.acqnote/acquisitions/acquisition-strategy

Adaptive Acquisition Framework, Defense Acquisition University.
https://aaf.dau.edu

Air Force Digital Campaign—Contracting Approaches (AFMC)
https://wss.apan.org/af/aflcmc (request user account and password)

Air Force Materiel Command (AFMC), Development Planning Guide, June 17, 2010.

Analysis of Alternatives, Defense Acquisition University.
www.acqnote/acquisitions/analsis-of-alternatives

Analysis of Alternatives (AoA) Handbook, Office of Aerospace Studies, August 2017.
https://afacpo.com/AQDocs/AoAHandbook.pdf

CJCS. Manual for the Operation of the Joint Capabilities Integration and Development System (JCIDS Manual), Chairman of the Joint Chiefs of Staff, J-8, October 30, 2021.

CJCSI 3100.01E, Joint Strategic Planning System, Chairman of the Joint Chiefs of Staff, May 21, 2021.

CJCSI 5123.01I, “Charter of the Joint Requirements Oversight Council (JROC) and Implementation of the Joint Capabilities Integration and Development System (JCIDS),” Chairman of the Joint Chiefs of Staff, J-8, October 30, 2021.

DCMA-INST-3401, Defense Industrial Base Mission Assistance.
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-3401.pdf

Defense Technical Risk Assessment Methodology (DTRAM) Tier 0-1 Criteria.
https://ac.cto.mil/wp-content/uploads/DTRAM-0-1.pdf

Design for Manufacturing and Assembly (DFMA).
https://www.dau.mil/cop/pqm/DAU%20Sponsored%20Documents/DFMA%20new.doc

DFARS Clause 207.106, “Additional Requirements for Major Systems.”

DFARS Clause 252.204-7012, “Safeguarding Covered Defense Information and Cyber Incident Reporting.”

DoD Digital Engineering Body of Knowledge, February 2022.
https://www.dodtechipedia.mil/dodwiki/pages/viewpage.action?pageId=760447627

DoD Digital Engineering Strategy, Office of the Under Secretary of Defense for Research and Engineering, June 2018.
https://ac.cto.mil/wp-content/uploads/2019/06/2018-Digital-Engineering-Strategy_Approved_PrintVersion.pdf

DoD Directive 4200.15, “Manufacturing Technology (ManTech) Program,” October 15, 2018.

DoD Directive 5137.02, “Under Secretary of Defense for Research and Engineering, USD(R&E),” July 15, 2020.

DoD Directive 5000.01, “The Defense Acquisition System,” September 9, 2020.

DoD Handbook 5000.60H, “Assessing Defense Industrial Capabilities,” April 1996.

DoD Instruction 4245.15, “Diminishing Manufacturing Sources and Material Shortages Management,” November 5, 2020.

DoD Instruction 5000.02, “Operation of the Adaptive Acquisition Framework,” January 23, 2020.

DoD Instruction 5000.60, “Defense Industrial Capabilities Assessments,” July 2014.

DoD Instruction 5000.67, “Prevention and Mitigation of Corrosion on DoD Military Equipment and Infrastructure,” August 2018.

DoD Instruction 5000.80, “Middle Tier of Acquisition,” December 2019.

DoD Instruction 5000.81, “Urgent Capability Acquisition,” December 2019.

DoD Instruction 5000.83, “Technology and Program Protection to Maintain Technological Advantage, Change 1,” May 21, 2021.

DoD Instruction 5000.85, “Major Capability Acquisition,” August 6, 2020.

DoD Instruction 5000.88, “Engineering of Defense Systems,” November 18, 2020.

DoD Manual 4245.7-M “Transition from Development to Production,” September 1985.
https://apps.dtic.mil/dtic/tr/fulltext/u2/a303209.pdf

DoD Manufacturing and Quality Body of Knowledge, January 2021 (or latest version).
https://www.ac.cto.mil/maq/

DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs, Office of the Deputy Assistant Secretary of Defense for Systems Engineering, January 2017.

DoD Systems Engineering Plan (SEP) Outline, Version 4.0, Office of the Under Secretary of Defense for Research and Engineering, September 2021.
https://ac.cto.mil/erpo/

Engineering of Defense Systems Guidebook, Office of the Under Secretary of Defense for Research and Engineering, February 2022.
https://ac.cto.mil/erpo/

GAO Report 09-665, Analysis of Alternatives, September 2009.

GAO Report 20-48G, Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects, January 2020. https://www.gao.gov/assets/710/703694.pdf

IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs, July 7, 2015.

Independent Logistics Assessment Guidebook, Defense Acquisition University, July 2011. https://www.dau.edu/tools/t/Logistics-Assessment-Guidebook

Independent Technical Risk Assessment (ITRA) Resources, Office of the Under Secretary of Defense for Research and Engineering. https://ac.cto.mil/itra/

Manufacturing Maturation Plan (See MRL Deskbook). MRL Working Group. http://www.dodmrl.org

Manufacturing Readiness Level (MRL) Deskbook. MRL Working Group. http://www.dodmrl.org

The Measures Handbook. Office of Aerospace Studies, Kirtland Air Force Base, August 2014.

MIL-HDBK-727, Design Guidance for Producibility.

MIL-HDBK-896, Department of Defense Handbook Manufacturing Management Program Guide.

Mission Engineering Guide, Office of the Under Secretary of Defense for Research and Engineering, November 2020. https://ac.cto.mil/erpo/

NAVSO P-3687, Producibility Systems Guidelines, December 1999. http://everyspec.com/USN/NAVY-General/NAVSO_P-3687_8510/

NIST SP 800-171 Rev 2, Protecting Controlled Unclassified Information in Non-Federal Systems and Organizations, February 2020.

Reliance 21 Operating Principles: Bringing Together the DoD Science and Technology Enterprise. Defense Science and Technology, January 2014. https://defenseinnovationmarketplace.dtic.mil/wp-content/uploads/2019/08/Reliance_21_Op_Principles_Jan_2014.pdf

SD-26, Defense Standardization Program Office DMSMS Contract Language Guidebook, October 2019. https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=283456

Systems Engineering Guidebook, Office of the Under Secretary of Defense for Research and Engineering, February 2022. https://ac.cto.mil/erpo/

Technology Readiness Assessment (TRA) Guidance. Assistant Secretary of Defense for Research and Engineering, April 2011.

Department of Defense Manufacturing and Quality Body of Knowledge (M&Q BoK)

Office of the Under Secretary of Defense for Research and Engineering
Executive Director, Systems Engineering and Architecture
3030 Defense Pentagon
Washington, DC 20301-3030
Email: osd.r-e.comm@mail.mil | Attention: SE&A
https://ac.cto.mil/engineering

Approved for public release. DOPSR Case # 23-S-0359.