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

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

Version 3.0

July 2025

Office of the Under Secretary of Defense for
Research and Engineering

Washington, D.C.

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

July 2025

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Approved by
Principal Deputy Executive Director, Systems Engineering and Architecture
July 2025

M&Q BoK Chapter 1 Change Record

Date	Change
2018	Original release.
2021	Revised references and phase descriptions following the revision of DoD Instruction 5000.02.
2025	Revised to incorporate additional information to align with DoD Adaptive Acquisition Framework pathways.

Contents

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Tables

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 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 six 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 twelve 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 are available to M&Q personnel 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.

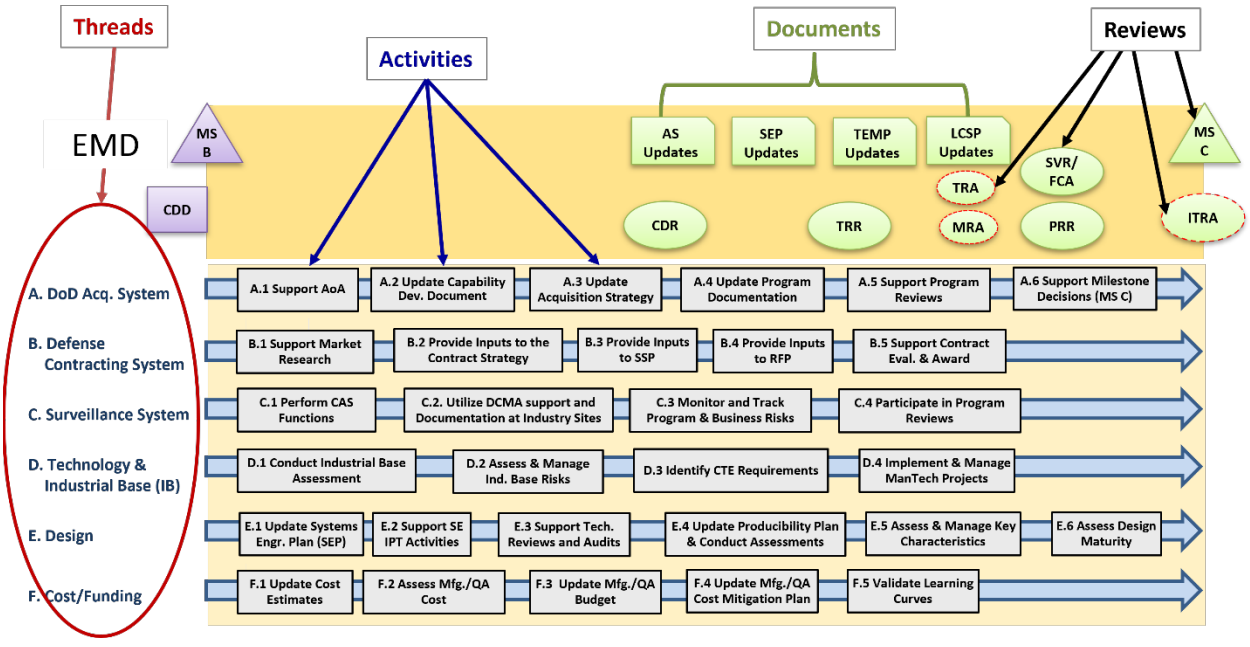
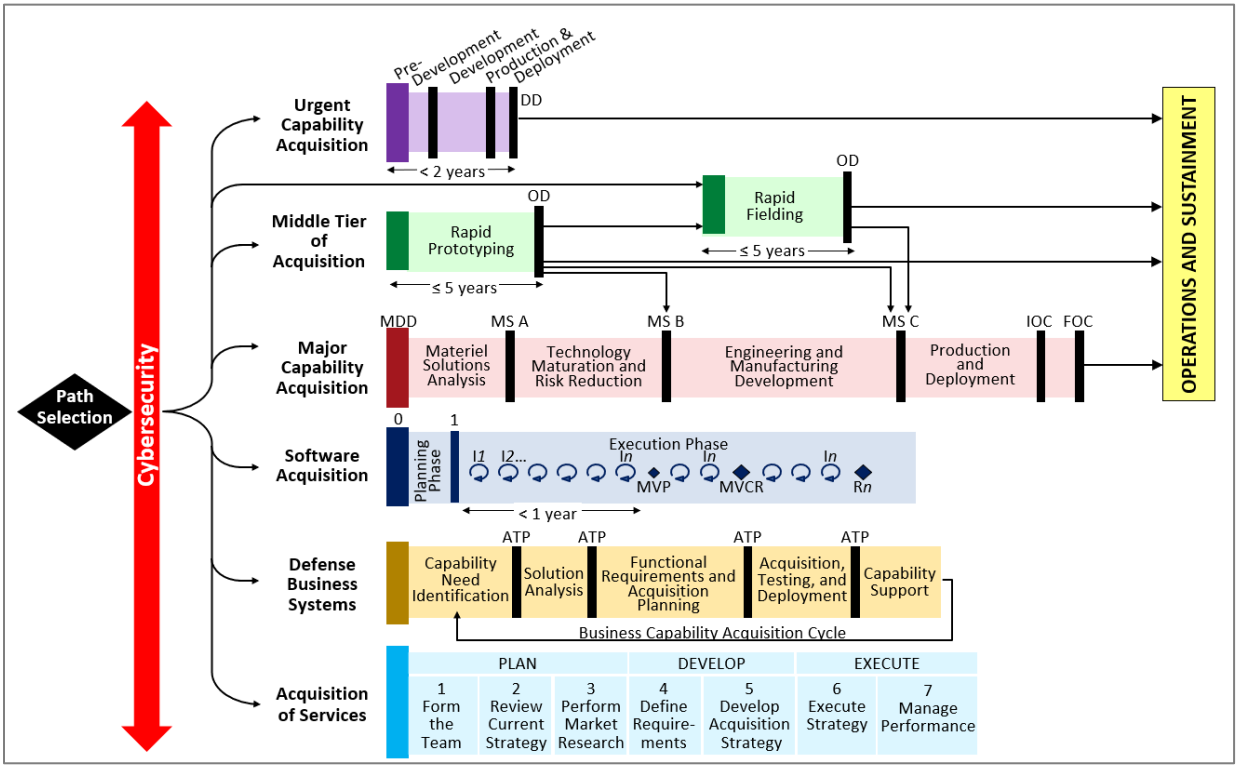


Figure 1. Sample Activity Chart

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

This BoK follows DoDI 5000.02 and 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 the related BoK chapters to identify and tailor tasks and activities to meet their program requirements while addressing manufacturing and quality risks, issues and opportunities.

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) 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 the 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 through 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.

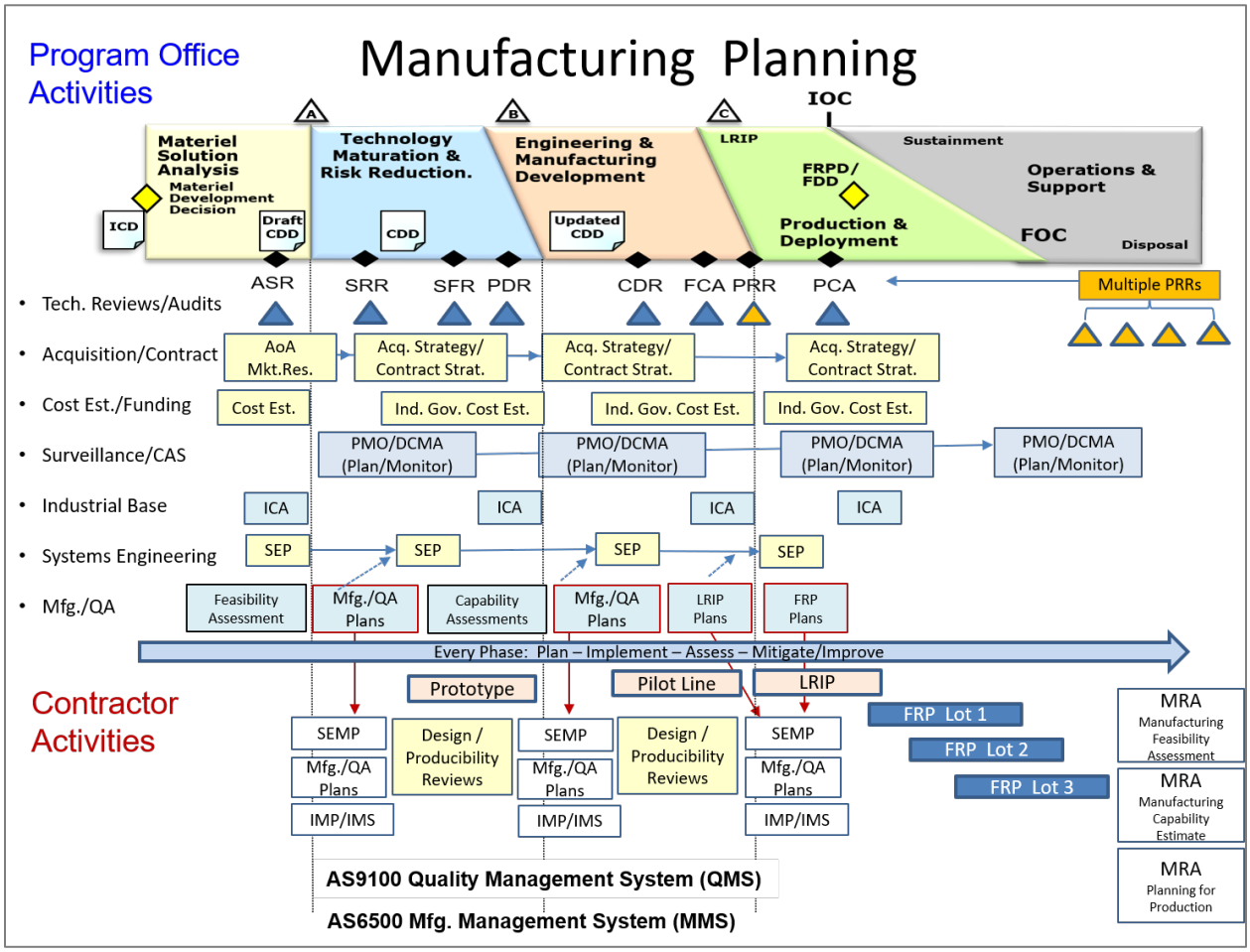


Figure 3. Typical Manufacturing and Quality Planning Activities

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 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 the 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 refer to 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 M&Q Engineering 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
- DoD Technology Readiness Assessment (TRA) Guide https://www.cto.mil/wp-content/uploads/2023/07/TRA-Guide-Jun2023.pdf
- Technology Readiness Assessment Guidebook, DoD, https://www.cto.mil/wp-content/uploads/2023/07/TRA-Guide-Jun2023.pdf

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 obtaining 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).

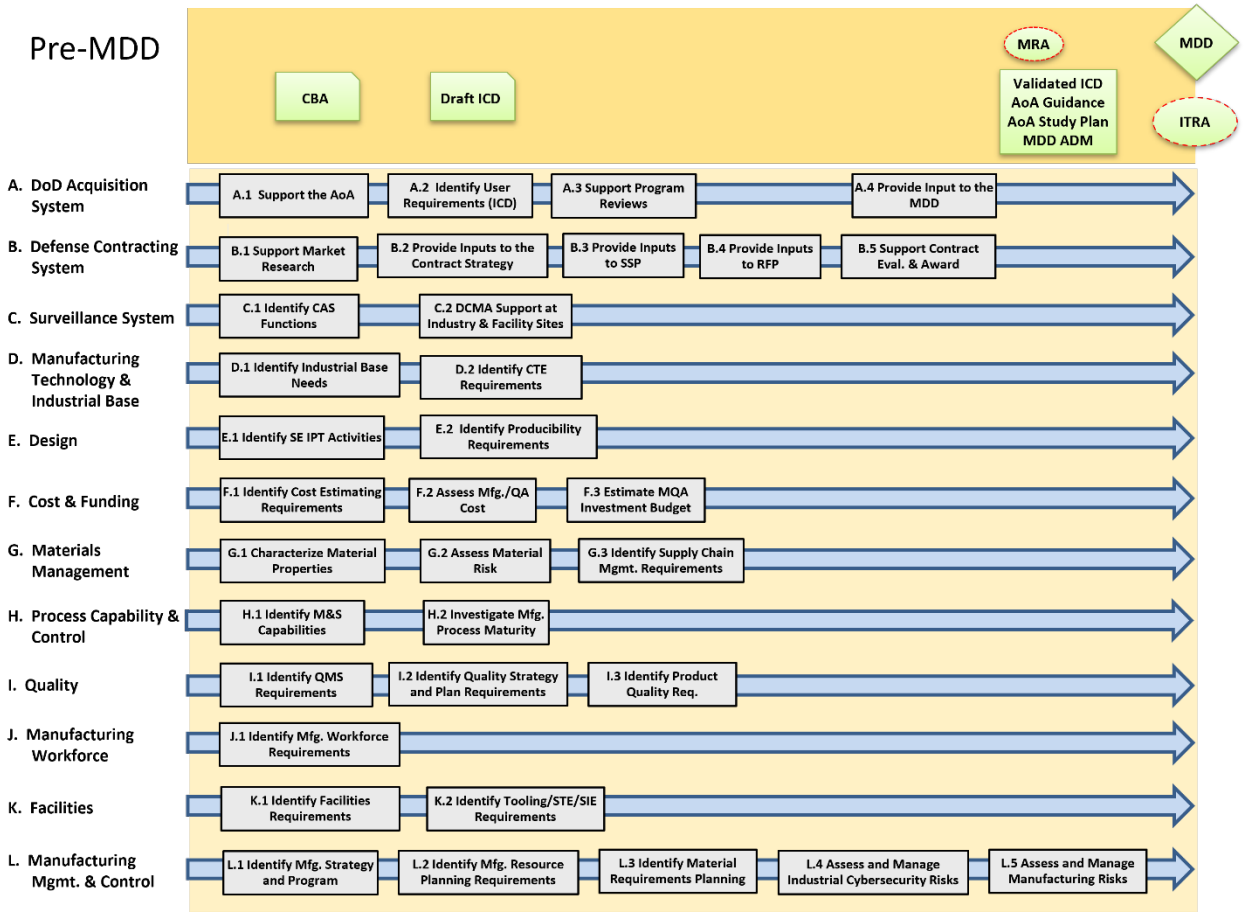


Figure 1-1. Pre-MDD Phase Manufacturing and Quality Activities

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 needs 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 third 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., Joint Capabilities Integration and Development System (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

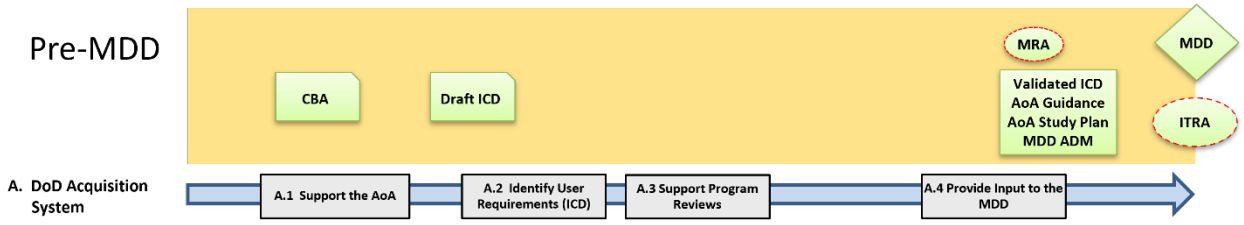


Figure 1-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

The Defense Acquisition System is one of three (3) processes (**Acquisition,** Requirements, and Funding) that make up and support the Defense Acquisition System and is implemented by DoDI 5000.02 “Operation of the Adaptive Acquisition Framework”.

The Acquisition process is an event-based where a program goes through a series of processes, milestones (five phases), and reviews where it is determined if 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 thread (Acquisition) will focus on the following sub-threads as required in each phase:

- Analysis of Alternatives (AoA)
- User Requirements
- Acquisition Strategy
- Program Documentation
- Program Reviews
- 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 (KPPs), Key System Attributes (KSAs), 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 analyzes 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 the Analysis of Alternatives (AoA)

An Analysis of Alternatives (AoA) is an analytical comparison of the operational effectiveness, suitability, and life-cycle cost of alternative materiel solutions that could satisfy identified user capability needs as identified in the Initial Capabilities Document (ICD).

The purpose of the AoA is to help decision-makers understand the trade space for new materiel solutions to satisfy an operational capability need, while providing the analytic basis for performance attributes documented in the JCIDS documents.

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 focuses on the identification and analysis of alternatives, Measures of Effectiveness (Moe), Concept of Operations (CONOPS), schedule, and overall risks. An AoA also assessed Critical Technology Elements (CTEs) associated with each proposed materiel solution, including technology maturity, integration risks, manufacturing feasibility, and technology maturation and demonstration needs.

There are three primary AoA products:

- AoA Study Guidance
- AoA Study Plan
- AoA Final Report

AoA Study Team: The AoA Study Team membership normally includes operators, logisticians, intelligence analysts, cost estimators, and other specialists. Study team membership should include representatives from the stakeholder community such as the appropriate lead command, operating commands, implementing commands, combatant commands. Participants in previous applicable studies and others with special skills or expertise such as Systems Engineering, Manufacturing and Quality, Logistics, etc., should be considered for team membership as well.

AoA Study Guidance: The 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.

Analysis of Alternative (AoA) Outline should include the following:

- Capability Need, Deficiencies and Opportunities
- Program Description
- Threats
- Operational Environments
- Operational Concepts
- Operational Requirements

- Status Quo (Baseline) Alternatives
- System Description, Performance, and Measures of Effectiveness (MoE)
- Life Cycle Cost of Baseline and Alternatives
- Life Cycle Cost per unit system
- Life Cycle Cost per specified quantity of systems
- Analysis of Alternatives
- Trade-off Analysis
- Sensitivity Analysis
- Recommendations and Conclusions

AoA Study Plan: The AoA requires the development of an AoA Study Plan which establishes a road map for the conduct of the AoA. M&Q personnel need to be actively engaged in the assessment of the alternative solutions to assess manufacturing impacts and plan for future implementation. The AoA Study Plan template looks at potential material solutions (alternatives) to address:

- Critical Technology Elements: Assess the critical technology elements associated with each proposed alternative, including technology maturity, integration risk, manufacturing feasibility, and, where necessary, technology maturation and demonstration needs.
- Cost Analysis: Assess Lifecycle Cost Methodology - Describe the approach to the life cycle cost analysis, which is normally performed in parallel with the operational effectiveness analysis. Estimate the total life cycle cost of each alternative and combine its results later with the operational effectiveness analysis to portray cost-effectiveness comparisons. When the costs of the alternatives have significantly different time periods or distributions, use appropriate discounting methods to calculate the life cycle cost of each alternative.
    - Models and Data
    - Cost Sensitivity or Risk Analysis
- Organization and Management:
    - Study Team Organization – The study team is usually organized along functional lines into panels (e.g., threats and scenarios, technology and alternatives, operations and support concepts, effectiveness analysis and cost analysis) staffed by military, civilians, and contractors. The effectiveness panel will integrate the work of the other panels. Team members should not reside in the program office.

AoA Final Report: The AoA Final Report template recommends the following outline:

- Purpose and Scope
- Study Guidance
- Capability Gaps
- Stakeholders
- Key Ground Rules, Constraints, and Assumptions

- Description of Alternatives
- Effectiveness Analysis
- Cost Analysis, Lifecycle Cost Results, Cost Risks, and Sensitivity Analysis
- Risk Assessment
- Conclusions and Recommendations

M&Q personnel need to support the development of the AoA Study Plan, AoA Guidance, and AoA Report.

Manufacturing and Quality Tasks

- Support the development of the Analysis of Alternatives (AoA) Guidance developed prior to the MDD and may be updated later.
- Support the development of the Analysis of Alternatives Study Plan developed prior to the MDD and may be updated later.
- Support the development of the AoA Final Report.
- Review AoA Inputs:
  - Operational Concept
  - Required Capability Defined (Baseline)
  - Capability Gaps Identified
  - Material Approaches Identified
  - Affordability Analysis Conducted
- Support the Technology and Alternatives Working Group.
- Support the Risk Assessment Working Group.
- Support the Effectiveness Analysis Working Group.
- Support the Cost Analysis Working Group.
- Support the Working Integrated Product Team (WIPT) or Core Team.
- 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.

Tools

- Analysis of Alternatives (AoA) Study Plan Template
- AoA Study Guidance Template
- AoA Final Report Template
- Market Research Reporting Template
- Multi-Attribute Tradespace Exploration (MATE)
- Pugh Matrix Template

- Quality Function Deployment or House of Quality Matrix
- Requirements Traceability Matrix Template
- Requirements Verification Matrix
- Assessment of Manufacturing Readiness, DI-SESS-81974
- Interactive MRL Users Guide (Checklist)
- Industrial Base Assessment Survey Form, Industrial Analysis Center
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.84 Analysis of Alternatives
- AoA Handbook
- DoD Engineering of Defense Systems Guidebook
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Pre-MDD Analysis Handbook
- DoD Market Research Guide
- SD-5 Market Research
- Requirements Traceability Matrix Guide
- DoD Technology Readiness Assessment (TRA) Guide

A.2 Identify User Requirements

The JCIDS process was created to support the statutory responsibility of the Joint Requirements Oversight Council (JROC) to validate joint warfighting requirements. The JCIDS process plays a key role in identifying the capabilities required by the warfighter in support of the National Defense Strategy (NDS). The primary objective of the JCIDS process is to ensure the capabilities required by the warfighter are identified, along with associated operational performance criteria (requirements), to successfully execute the missions assigned. This is done through an open process that provides the JROC with the information needed and supports the Planning, Programming, Budget, and Execution System (PPBS).

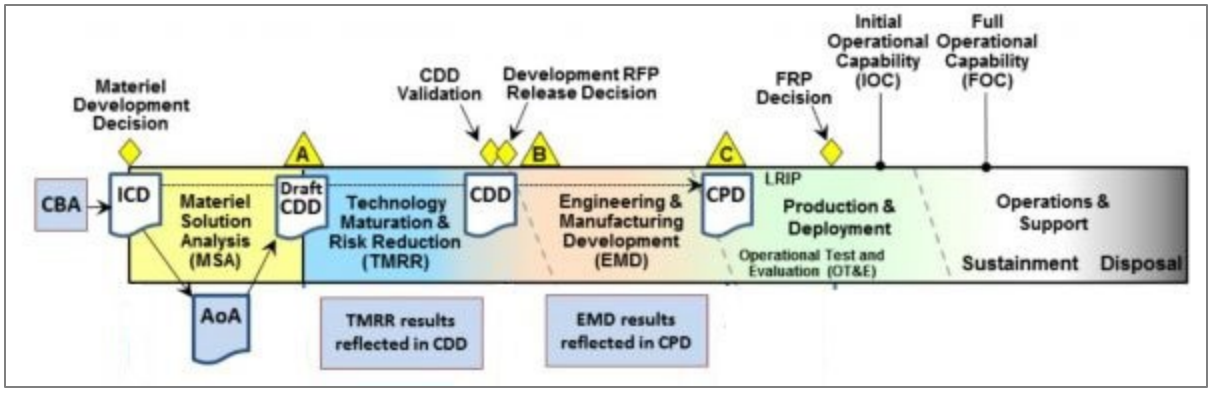


Figure 1-3. JCIDS Process

Steps in the JCIDS Process:

1. Capabilities Based Assessment (CBA) conducted
2. Development and Approval of the Initial Capabilities Document (ICD)
3. Development and Approval of the Capabilities Development Document (CDD)

The **Capabilities Based Assessment (CBA)** is the starting point in identifying the DoD's needs and recommending solutions. It must frame the military issue, the applicable scenarios, and the CONOPs for those scenarios. It must describe how the DoD decides whether it is effective, estimates overall effectiveness, and say under what circumstances the DoD falls short (or is overbuilt). Finally, the CBA must develop the supporting information for the recommendations.

The draft **Initial Capabilities Document (ICD**) contains the initial KPPs, KSAs, 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.

The Initial Capabilities Document (ICD) documents the need for a materiel approach or an approach that is a combination of materiel and non-materiel, to a specific capability gap. A capability gap derived from an initial analysis of materiel approaches executed by the operational user and as required, an independent analysis of materiel alternatives. It defines the capability gap in terms of the functional area, the relevant range of military operations, desired effects, and time. The ICD summarizes the results of the DOTMLPF analysis and describes why non-material changes alone have been judged inadequate in fully providing the capability.

The **Capability Development Document (CDD)** specifies the operational requirements of the system that will deliver the capability that meets operational performance criteria specified in the ICD. The CDD outlines a militarily useful increment of capability with its own set of attributes and performance values (thresholds and objectives).

One of the major activities of the ICD is to identify the "enabling capabilities" required to achieve the desired outcome. And if the outcome of the DOTMLPF study is a 'materiel solution" then the materiel approach needs to be identified:

- Existing system
- Replace or recapitalize an existing system
- Develop a new capability

Manufacturing and Quality Tasks

M&Q personnel have a limited role in supporting the development of the Initial Capabilities Document (ICD), Capabilities-Based Assessment (CBA). M&Q personnel may need to support the following:

- Capabilities Based Assessment (CBA) activities identified in the CBA Handbook:
    - Define the study
    - Identify the problem
    - Conduct gap analysis
    - Characterize the gaps
    - Conduct risk assessment
    - Prioritize the gaps
    - Identify solutions
    - Conduct cost analysis
    - Assess viability of solutions
- Initial Capabilities Document (ICD) developed.
- Section 5: Development of KPPs, KSAs, and APSs:
    - Support the development of KPPs, KSAs, and APAs for potential M&Q impacts.
    - Provide inputs to the development of KPPs, KSAs, and APAs, including inputs to Force Protection, System Survivability, Sustainment, and Energy KPPs (four of the six mandatory KPPs).
    - Support the traceability of technical requirements to include, KSAs, and APAs.
- Section 10: Technology Readiness Assessments:
    - Support any technology readiness or other technical assessments in support of proposed material solutions.
    - Provide inputs on manufacturing feasibility and capability assessments
    - Support technical reviews of the proposed material solutions
- Section 12 Program Affordability:
    - Support the identification of projected life cycle costs which will result from pursuing the capability solution.
- 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 from 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.

Support the Cost Capabilities Analysis (CCA) if conducted, and address the following requirement concerns:

- The CCA Guide suggests looking at gaps, developmental planning, concepts and AoA:
  - Are the capability gaps prioritized?
  - What is the military value as operational capability is increased (or decreased) for each gap?
  - What tradeoffs between cost, schedule and capability will be evaluated?
  - What is (are) the preferred concept(s)? Is it cost effective? Does it fit within the affordability goals?
  - For the preferred option(s), what are the primary drivers

Tools

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

Resources

- CJCSI 5123.01H, Joint Capabilities Integration and Development System (JCIDS)
- CJCS JCIDS Manual
- Capability-Based Assessment User's Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Initial Capabilities Document (ICD) Writer's Guide, TRADOC
- AFI 10-601 Operational Capability Requirements Development
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment (TRA) Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 1.3 and 2.6 Industrial and Manufacturing Capability Assessments in the Acquisition Lifecycle
- Pre-MDD Analysis Handbook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- AFMC Pre-MDD Analysis Handbook

A.3 Support Program Reviews

Manufacturing and Quality (M&Q) personnel should be actively engaged in the organization and execution of numerous formal reviews and audits during a program's acquisition life cycle to include:

- Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)

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

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

Technical reviews are an important tool for program management, independent assessors, and subject matter experts including M&Q personnel, to identify and evaluate risks early and allow them time to develop and implement mitigation plans. Several of the reviews may be used to support a Materiel Development Decision (MDD).

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.

The primary reviews that may be conducted pre-MDD include an MRA and an ITRA. Technical Reviews can be used to assess the draft ICD, the AoA Study Guidance, and preliminary CONOPS for manufacturing and quality analyses of the materiel solution alternatives. Support of the technical reviews will provide detailed manufacturing and quality 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

Manufacturing and Quality Tasks

Support, as appropriate, the conduct of:

- Manufacturing Readiness Assessments (MRAs).
- Technical Readiness Assessments (TRAs).
- Independent Technical Risk Assessments (ITRAs) when required by the MDA during Pre-MDD.

Tools

- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974,
- Independent Technical Risk Assessments (ITRAs) Execution Guidance
- Defense Technical Risk Assessment Methodology (ITRA criteria)
- Technical Readiness Assessments (TRAs) Checklist
- Interactive MRL Users Guide (Checklist)
- Manufacturing Capability Assessment Worksheet
- Manufacturing Maturation Plan

Resources

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Defense Technical Risk Assessment Methodology (DTRAM
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 1.3 and 2.6 Industrial and Manufacturing Capability Assessments in the Acquisition Lifecycle
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Independent Technical Risk Assessment Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment (TRA) Guide

A.4 Provide Input to the Materiel Development Decision (MDD)

Materiel Development Decision (MDD) is a mandatory review that is the formal entry point into the acquisition process for all programs. A successful MDD may approve entry into the acquisition process at any point consistent with phase-specific entrance criteria and statutory requirements but will normally be followed by a Materiel Solution Analysis (MSA) phase. The principal documents at this decision point are the Initial Capabilities Document (ICD) study guidance and study plan for the Analysis of Alternatives (AoA). The Milestone Decision Authority (MDA) will determine if a program can proceed into the Material Solution Analysis (MSA) Phase. M&Q personnel need to provide technical advice to support the MDD.

Manufacturing and Quality Tasks

- Participate in the Overarching Integrated Product Team (OIPT) activities in support of the Defense Acquisition Board (DAB) and MDD process.
- Support Pre-MDD Analysis of:
    - AoA Study Guidance and Study Plan
    - Initial Capabilities Document
- Support the development of the Written Determination which includes:
    - Program fulfills ICD/CDD
    - Market Research conducted
    - Key Requirements (KPPs, KSAs, and APAs)
    - Entry/Exit Criteria
    - Trade-offs
    - Risks and Opportunities
    - Cost Estimates (Service Cost Position and Independent Cost Estimate)
    - Systems Engineering Approach
- Support Affordability Assessments.
- Identify a range of technically feasible materiel solution approaches that address considerations of industrial, production, manufacturing, and quality constraints.
- 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, single, sole, domestic, and foreign sources
    - Identify M&Q scheduling impacts and constraints (risks and opportunities) for each materiel solution
    - Review signed Acquisition Decision Memorandum (ASM)
- 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.
- Program 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
- Cost and Affordability Analysis Tools (numerous)
- DCMA Industrial Capability Assessment Survey Form
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

- Independent Technical Risk Assessment Checklist
- Integrated Master Plan/Schedule

Resources

- DCMA Instruction 3401, Defense Indusial Base Mission Assurance
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment (TRA) Guide
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- Cost and Affordability Analysis Guides (numerous)
- DoD Market Research Guide
- Pre-MDD Analysis Handbook

B. DEFENSE CONTRACTING SYSTEM

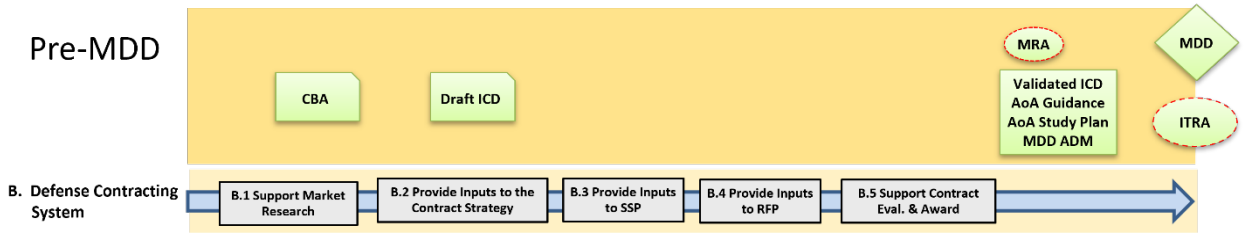


Figure 1-4. Defense Contracting System Manufacturing and Quality Activities

Introduction

DoD contracting requirements and activities are required by various statutory and regulatory requirements as outlined in the Federal Acquisition Regulation (FAR)/Defense Federal Acquisition Regulation (DFAR) and DoD, Service, and Agency regulations, policies, and guidance documents. The contract is the vehicle used to establish a 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. The Procuring Contracting Officer (CPO) is responsible for the solicitation of offers, negotiation, development, award, oversight, modifications, and closeout of any contract that is entered into on behalf of the government for their organization. They work closely with the Program Manager (PC) when developing Request for Proposal (RFP), Statement of Work (SOW), and executing Source Selections. Only the PCO acting within their delegated authority is empowered to execute a contract on behalf of the Government.

The contracting process for acquisitions is as follows:

1. Pre-solicitation Procurement Planning
    a. Form Team
    b. Market Research (include M&Q)
    c. Define Requirements (PWS, SOW, SOO)
    d. Acquisition Strategy
2. Solicitation/Award
    a. Solicitation (RFQ, IFB, RFP)
    b. Evaluation
    c. Negotiation
    d. Award
3. Post-award Contract Management
    a. Monitor Performance
    b. Assess Deliverables
    c. Payments
    d. Contract Closeout

M&Q personnel are often called upon to support various contracting functions and activities to ensure that production planning, transition to production, concurrent engineering, quality management, continuous improvement, and manufacturing technology and other M&Q concerns are addressed. 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.

This thread (Contracting) will focus on the following sub-threads as required in each phase:

- Market Research
- Contract Strategy
- Source Selection Plan
- Request for Proposal
- Contract Evaluation and Award

Note: Due to the early nature of pre-MDD activities, not all these sub-threads may be required. As a minimum there needs to be some sort of contract to cover the work being done, and there needs to be an assessment of contract performance.

B.1 Support Market Research

Market Research (FAR Part 10) is conducted to determine the availability of commercial products and services and to identify and evaluate market practices and is required before developing new requirements documents for an acquisition and before soliciting offers for acquisitions in excess of the simplified acquisition threshold. It is a continuous process of finding viable sources of goods and services to meet government requirements and is mandated for all acquisition programs. It is conducted by key members of a program's Integrated Product Team (IPT) with the goal of pulling together the necessary market information to be analyzed so an informed decision can be reached on how to satisfy a need. The results of market research are included in the program's Acquisition Strategy.

Market Research can be either Strategic or Tactical:

- Strategic market research is conducted continuously and enables acquisition, engineering, project management, and other personnel to stay informed about overall market developments, trends, and capabilities. During strategic market research, any identified users' requirements need to be kept in mind.
- Tactical market research is conducted at specific points during the acquisition process, which will vary with the scope and complexity of the acquisition. Tactical market research is designed to provide in-depth information to answer specific questions about the capabilities, products, or services available in the market.

Market Research is intended to determine and help:

- Determine if sources capable of satisfying the agency's requirements exist
- Determine the extent to which commercial items or non-developmental items could be used to meet agency requirements.
- Determine the practices of firms engaged in producing, distributing, and supporting commercial items, such as type of contract, terms for warranties, buyer financing, maintenance, and packaging, and marking
- Identify the availability (if any) of commercially available solutions
- Identify customary industry terms, conditions, and warranties
- Understand distribution and logistics capabilities
- Uncover historical acquisition information
- Ensure maximum competition
- Reveal pricing information
- Ensure maximum practicable use of recovered materials (see Subpart 23.4) and promote energy conservation and efficiency
- Determine whether bundling is necessary and justified

Market Research is a primary means of determining the availability and suitability of commercial items and the extent to which the interfaces for these items have broad market acceptance, standards-organization support, and stability. In addition, market research is important in seeking small business capabilities. Through market research needs to be conducted to determine whether small businesses are capable of satisfying their requirements. Methods include researching the Small Business Administration's Dynamic Small Business Search, and/or using format requests such as:

- Sources Sought Notice (SSN)
- Request for Information (RFI)
- Release Draft Statement of Work for comment

Market research supports the acquisition planning and decision process, supplying technical and business information about commercial technology and industrial capabilities to arrive at the most suitable approach to acquiring, distributing, and supporting supplies and services. Market research tailored to program needs should continue throughout the acquisition process and during post-production support. Market research should yield an understanding of potential material solutions, their technology maturity, and potential sources, and should suggest strategies for acquiring them.

Manufacturing and Quality Tasks

- Support market research to include:
  - Identify market data such as the number of suppliers in the market and market share

  - Identify potential suppliers (name, size, and annual sales)
    - Business Practices (e.g., ISO 9001, etc.)
    - Production capability and capacity
    - Ability to surge/mobilize
    - Distribution capabilities (preservation, packaging, handling, storage, and transportation)
  - Identify the availability of commercial items
  - Identify the willingness of suppliers to modify commercial items to meet requirements
  - Identify other government customers or past government work by potential suppliers
  - Identify other government agencies that are buying the same proposed product
  - Identify other government agency market research activities on this product
  - Identify the existence of any new developments in this product area
  - Identify any general market information from other sources (trade shows, conferences, training programs, industry associations, etc.)
- 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 input for sources sought activity, as appropriate.
- 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.

Tools

- Market Research Methods – DAU, Mar 2017
- Market Research Reporting Template
- NAVSUP Market Research and Screening Checklist
- Pugh Matrix Template

Resources

- 10 USC 2377 Preference for Commercial Products
- FAR Part 7 Acquisition Plans
- FAR Part 10 Market Research
- DFAR 210 Market Research

- DoD Market Research Guide (*See* DAU AcqNotes Market Research website)
- SD-5 Market Research
- HQ AFMC Market Research Process Guide, Sep 2007
- NAVSUP Market Research Link
- Supplier Performance Risk System (SPRS) Market Research Report

B.2 Provide Inputs to the Contract Strategy

Numerous laws, regulations, and guidance documents outline the requirements for a contracting strategy. 10 USC 2431a(E) requires the consideration of a Contracting strategy, including:

- Contract Type and how the type relates to level of program risk in each acquisition phase
- How the plans for the program or system to reduce risk enable the use of fixed-price elements in subsequent contracts and the timing of the use of those fixed price elements
- Market Research
- Consideration of small business participation

Contracting Strategy

Contracting Strategy refers to a discussion of the planned contract type (fixed-price, cost-reimbursement, incentive, indefinite-delivery, and time and materials) and how it relates to risk management in each of the acquisition phases; whether risk management enables the use of fixed-price elements in subsequent contracts; market research; and small business participation.

Contract Type

Contract type selection is the principal method of allocating cost risk between the Government and the contractor. The goal is to balance technical, cost, and schedule risks by identifying the right contract type and incentive approach. There is no single approach that is right for every contracting situation.

Selection must be made on a case-by-case basis considering contract risk, incentives for contractor performance, and other factors such as the adequacy of the contractor's quality management system. The objective should be to select a contract type that will result in reasonable contractor risk with the greatest incentive for efficient and economical contract performance. Selecting the proper contract type will make the work more attractive to more potential offerors, thereby increasing competition.

FAR 16.104 identifies the following factors in the selection of contract type:

- Price Competition, Price Analysis and Cost Analysis
- Type and complexity of requirements
- Urgency of the Requirement
- Period of Performance or length of production run
- Contractor’s technical capability and financial responsibility

- Adequacy of contractor's accounting system
- Extent and nature of proposed subcontracting
- Acquisition history (past performance)

Contract Risks can include:

- Cost Risk is the risk of achieving point estimate and estimated cost growth (variation)
- Performance Risk is the estimated uncertainty in being able to achieve program performance requirements.
- Technical Risks is the risk of not meeting design, manufacturing and quality maturity dates and expectations.

The Contracting Cone outlines the full spectrum of available FAR and Non-FAR contract strategies. The supporting materials provide details about each contracting strategy, to enable collaborative discussions to select the right strategy based on environment, constraints, and desired outcomes. The interactive graphic below is available at [Contracting Cone | Adaptive Acquisition Framework https://aaf.dau.edu/aaf/contracting-cone/](https://aaf.dau.edu/aaf/contracting-cone/).

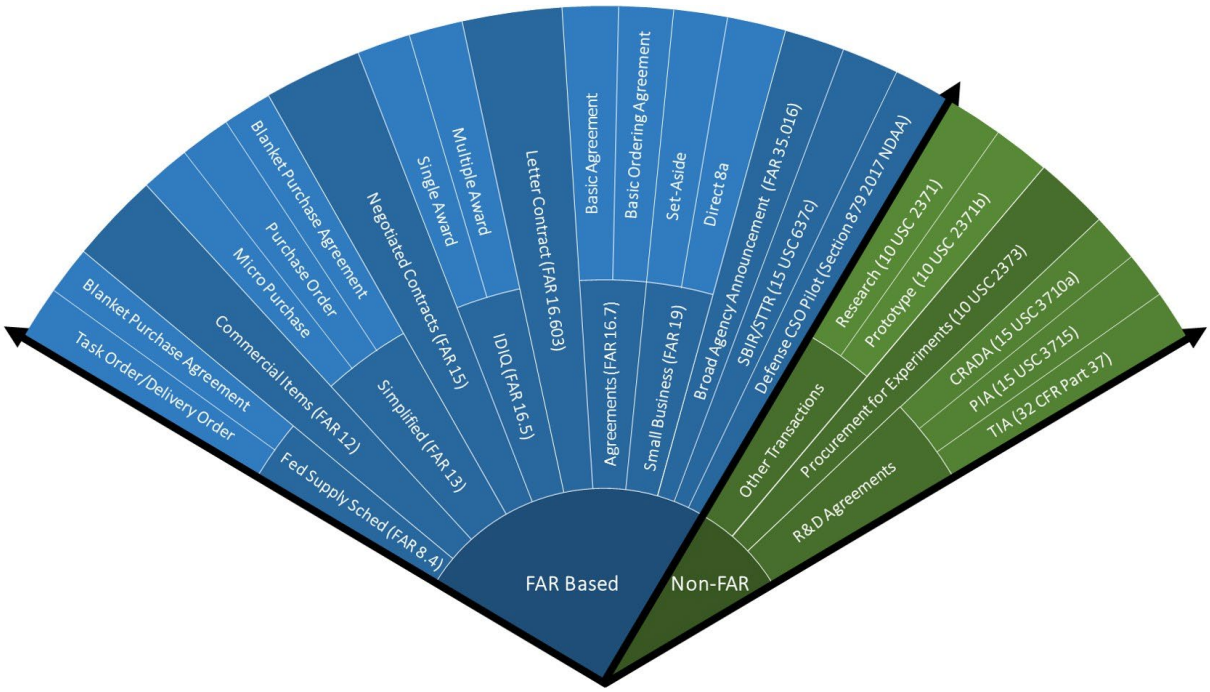


Figure 1-5. Contracting Cone

Contract Determination (Contract Type):

After selecting the primary strategy from the contracting cone, select the appropriate contract type. The contract type should be based on the specific conditions and risks for each contract. The contracting officer, in partnership with the program manager, should explore all the available contract types identified in the table below and assess the pros/cons of each for what they are trying to acquire.

Of particular concern are contracts with incentive or award fees. This is the perfect time for Manufacturing and QA personnel to identify significant factors that merit additional management attention and establish incentives or awards around those criteria.

Manufacturing and Quality Tasks

Support the development of the Contracting Strategy (Type/Competition/Incentives)

- FAR Based Strategies to include:
  - Federal Supply schedules
  - Commercial Items
  - Simplified Acquisition
  - IDIQ Contract
  - Letter Contract
  - Agreements
  - Small Business
  - Broad Agency Announcements
  - Commercial Solutions Opening (CSO)
- Statutory Strategies to include:
  - SBIR/STTR
  - Other Transactions
  - Procurement for Experiments
  - R&D Agreements
  - Cooperative T&D Agreement
  - Partnership Intermediary Agreement
  - Technology Investment Agreement
- M&Q potential strategies to use:
  - Advanced Manufacturing
  - Lean/Six Sigma

Tools

- DAU Provision and Clause Matrix
- FAI Contracting Professionals Smart Guide
- FAI Acquisition Gateway
- DAU Powerful Interactive Contract Strategy Tool
- DAU Contracting Subway Map
- Space and Missile Systems Center Incentives Guide – DAU
- Award Fee Template - USAF
- Incentive Fee Template - USAF

Resources

- 10 USC 2304, Contracts: Competition Requirements
- 10 USC 2305, Contracts: Planning, solicitation, evaluation, and award procedures
- FAR 6.101 Full and Open Competition
- FAR 16 Types of Contracts
- FAR 16.4 Incentive Contracts
- DAU Contract Strategy Fact Sheets
- DoD Guidance on Using Incentive Contracts
- DoD/NASA Incentive Contracting Guide
- Award Fee Guide – USAF
- Award Fee Guide – US Army
- Award Fee Guide - US Navy

B.3 Provide Inputs to the 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 to evaluate and select the best suited supplier. Selecting the correct evaluation factors is the most important decision in the evaluation process. Structure the evaluation factors and their relative importance to clearly reflect the needs of your acquisition. It serves as the guide for conducting the evaluation and analysis of proposals, and the selection of source(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. Common evaluation factors are cost/price, technical, past performance, and small business participation.

FAR 15.303(a) states "Agency heads are responsible for source selection. The contracting officer is designated as the source selection authority, unless the agency head appoints another individual for a particular acquisition or group of acquisitions."

Source Selection Plan (SSP) Document should include:

- **Acquisition Strategy,** including the requirement, expected competition, and method or procurement
- Source selection organization, including the recommended members identified by name, position title, or functional area.
- Pre-solicitation activities, including market research and synopsis.
- Evaluation procedures, including whether the award will be made based on the identified low-priced technically acceptable offer or a trade-off evaluation.
- Evaluation factors/subfactors and their relative importance, including:

  - Price or cost;
  - Technical (M&Q personnel should play a key role here)
  - Management; and
  - Past performance.
- Schedule of events, including key events and the projected dates for completion. Key events should include such activities as:
  - Issuing the solicitation
  - Receiving offers
  - Completing offer evaluation
  - Source Selection Authority (SSA) decision
  - Contract preparation and signature
  - Contract approval
  - Contract award
- Evaluation Procedures: The SSEB shall conduct an in-depth review of each proposal against the factors and subfactors established in the solicitation and assign evaluation ratings (see FAR 15.305). The standardized rating tables and rating definitions detailed in this document are required to be used for adjectival ratings. For any technical factors and factors/subfactors evaluated on other than an "acceptable/unacceptable" basis, including risk, the ratings in this section shall be utilized.

The SSP is required for all "best value, negotiated, "competitive acquisitions under FAR Part 15, regardless of the dollar value of the acquisition or source selection. There are no phase unique considerations for the SSP.

Manufacturing and Quality Tasks

- Support the development of the Source Selection Plan (SSP) to include:
  - Identify and assess the Acquisition Strategy
  - Identify the Source Selection Team (SST), note that the team should include technical personnel (systems engineers, manufacturing, and quality)
  - Identify evaluation criteria (factors and subfactors) in the SSP
  - Identify the types of documents that will be prepared
    - Source Selection Board Evaluation Report
  - Support the development of the RFP (another thread)

Tools

- Source Selection Plan Template
- Proposal Evaluation Plan Template

Resources

- 10 USC 2305, Contracts: Planning, Solicitation, Evaluation, and Award Procedures
- FAR Part 12 Acquisition of Commercial Items
- FAR Part 15 Contracting by Negotiation
- FAR Part 15.1 Source Selection Plan and Techniques
- FAR Part 15.2 Solicitation and Receipt of Proposals and Information
- DoD Source Selection Procedures, Aug 2022
- Source Selection Procedures (SSP) Guide (IG 5315.303)
- AFLCMC Standard Process for Source Selections

B.4 Provide Inputs to the Request for Proposal

When the DoD decides that a materiel solution is needed, then the DoD turns to contracting as a vehicle to achieve that solution. However, in DoD Contracting, every procurement will be different—different timelines, different missions, different requirements, different funding types, different registrations and certifications, different proposal templates and instructions, different evaluation criteria, different entry points and innovation hubs, different Intellectual Property (IP) considerations, different regulations, and policies. Some follow the Federal Acquisition Regulation (FAR), and supplemental regulations and others ignore the FAR altogether and find their foundation in statute alone, such as Other Transactions. Program offices and contractors need to understand these differences and abide by them in developing, proposing, and winning contracts, and then in delivering on those contracts.

M&Q personnel do not own the contracting process, but from should be asked by program personnel to support various contracting activities including RFPs and RFQs. This may include inputs to Sections C, H, L and M.

A Request for Proposal (RFP) is a solicitation used in negotiated acquisition to communicate government requirements to the prospective contractors and to solicit proposals. At a minimum, solicitations shall describe the Government's requirement, anticipated terms and conditions that will apply to the contract, information required in the offeror's proposal, and (for competitive acquisitions) the criteria that will be used to evaluate the proposal and their relative importance. FAR Subpart 15.2 "Solicitation and Receipt of Proposals and Information" is the main guidance for government solicitations and RFP's.

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. The input to the RFP needs to be short and very succinct. 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. As a minimum, M&Q considerations should include Manufacturing Management Program (AS6500), a Quality Management Program (AS9100), MRL requirements, and appropriate Data Item Descriptions (DIDs). M&Q personnel should look at the Early Manufacturing and Quality Engineering Guide, Appendix F: Recommended Contracting Approach for M&Q Activities, the Producibility and Manufacturability Engineering Guide for developing the inputs.

Contract Section C – Description of services and prices/costs. The Statement of Work identifies the technical requirements of the contract. Each contract line item (CLIN) must be defined and described in detail so that both the Government and contractor fully understand the work to be accomplished.

Contract Section F – Deliveries or Performance, Section F.4 addresses the Schedule of Deliverables to include data deliverables identified on the DD Form 1423 Contract Data Requirements List. M&Q personnel may want to add one or more of the following to the contract:

- Integrated Program management Report (IMPR) DI-MGMT-81861
- Integrated Master Schedule (IMS) DI-MGMT-81650
- Critical Manufacturing Process Description (PCMPD) DI-SESS-81012F
- Contractor's Configuration Management Plan DI-CMAN-80858B
- Contract Performance Report (CPR) DI-MGMT-81466A
- Systems Engineering Management Plan (SEMP) DI-SESS-81785A
- Quality Status Report DI-MGMT-82186
- Quality Program Plan (QPP) DI-QCIC-81722
- Quality Management System (QMS) DI-MGMT-82184
- Quality Engineering Inspection Requirements and Equipment List DI-QCIC-80756A
- Quality Assurance Program Plan DI-QCIC-81794
- Quality Assurance Provisions (QAP) DI-SESS-80789A
- Producibility Analysis Report DI-MGMT-80797A
- Manufacturing and Quality Assurance Status Report DI-QCIC-82323
- Manufacturing Plan DI-MGMT-81889A
- Manufacturing Risk Assessment Report DI-SESS-81974
- Manufacturing Nonconformance Material Report DI-MGMT-891137
- Manufacturing Technology (ManTech) Report DI-MISC-81176A
- Long Lead Times Material Report DI-PSSS-82201
- Production Line of Balance (LOB) Status DI-MGMT-80034

Contract Section H – Special contract requirements are identified here that are not included in Section I, Contract Clauses. This section may include contractor performance information, use of facilities, supplier or services, contractor commitments, warranties, and representations.

Contract Section L – Instructions, Conditions, and Notice to Offeror's include conditions, and notices to offerors or respondents. Insert in this section solicitation provisions and other information and instructions not required elsewhere to guide offerors or respondents in preparing proposals or responses to requests for information. Prospective offerors or respondents may be instructed to submit proposals

or information in a specific format or several parts to facilitate evaluation. The instructions may specify further organization of proposal or response parts, such as:

- Administrative
- Management
- Technical
- Logistics
- Past Performance
- Cost and Pricing Data

Contract Section M – Evaluation Factors for Award include any significant factors/subfactors that will be considered in awarding the contract and their relative importance. Decision for award is based on evaluation factors/subfactors that are tailored to each specific acquisition. Evaluation factors/subfactors must represent key areas of importance and emphasis to be considered in the source selection decision; and support meaningful comparison and discrimination between competing proposals. Section M Factors and Subfactors could include:

- Technical
    - Technical Maturity
    - Manufacturing Readiness
    - Quality Assurance
    - Past Performance
    - Staffing

Requests for proposals (RFPs) are used in negotiated acquisitions to communicate Government requirements to prospective contractors and to solicit proposals. RFPs for competitive acquisitions shall, at a minimum, describe the:

- Government's requirement
- Anticipated terms and conditions that will apply to the contract
- Information required to be in the offeror's proposal
- Factors and subfactors that will be used to evaluate the proposal and their relative importance or weight
    - Evaluation Factors/Subfactors
    - Evaluation Factor/Subfactor Weighting
    - Evaluation Factor/Subfactor Documentation

A well-written RFP is critical to the success of the source selection. The source selection team shall ensure consistency between the requirements documents, 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. The development of evaluation factors, subfactors, and weighting should include M&Q personnel, and the identification and inclusion of M&Q requirements and metrics in the contract.

The RFP should contain the following:

Part I.

A. Solicitation/Contract Form
B. Supplies or Services and Prices/Costs
C. Description/ Specifications/Statement of Work (SOW)
   - **This is where M&Q personnel can make an impact**
D. Packaging and Marking
E. Inspection and Acceptance
F. Deliveries or Performance
G. Contract Administrative Data
H. Special Contract Requirements

Part II.

I. Contract Clauses

Part III.

J. List of Attachments (CDRLs, financial data, etc.)

Part IV.

K. Representations, Certifications and Other Statements of Offerors
L. Instructions, Conditions, and Notices to Offerors
M. Evaluation Factors for Award
   - **This is where M&Q personnel can make an impact.**

Contracting is required in all phases of acquisition.

Manufacturing and Quality Tasks

- See Early Manufacturing and Quality Guide, Sections 2 and 3
- Support writing of the RFP and participate in RFP review teams
- Analyze M&Q results
- Specify requirements for the contractor to describe the best practices it will use for:
  - Manufacturing Management System (AS6500)
  - Quality Assurance System (ISO 9001 or AS9100)
- Specify requirements for contractors to identify and describe their proposed specific processes, methods, and actions to address:
  - Manufacturing Feasibility
  - Producibility

  - M&Q risks associated with proposed solutions

- Specify appropriate requirements for Contract Data Requirements List (CDRLs) Data Item Descriptions (DIDs), needed to support requisite M&Q processes and approval processes:
  - Manufacturing Reporting
  - Quality Reporting
  - Supplier Management
  - Metrics for the above
- Analyze the design for producibility and manufacturability:
  - Support development of the performance and detailed specifications
  - Conduct producibility analysis, and support Design Failure Modes and Effects Analysis (DFMEA)
  - Identify and manage key and critical characteristics in the Technical Data Package (TDP)
  - Implement Variability Reduction to reduce part-to-part variation of key and critical characteristics
  - Identify and manage key and critical manufacturing processes
  - Conduct Process Failure Modes and Effects Analysis (PFMEA) on critical manufacturing processes
- Identify manufacturing risks:
  - Integrate M&Q activities into the program RIO management process
  - Conduct and document manufacturing feasibility
  - Identify MRL targets and document MRL risks through assessments
- Plan for &Q:
  - Establish and maintain a manufacturing plan that includes:
    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing Modeling and Simulation (M&S)
    - Identify and assess manufacturing cost and cost drivers
    - Manufacturing system verification
    - Manufacturing workforce requirements
    - Facilities
    - Tooling and test equipment to include special tooling, special test equipment, and special inspection equipment
- Manage M&Q operations:
  - Production planning and control
  - Quality planning and control
  - Manufacturing surveillance

  - Continuous improvement
  - Process control plans
  - Process capabilities
  - Production process verification
  - First Article Inspection (FAI) and First Article Test (FAT)
  - Supplier management and control
- Specify contractual requirements for:
  - Implementing a variability reduction program
  - Managing materials and resources
  - Managing materials and subcontractors
  - Using COTS, GOTS, and NDIs

Tools

- Early Manufacturing and Quality Guide
- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- DAU Contract Review Checklist (CMC100 Job Aid)
- Air Force Development RFP ADDM Template

Resources

- 10 USC 2305 Contracts: Planning, Solicitation, Evaluation, and Award Procedures
- FAR 15.2 Solicitation and Receipt of Proposals and Information
- DFAR 215.3 Source Selection
- Request for Proposal Evaluation Guide – USAF, Mar 2010
- 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
- DoD Guidance on Using Incentive and Other Contract Types, Apr 2016
- DoD Memo, Source Selection Procedures, Chapter 2.3 Develop the Request for Proposal, Mar 2016
- MIL-HDBK-29612-1A, Guidance for Acquisition of Training Data Products and Services, Ag 2001
- MIL-HDBK-245D, Handbook for Preparation of Statement of Work, Apr 1996
- Air Force Systems Engineering Request for Proposal Guide, Mar 2010
- Defense Manufacturing Management Guide for Program Managers, Chapter 10.5.3 Request for Proposal

B.5 Support Contract Evaluation and Award

The evaluation phase begins when the government contracting office (CO) receives the offerors' proposals to the solicitation. To determine which proposal will provide the government with the best quality product or service at a fair and reasonable price/cost, CO reviews both the offerors' technical and business proposals. Determinations are based on a full and fair assessment of each proposal. As the technical experts, the Program Office reviews and evaluates the technical proposal. Then, along with CO's guidance and assistance, the Program Office reviews the business proposals.

FAR 15.305 Proposal evaluation notes that a proposal evaluation is an assessment of the proposal and the offeror's ability to perform the prospective contract successfully. An agency shall evaluate competitive proposals and then assess their relative qualities solely on the factors and subfactors specified in the solicitation. Evaluations may be conducted using any rating method or combination of methods, including color or adjectival ratings, numerical weights, and ordinal rankings. The relative strengths, deficiencies, significant weaknesses, and risks supporting proposal evaluation shall be documented in the contract file.

DFAR 215.3 Source Selection notes that Source Selection Evaluation Boards (SSEBs) will evaluate proposals based on factors and subfactors that were established in the solicitation and will then assign evaluation ratings to each proposal. Ratings are often established for cost, technical, and past performance. M&Q personnel may be asked to support or participate in the SSEB by providing subject matter expertise.

The Contracting Officer is responsible for giving the evaluation team complete instructions regarding the evaluation process. The Contracting Officer finalizes the award documentation, including the contract, price negotiation memorandum, and any other documents required by the FAR, DFARS and agency policy. Once the award documentation is reviewed, approved, and signed by the interested parties, the Contracting Officer announces the award within the GFE portal that was used to post the solicitation, such as FedBizOpps and then the government conducts post-award activities, which may include a Post Award Conference.

Typical Evaluation factors can include:

- Cost/Price (Reasonableness, Realism, and Affordability)
- Technical (Management Approach, Technical Capability, Transition Plan, and Small Business Utilization)
- Past Performance (Past Contracts, Relevance of past contract to this effort, and Performance Confidence)

The objective is to evaluate all proposals received in response to a solicitation in a method consistent with the instructions and evaluation criteria in Section L and M of the Request for Proposal (RFP) package. The evaluation will identify the strengths, weaknesses, significant weaknesses, and deficiencies contained in each proposal. The results will provide evaluation information to the source selection authority (SSA) and Program Contracting Officer (PCO) to make an award decision.

- ***Planning***. This stage includes establishing the evaluation criteria for the award and submitting the evaluation criteria to the source selection authority for approval.
- ***Forming The Evaluation Team.*** This stage includes: i) determining the specific teaming approach to be used; ii) nominating team members and selecting supporting contractor personnel; iii) briefing panel members on their responsibilities; iv) distributing documents and instructions to be used during the proposal evaluation; and v) convening the evaluation panel.
- ***Conducting The Evaluation.*** This stage is tailored based on whether the tradeoff, LPTA, or sole-source approach is used.

M&Q personnel need to support the development of the contracts Section L and M inputs.

Section L are instructions to Offerors Guidance. Section L should contain the following requirements (see Early Manufacturing and Quality Guide, Appendix F, Section 3):

- Manufacturing Readiness Level Demonstrations. 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.

Manufacturing Planning. The offeror shall describe:

- How their manufacturing management system meets the requirements of AS6500A.
- The major assembly sequence chart and anticipated manufacturing process flow.
- The manufacturing build schedule, including drawing release; tooling design, build, and proofing; key supplier deliveries; and fabrication, assembly, and delivery schedules.
- Facility requirements and layouts.
- The offeror's plans to provide the needed manpower, facilities, and equipment for expected delivery rates.

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.

Supplier Management. The offeror shall describe their:

- Approach to selecting and managing key suppliers.
- Processes for integration of key supplier activities into the overall program plan to ensure that supplier activities support the overall program performance.
- Specific supplier risks to the program and plans for mitigating those risks.
- Plan for preventing the intrusion of counterfeit parts in factory equipment and delivered products.

Section M is the Evaluation Guidance. Section M should contain the following requirements;

- Manufacturing Readiness Level Demonstrations. 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.

Manufacturing Planning. 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:

- Describes how their manufacturing management system meets the requirements of AS6500A.
- Describes the major assembly sequence and manufacturing process flows.
- Includes an integrated, achievable schedule incorporating design, tooling, supplier, fabrication, assembly, and delivery milestones.
- Describes facility requirements and layouts.
- Describes achievable plans to provide the needed manpower, facilities, and equipment for expected delivery rates.

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:

- Assure product quality.
- Achieve stable, capable processes.
- Prevent defects.
- Results in effective root cause analyses and corrective actions.

Supplier Management. This sub-factor evaluates the offeror's proposed supplier management program. This sub-factor is met when the offeror's proposal:

- Describes how key suppliers are selected and managed.
- Describes how supplier activities will be integrated into the overall program plan.
- Lists specific supplier risks and achievable plans for mitigating those risks.
- Describes effective plans for preventing the intrusion of counterfeit parts in factory equipment and delivered products.

A pre-award survey may be conducted on a proposed contractor to assess the ability of the prospective contractor to perform under the terms of the proposed contract. A pre-award survey typically requires

an on-site visit to the contractor's facility and due to the length and expense of the survey, they are not typically performed on contracts that are less than $100,000. Note that preaward surveys are conducted by DCMA personnel, not program office.

- A Post-Award Conference or Orientation is conducted to aid Government and contractor personnel to achieve a clear and mutual understanding of all contract requirements and to identify and resolve any potential problems.

Manufacturing and Quality Tasks

- Support contract/proposal technical evaluation to include:
  - The overall technical proposal is adequate and addresses the scope, deliveries, and schedules required by the RFP
  - The contractor's technical approach in the proposal is based upon sound engineering concepts
  - The contractor provides adequate information to support specific quantities of labor and materials
  - The contractor's proposal contains an adequate description of its basis for direct labor hours, including sufficient rationale for engineering judgment and projections from prior work completed on similar programs
  - The contractor provides adequate explanation for factored labor hours
  - The contractor's proposal provides supporting data to justify proposed material, scrap, rework, attrition, or other factors
  - The contractor provides reasonable rationale for special tooling and test equipment to establish that the proposed items are required for the program
- Support the review of contractor past performance to include:
  - Support the development and assessment of Learning Curves:
  - Identify or develop a learning curve model
  - Validate the model
  - Assess performance against the model
  - Identify risks and issues and mitigate
  - Review of the Past Performance Information Retrieval System (PPIRS)
  - Review contractor Past Performance Questionnaire
  - Review contractor Past Performance Citations
- Review of contract plans including:
  - Project Management Plan
  - Manufacturing Management Plan
  - Quality Management Plan
  - Risk Management Plan

- Support contract negotiations including:
  - Review of contractor cost and pricing
  - Compare to Independent Government Cost Estimate
- Support contractor selection including:
  - Ensure contract evaluation plan is complete and adequate
  - Establish source selection approach (e.g., best value, lowest price/technically acceptable, etc.)
- Support the administration of the contract and contractor performance including:
  - Ensure quality
  - Ensure on-time delivery
  - Manage subcontracts
  - Manage changes

Tools

- Acquisition Requirements Roadmap Toolsuite Evaluation Factors Help Guide (DAU)
- Pre-Award/Post-Award
- Post-Award Conference Record (DD Form 1484)
- CMC Job Aid Post-Award Orientation Conference

Resources

- 10 USC 2304, Contracts: Competition Requirements
- 10 USC 2305, Contracts: Planning, solicitation, evaluation, and award procedures
- 10 U.S.C.2431a Acquisition Strategy
- FAR 6.101 Full and Open Competition
- FAR 16 Types of Contracts
- FAR 15.1 Source Selection Process and Techniques
- FAR 15.305 Proposal Evaluation
- FAR 42.503.2 Postaward conference procedure
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 10.5.4 Evaluation Phase
- Defense Manufacturing Management Guide for Program Managers, Chapter 10.5.5 Contract Award

C. SURVEILLANCE SYSTEM

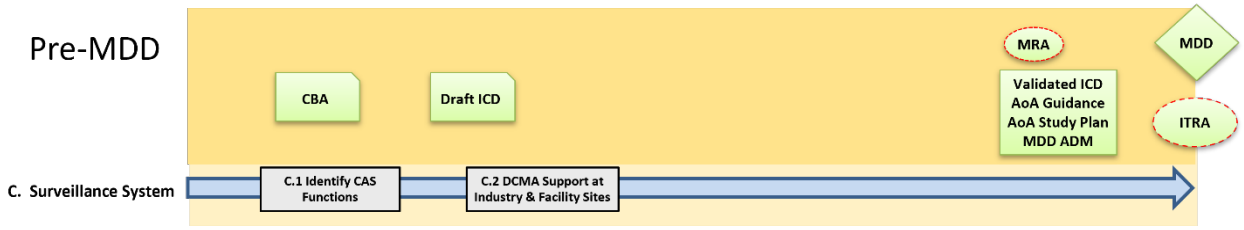


Figure 1-6. Surveillance System Manufacturing and Quality Activities

Introduction

Program managers utilize risk-based surveillance of a contractor's contract cost, schedule, products, services, processes, and systems. This method supports an overall assessment of contractor performance, progress, or compliance with requirements. Surveillance can be applied to multiple procurement instruments, as well as internal and external processes and procedures. Surveillance activities apply primarily to post-award; however, some surveillance may be performed pre-award when requested by the customer.

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 to accomplish.

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. This thread (Surveillance) will focus on the following sub-threads in each phase:

- Perform Contract Administration Service (CAS) Functions
- DCMA Support at Industry Sites
- Monitor and Track Risks
- Participate in Program Reviews

C.1 Identify Contract Administration Service (CAS) Functions

Contract administration is a function that ensures both parties (government and contractor) understand and can meet the specified terms and conditions of the contract. Contract administration is composed of many functions, as identified in FAR Part 42.302, for monitoring contract compliance, performing property administration, and performing quality assurance.

Government surveillance is often multifunctional, requiring the support of business and technical personnel from the program office, Engineering Support Activity (ESA), and Defense Contract Management Agency (DCMA). These 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.

Production surveillance begins during the source selection process as the program office assesses potential contractors and may include the use of preaward surveys and continues post contract award. Surveillance includes efforts to ensure supplies, services, and construction is delivered IAW the terms, conditions, and standards expressed in the contract. Production surveillance involves Government review and analysis of:

- Contractor performance plans, schedules, controls, and industrial processes
- Contractor performance under the contract

Government on-site surveillance is usually performed by DCMA personnel and augmented by program office personnel. Production/quality surveillance activities include:

- Contractor plans and schedules (manufacturing and QA plans)
- Policies and procedures
- Cost and schedule reports (and other financials)
- Subcontractor management
- Performance data (work measurement, learning curves, other performance metrics)
- Continuous improvement and lessons learned

Current DCMA instruction directs their personnel to adopt a “Detection to Prevention (D2P)” surveillance/management strategy that reduces redundant surveillance and end product inspections. D2P focuses instead on process capability; risk assessment/mitigation; verification of contractors’ systems, processes, and outputs; and data driven actionable information.

Manufacturing and Quality Tasks

- Support the program, product, and program offices regarding program reviews, program status, program performance and actual or anticipated program problems to include:
    - Ensure timely submission of required reports (cost, schedule, performance, etc.)
    - Assess contractor reports (cost, schedule, performance, etc.)
- Assess and monitor the industrial security program.
- Perform property administration to include:
    - The evaluation of contractor requests for Government property and for changes to existing Government property and provide appropriate recommendations to the contracting officer
    - Support the screening of Government property before acquisition by the contractor
    - Evaluate the use of Government property on a non-interference basis, Use and Charges
- Assess, monitor, and disposal of accountable contractor inventory.
- Perform production support, surveillance, and status reporting including:
    - Assess and monitor production capability and capacity
- Ensure timely reporting of potential and actual slippage in contract delivery schedules.
- Perform/support preaward surveys (Technical, Production, Quality, and Financial).
- Support evaluation of proposals.
- Support forward pricing rate agreement negotiations.
- Support the negotiation of prices and supplemental agreements.
- Support post-award orientation conferences.
- Monitor contractor industrial labor relations to include:
    - Apprise program office and contracting officer of potential labor disputes
    - Coordinate the removal of urgently required material from the strikebound contractor's plant upon instruction from the contracting officer
- Review and evaluate preservation, packaging, and packing.
- Support the evaluation of contractor compliance with contractual safety requirements.
- Ensure contractor compliance with contractual quality assurance requirements.
- Support the review and surveillance of the contractor's purchasing system and Make/Buy.
- Advise and assist contractors regarding their Defense Priorities and Allocations System responsibilities.
- Review and evaluate for technical adequacy the contractor's logistics support, maintenance, and modification programs.
- Assist in evaluating and making recommendations for acceptance or rejection of waivers and deviations.
- Evaluate and monitor the contractor's procedures for complying with procedures regarding restrictive markings on data.

- Maintain surveillance of flight operations.
- Perform engineering surveillance to assess compliance with contractual terms for schedule, cost, and technical performance in the areas of design, development, and production.
- Evaluate for adequacy and perform surveillance of contractor engineering efforts and management systems that relate to design, development, production, engineering changes, subcontractors, tests, management of engineering resources, reliability and maintainability, data control systems, configuration management, and independent research and development.
- Report to the contracting office any inadequacies noted in specifications.
- Perform engineering analyses of contractor cost proposals.
- Review and analyze contractor-proposed engineering and design studies and submit comments and recommendations to the contracting office, as required.
- Review engineering change proposals for proper classification, and when required, for need, technical adequacy of design, producibility, and impact on quality, reliability, schedule, and cost; submit comments to the contracting office.
- Monitor the contractor's value engineering program.
- Monitor the contractor's environmental practices for the adverse impact on contract performance or contract cost, and for compliance with environmental requirements specified in the contract:
    - Requesting environmental technical assistance, if needed
    - Monitoring contractor compliance with specifications requiring the delivery or use of environmentally preferable products, energy-efficient products, products containing recovered materials, and biobased products
    - Ensure that the contractor complies with the reporting requirements relating to recovered material content utilized in contract performance.
- Support the review of requests for payments under the progress payments or performance-based payments.
- Support reviews of contractor cost reports and ensure timely notification by the contractor of any anticipated overrun or underrun of the estimated cost.
- Support monitoring of the contractor's financial condition.
- Support contract closeout procedures.

Tools

- AS9100 Checklist
- ISO 9001 Checklist
- AS6500 Checklist
- DCMA Industrial Capability Assessment Survey Form
- DCMA Pre-award survey (technical, production, quality, and financial)
- 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

- FAR 42.11 Production Surveillance and Reporting
- FAR 42.302 Contract Administration Functions
- DCMA Manual 2302-01 Surveillance
- DCMA-INST-124, Contract Property Management
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-213, Technical Pricing Support
- DCMA-INST- 219, Supply Chain Management Through Standard Contract Surveillance
- DCMA-INST-221, Integrated Surveillance Plan
- DCMA-INST-302, First Article and Production Lot Testing
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-311, Process Review – QA
- DCMA-INST-322, Quality Audit

Resources

- FAR 42.11 Production Surveillance and Reporting
- FAR 42.302 Contract Administration Functions
- DCMA Manual 2302-01 Surveillance
- DCMA-INST-124, Contract Property Management
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-213, Technical Pricing Support
- DCMA-INST- 219, Supply Chain Management Through Standard Contract Surveillance
- DCMA-INST-221, Integrated Surveillance Plan
- DCMA-INST-302, First Article and Production Lot Testing
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-311, Process Review – QA
- DCMA-INST-322, Quality Audit

C.2 DCMA Support at Industry and Facility Sites

Defense Contract Management Administration (DCMA) provides contract administration services for the Department of Defense, other federal organizations, and international partners, and is an essential part of the acquisition process from pre-award to production, sustainment, and closeout. DCMA's mission is to assure that contractor supplies and services are delivered on time, at projected cost, and meet all performance requirements.

DCMA program support is established under DCMA Manual 3101-01, Program Support utilizing a CMO-level support agreement (Memorandum of Understanding or Memorandum of Agreement). DCMA surveillance support is established under DCMA Manual 2303-01 Surveillance.

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. DCMA Instructions provide guidance for a variety of support services with many of these services providing documentation of that support to include:

- Major Program Support and Program Assessment Reports
- Manufacturing and Production Operations
- Quality Assurance Operations
- Government Contract Property Management
- Engineering Surveillance
- Contract Administration and Oversight
- Quality Audits and Product Examination
- Technical Reviews
- Industrial Analysis
- Technical Pricing Support
- Assessment of Financial Stability
- Market Research
- Forward Pricing Rate Agreements
- Supply Chain Management Risk Management
- Integrated Surveillance Plans
- First Article Inspection and Production Lot Testing
- Government Contract QA Surveillance Planning
- Process Review (QA
- Data Collection and Analysis
- Product Examination, Status Reporting, and Capacity Analysis
- Technical Reviews
- Industrial Analysis
- Product Quality Deficiency Report

- Corrective Action Process
- Control of Nonconforming Material
- Evaluating Contractor Effectiveness

Manufacturing and Quality Tasks

- Develop and implement agreements with DCMA, and other Agencies for manufacturing and quality support services:
    - Develop Memorandum of Agreement (MOAs) or Letters of Delegation (LODs) with DCMA for support
    - 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
    - Request DCMA provide supporting rationale for recommendations on the emerging technology maturity
- Assess contractor performance and submit performance reports on:
    - Major Program Support and Program Assessments
    - Integrated Surveillance Plans
    - Data Collection and Analysis
    - Evaluating Contractor Effectiveness
    - Government Contract Property Management
    - Manufacturing and Production Assessment and Surveillance
    - Engineering Surveillance
    - Configuration Management and Engineering Change Control
    - Technical Reviews
    - Industrial Analysis
    - Assessment of Financial Stability
    - Technical Pricing Support
    - Market Research
    - Forward Pricing Rate Agreements
    - Supply Chain Management Risk Management
    - First Article Inspection and Production Lot Testing
    - Government Contract QA Surveillance Planning
    - Process Review (QA)
    - QA Audits
    - Product Examination, Status Reporting, and Capacity Analysis
    - Product Quality Deficiency Report
    - Corrective Action Process
    - Control of Nonconforming Material

- 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
- 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 requests 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 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 makers

Tools

- 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
- 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
- DCMA Industrial Capability Assessment Survey Form
- DCMA Pre-Award Survey
- DCMA Program Support Plan per DCMA-ANX 205-02
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- 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
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD Technology Readiness Assessment (TRA) Guide

D. MANUFACTURING TECHNOLOGY AND INDUSTRIAL BASE

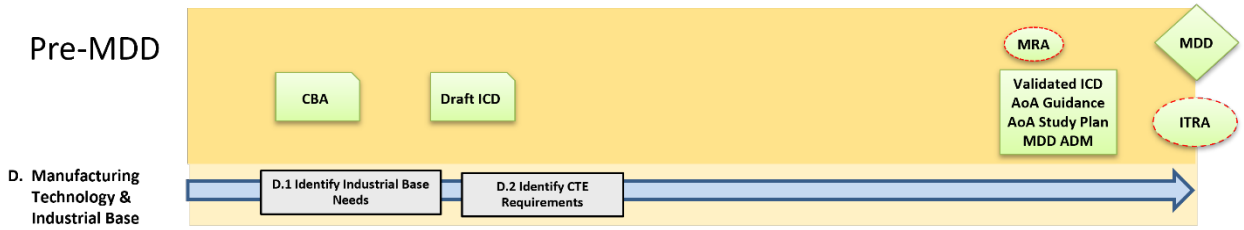


Figure 1-7. Manufacturing Technology and Industrial Base M&Q Activities

Introduction

10 USC Section 4820 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 considerations for 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 (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 (Technology and Industrial Base) will focus on the following sub-threads as required in each phase:

- Industrial Base Assessments (IBAs)
- Industrial Base Risk Management
- Critical Enabling Technologies
- ManTech Projects

D.1 Identify Industrial Base Needs

An industrial capability includes skills, facilities, processes, or technologies needed to design, develop, produce, repair, or maintain products used by the Department of Defense (DoD). Defense industrial capabilities include private and public industrial activities. The DoD needs to conduct industrial base assessments to ensure that the current and future industrial base needs can be met for all acquisition

programs throughout their lifecycle. This analysis includes a look at the capability, capacity, and financial stability and helps guide decision-making and the development and implementation of legislation, policy, and programs.

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 (sole source, foreign source, etc.)
- Support for a resilient supply base for critical defense capabilities
- Support for procurement surges and contractions

As a member of the Systems Engineering IPT, M&Q managers should develop an industrial base assessment or update any previous ones.

Manufacturing and Quality Tasks

M&Q managers, as members of the Systems Engineering IPT, should conduct an industrial base assessment to identify any gaps or shortfalls in the base.

- 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 supports 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

- DCMA Industrial Capability Assessment Survey Questionnaire
- DD Form 2737 Industrial Capabilities Questionnaire
- SF 1405 Preaward Survey – Production
- Defense Industrial Base Assessment Survey OMB 0694-0119
- AoA Study Plan Template
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Numerous M&S models are available that the contractor may use; government should be familiar with these tools

Resources

- 10 USC – Section 4811 National security strategy for national technology and industrial base
- 10 USC – Section 4813 National defense program for analysis of the technology and industrial base
- 10 USC – Section 4816 National technology and industrial base: periodic defense capability assessments
- 10 USC – Section 4817 Industrial Base Fund
- 10 USC – 4919 Modernization of acquisition processes to ensure integrity of industrial base
- 10 USC 4820 National technology and industrial base plans, policies, and guidance
- DFAR Subpart 207.1 Acquisition Plans
- Air Force AoA Handbook
- DCMA-INST 401, Industrial Analysis
- DCMA Instruction 3401, Defense Indusial Base Mission Assurance
- DoDD 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework

- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.85, 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
- ASME Y14.41, Digital Product Definition Data Practices
- MIL-STD-31000B, Technical Data Package
- NISTIR 7749, Model Based Enterprise Technical Data Package Requirements
- Manufacturing Readiness Level (MRL) Deskbook
- Defense Manufacturing Management Guide for Program Managers, Chapter 2 Industrial Base Defense

D.2 Identify Critical Technology Elements (CTEs) Requirements

A technology element is "critical" if the system being acquired depends on this technology element to meet operational requirements (with acceptable development cost and schedule and with acceptable production and operation costs) and if the technology element or its application is either new or novel, or in an area that poses major technological risk during design or demonstration. Said another way, an element that is new or novel or used in a new or novel way is critical if it is necessary to achieve the successful development of a system, its acquisition, or its operational utility.

The acquisition community provides the operational user capabilities. User need and its associated S&T/R&D technical development must be vetted and prioritized before spending limited funding resources on them. When bringing technical development forward, the S&T/R&D community should be aware of the acquisition community's need for a credible cost and schedule baseline and the broadness (or limitations) of the industrial base capable of producing the related operational capability. Some framework is necessary to coherently evaluate and design a successful transition from an S&T/R&D development into acquisition and operational use.

Critical and emerging technologies include equipment, technologies or methodologies that can provide increased performance or capabilities for the warfighter. The Work Breakdown Structure (WBS) can be used to identify CTEs. In addition, Services and Agencies need to develop and implement technology roadmaps to help direct efforts in this area. Technology traditionally looks at:

- Mission Areas (Requirements)
- Functions
- Capabilities
- Technologies

Manufacturing USA and other organizations support the development and advancement of over seven hundred research and development projects focused on advanced manufacturing. In addition, the OSD ManTech program supports research in advanced manufacturing technologies and processes in multiple critical technology areas such as advanced materials, Hypersonics, directed energy, etc. M&Q personnel can support the assessment of critical technologies through the identification of CTEs as early as the Analysis of Alternatives by addressing technology maturity, integration risks, manufacturing feasibility, and technology and manufacturing maturation and demonstration.

- Manufacturing Readiness Level (MRL) 3
- Maturity at end is no greater than MRL 7
- Clear transition and implementation path to warfighter or to the next funding agent

The need for assessing and managing manufacturing technology projects during pre-MDD is dependent on future plans and potential emerging technologies.

Manufacturing and Quality Tasks

- Identify the CTEs and assess the M&Q maturity for the AoA:
  - Assess the WBS or flow diagrams to identify CTE candidates
  - 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 any technical reviews, 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 potential CTE contracting activities (RFP, SSP, etc.) and address M&Q maturation of critical technologies.

Tools

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

Resources

- DoDD 4200.15, ManTech
- DoD Systems Engineering Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- Early Manufacturing and Quality Engineering Guide
- Engineering of Defense Systems Guidebook
- Defense Manufacturing Management Guide for Program Managers, Chapter 8, Technology Development and Investments
- NAVSO P-3687, Producibility Systems Guidelines
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment (TRA) Guide

E. DESIGN

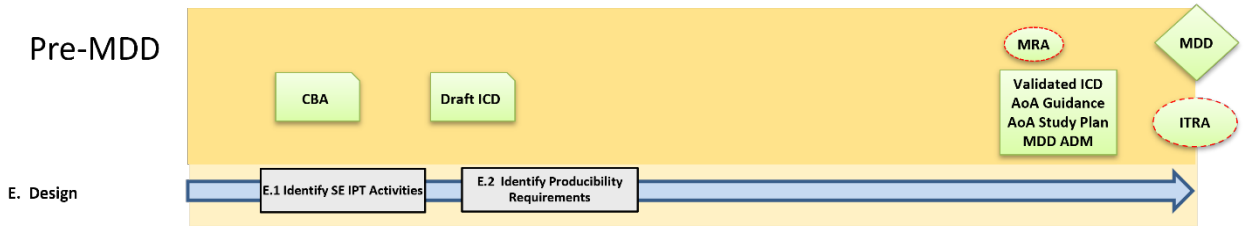


Figure 1-8. Design Manufacturing and Quality Activities

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 sixteen processes: eight technical processes and eight technical management processes. These sixteen 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.

Table 1-1. Systems Engineering Processes

Technical Management Processes	Technical Processes
Technical Planning	Stakeholder Requirements Definition
Decision Analysis	Requirements Analysis
Technical Assessment	Architecture Design
Requirements Management	Implementation
Risk Management	Integration
Configuration Management	Verification
Technical Data Management	Validation
Interface Management	Transition

Systems engineering encompasses many engineering functions and activities to include digital engineering, software engineering, and specialty engineering (Human Systems Integration, Manufacturing and Quality Engineering, Reliability and Maintainability Engineering, Systems Safety Engineering, and Value Engineering). All these activities and functions play a significant role in achieving acquisition outcomes.

Digital engineering is a means of using and integrating digital models and the underlying data to support the development, test and evaluation, and sustainment of a system. The DoD Digital Engineering Strategy provides guiding principles to promote consistency in engineering processes using digital tools, models, and curated data throughout a system's life cycle.

The digital thread allows different acquisition professionals to utilize digital data from various digital products to support the following activities:

- Requirements analysis
- Architecture design and development
- Design evaluation and optimization
- System, subsystem, and component definition
- System, subsystem, and component implementation
  - Production (build prototypes, LRIP, and FRP)
- System, subsystem, and component integration
- System, subsystem, and component verification
- System, subsystem, and component validation
  - Testing (Developmental and Operational)
  - Air worthiness
- Product support and sustainment through disposal
- Cost estimating
- Training aids and devices development

Digital manufacturing initiatives can be used to optimize operations using real-time data and analytics to improve labor efficiency, reduce bottlenecks and machine downtime, decrease inventories, shorten manufacturing cycle times, and improve throughput, reduce the cost of poor quality, and improve forecasting accuracy. Thanks to the Industrial Internet of Things (IIoT), analytics, artificial intelligence (AI), and edge computing, manufacturers can now digitize plant floor operations, processes, and even the products themselves.

The SEP describes the integration of SE activities with other program management and control efforts, including the Integrated Master Plan (IMP), Work Breakdown Structure (WBS), Integrated Master Schedule (IMS), Risk Management Plan, Technical Performance Measures (TPMs) and other documentation fundamental to successful program execution. The SEP also describes the program's technical requirements, engineering resources and management, and technical activities and products as well as the planning, timing, conduct, and success criteria of event-driven SE technical reviews throughout the acquisition life cycle.

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 (Design) will focus on the following sub-threads as required in each phase:

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

E.1 Identify Systems Engineering (SE) Integrated Product Team (IPT) Activities

Systems Engineering (SE) establishes the technical framework for delivering materiel capabilities to the warfighter. It provides the foundation upon which everything else is built and supports program success. SE seeks to ensure the effective development and delivery of capability through the implementation of a balanced approach with respect to cost, schedule, performance, and risk, using integrated, disciplined, and consistent SE activities and processes regardless of when a program enters the acquisition life cycle.

SE processes are used by contractors and Government organizations to provide a framework and methodology to plan, manage and implement technical activities throughout the acquisition life cycle. The practice of SE is composed of sixteen processes: eight technical management processes and eight technical processes. These sixteen processes provide a structured approach to increasing the technical maturity of a system and increasing the likelihood that the capability being developed balances mission performance with cost, schedule, risk, and design constraints.

An IPT is a multidisciplinary group of representatives that includes the lead systems engineer that should ensure that all Specialty Engineering (Reliability and Maintainability (R&M), Manufacturing, Quality, Human Systems Integration (HIS), and System Safety) design considerations are addressed at the enterprise level. SE is typically structured as one or more integrated product teams (IPTs) that assess the interdependence and integration of all design considerations and are collectively responsible for delivering a defined product or process. The IPTs work together to build successful programs, identify, and resolve issues, and make sound and timely recommendations to facilitate decision-making. IPTs are used in complex development programs/projects for review and decision-making. The emphasis of the IPT is on the involvement of all stakeholders (users, customers, management, developers, contractors) in a collaborative forum.

IPTs provide both the Government and developer stakeholders with the opportunity to maintain continuous engagement. This engagement is necessary to ensure a common understanding of program goals, objectives, and activities. These Government/and developer IPTs should further maintain effective communication as they manage and execute activities and trade-off decisions. The program's SE processes should include all stakeholders to ensure the success of program efforts throughout the

acquisition life cycle. The best practice is to establish a Cyber IPT or working group early in the SE life cycle to ensure cyber engineering is integral to all SE processes. For example, performing early and iterative updates for mission-based cyber risk assessments with operational users, developers, engineers, and cyberspace threat emulation (testers) consistently enhances the design and trade-off efforts during the SE process.

There are three types of IPTs:

- Overarching IPT (OIPT): Focuses on strategic guidance, program assessments, and issue resolution.
- Working level IPT (WIPT): Focuses on identifying and resolving program issues, determining program status, and seeking opportunities for improvement.
- Program-level IPT (PIPT): Focus on program execution and may include representatives for both government and industry after contract award.

The digital thread allows different acquisition professionals to utilize digital data from various digital products to support the following activities:

- Requirements analysis
- Architecture development
- Design evaluation and optimization
- System, subsystem, and component definition and integration
- Cost estimating
- Training aids and devices development
- Developmental and operational tests
- Product support and sustainment through disposal
- Air worthiness

As a best practice, the technical team should consider M&Q digital data requirements needed to support product development (life cycle), develop, and implement smart factories, and support value chain management during the development and establishment of the digital thread. Digital engineering along with Industry 4.0, can unlock vast potential across the entire factory network. Additionally, the technical team should consider utilizing DE principles, methods, and tools as defined in the DE Body of Knowledge (DEBoK). The M&Q and other personnel can expect to see digital data in many forms to include:

- Product Lifecycle Management (PLM) provides program and technical managers with the ability to manage end-to-end, design-to-delivery processes using various software tools to access critical (digital) data in real time, not only at the prime contractor but up and down the supply chain.
- A Technical Data Package (TDP) is a technical description of an item adequate for supporting an acquisition strategy, development, manufacturing development, production, engineering, and logistics throughout the item's lifecycle. A TDP consists of applicable technical data such

as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation, and packaging details. Many of today's TDPs are in a digital format providing a product model and other technical information in a standard, trusted, reusable format that can be used by multiple functions and organizations.

- Product Manufacturing Information) is an industry term that provides information about how to manufacture, analyze, inspect, or install a product directly into the 3D CAD model, conveying non-geometric attributes, which is included in a 3D CAD model or file. PMI includes the following:
  - Bill of materials (BOM)
  - GD&T (Geometric dimensions & tolerances)
  - Surface finish
  - Weld symbols
  - Material specifications
  - Metadata & notes
  - History of engineering change orders
  - Legal/proprietary/export control notices
  - Other definitive digital data

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 material approaches to life cycle and technical requirements.
- Identify and evaluate reasonable technologies that can be available in the timeframe available.
- Identify and assess opportunities to promote advanced manufacturing technologies and techniques
- Identify and evaluate opportunities to promote DMSMS resilience and the proactive assessment of parts obsolescence risk when selecting parts.
- Develop and implement formal plans, methodologies, and accepted standards for the use of digital engineering and models throughout the life cycle of a program and integrate these activities into the programs' plans and schedules.
- Support the identification of future design validation and verification activities.
- M&Q personnel should support the assessment of all technical data and all digital artifacts to perform manufacturing data analysis:
  - Design specifications
  - Technical drawings
  - Design documents

- Producibility analysis
- Design optimization
  - Parameter Design
  - Tolerance Design
- Interface documents
- Bills of Material (BOM)
  - eBOM
  - mBOM
- Work Breakdown Structure (WBS)
- Market predictions and Demand analysis
- Material planning
- Production planning
- Manufacturability analysis
- Production work instructions
- Factory floor layout and flow
- Capacity and line balancing
- Quality control
- Fault diagnosis
- Preventive maintenance
- Cybersecurity implementation
- Process optimization
- Energy optimization

Tools

- Acquisition Plan Preparation Guide template
- Capability Development Document (CDD) template
- DCMA-INST-2303 Surveillance
- DCMA Industrial Capability Assessment Survey Form
- Market Research Reporting Template
- Producibility Assessment Worksheet (PAW)
- Pugh Matrix Template
- Design for Manufacturing and Assembly (DFMA)
- Product Lifecycle Management (PLM) is a software tool that includes:
  - Factory Layout Design
  - Plant Layout Design
  - Equipment and Layout Engineering
  - Machining and Tooling Design
  - Factory Simulation
  - Shop Floor Equipment Engineering

  - Ergonomic Simulation
  - Producibility Analysis
- 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
- DoD Market Research Guide
- AS9100, Quality Management Systems – Requirements for Aviation, Space and Defense Organizations
- AS 9103, Variation Management of Key Characteristics
- ISO 9001:2015, Quality Management Program
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896A, Manufacturing Management Program Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoDI 5000.97, Digital Engineering
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H Assessing Defense Industrial Capabilities
- 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
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge
- ASME Y14.5 Dimensioning and Tolerancing
- ASME Y14.41, Digital Product Definition Data Practices
- MIL-STD-31000B, Technical Data Package

- NISTIR 7749, Model Based Enterprise Technical Data Package Requirements
- LCSP memo, Sep 2011
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- Defense Manufacturing Management Guide for Program Managers, Chapter 14.6.3.1 Integrated Product and Process Teams (IPPTs)
- Producibility Systems Guidelines, NAVSO P-3687
- Systems Engineering Plan (SEP) Outline
- DoD Technology Readiness Assessment (TRA) Guide
- TEMP Guide

E.2 Identify Producibility Requirements

Producibility can be defined as a measure of the relative ease of producing a product, more correctly producibility is "…the composite of characteristics, which, when applied to equipment design and production planning, leads to the most effective and economic means of fabrication, assembly, inspection, test, installation, checkout, and acceptance of systems and equipment.

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 of both production and sustainment costs.

Proposed materiel solutions should be assessed for producibility and manufacturability 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.

DOD policy makes producibility risk considerations a requirement in the Acquisition Program Baseline (APB) prior to the start of technology development. Producibility is an important determinant of product cost, due to the impacts on Engineering Manufacturing Development (EMD), Production and Deployment (P&D), and Operations and Support (O&S) costs. Ignoring producibility may lock the acquisition program into design solutions which can only be accomplished at unnecessarily high costs and/or designs which can entail substantial technical, cost and schedule risk.

Producibility planning involves the following major producibility activities:

- Organizing for producibility

- Producibility Planning
- Producibility Engineering
- Process Capability
- Process Measurement and Improvement

Organizing for producibility recognizes that producibility is a design accomplishment resulting from a coordinated effort by engineering specialties such as: design engineers, reliability and maintainability, system safety, human systems integration, manufacturing, quality, test, software, configuration management, and logistics specialists to create a functional design that optimizes the ease and economy of fabrication, assembly, inspection, test, maintenance, and acceptance of the hardware without sacrificing desired function, performance, or quality.

Producibility planning is focused on making a product easier to manufacture. Producibility planning is advanced planning to ensure the design of a part, component, assembly, subsystem, or system is ready for production and optimized to achieve program goals at the least cost. Producibility planning is a continuous process that should begin during the early system concept development and continue through design and manufacturing operations. Producibility plans should be integrated into the Systems Engineering Plan (SEP).

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

Producibility Engineering is not a recognized engineering discipline but is the best practice by which the SE IPT can influence the design and prepare the factory floor to implement the design in the most cost efficient and productive manner. Thus, producibility encompasses the various dimensions of the production environment (manpower, machines, methods and processes, materials, etc.).

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.

Process capability comes from a dedicated effort to create a robust product and process design, and process control activities to include continuous process improvement to identify and remove sources of variation and create a final product that is uniform, defect-free and provides consistent performance and is affordable.

Process measurement and control utilize various measurement techniques (Statistical Process Control, Design of Experiments, Measurement System Analysis, Process Capability Studies, and Lean/Six Sigma, etc.) to reduce lead times, eliminate non-value added activities, reduce variation, and improve efficiency.

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, use of common parts, ease of assembly, simplicity of fabrication, safety, etc.

Production, quality, and manufacturing (PQM) personnel, working for the Program Manager (PM) and supporting the SE process, will ensure manufacturing, producibility, and quality risks are identified and managed throughout the program's lifecycle.

Manufacturing and Quality Tasks

- Identify and conduct an initial assessment of CTEs.
- Identify potential design constraints.
- Assess use of digital data for product modeling for producibility and manufacturability.
- 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 parts selection practices to minimize Diminishing Manufacturing Sources and Material Shortages (DMSMS) risks and impacts
    - Identification of technical risks
- Develop and implement formal digital engineering processes, practices, tools, and guidance into systems engineering IPT activities throughout the life cycle of a program and integrate these activities into the programs' plans and schedules.

- 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.
  - Advanced Product Quality Planning (APQP)
  - Measurement System Analysis (MSA)
- Conduct additional analysis of the following areas as the concepts mature:
  - Technology maturity
  - Industrial base capability
  - Manufacturability
  - Lean/Six Sigma activities
  - 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
- AS9100 Checklist
- AS6500 Checklist
- Systems Engineering Plan (SEP) Outline
- Producibility Engineering and Planning (PEP) Data Item Description
- Manufacturing Producibility Assessment Worksheet (PAWs)
- Design for Manufacturing and Assembly (DFMA)
- Failure Modes and Effect Analysis
- Process Failure Modes and Effects Analysis
- Design Failure Modes and Effects Analysis
- DCMA Industrial Capability Assessment Survey Form
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- CAD/CAM software
- PLM (digital) software tools include:

  - Factory Layout Design
  - Plant Layout Design
  - Equipment and Layout Engineering
  - Machining and Tooling Design
  - Factory Simulation
  - Shop Floor Equipment Engineering
  - Ergonomic Simulation
  - Producibility Analysis
- Fault Tree Analysis
- Quality Function Deployment (QFS) Worksheet
- Preliminary Hazards List
- Pugh Matrix
- Six Sigma and Lean Techniques
- TRA Checklist

Resources

- 10 USC 144B, Sec 2366 and 2448
- DoD Producibility/Manufacturability Guide (Draft)
- NAVSO P-3687 Producibility Systems Guidelines
- NAVSO P-6071, Best Practices for Transitioning from Development to Production
- DoD Manual 4245.7-M, Transition from Development to Production
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-727, Design Guidance for Producibility
- Design for Manufacturability Handbook, Bralla
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- Systems Engineering Plan (SEP) Outline
- DoD Systems Engineering Guidebook, Chapter 5.14.3 Producibility
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning
- NIST Guide to Industrial Control Systems (ICS) Security
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Digital Engineering Body of Knowledge
- ASME Y14.41, Digital Product Definition Data Practices
- MIL-STD-31000B, Technical Data Package
- NISTIR 7749, Model Based Enterprise Technical Data Package Requirements
- AS6500 Manufacturing Management Program

- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9100 Quality Management System
- ISO 9001 Quality Management System
- AS9103 Variation Management of Key Characteristics
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- AIAG Measurement Systems Analysis (MSA) Manual
- MIL-STD-1629A Failure Modes Effect and Critical Analysis
- SAE J1739-202101 Potential Failure Mode and Effects Analysis
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment (TRA) Guide

E.3 Cost/Funding

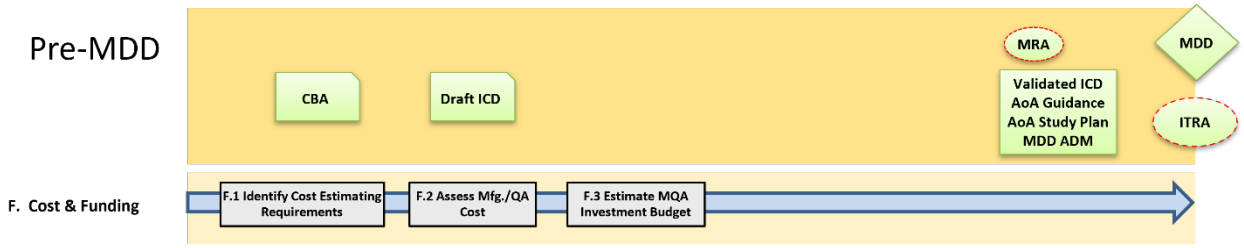


Figure 1-9. Cost and Funding Manufacturing and Quality Activities

Introduction

All Department of Defense (DoD) Military Departments and Defense Agencies (DoD Components) prepare life cycle cost estimates (LCCEs) in support of their acquisition programs. A LCCE attempts to identify all the costs of an acquisition program, from its initiation through disposal of the resulting system at the end of its useful life and to properly phase, or spread, the costs for inclusion in budget submission documents. 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).

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.

A key contributor to a sound cost estimate is an accurate and detailed program definition. There are many formal program documents that address the goals and content of a program (in varying levels of detail depending on the maturity of the program). Cost analysts require a complete and detailed description of the programmatic, performance, technical, and schedule aspects of the program, which should be suitable for any type of cost estimate. The program manager and functional experts throughout the program office are responsible for defining the program. The Cost Analysis Requirements Description (CARD) provides a complete, detailed description of the program baseline prepared by the program office. The CARD represents a snapshot of that program. DoDI 5000.73 requires a CARD for all major capability acquisition programs. The CARD thoroughly describes the programmatic, performance, technical, operational, sustainment, and schedule characteristics of a program, along with some initial supporting data sources, and provides program information necessary to develop a cost estimate.

The program WBS provides a framework for program and technical planning, cost estimating, resource allocations, performance measurements, and status reporting. The WBS should define the total system

to be developed or produced; display the total system as a product-oriented hierarchy composed of hardware, software, services, data, and facilities; and relate the elements of work to one another, as well as to the end product. Major acquisition program offices may tailor a program WBS in accordance with MIL-STD-881. MIL-STD-881 contains appendices with a strawman WBS and dictionary for eleven types of systems down to at least WBS level 3. Elements common to all system are contained in a separate "common elements" appendix. Cost breakouts by WBS elements are useful to the program office and contractors in managing the program.

The Integrated Program Management Data Analysis Report (IPMDAR) is used to measure a contractor's cost, schedule, and technical performance on DoD contracts. The IPMDR is normally prepared monthly and provides current performance data the customer can analyze for early identification of problems that may have significant cost, schedule, or technical impacts for use in making and validating management decisions. The IPMDAR consists of three datasets:

- Contract Performance Dataset (CPD)
- Schedule made up of two items:
  - Schedule Performance Dataset (SPD)
  - Native Schedule (Integrated Master Schedule)
- Performance Narrative
  - Executive Summary
  - Detailed Analysis

This thread (Cost and Funding) requires an analysis of the risk that system development and deployment will not meet the DOD cost and funding goals. This thread (Cost and Funding) will focus on the following sub-threads as may be required in each phase:

- Cost Modeling & Estimating
- Assessment of M&Q Costs
- Preparation of M&Q Budgets
- Development of M&Q Cost Mitigation Plans
- Development and Validation of Learning Curves and Work Measurement

E.4 Identify Cost Estimating Requirements

The Department of Defense (DoD) must spend the DoD budget on the right things, in the right amounts, at the right time. DoD cost analysts play a critical role in this by producing cost estimates that support the planning, programming, budgeting, acquisition, and requirements generation processes. There are numerous laws and regulations that direct the development of cost estimates that support the

acquisition process. The Director of CAPE (DCAPE) has prescribed policies and procedures for the conduct of cost estimation and cost analysis, to include Independent Cost Estimates (ICEs), Analysis of Alternatives (AoA), multiyear procurements (MYP), data collection, etc.

Cost modeling is used when there is insufficient information on actual costs to develop a good estimate. The cost model is a cost estimating methodology called a parametric estimate, which is based on cost drivers and cost estimating relationships. Cost modeling is an advanced statistical model that can be used to provide insight into costs and cost drivers. The cost model may take into consideration various costs that may be incurred and bases the model on one or more independent variables such as performance, speed, weight, etc.

Cost estimating is a blend of art and science to develop a realistic cost forecast of proposed products or services usually based on historical costs. The cost model is what the analyst builds and utilizes to characterize the behavior of the program and produces a credible cost estimate. The cost estimate is a product of the cost model and the cost projection of the subject program, given a set of cost model inputs. Often large programs (e.g., aircraft, tanks, ships, etc.) develop cost models for separate elements of the work breakdown structure, airframe, propulsion, navigation, etc.

Cost estimate type is a function of the program category, events, its purpose, and the organization responsible for its development. The following are broad cost estimate types:

- **Independent Cost Estimate (ICE):** A life-cycle cost estimate is statutorily required for all MDAPs during acquisition and sustainment decision reviews and other significant out-of-cycle reviews such as Critical Nunn-McCurdy breaches. This cost estimate is conducted independently of the Program Office or defense agency by an outside organization.
  - 10 USC 2334 Independent Cost Estimation and Cost Analysis
- **DoD Component Cost Estimate (CCE):** A life-cycle cost estimate developed by one of the Components typically developed by the Component Cost Agency but may be delegated to the Program Office. Required at MS A, B, C, and the FRP decision.
  - CAPE Operating and Support Cost Estimate
  - DoDI 5000.73 Cost Analysis Guidance Procedures
- **Program Office Estimate (POE):** A life-cycle cost estimate developed by the program office and used as a baseline for all subsequent tracking and auditing purposes throughout the life of the program. A program updates its POE as required to capture actual incurred costs to date and refined estimating methods. The program manager uses the POE to support high-level decisions (DoD Component Cost Estimate).
  - DoDI 5000.02 Operation of the Defense Acquisition System (requires a POE in support of program initiation).
  - DoD Operating and Support Cost Estimating Gude
  - DoDI 5000.73 Cost Analysis Guidance Procedures
- **DoD Component Cost Position (CCP):** The CCP is the outcome of the reconciliation between

the CCE and the POE, except for the DON. It serves as the program official cost position from that Component. For the DON, the POE serves as its official cost position, in the absence of a CCP. The DoD is expected to fully fund a program to its cost position under DoD's Full Funding Policy.

- **Cost Capability Analysis (CCA):** An estimate typically developed by the program office to support the program manager in the delivery of cost-effective solutions through deliberate trade-off analysis between operational capability and affordability based on requirements. The CCA uses Multi-Objective Decision Analysis (MODA) to study the trade space between cost and warfighter capability.
  - AFLCMC Standard Process for Cost Capability Analysis
- **Independent Government Cost Estimate (IGCE):** Pertains mostly to services acquisitions, specifically contracts, as mentioned in DoDI 5000.74. It provides a government-developed cost estimate for an individual contract. The analyst conducts an IGCE to check the reasonableness of a contractor's cost proposal and to make sure that the offered prices are within the budget range for a particular program.
  - AFARS 5107.90 Independent Cost Estimates
  - DoD Independent Government Cost Estimate (IGCE) Handbook for Services Acquisition
- **Should Cost Estimate (SCE):** The objective is to proactively target cost reduction through process and productivity improvements. The FAR definition of "should cost" relates to developing a negotiating position for production contracts. The focus is on identifying inefficiencies in contractor production processes and overhead to find areas that could be streamlined or changed to save costs.
  - DFARS 215.407-4 Should-cost review

Work Breakdown Structure and Estimate Structure

The Work Breakdown Structures for Defense Materiel Items (MIL-STD-881D) describes WBS as a consistent and visible framework for product-oriented materiel items and contracts within a defense program. Cost analysts use MIL-STD-881 WBSs as the basis for acquisition cost estimates. M&Q personnel should measure and assess material, labor, and other costs and establish traceability to the work package level of the WBS and assess program progress. The DoD CAPE Cost Estimating Guide provides consolidated information on the cost estimating process and applies to all types of cost estimates.

Cost Estimating Process

1. Define the program to be used to prepare the cost estimate.
2. Identify the basis for the cost estimate to include the scope (level of detail), framing assumptions, ground rules, calendar years to express costs, life-cycle phases to be estimated, level of detail, need for what-if analysis, and anything else that influences how the estimate is performed, as well as the schedule for the completion of the cost estimate.

3. Cost data or elements: Data is the heart of the estimate and must include the identification, validation, normalization, and analysis of quality data influence all of the remaining steps in the cost estimating process.
4. Methods/Models: The selection of the best cost/schedule estimating methods. The estimating methods address a variety of applicable influences such as the effects of weight, volume, and power; quantities produced (learning curve and rate effects); quantities per year; phasing; and many others. The time and availability of data required to implement the method is a consideration when selecting methods.
5. Initial Results and Iterations: The estimate or model now must be validated, and this process could include:
    a. Cross-check: Evaluates the model's results for accuracy at various levels in the estimate by comparing them to the cost and/or schedule of completed projects, or by comparing against the results of a relevant, alternative cost model that applied different data and/or methods.
    b. Sensitivity: Evaluates the model's ability to estimate the impact on total cost by changing a specific cost driver.
    c. What-if Analysis: Tests the model's ability to estimate the impact of changing a variety of cost drivers that define a specific alternative.

Cost Estimating Techniques

- **Expert Opinion:** Relies on the judgment of "experts" and is used when data is insufficient (or inadequate) to use analogous, parametric, or engineering methods. "Expert" opinion is subject to bias and becomes less reliable as complexity increases and the number of "experts" decrease.
- **Analogous:** Relates the cost of a new system to that of technically similar systems for which there is accurate cost and technical data.
- **Parametric**: Uses regression analysis of a database of two or more similar systems to develop cost estimating relationships (CERs) which estimate cost based on one or more system performance or design characteristics (e.g., speed, range, weight, thrust).
- **Engineering**: Is a "bottom up" approach which details costs associated with each part of the acquisition item in contrast to analogous and parametric techniques which estimate acquisition costs in a "top down" manner.

Note: Often a cost estimate for a system may be made be made up of several cost estimating methodologies, especially if the WBS is comprised of some new and some existing technologies. Cost estimates may be required to support the Analysis of Alternatives (AoA), Economic Analysis (EA), Business Case Analysis (BCA), and Source Selection/Proposal Evaluations.

Cost modeling and estimating can occur in every phase where there are costs.

Manufacturing and Quality Tasks

- Support AoA cost estimates
- Support the development and assessment of various cost models:
    - Independent Cost Estimate (ICE)
    - DoD Component Cost Position (CCP)
    - DoD Component Cost Estimate (CCE)
    - Program Office Estimate (POE)
    - Cost Capability Analysis (CCA)
    - Independent Government Cost Estimate (IGCE)
    - Should Cost Estimate (SCE)
- Ensure that the cost estimate includes the following:
    - The cost estimate includes all life cycle costs
    - The technical baseline description completely defines the program, reflects the current schedule, and is technically reasonable.
    - The cost estimate WBS is product-oriented, traceable to the statement of work, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double counted.
    - The estimate documents all cost-influencing ground rules and assumptions and was used as inputs to any sensitivity analysis.
    - Cost documentation shows the source data used, the reliability of the data, and the estimating methodology used to derive each element's cost.
    - Cost documentation describes how the estimate was developed so that a cost analyst unfamiliar with the program could understand what was done and replicate it.
    - Cost documentation discusses the technical baseline description and the data in the technical baseline are consistent with the cost estimate.
    - The cost model was developed by estimating each WBS element using the best methodology from the data collected. Note: Each WBS could have a different estimating methodology.
    - Variances between planned and actual costs are monitored, documented, explained, and reviewed on a regular basis.
    - Cost risk and uncertainty analysis was conducted that quantifies risks and identifies the effects of changing key cost driver assumptions and factors.
- 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
- Review of the Cost Capability Analysis Guide looking at gaps, developmental planning, concepts and AoA:
  - Are the capability gaps prioritized?
  - What is the military value as operational capability is increased (or decreased) for each gap?
  - What tradeoffs between cost, schedule and capability will be evaluated?
  - What is (are) the preferred concept(s)? Is it cost effective? Does it fit within the affordability goals?
  - For the preferred option(s), what are the primary drivers
- Digital engineering models should be used to support cost estimating for development (design), prototyping, production, sustainment, and disposal activities.
- Digital engineering should be used to identify and optimize designs, manufacturing processes and controls, and life cycle cost models.

Tools

- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Cost Analysis Requirements Description Template (CARD) (*See* CAPE website for tools)
- Program Office Estimate (POE) ADDM Template
- Acquisition Requirements Roadmap Tool (ARRT) Cost Estimating Worksheet
- Joint Agency Cost Estimating Development Handbook
- DCAAM 7640.1 DCAA Contract Audit Manual, Chapter 9 Audit of Cost Estimates and Price Proposals
- ONR Cost Proposal Worksheet
- DARPA Cost Proposal Worksheet

- Contract Audit Manual, Chapter 9 Audit of Cost Estimates and Price Proposals
- Earned Value Management (EVM)
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Funds Management Platinum Card
- Analogy and Parametric Estimating Techniques
- Manufacturing Cost Estimating Worksheet
- *See* CAPE website for tools http://www.cape.osd.mil/

Resources

- 10 USC Section 2334 Independent Cost Estimation and Cost Analysis
- 10 USC 2337a Assessment, Management, and Control of Operating and Support Cost for Major Weapon Systems
- 10 USC 2336a, b and c MDAP Submissions to Congress for Milestone A, B and C
- DoD Cost Estimating Guide
    - Department of the Army Cost Analysis Manual
    - AFI 65-508 Cost Analysis Guidance and Procedures
    - DON Cost Estimating Guide
    - Missile Defense Agency Cost Estimating and Analysis Handbook
    - DoD Operations and Support Cost Estimating Guide
- Air Force Life-Cycle Management Center Standard Process for Cost Capability Analysis
- DCMA-INST-213 Technical and Pricing Support
- DCMA-INST-120 Pricing and Negotiation
- DCMA-INST-123 Cost Monitoring
- DCMA-ANX-213-01 Technical Support to Negotiations
- Defense Manufacturing Management Guide for Program Managers, Chapter 9, Manufacturing Cost Estimating
- DoDI 5000.01, The Defense Acquisition System
- DoDI 5000.02 Operation of the Adaptive Acquisition Framework
- DoDI 5000.04 Cost and Software Data Reporting
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.80 Operation of the Middle Tier of Acquisition (MTA)
- DoDI 5000.81 Urgent Capability Acquisition
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.97, Digital Engineering
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Cost Estimating Guide
- DoD Operations and Support Cost Estimating Guide
- Acquisition Requirements Roadmap Toolsuite (ARRT) Cost Estimating Guide, DAU

- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Digital Engineering Body of Knowledge
- Defense Manufacturing Management Guide for Program Managers, Chapter 9 Cost Estimating
- Cost/Schedule Control Systems Criteria Reference Guide
- Guidelines for the Preparation and Maintenance of CARD Tables
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-766, Design to Cost
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Should-Cost and Affordability Memo
- Parametric Estimating Handbook

E.5 Assess Manufacturing and Quality Cost

DoDI 5000.04, Cost and Software Data Reporting (CSDR) requires program management offices (PMS's) for *"managing, overseeing, and executing funding (either appropriated funding or working capital funds) for developing, procuring (either initial procurement or procurement of spares or replacement parts), testing and evaluating, or sustaining a DoD acquisition program at any phase of the lifecycle."*

Services and Agencies are required to assess and manage program costs, schedule, and performance, to identify and mitigate potential problems, and ensure government fiscal responsibility. Cost assessment often begins during the evaluation of contractor proposals and continues post-contract award to monitor contractor performance. Most cost reporting is at level three of the contract work breakdown structure. However, the contractor should have data at much lower levels, but this information is not required for reporting purposes.

CSDR is required on all programs with anticipated expenditures of over $100M and includes the following deliverables:

Table 1-2. CSDR Deliverables

CSDR Deliverables	DID Number	Form Number
Contract Work Breakdown Structure	DI-MGMT-81334D	N/A
Cost Data Summary Report	DI-FNCL-81565C	DD Form 1921
Functional Cost-Hour Report	DI-FNCL-81566C	DD Form 1921-1
Progress Curve Report	DI-FNCL-81567C	DD Form 1921-2
Sustainment Functional Cost-Hour Report	DI-FNCL-81992	DD Form 1921-5
Contractor Business Data Report	DI-FNCL-81765B	DD Form 1921-3
Cost and Hour Report (FlexFile)	DI-FNCL-82162	N/A
Quantity Data Report	DI-MGMT-82164	N/A
Technical Data Report	DI-MGMT-82165	N/A
Maintenance and Repair Parts Data Report	DI-MGMT-82163	N/A
Enterprise Resource Planning Software Development Report	DI-MGMT-82035A	DD Form
Resource Distribution Table	N/A	N/A

Programs, contracts, subcontracts, and agreements for government-performed efforts are required to provide Contract Software Data Report (CSDR) based on all anticipated costs that individually or collectively surpass the corresponding dollar thresholds established in DoDI 5000.73.

Cost analysis encompasses the entire range of activities in the cost estimating process and once a contract is awarded as a way of evaluating program cost performance. Cost analysis includes activities such as sensitivity and what if analysis that are performed on the results of a cost estimate. Cost analysis refers to any effort performed in the support of generating a cost estimate and its documentation. All DoD Military Departments and Agencies prepare life cycle cost estimates and support a variety of cost estimates and assessments. Many of these assessments are used to support program milestones and decision reviews, and to track program progress.

M&Q personnel are routinely called in to support cost assessments and monitoring, and as such need a broad understanding of cost accounting and cost drivers. Given a bill of materials, a manufacturing plan, and contract schedule, M&Q personnel should be able to assess production costs and progress. In addition, M&Q personnel should be able to support the implementation of progress or performance payments.

Manufacturing and quality cost drivers and affordability gaps should be identified and managed. The three primary drivers of production costs are product complexity, rate, and quantity. Product cost includes:

- Direct Materials
- Indirect Materials
- Direct Labor
- Indirect Labor
- Manufacturing Overhead

Integrated Program Management Report (IPMR)

The purpose of the Integrated Program Management Report (IPMR) is to help the Government understand a contractor's cost and schedule performance by communicating a program's cost and scheduling information between the prime contractor and the Government. The report is used to:

- Integrating cost, schedule, and technical performance data
- Identifying potential problem areas that may cause significant cost and schedule variance
- Providing valid, timely, and accurate contract status information

Earned Value Management (EVM)

EVM is used by program managers to assess and manage cost, schedule, and performance. All work is planned, budgeted, and scheduled in time-phased "planned value" increments constituting a cost and schedule measurement baseline. The purpose of EVM is to ensure sound planning and resourcing of all tasks required for contract performance. It promotes an environment where contract execution data is shared between project personnel and government oversight staff and in which emerging problems are identified, pinpointed, and acted upon as early as possible. 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.

EVM is one tool for evaluating M&Q costs. Other tools are available for assessing these costs when EVM is not required.

Assessments of costs should occur in all phases.

Manufacturing and Quality Tasks

Support the assessment of M&Q cost:

- Support the assessment of M&Q Cost based upon the Program Office Estimate (POE), sometimes referred to as Life-Cycle Cost Estimate, as well as other cost estimates and actual costs:
    - Identify how cost estimates were developed (Analogy, Parametric, etc.)
    - Identify M&Q expertise with cost estimating experience
    - Identify M&Q cost drivers

- Assess Program plan and schedule against the Integrated Program Management Report or other contractor scheduling reports.
- Assess the Manufacturing Plan and Schedule.
- Utilize Earned Value Management (EVM) or other cost, schedule, and performance reporting to assess Budgeted Cost of Work Scheduled against Budgeted Cost of Work Performed.
- Utilize Earned Value Management (EVM) or other cost, schedule, and performance reporting to assess Actual Cost of Work Performed:
  - Identify and assess Schedule Variance
  - Identify and assess Cost Variance
- Review and assess Direct Cost:
  - Direct Material
  - Direct Labor
- Review and assess Indirect Cost:
  - Indirect Material
  - Indirect Labor
- Identify and assess Overhead Cost.
- Identify and assess M&Q cost related measures and metrics:
  - Learning curves
  - Work measurement
  - Throughput
  - Capacity utilization
  - Overall equipment effectiveness
- Identify original cost estimate and then compare it to actual cost.
- Support the review and assessment of the following cost documents:
  - Cost and Software Data Report Plan, DD Form 2794
  - Contractor Cost Data Summary Report DD Form 1921, should be viewed to at least the third level of the WBS
  - Functional Cost-Hour Report, DD Form 1921-1
  - Progress Curve Report, DD Form 1921-2
  - Sustainment Functional Cost-Hour Report
  - Contractor Business Data Report, DD Form 1921-3
  - Cost and Hour Report (FlexFile),
  - Technical Data Report
- Identify original cost estimate and then compare it to actual cost.
- Identify M&Q cost drivers of materiel solutions (e.g., proposed materials and process selections that may be inherent).
- Identify M&Q workforce and integration cost requirement implications.
- Digital engineering data should be used to support cost assessments for development (design), prototyping, production, sustainment, and disposal activities.

- Digital engineering should be used to identify and optimize designs, manufacturing processes and controls, and life cycle cost models to support achievement of affordability targets.

Tools

- Cost Analysis Requirements Description (CARD) Template
- DoD Program Office Estimate Template
- Acquisition Requirements Roadmap Tool (ARRT) Cost Estimating Worksheet
- Cost Analysis Requirements Description (CARD) Template
- Earned Value Management System (EVM) Cost Report
- Cost/Schedule Control Systems Criteria (C/SCSC) Reference Guide
- Integrated Program Management Data Analysis Report (IPMDAR)
- Integrated Program Management Report (IMPR) DI-MGMT-81861
- Cost Data Summary Report
- DoD Performance-Based Payments Tool
- Functional Cost-Hour Report
- Progress Curve Report
- Sustainment Functional Cost-Hour Report
- Contractor Business Data Report
- Cost and Hour Report (FlexFile)
- Quantity Data Report
- Technical Data Report
- Maintenance and Repair Parts Data Report
- Enterprise Resource Planning Software Development Report
- DAU Learning Curve Cost Estimator
- Work Measurement Time Study Worksheet, DD Form 2042
- Resource Distribution Table
- NIST Manufacturing Cost Estimating Guide (excel Tool)
- Contract Audit Manual, Chapter 9 Audit of Cost Estimates and Price Proposals
- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Manufacturing Cost Estimating Worksheet
- *See* CAPE website for tools

Resources

- 10 USC Section 2334 Independent Cost Estimation and Cost Analysis
- 10 USC 2337a Assessment, Management, and Control of Operating and Support Cost for Major Weapon Systems
- 10 USC 2336a, b and c MDAP Submissions to Congress for Milestone A, B and C
- FAR 52.232-16 Progress Payments
- FAR 52.232-32 Performance Based Payments

- DoD Cost Estimating Guide
  - Department of the Army Cost Analysis Manual
  - AFI 65-508 Cost Analysis Guidance and Procedures
  - DON Cost Estimating Guide
  - Missile Defense Agency Cost Estimating and Analysis Handbook
  - DoD Operations and Support Cost Estimating Guide
- DCMA-INST-213 Technical and Pricing Support
- DCMA-INST-120 Pricing and Negotiation
- DCMA-INST-123 Cost Monitoring
- DCMA-ANX-213-01 Technical Support to Negotiations
- DoDI 5000.01, The Defense Acquisition System
- DoDI 5000.02 Operation of the Adaptive Acquisition Framework
- DoDI 5000.04 Cost and Software Data Reporting
- DoD Manual 5000.04 Cost and Software Data Reporting
- DoDI 5000.73 Cost Analysis Guidance and Procedures
- DoDI 5000.80 Operation of the Middle Tier of Acquisition (MTA)
- DoDI 5000.81 Urgent Capability Acquisition
- DoDI 5000.97 Digital Engineering
- DODD 5105.84 Director of Cost Assessment and Program Evaluation (CAPE)
- DoD Cost Estimating Guide
- DoD Earned Value Management Implementation Guide
- Cost/Schedule Control System Criteria Reference Guide
- Guidelines for the Preparation and Maintenance of CARD Tables
- Integrated Program Management Data Analysis Report (IPMDAR) Implementation and Tailoring Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 9, Manufacturing Cost Estimating
- DoD Systems Engineering Guidebook
- Digital Engineering Body of Knowledge
- NIST Guide to Industrial Control Systems (ICS) Security
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK 766, Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook

E.6 Estimate Manufacturing and Quality Investment Budget

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).

Budgeting is a planned, disciplined approach to funds management and is a cornerstone of financial resource management. It is the process where planned program objectives are quantified into financial requirements for assigning cost to execute those plans. The budget establishes funding amounts and standards of performance from which to evaluate results. The DoD budget process is the process by which all DoD activities requests and obtain resources to execute the mission. The budget process involves budget formulation and budget execution.

Budget estimates are developed to provide the financial resources needed to improve affordability, reduce risks, mature emerging technologies for insertion and to 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.

M&Q personnel need to focus on developing budgets that support various manufacturing and quality investments and operating expenses for the coming period and phase. Budgets should include an investment strategy that includes long lead funding for capital equipment, facilities, new processes, new materials, workforce development, sustainable manufacturing, supply chains, ManTech, continuous process improvements, and digital engineering efforts such as Industry 4.0 capabilities, etc.).

Manufacturing and Quality Tasks

- Support the development and management of M&Q Budgets:
  - Program budget/estimate
    - Manufacturing budget (direct materials and labor, indirect materials, and labor)
    - Quality budget
    - Investments/Special projects budget (ManTech)
- Estimate investments required for materiel solution approach:
  - Capital equipment (tooling, machines, structures, etc.)
  - Tooling and testing equipment (specialized, environmental, etc.)
  - Inspection equipment and capabilities
  - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
  - Government-furnished equipment (GFE)
- Identify the cost estimating methodology (Analogy, Parametric, Engineering, Actual, Activity-based, etc. used for budget estimates.
- Identify cost drivers:

  - Materials (new, long lead, critical, hazardous, shelf-life, utilization, etc.)
  - Processes or methods (new or untested, expensive, limited, secondary processing, etc.)
  - Manpower (labor skills, training, certifications, availability, utilization, etc.)
  - Machines (utilization, down time, cycle times, set-up times, overall equipment effectiveness rate, etc.)
  - Transportation, inventory, motion, waiting, defects, etc.
  - Inspection and testing requirements
- Identify new or high-risk M&Q processes that require investments as part of a manufacturing feasibility assessment to meet concept requirements:
  - Assess ongoing ManTech, Title III, etc. program investments
  - Identify future ManTech, Title III, etc. program investments
  - Digital engineering models should be used to support cost estimating for development (design), prototyping, production, sustainment, and disposal activities to support budget estimates.

Tools

- DoD Cost Estimating Guide
  - Department of the Army Cost Analysis Manual
  - AFI 65-508 Cost Analysis Guidance and Procedures
  - DON Cost Estimating Guide
  - Missile Defense Agency Cost Estimating and Analysis Handbook
- Manufacturing Cost Estimating Worksheet
- Technology Readiness Level (TRL) Assessment Checklist
- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Manufacturing Maturation Plan

Resources

- 10 USC § 139a – Director of Cost Assessment and Program Evaluation
- DoDD 7045.14 Program Planning Budgeting & Execution (PBBE) Process
- DoD 7000.14-R Financial Management Regulation
- OMB Circular No. A-11, Preparation, Submission and Execution of the Budget
- DoDI 5000.01, The Defense Acquisition System
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.80 Operation of the Middle Tier of Acquisition (MTA)
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.81 Urgent Capability Acquisition
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.97, Digital Engineering

- MIL-HDBK-539, Digital Engineering and Modeling Practices
- DODD 5105.84 Director of Cost Assessment and Program Evaluation (CAPE)
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- AS6500, Manufacturing Management Program
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- DoD Systems Engineering Guidebook
- Digital Engineering Body of Knowledge
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

See CAPE website for guidance http://www.cape.osd.mil/

F. MATERIALS MANAGEMENT

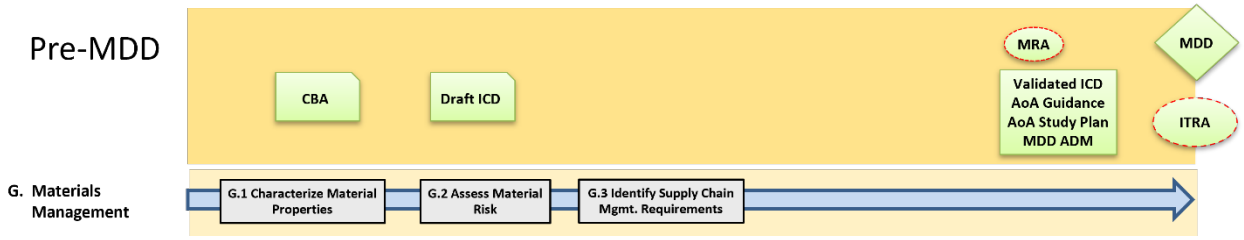


Figure 1-10. Materials Management Manufacturing and Quality Activities

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 throughout the entire supply chain. Materials management will require the characterization of materials and assessment of their 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.

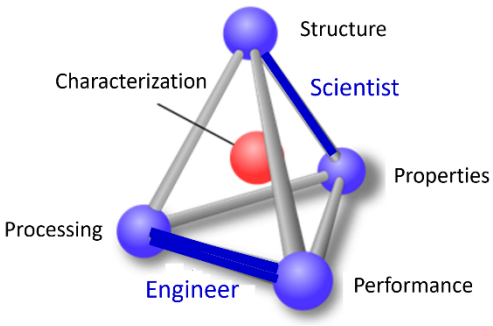
Material Management begins with customer requirements (demand signal), and this information flows throughout the supply chain, from the prime contractor, down many tiers, from raw materials, to fabrication, assembly, test, quality control, distribution and to the customer. The assessment of material requirements will identify the need for any additional research into mature materials and identify the properties, characteristics, and qualities deemed necessary to support the concepts being considered. Material properties, characteristics, and quality will require experiments for validation and assessment for basic manufacturability.

One of the key elements in a successful program is aggressive materials management and planning. Materials management ranges from basic considerations of materials and process properties, material 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 materials risks, issues, and opportunities should be assessed based on contractor data and plans to meet program requirements.

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

- Material Characterization and Maturity
- Assess Material Risks
- Supply Chain Management

F.1 Characterize Materials Properties



Material characterization is the intersection of material science and material engineering. Material characterization attempts to understand the interrelationships between structure, properties, processing, and performance and is often depicted as a "material science tetrahedron." The tetrahedron helps to define the relationship of materials science and engineering with material scientists focusing on structure and properties and materials engineers focusing on performance and processing.

Material Scientist perform studies to understand how materials perform and how they sometimes fail. By understanding the structure of matter, material scientists can create new ways to combine chemical elements into materials with advanced or improved functional properties or performance characteristics. Materials must be able to perform under many different operational conditions which may be tested through simulations, in lab environments, or real-world operational environments. The following is a partial list of properties that should be characterized.

- Mechanical properties include strength, toughness, hardness, ductility, elasticity, fatigue, and creep. Mechanical properties describe how parts will behave when subjected to mechanical loads (forces, moments etc.). In particular, how and when the part will fail (i.e., break, or otherwise change shape/size to go out-of-specification), under different conditions.
- Physical properties include density, specific heat, melting point, thermal expansion, conductivity, electrical and magnetic. Physical properties define the behavior of materials in response to physical forces rather than mechanical. Components must do more than withstand mechanical stress, they may also need to conduct electricity, allow heat to transfer, transmit or block light, etc. Physical properties are important in manufacturing because they often influence process performance.
- Chemical properties include reactivity, oxidation, corrosion, flammability, toxicity, etc. Chemical properties describe how a material or substance can undergo a chemical change or reaction to form new substances (e.g., iron + oxygen = iron oxide or rust).

Material Engineers provide manufacturing solutions to problems using materials developed by material scientists. Material engineers are concerned with all aspects of production to include rate, quantity, costs, production processes, and product quality. They may assess production costs, develop production budgets, assess manufacturing processes, identify areas for production improvement, identify faulty products and develop corrective action plans. Material engineers are often responsible for failure analysis, material properties, and process specifications.

Manufacturing Engineers are responsible for the handling and developing of efficient manufacturing systems and processes that will be used to produce products. They are concerned with all aspects of

production including rate, quantity, costs, production processes, and product quality. They may assess production costs, develop production budgets, assess manufacturing processes, identify areas for production improvement, identify faulty products and develop corrective action plans.

When materials are new and or are not well characterized (understood) then there is a risk that either in production or in the field they will fail. One of the major goals of material characterization is the maturing of the material so that material characteristics and manufacturability are well understood. Material properties, characteristics, and quality may require experiments for validation and assessment for basic manufacturability. In addition to experimentation and testing, material engineers need to assess ongoing performance by reviewing field failures and other reliability data that may indicate problems with either material selection and properties or manufacturing process problems. Design engineers should select materials based on availability, suitability (properties), manufacturing readiness, and cost. Engineers need to be able to make design choices that provide the system with the best performance at the lowest costs.

Manufacturing and Quality Tasks

- Ensure material properties are adequately defined in technical data packages in order to support design, production, and support of items.
- Identify material characteristics against manufacturing processes (casting, forging, welding, soldering, brazing, heat treatment, plating, bonding, riveting, swaging, staking, crimping, painting, bending, rolling, stamping, spinning, etc.).
- Identify material properties against machine processes (turning, milling, grinding, drilling, reaming, broaching, hobbing, cutting, sanding, moulding, machining, etc.).
- Identify material properties for quality (inspection, testing, tolerancing, etc.):
    - Identify and document appropriate metrics for evaluating materials against requirements
- Assess material capability to meet the threshold and objective requirements.
- Identify additional research and development (R&D) and experiments required for materials validation and assessment of basic manufacturability.

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
- DoD Technology Readiness Assessment (TRA) Guide
- TRL Assessment Questionnaire Checklist

- Design for Six Sigma (Tools)
- Design of Experiments Analysis
- Taguchi Loss Function Analysis
- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- Lead Time Estimator
- Manufacturing Maturation Plan
- DMSMS Product Life Cycle Assessment (consult Defense Logistics Agency website)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Rough Cut Capacity Planning
- TRL Assessment Questionnaire

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- AIAG Production Part Approval Process (PPAP) Manual
- SD-19, Parts Management for DMSMS
- 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
- DoD Technology Readiness Assessment (TRA) Guide
- DMSMS Guidebook, SD-22
- ESOH in Acquisition Guide
- ASME Y14.41, Digital Product Definition Data Practices
- MIL-STD-31000B, Technical Data Package
- NISTIR 7749, Model Based Enterprise Technical Data Package Requirements

- ISO 9001, Quality Management System

F.2 Assess Material Risks

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:

- Material availability:
  - Material planning
  - Material metrics
  - Scaling up production
  - Critical materials
  - Make/Buy decisions
  - Parts selection practices
  - DMSMS/Obsolescence
  - Product recalls
  - De-Mil/Shutdown
- Material maturity.
- Material quality:
  - Counterfeit Parts
  - Defective Parts
- Special handling and control.
- Global Risks:
  - Business threats (loss of suppliers)
  - Adversary threats (changing requirements or supply chain disruptions)
  - Material shortages

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. M&Q personnel need to analyze and understand the maturity of material properties, characteristics, process requirements, and quality.

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, difficult to obtain, process, and/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.

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.

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.

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:

- No action (assume the risk)
- 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 a new technology
- Smart shutdown

Advances in material processing such as Additive Manufacturing (AM), defined as “a process of joining materials to make parts from 3D model data, usually layer by layer, also known as 3D printing” are providing organizations with the ability to process materials in small batches and even lot sizes of one to meet emerging needs. ASTM has identified seven processes in the realm of additive manufacturing:

- Vat photpolymerization
- Material jetting
- Material extrusion
- Powder bed fusion
- Binder jetting
- Sheet lamination
- Directed energy deposition

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, DMSMS/Obsolescence, ITAR, anti-tamper, and military vulnerability. The contractor may have proposed alternate materials which 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 prior to future acquisition activities.

Part selection considerations include performance, cost, quality, qualification, reliability, maintainability, supportability, standardization, technology features and life-cycle stage, manufacturing processes and producibility, Diminishing Manufacturing Sources and Material Shortages (DMSMS) risk, system security, cyber weaknesses and vulnerabilities, hardware and software assurance, and supply chain. Organizations need to promote DMSMS resilience through proactive assessments of parts obsolescence risks when selecting parts.

Manufacturing and Quality Tasks

- Assess contractor Make/Buy plans and criteria.
- Assess materials maturity and availability M&Q risks that are:
    - New or critical materials in development
    - Developed in a lab environment, but are not immediately available
    - Readily available within the 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
- Identify the availability of essential raw materials, special alloys, composite materials, and components required to support the concepts being considered.
- Assess material scale-up issues for materiel solutions.
- 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).
- Identify material risks from a Diminishing Manufacturing Sources and Material Shortages (DMSMS) perspective.

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
- Long Lead Times Material Report, DI-PSSS-82201
- Manufacturing Maturation Plan
- Market Research Reporting Template
- Supply Chain Management Risk Assessment Checklist
- 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
- SD-19, Parts Management for DMSMS
- SD-22 Diminishing Manufacturing Sources and Material Shortages
- DoD Technology Readiness Assessment (TRA) Guide
- Supply Chain Operations Reference (SCOR) Model

F.3 Identify Supply Chain Management Requirements

Supply chain management is the management of the flow of the product, information, and money from the procurement of raw materials to the delivery of the final product to the customer and includes the return function when product does not meet user requirements.

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.

Supply Chain Metrics include measurements for procurement, production, transportation, inventory, warehousing, material handling, packaging, and customer service. There are hundreds of metrics that can be used to score Supply Chain Management performance. The following are some of the most common metrics that are used to measure SCM performance:

- Customer facing (satisfaction) can include Perfect Order Fulfillment (Delivered complete, on-time, and in perfect condition), Supply Chain Cycle Time, Order Visibility, Material Readiness and Material Availability, Customer Wait Time, etc.
- Internal facing includes many cost metrics to include supply chain cost, inventory, procurement cost, production cost, transportation cost, warehousing cost, quality cost, and asset utilization.
- DoD metrics often look at Readiness/Sustainment and can include impacts on Mission Capable Rates, Material Reliability, Mean Down Time, Mean Time Between Failure, Mean Time to Repair, and Availability.

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 itself until the component is integrated into the system. Program offices and contractors often make efforts to identify and manage problems at first tier suppliers, 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.

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 into the marketplace. One day there might be 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.

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:
    - 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
- Recommend industry best practices to be followed for management of the supply chain for the concepts being considered:
    - Quality management standards (e.g., ISO 9000, AS9100, etc.)
    - Manufacturing management standards (e.g., AS6500, MIL-HDBK-896, IEEE 15288, etc.)
- Assess the contractor M&Q processes for compliance with or adherence to Company policy, process, and contracts, utilizing DCMA support (if available).
- Identify the best practices for subcontracting and procurement:
    - Make/Buy decisions
    - Supplier qualifications
    - Parts selection
    - Flow down requirements
    - 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

- Bill of Materials
- Make/Buy Decision Tools
- Lead Time Estimator
- DCMA Industrial Capability Assessment Survey Form
- Diminishing Manufacturing Sources and Material Sources (DMSMS) Product Life Cycle Assessment (Consult Defense Logistics Agency (DLA))
- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist), Material Management thread
- Manufacturing Maturation Plan
- Supply Chain Management Risk Assessment Checklist
- Market Research Reporting Template
- Technology Readiness Level Assessment Checklist

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 252.246-7007, 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
- SD-19, Parts Management for DMSMS
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD 4140.01-R, Supply Chain Materiel Management
- DoD Market Research Guide SD-5
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD Systems Engineering Guidebook

F.4 IEEE 15288.2, Technical Reviews and Audits on Defense Programs

- ISO 9001:2015, Quality Management System
- MIL-HDBK-896A Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

- NIST 800-82, Guide to Industrial Control Systems Security

G. PROCESS CAPABILITY AND CONTROL

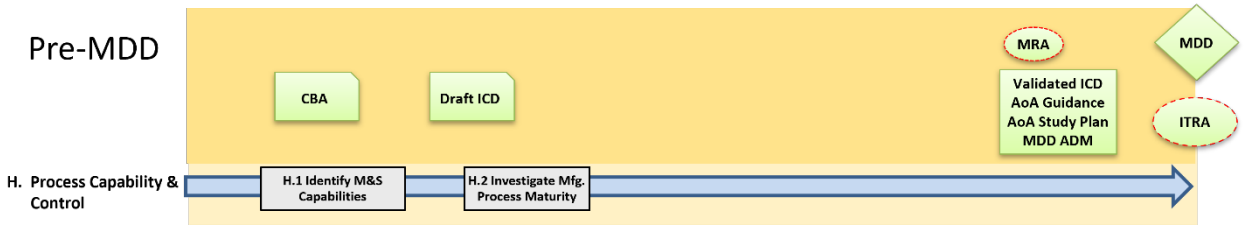


Figure 1-11. Process Capability and Control Manufacturing and Quality Activities

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. M&Q personnel should support the assessment of manufacturing processes in order to determine if those processes are capability and in control. This assessment should include the investigation of process maturity for all key and critical manufacturing processes, and for new or emerging processes. Critical and key manufacturing processes can be identified during the assessment through Modeling and Simulation (M&S) or experimentation.

Process capability and control is a requirement of the AS6500 Manufacturing Management Program standard, AS9100 quality standards, AS9003 Variation Management of Key Characteristics, and AS9138 Quality Management Systems Statistical Product Acceptance Requirements. These standards require a process control plan to describe activities to demonstrate process capabilities. Process capability clarifies the inherent variability of a given process or characteristic. A capability study assesses the ability of a process to meet drawing and specification requirements. 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.

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 the capability metric or target should be.

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. This thread will focus on the following sub-threads as required in each phase:

- Modeling and Simulation (M&S) of Processes
- Process Capability Studies
- Process Yields and Rates
- Process Demonstrations (Maturity)

G.1 Identify Modeling and Simulation (M&S) Process Capabilities

A model is a simplified representation of a system and is used to promote understanding of a real system. Modeling and Simulations (M&S) help analysis to understand and predict the performance of the system. M&S allows researchers to change variables and parameters to identify key variables and to improve the outcome or performance of a system. M&S can be used to virtually evaluate manufacturing methods and procedures – including processes such as production, assembly, inventory, and transportation. This reduces the time and costs that physical testing of a manufacturing system would incur.

Product Lifecycle Management (PLM) provides program and technical managers with the ability to manage end-to-end, design-to-delivery processes using various software tools to access critical data in real time, not only at the prime contractor but up and down the supply chain.

AS6500 requires organizations to analyze their manufacturing processes using M&S techniques to identify potential bottlenecks (constraints), to assess and validate cycle times, conduct resource planning (manpower, machines, tooling, facilities, etc.), and assess process variables that could impact quality or product performance.

Manufacturing M&S software can be used to predict the performance of a planned manufacturing system and to compare solutions for any problems discovered in the system's design. This makes manufacturing simulation a significantly competitive capability – allowing manufacturers to evaluate a range of scenarios before buying tooling, reserving capacity, or coordinating other expensive production resources. By using simulation software to determine exactly what is needed, the manufacturer can avoid problems during production while also reducing scrap and rework.

Advances in digital engineering to include model-based definition, model based system engineering, and industry 4.0 along with continual improvements in computer performance have made it possible to perform comprehensive analysis of virtual parts and to evaluate 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 processing 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.

Product developers that are managing concept development and program offices that will eventually acquire these concepts 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 the 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.

Manufacturing and Quality Tasks

- Support the development of an M&S strategy:
  - Identify and allocate M&S responsibilities (government and contractor)
  - Identify and allocate M&S responsibilities by phase
  - Identify and assess M&S requirements (where can M&S be used to reduce risks?)
- Identify and assess M&S objectives and outcomes:
  - Design
  - Manufacturing and Quality
  - Operations and Sustainment
  - Affordability and Cost Models/Drivers
- Identify and assess M&S tools that make it possible to perform a comprehensive analysis of virtual parts and to assess the capability of processes before actual manufacturing begins:
  - Identify and assess M&S objectives and outcomes
  - Identify and implement M&S contract language and provisions
  - Assess contractors' experience and expertise in program related M&S activities as a part of the source selection process
- 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 and assess opportunities to utilize advanced manufacturing technologies and techniques.
- Identify and assess M&S tools:
  - Producibility Analysis
  - Factory Layout and Resource Allocation
  - Process Planning
  - Material Flow
  - Design and Balance of Assembly Lines

  - Production System Planning
  - Ergonomics
  - Programming Robotics and Automation of Equipment
  - Throughput and Capacity Planning and Optimization
- Identify, assess, and implement M&S programs:
  - Design:
    - Requirements Analysis
    - Functional Architecture
    - Functional and System Definition
    - Interface Management
    - Behavioral Analysis
    - Producibility Analysis
    - Tolerance/Parameter Design
  - Manufacturing and Quality
    - Plant Design
    - Factory Flow Analysis
    - Process Planning
    - Manufacturing Simulation
    - Ergonomic Analysis
    - Tool Design
    - Dimensional Management
  - Operations and Sustainment
  - Affordability and Cost Models/Drivers
- Digital engineering should be used to support process capability studies and follow-on process control activities.
- Identify and implement M&S contract language and provisions.
- Assess contractors' experience and expertise in program related M&S activities as a part of the source selection process.

Tools

- SAE AS9100 Checklist
- SAE AS6500 Checklist
- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- Product Life Cycle Management (PLM) (digital) software tools include:
  - Factory Layout Design
  - Plant Layout Design

  - Equipment and Layout Engineering
  - Machining and Tooling Design
  - Factory Simulation
  - Shop Floor Equipment Engineering
  - Ergonomic Simulation
  - Producibility Analysis
- Design Failure Mode and Effects Analysis Checklist
- Process Failure Mode and Effects Analysis Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Learning Curve Worksheet
- Independent Technical Risk Assessment Checklist
- DI-MSSM-81750 Department of Defense (DoD) Modeling and Simulation (M&S) Accreditation Plan
- DI-MSSM-81751 Department of Defense (DoD) Modeling and Simulation (M&S) Verification and Validation (V&V) Plan
- DI-MSSM-81752 Department of Defense (DoD) Modeling and Simulation (M&S) Verification and Validation (V&V) Report
- DI-MSSM-81753 Department of Defense (DoD) Modeling and Simulation (M&S) Accreditation Report
- 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

- DoD Directive 5000.59, DoD Modeling and Simulation Management
- DoD 5000.59-P, Modeling and Simulation Master Plan
- DoD Modeling and Simulation Related Standards and Best Practices Guide
- Modeling and Simulation Guidance for the Acquisition Workforce
- MIL-STD-3022, DoD Standard Practice Modeling and Simulation Verification, Validation and Accreditation Documentation
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9100, Quality Management System
- AS9103, Variation Management of Key Characteristics
- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- AIAG Production Part Approval Process (PPAP) Manual

- Defense Manufacturing Management Guide for Program Managers, Chapter 14.6.2 Advanced Simulation
- Defense Technical Risk Assessment Methodology (DTRAM)
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 1516, Standard for Modeling and Simulation High-Level Architecture
- DoDI 5000.97, Digital Engineering
- Digital Engineering Body of Knowledge
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Simulation Applications
- Modeling and Simulation Guidance for the Acquisition Workforce

G.2 Investigate Manufacturing Process (Maturity)

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.

Manufacturability is a focus on the factory floor activities (the 5Ms – manpower, machines, materials, methods, and measurement). Manufacturability processes work to improve efficiency with efforts such as Lean manufacturing techniques, theory of constraints, production parts approval process, and advanced product quality planning, Each of these 5Ms need to be matured at the appropriate time and place, and that maturity demonstrated. Manufacturability is an important consideration early on in the eight systems engineering technical and eight technical management processes.

The process reliability and effectiveness of a product (with respect to key and critical characteristics) prior to inspection (by contractor/subcontractor) is determined by the maturity of a process and the ability to provide defect free product on the first production pass.

Immature processes are a major source of risks on acquisition programs, especially during the EMD phase when the design is maturing and most production is just emerging and starting to mature. As a program moves forward, process maturity takes on greater importance. DoDI 5000.88 requires that manufacturing readiness and risks be assessed and documented in the Systems Engineering Plan (SEP) and manufacturing and quality risks be identified and managed throughout the programs lifecycle.

Process demonstrations provide a way of analyzing and ensuring that manufacturing processes mature at an acceptable time based on the acquisition phase. Process demonstrations are able to reflect the design intent for achieving technical performance goals while remaining repeatable and affordable.

Process Demonstrations include the identification of key and critical manufacturing processes and actual demonstration of product performance and adherence to technical requirements (engineering drawings) within product and process parameters.

During pre-MSA phase M&Q personnel should identify new and emerging manufacturing processes that will need to be demonstrated at some level. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes.

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

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
- Assess the status of risks from previous demonstrations of M&Q processes 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)
    - Work instructions and processes (e.g., cleaning, heat treating, ESD protection, clean rooms, etc.)
    - Human factors (i.e., noise, vibrations, ergonomics)
    - Materials and components
    - Environmental Safety and Occupational Health (HAZMAT, Safety, security, etc.)
    - Environmental conditions (i.e., temperature, humidity, air quality)
    - Tooling and test equipment
    - Capability to meet the cost, schedule, and performance requirements
    - Estimates of manufacturing costs
    - Manufacturing key performance indicators (OEE, cycle times, takt time, yields, rates, etc.)
- Assess risks, issues, and impacts of the manufacturing environment on M&Q processes and develop recommended mitigation plans for both the contractor and the supply chain.
- Collect data from process demonstrations and production of components and items in the appropriate manufacturing environment throughout the supply chain to support verification, validation, and authentication of M&S for that phase:
    - Ensure data is under configuration control

- Update status of the comprehensive M&Q Plans based on demonstrations of M&Q processes for the appropriate manufacturing environment:
  - 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 MRL assessments as required in support of program office decisions:
  - System-level target should utilize MRL criteria and metrics at the appropriate level for that phase
  - Subsystem, item, and components targets should utilize MRL criteria and metrics for that phase
- Identify any manufacturing implications in order to address potential manufacturing shortfalls and identify opportunities for advancing manufacturing products and processes.
- Address manufacturing implications during basic and applied research to address manufacturing shortfalls and opportunities.
- Identify new and emerging manufacturing concepts and processes in order to assess manufacturing feasibility and risks.
- Assess feasibility of similar materials and/or similar manufacturing process approaches, and the projected gaps.
- 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
  - Implementation of Lean/Six Sigma activities
  - Anticipated M&Q risks and potential cost and schedule impacts
  - Establish plans for identifying critical manufacturing processes and their continuous improvement
- Consider the need for:
  - Process Capability Studies
  - FMEA Templates (DFMEA and PFMEA)
  - Assessment of yield rates
  - Use of quality tools (SPC, Histograms, Cause and Effect Diagrams, etc.)

- Collection and analysis of quality data

Tools

- AS9100 Checklist
- ISO 9001 Checklist
- AS9145 Checklist
- AS6500 Checklist
- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- Feasibility Study Checklist
- Cause and Effect Diagram
- Cost of Quality Estimates
- First Pass Yield Estimates Worksheet
- Pareto Analysis
- Histograms
- FMEA Templates (DFMEA and PFMEA)
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Studies (Cp and Cpk assessment)
- Statistical Process Control Charts
- Producibility Assessment Worksheet (PAW)
- Six Sigma Worksheet

Resources

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- AS9100, Quality Management System
- AS9103, Variation Management of Key Characteristics
- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program
- ISO 9001, Quality management systems – Requirements
- ISO 17025, Testing and Calibration Labs
- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook

G.3 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
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook

H. QUALITY MANAGEMENT

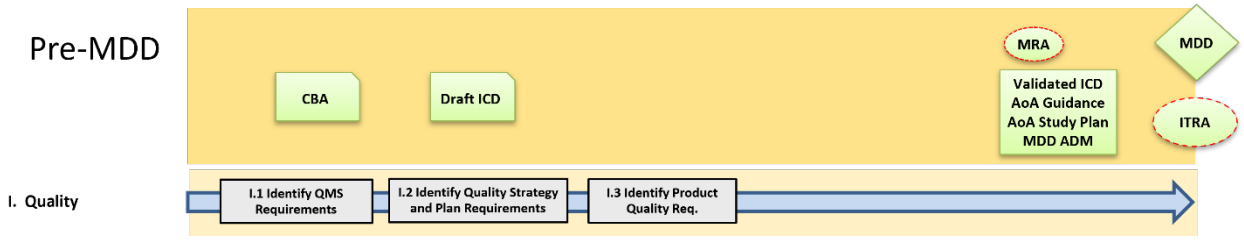


Figure 1-12. Quality Management Manufacturing and Quality Activities

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 a 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 Quality Management System (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.

Quality management is an integral part of design and development efforts. Most DoD programs require contractors to implement a basic quality management system such as ISO 9001, Quality Management Systems–Requirements or AS9100, Quality Management Systems–Requirements for Aviation, Space and Defense Organizations.

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 their internal processes, procedures, and standards.

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:

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

H.1 Identify Quality Management System Requirements

The DoD relies on organizations to provide the warfighter (customer) with weapon systems that reflect the critical dimensions of quality (performance, reliability, durability, serviceability, and availability) and are affordable. Defect-free products are a result of an organization implementing a quality management system that directs and controls internal and external activities directed at supporting the acquisition and systems engineering processes. DoD contractors and production organizations need to implement an efficient and effective quality management system in order to provide products and services the warfighter needs. In addition, the program manager needs to regularly review, assess, and evaluate these management systems to ensure the adequacy of contractor implementation.

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. All organizations, including the supply chain, need to develop, implement, and manage 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.

The Quality Management System (QMS) is defined as a formalized system that documents processes, procedures, and responsibilities for achieving quality policies and objectives. A QMS helps coordinate and direct an organization's activities to meet customer and regulatory requirements and improve its effectiveness and efficiency on a continuous basis. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

The QMS needs to demonstrate the ability to consistently provide products that meet customer requirements, as well as statutory and regulatory requirements. The goal is to satisfy the customer through the application of organizational policies and practices, including the process for improvement of the system.

M&Q personnel need to 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 52.246.11 Higher-Level Contract Quality Requirements. Best practices should see 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 need to support the assessment of a contractor's QMS and ensure that the requirements for a QMS are passed down in contracts through the supply chain and that the prime contractor is evaluating the contractor's control of subcontractors.

Manufacturing and Quality Tasks

- Identify and ensure an appropriate QMS is put in the contract.
- 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
- Support the assessment of a contractor's QMS and ensure that the requirements for a QMS are passed down in contracts through the supply chain and that the prime contractor is evaluating the contractor's control of subcontractors.
- Specify the contract quality management requirements to be met by the contractor or government entity as appropriate:
    - Ensure contract quality requirements are flowed down to subcontractors and vendors
- 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 for the following:
  - Understanding the Organization and its Context
  - Assess the QMS
  - Develop and Implement a Quality Policy
  - Establish Management Roles and Responsibilities
  - Ensure Leadership Commitment
  - Develop and Implement a Quality Systems and Quality Manual (AS9120)
  - Conduct Internal Quality Audits
  - Conduct Training
  - Measure and Customer Expectation and Satisfaction
  - Develop and Implement Support (Resources, Competence, Awareness, Communication, etc.)
  - 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:
  - Contractors Measurement System by conducting Measurement System Analysis (MSA) evaluates measurement instruments, inspection equipment, and test methods to understand the integrity of the inspection and quality data and the uncertainty and error resulting from the measurement system.
  - 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 with 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
- Evaluate the contracts and appropriate agreements with other agencies, e.g., the DCMA to ensure quality and manufacturing requirements are included.
- Request DCMA support and assistance to assess adequacy and completeness of contractor and supply chain QMSs application to system, subsystems, items, and components.
- Ensure that the QMS evaluation of potential contractors and suppliers for each concept being considered includes DCMA input.
- Ensure the organization is striving for continuous product and process improvement using proven Lean/Six Sigma concepts, tools, and practices

Tools

- AS9100, Quality Audit Checklist
- ISO 9001, Quality Audit Checklist
- Quality Management Plan
- Manufacturing Maturation Plan
- Interactive MRL Users Guide (Checklist), Quality Management thread
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Manufacturing and Quality Assurance Status Report DI-QCIC-82323
- Quality Status Report DI-MGMT-82186
- Quality Program Plan (QPP) DI-QCIC-81722
- Quality Management System (QMS) DI-MGMT-82184
- Quality Engineering Inspection Requirements and Equipment List DI-QCIC-80756A

- Quality Assurance Program Plan DI-QCIC-81794
- Quality Assurance Provisions (QAP) DI-SESS-80789A
- Critical to Customer Assessment
- Critical to Quality Tree

Resources

- AS9100, Quality Management System (QMS) – Requirements for Aviation, Space, and Defense Organizations
- ISO 9001, Quality Management System (QMS) – Requirements
- FAR 46.202 Types of Contract Quality Requirements
- FAR 52.246-11 Higher-Level Contract Quality Requirements
- DoDI 5000.88, Engineering of Defense Systems
- AFMC Instruction 63-145, Manufacturing and Quality
- AFMC Instruction 63-501, AFMC Quality Assurance
- AFLCMC Manufacturing and Quality Assurance Acquisition Process Deskbook
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- Digital Engineering Body of Knowledge
- IEEE 15288, Best Practices for Using Systems Engineering Standards
- IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- Defense Manufacturing Management Guide for Program Managers, Chapter 5.3.5.1 ISO 9001/AS9100
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook

H.2 Prepare Initial Quality Strategy and Plan

Strategies play an important role in establishing the overall value of an organization and set the framework and strategic vision and goals that direct the activities of the organization and its employees. The Acquisition Strategy is a comprehensive, integrated plan developed as part of acquisition planning activities. It describes the business, technical, and support strategies to manage program risks and meet program objectives.

Just as an Acquisition Strategy identifies and describes the acquisition approach a program office will follow to manage a specific program to meet program goals, a Quality Strategy is used by organizations to set the overall value of quality in meeting organizational goals.

Quality Strategies involve leadership, strategic planning, a customer focus, efficient utilization of the workforce, an operational focus, and be results oriented. Quality strategies should be aligned with

corporate strategies, with quality being a major enabler of corporate success and the achievement of the following dimensions of Quality (Performance, Features, Reliability, Conformance, Durability, Serviceability, Aesthetics, and Perceived Quality).

M&Q managers support the development and updates to the Acquisition strategy by providing their input into the Systems Engineering Plan (SEP). Quality Assurance managers can look at FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as 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 the success of a program.

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 describes 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. Product or service quality is achieved through the development, implementation and updating of the following plans that can support the 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. Quality plans are a component of the Acquisition Strategy, Systems Engineering Plan, and program plans. Contractor activities 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.

Contractor or organizational quality plans may be developed during the earliest phase of contract performance. Contractors will conduct a complete review of the requirements of the contract to identify, and make timely provision for the special controls, processes, test equipment, fixtures, tooling, and skills required for assuring product quality. This initial planning will recognize the need and provide for research, when necessary, to update inspection and testing techniques, instrumentation and correlation of inspection and test results with manufacturing methods and processes. Planning will also provide appropriate review and action to assure compatibility of manufacturing, inspection, testing and documentation.

Planning is an important aspect of any organization and the Systems Engineering Plan (SEP), which provides the foundational engineering approach for all technology-based programs. The SEP should include manufacturing and quality plans.

Quality Planning should be accomplished by both the contractor and the government and should address the following:

- Management Quality Philosophy
- Management Quality Structure to include the identification of roles and responsibilities (Program Office, DCMA, Contractor, etc.)
- Quality System Procedures and Controls to include Memorandums of Agreement
- Project or Program Surveillance Plan
- QA Data Collection and Analysis
- QA Risk Identification, Analysis, Mitigation, and Monitoring

Many organizations focus on Lean Manufacturing for improving manufacturing efficiency by eliminating waste, including reducing lead times and eliminating non-value-added processes—thus improving ease of manufacture and quality. Seven commonly identified types of waste include: transportation, inventory, motion, waiting, overproduction, over-processing, and defects, commonly referred to as TIMWOOD. Some organizations include wasted skills, talent, or human potential as an eighth category of waste. To reduce waste, Lean manufacturing tools summarized in can be applied throughout manufacturing operations to enhance producibility and manufacturability.

M&Q personnel need to support the development and implementation of QA strategies and plans and continually assess contractor quality plans and implementation of those plans.

Manufacturing and Quality Tasks

- Review and update the program's Quality Strategy (Government and Contractor):
  - The Quality Strategy should be developed to link corporate goals and objectives with operations, customer requirements, regulatory requirements, growth, and innovation
  - Quality strategies should outline the following based on AS9100 or other industry best practice:
  - Vision and Leadership Commitment
  - Goals and Objectives
  - Management Responsibilities
  - Resource Management (Allocation and Use)
  - Product realization requirements (e.g., risk management, design, and development, purchasing, etc.)
  - Risks, issues, and opportunities
  - Measurement, analysis, and improvement requirements
  - Supply Chain Requirements
  - Strategic Tradeoffs

  - The Quality Strategy should identify contract quality requirements per FAR 52.246 Contract Quality Requirements
  - The Quality Strategy should establish quality performance metrics that are tied to Key Performance Parameters, Key System Attributes, Measures of Performance, and Technical Performance Measures
  - The Quality Strategy should identify and implement and internal audit program
  - The Quality Strategy should identify and establish appropriate agreements, delegations, and contracts with other agencies, e.g., DCMA, throughout the supply chain
- Identify best practice business quality strategies that address the following areas:
  - Customer Focus
  - Benchmarking
  - Continuous Improvement
  - Process Approach
  - Engaged Workforce
  - Evidence-based Decision Making
  - Periodic Audits
- Provide the Quality Management Strategy with appropriate language and references for inclusion in the Acquisition Strategy and the SEP.
- Ensure quality plan addresses the following areas:
  - Contract Review
  - Resource Identification and Allocation
  - Product Realization
  - Product Acceptance Plan and Procedures
  - Quality Checklists
  - Process Controls
  - Process Improvement Plan
  - Quality Performance Objectives and Metrics
  - Baseline Metrics and Goals
  - Servicing
  - Request for DCMA Support
- Review and update the programs and contractor's Quality Plan:
  - Review and evaluate contractors advanced product quality planning processes
  - The Quality Plan should establish quality performance metrics that are tied to Key Performance Parameters, Key System Attributes, Measures of Performance, and Technical Performance Measures
  - The Quality Plan should identify and implement and internal audit program
  - The Quality Plan should address the use of continuous improvement tools and techniques
- The Quality Plan may also be involved in the following:
  - 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
- 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 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
- Draft an initial program Quality Management Plan for incorporation into the SEP that includes details from the analyses.

Tools

- Acquisition Strategy Outline
- Acquisition Strategy Template
- Acquisition Strategy Building Blocks on Major Acquisitions – DAU
- Systems Engineering Plan (SEP) Outline
  - Manufacturing Plan
  - Quality Assurance Plan
- AS9100 Quality Audit Checklist
- ISO 9001, Quality Audit Checklist
- Manufacturing Maturation Plan
- Quality Management Plan
- Interactive MRL Users Guide (Checklist), Quality Management thread
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Manufacturing and Quality Assurance Status Report DI-QCIC-82323
- Quality Status Report DI-MGMT-82186

- Quality Program Plan (QPP) DI-QCIC-81722
- Quality Assurance Program Plan, DI-QCIC-81794
- Quality Management System (QMS) DI-MGMT-82184
- Quality Engineering Inspection Requirements and Equipment List DI-QCIC-80756A
- Quality Assurance Program Plan DI-QCIC-81794
- Quality Assurance Provisions (QAP) DI-SESS-80789A
- Critical to Customer Assessment
- Critical to Quality Tree

Resources

- 10 USC 2431a. Acquisition Strategy
- FAR Part 7.105 Contents of Written Acquisition Plans
- Acquisition Strategy Guide (DSMC)
- Acquisition Strategy Guide (NAVSEA)
- AS9100, Quality Management System – Aerospace
- ISO 9001 Quality Management System (QMS) – Requirements
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- FAR 46.202 Types of Contract Quality Requirements
- FAR 52.246-11 Higher-level Contract Quality Requirements
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- AFMC Instruction 63-501, AFMC Quality Assurance
- AFLCMC Manufacturing and Quality Assurance Acquisition Process Deskbook, Chapter 4.7 Document the Quality Strategy in a Program Quality Plan
- DoD Systems Engineering Guidebook
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program
- Early Manufacturing and Quality Engineering Guide
- IEEE 15288, Best Practices for Using Systems Engineering Standards
- IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5.2 Quality Planning and Approach
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- DCMA-MAN-2303-02 Surveillance Planning
- DCMA-INST-219 Supplier Risk Management
- DCMA-INST-302 First Article and Production Lot Testing
- DCMA-INST-309 Government Contract QA Surveillance Planning

- DCMA-INST-311 Process Review
- DCMA-INST-322 QA Audits
- DCMA-INST-323 Data Collection and Analysis
- DCMA-INST-324 Product Examination
- DCMA-INST-1201 Corrective Action
- DCMA-INST-1207 Effective Control of Nonconforming Material

H.3 Identify Product Quality Requirements

Quality of Conformance is the degree to which a product or service meets or exceeds its design specifications and is free of defects or other problems that could degrade its performance. The manufacture, processing, assembling, finishing, and review of the first article and first production units, is where failure or success in quality of conformance is first measured. Any operation which causes the characteristic to be outside of the specified limits is nonconforming and this could impact cost, schedule, and performance.

Quality Control is the inspection aspect of quality management and consists of inspection, testing and quality measurements that verify that the product deliverables conform to specification, is fit for purpose and meet stakeholder's expectations. Quality control techniques are varied and driven by the nature of the product. Product inspections and tests that are done to check whether a product meets its specification are the most obvious form of QC. The inspection and test methods used depends on the technical nature of the product being developed. These methods could include product and process inspection, First Article Inspection, First Article Testing, Production Lot Testing, Qualification Testing, and Production Qualification Testing.

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.

Product Quality begins with quality planning, which should provide the assurance that the QMS can achieve its intended results and involves the identification of methods to verify product quality (measurement) that meets the customers' requirements. Product Quality then extends to Quality Assurance, Quality Control, and finally Continuous Improvement.

Quality planning begins by determining the requirements or stakeholder expectations for:

- Personal and product safety
- Producibility and Inspectability

- Measurement systems
- Process for acceptance of products and services
- Process for dealing with Nonconforming Material (NCM)
- Continuous improvement
- Reliability, Availability, and Maintainability
- Suitability of parts and materials used in the product
- Product obsolescence
- Packaging, Handling, Storage, and Transportation (PHS&T)
- Disposal at the end of its useful life
- Note: In many cases these expectations can be expressed as a metric or a goal.

Manufacturing and Quality Tasks

- Develop the planning for product realization, quality processes, product quality, and supply chain quality including:
    - Identify role(s) of Government (Program Office and DCMA) and contractor (including supply chain)
    - Inspection and testing (receiving, In-process and final) at prime and throughout the supply chain
    - Analysis of Measurement Systems
    - First Article Inspections (FAIs) and First Article Tests (FATs) at the system, subsystem, and component level
    - Qualification, approval, and removal processes for suppliers, monitoring and tracking of supplier performance, and periodic reassessment
    - Identify product quality metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Identify and evaluate product quality requirements:
    - 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 (Statistical process controls, rates, and yields) and management of same
    - Process control plans for variability reduction
    - Statistical control of process capabilities (i.e., $C_{p,}$ $C_{pk,}$ $P_{p,\text{ and }}$ P_{pk})
    - Production process verification
    - Measurement traceability (metrology and calibration) to approved standards

  - 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

- Assess contractor and supply chain 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
  - Identify and manage certification requirements (manpower, machines, processes, etc.)
  - All quality instructions, sequencing, in-process tests, and test procedures (including those in work instructions)
  - Control of data and records, data storage, management, and security (physical and cyber)
  - Quality model and simulations
  - 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
  - Management of environmental, safety, occupational health, transportation, storage, etc.
  - Management of COTS items, GOTS items, and NDIs
  - Management of Government Furnished Equipment/Government Furnished Property (GFE/GFP)
  - 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 on schedule and performance)
  - Quality of materials' sources and selections

- Identify and manage Quality in Design:
  - Establish, implement, and maintain a design and development processes
  - Identify key and critical characteristics
  - Conduct design reviews and associated verification and validation activities
  - Support the requirements process to include the allocated and functional designs
  - Ensure Geometric dimensioning and tolerancing (GD&T) is a system used by engineers and manufacturers for defining and communicating engineering tolerances

- Metrology and Calibration (Tooling, Test, and Inspection Equipment):
  - 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
  - Assess contractor implementation of a Measurement Systems Analysis program to evaluate the integrity of their inspection system and overall measurement system
    - Include an evaluation of any Gage R&R efforts
- Conduct and manage quality audits at primes and subcontractors.
- Develop and execute a quality improvement plan/program:
  - Assess contractor implementation of any Lean/Six Sigma activities to improve overall performance and quality
  - Continuous manufacturing surveillance and effective metrics to monitor, evaluate, verify, improve processes, and prevent defects
  - Utilization of processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
  - Predictive indicators to provide early detection of potential quality problems
  - Continuous process improvement results
- 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
  - AS9102, First Article Inspection Checklist
  - AS9103, Variation Management of Key Characteristics Checklist

  - AS9133, Qualification Procedure for Aerospace Parts Checklist
  - AS9134, Supply Chain Management Guidelines Checklist
  - AS9136, Root Cause Analysis and Problem-Solving Checklist
  - AS9138, Statistical Process Acceptance Checklist
  - AS9145, Advanced Product Quality Program/Production Part Approval Process Checklist
- ISO 9001, Quality Management Systems, Quality Audit Checklist
- Critical to Customer Assessment
- Quality Management Plan Template
- Critical to Quality Tree
- Lot Acceptance Testing Calculator
- Control Charts (Attributes and Variables)
- QA Surveillance Template
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist), Quality Management thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- AS9100, Quality Management System
  - 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-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program
- ISO 9001, Quality Management Systems
- ISO 17025, Testing and Calibration Labs
- Defense Manufacturing Management Guide for Program Managers, Chapter 5.3.5.1 ISO 9001/AS9100
- AS6500, Manufacturing Management Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- ASME Y14.5 Dimensioning and Tolerancing
- AIAG Measurement Systems Analysis (MSA) Manual
- SAE J1739 Potential Failure Mode and Effects Analysis (Design FMEA, Process FMEA)

- AIAG APQP Manual
- AIAG Measurement Systems Analysis (MSA) Manual
- IAQG Aerospace APQP Manual
- ASME Y14.5 Dimensioning and Tolerancing
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- 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
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
    - Manufacturing and Quality Assurance Status Report DI-QCIC-82323
    - Manufacturing Nonconformance Material Report DI-MGMT-891137
    - Quality Status Report DI-MGMT-82186
    - Quality Program Plan (QPP) DI-QCIC-81722
    - Quality Management System (QMS) DI-MGMT-82184
    - Quality Engineering Inspection Requirements and Equipment List DI-QCIC-80756A
    - Quality Assurance Program Plan DI-QCIC-81794
    - Quality Assurance Provisions (QAP) DI-SESS-80789A

I. MANUFACTURING WORKFORCE

Figure 1-13. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

M&Q Workforce requirements, planning, and analysis cover a wide range of knowledge, skills, and abilities from a competency perspective. In addition is the concern over workforce availability as many companies face serious 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 numbers of types of materials. Leading the M&Q effort at many industrial organizations are the M&Q professionals with degrees in Industrial Engineering, Manufacturing Engineering and Quality Engineering. Most of these workforce requirements belong to the contractor and M&Q program personnel need to be aware of these activities and provide oversight as part of their assessment of risks and management of those risks.

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) requires the assessment of the required skills and availability in required numbers of personnel to support the manufacturing effort. This thread (Workforce) will focus on the following sub-threads as required in each phase:

- Workforce Requirements Planning
- Workforce Management
- Workforce Risks and Availability

I.1 Identify Manufacturing Workforce Requirements

Contractor workforce requirements planning provides quantitative inputs to program planning. Workforce planning should align the skills and workforce numbers required to the scope of the technical effort required while program office personnel monitor these requirements. Workforce Planning is the process of analyzing, forecasting, and planning workforce supply and demand, assessing gaps, and determining target talent management interventions to ensure that an organization has the right people - with the right skills in the right places at the right time - to fulfill its mandate and strategic objectives. Workforce planning should address the following items to determine the scope of the M&Q workforce requirements required to develop, produce, field, and sustain the system:

- Strategic Direction: Understand the business and its direction
- Demand Analysis: Assess current and future workforce demands (forecasting how many workers are needed, and their competencies based on sales or production demands)
- Supply Analysis: Understand labor markets, trends, and planning for changes over time (look at the existing market to see how many workers are available)
- Gap Analysis: Identify skills gaps between demand and supply
- Solution Identification and Management: Identify ways to close the gaps between Demand and Supply
    - Recruitment and retention
    - Develop training and development programs
- Monitor and Manage Workforce Requirements

Workforce requirements should be based on current manufacturing competency models, such as the Aerospace Industry Competency Model. This model addresses several competency areas:

- Management Competencies
- Specific Occupational Competencies (welding, machining, etc.)
- Sector Competency Requirements (shipbuilding, ground systems, aircraft, missiles and space, radar and electronics, munitions, soldier systems, etc.)
- Workplace (teamwork, planning and organizing, innovation, problem solving, decision making, business, quality, tools, and technology)
- Academic (reading, writing, mathematics, science, engineering, communication, analytical thinking, and computer skills)

M&Q Workforce requirements, planning, and analysis cover a wide range of knowledge, skills, and abilities from a competency perspective. In addition is the concern over workforce availability as many companies face serious 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 numbers

of types of materials. Leading the M&Q effort at many industrial organizations are the M&Q professionals with degrees in Industrial Engineering, Manufacturing and Quality Engineering.

M&Q personnel need to support the identification of workforce skills, training, and availability requirements based on the identified factory floor processing requirements (manpower). The need for accessing and managing workforce requirements during the various acquisition phases is discussed below.

Manufacturing and Quality Tasks

- Conduct an analysis of the supply of workforce:
  - Have industry and sector M&Q workforce competencies been identified?
    - Technical competencies
    - Academic competencies
    - Competencies for advanced manufacturing
    - Competencies for additive manufacturing
    - Lean/Six Sigma and CPI
  - Has a workforce requirements analysis been conducted by job and skills category?
  - Identify new M&Q skills and training/workforce development requirements for materiel solution approaches to include the need for a Training and Certification Program.
  - How well does the current workforce supply align/support the plan for production?
  - How many employees are required at each skill category and level?
  - Have M&Q skills been identified to address digital engineering skills?
  - How will be turnover of key personnel affect the organization's ability to deliver products?
  - What are the critical positions to fill?
  - What positions are difficult to fill positions with quality applicants?
  - Are there local recruitment sources that can provide top talent?
  - What new ways of working or skill mix would aid in recruitment?
  - Can the workforce be arranged differently to better facilitate workload coverage?
  - What is the current distribution of employee years by years of service?
- Conduct an analysis on workforce demand:
  - 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
  - What drivers affect organizational workload?

  - How is workload measured?
  - How many employees are needed to deliver the product by skill category?
  - What percentage of an FTE's time is required to deliver the product?
  - Are there anticipated changes in technology, policies, regulations, or supplier base that would affect workload demand?
  - 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.
  - How would the workload on each product line be impacted by those changes? (as one line expands, what is the impact and as one-line decreases, what is the impact)?
  - How would changes in FTEs affect workload?
  - What opportunities are there to leverage resources with other programs or products?

- Conduct an analysis on the workforce gap (Demand – Supply):
  - What workforce competency/skill gaps exist?
  - How are those competencies/skills being updated to reflect the changing business environment?
  - Identify and assess gaps in manufacturing workforce knowledge of the digital engineering and industrial cybersecurity concerns
  - Identify potential workforce shortfalls based on an aging workforce and needs for early recruitment of new employees
  - Are there certain occupations or geographic areas with hard to fill positions?
  - Are there certain occupations that require hard-to-find skills?
  - Identify, plan for, and mitigate potential workforce disruption (Covid, natural disasters, etc.)
  - How will retirement affect the overall spread of employees?

- Develop a plan to address the workforce gaps:
  - Are short-term and long-term organization plans/ strategies being used to inform workforce goals? How is workforce planning aligned with organizational strategy and direction? Where are the organization’s greatest workforce planning needs?
  - Train or acquire personnel appropriately to address the digital engineering knowledge gaps and expertise needed.
  - Identify traditional and non-traditional training and education opportunities for workforce development to meet goals.
  - What metrics/ratios will best help to monitor/identify workforce challenges/risks? What metrics/ratios should be used to diagnose workforce challenges?
  - What workforce data source best supports workforce gap analysis, planning, and management?

- Monitor progress toward meeting workforce goals:
    - How is workforce planning success defined? What types of metrics will help determine and manage success?
    - How is organizational workforce planning going to meet its objective? Was there an action plan and was it completed on time?
    - Does the organization's workforce strategy need to be refined? Have there been changes in the workforce that would cause strategies to need revision?

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

- AS6500, Manufacturing Management System
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896, Manufacturing Management Program Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- Digital Engineering Body of Knowledge
- Defense Manufacturing Management Guide for Program Managers, Chapter 6 Manufacturing Planning
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)

J. FACILITIES

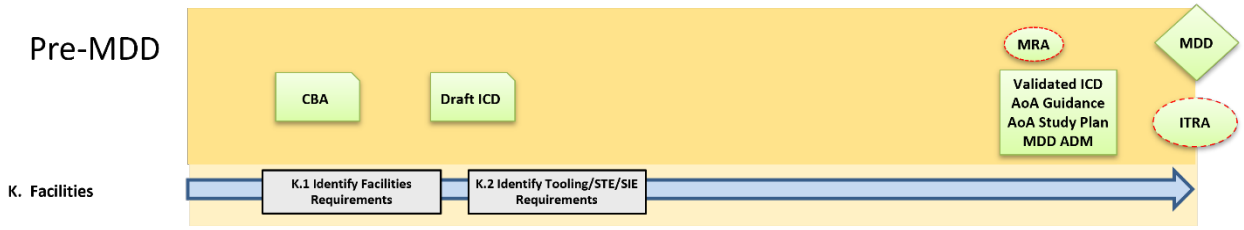


Figure 1-14. Facilities Manufacturing and Quality Activities

Introduction

Facilities management is a contractor responsibility that encompasses a variety of professional skills that focus on the design, construction, and management of an installation including plant, equipment, and tooling. 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 plant location, facility size and layout, production system or environment, environmental, safety, and occupational health considerations, property management and control, environmental controls (HVAC), maintenance, security considerations, and budgeting of such property through final disposal or facility shutdown. The plant includes the plant, receiving/inspection, production equipment, fabrication and assembly operations, material storage and handling, inspection and test stations, and final inspection/testing, and shipment. Program office personnel monitor these requirements.

In developing the facility plan, both the quantitative and qualitative demands of the product must be considered. The quantitative analysis will determine the size and kinds of processing departments within the facility (job shop, batch processing, continuous flow, etc.). This analysis should consider the complexity of the design and 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 which 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.

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 include 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 to be considered.

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 (Facilities and Tooling) will focus on the following sub-threads as required in each phase:

- Facility/Tooling Strategy
- Facility Planning and Assessment
- Tooling Planning and Assessment

J.1 Identify Facilities Requirements

Contractor manufacturing facilities planning and assessment includes an analysis of the capabilities and capacity of the production facilities to develop, product and maintain, product according to each phase of acquisition with program office M&Q personnel monitoring these activities and risks. Facilities assessments should include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur.

Good facility planning has the following characteristics:

- Facility Production System:
    - Job Shop
    - Disconnected Line
    - Connected Line
    - Continuous Flow
- Plant design, construction, and management (Floorplans, utilities, etc.).
- Factory Simulation and Workflow Analysis (Manufacturing Planning and Control)
- Capital Equipment Purchase and Installation:
    - Equipment Maintenance
- Capacity Planning (Rough cut and Capacity Requirements)
- Warehousing, Inventory Management and Material Movement
- Environmental (heating, cooling, lighting, etc.)
- Safety considerations

- Ergonomics and Accessibility:
  - Dimensions between equipment and aisles
  - Effective use of space, floor plan
- Security and Plant Clearance considerations
- Industrial Cybersecurity and Operational Technology considerations
- Visual Communication
- Flexibility for growth or downsizing
- Key Performance Indicators (KPSs): Inventory, cycle times, overall equipment effectiveness, and other metrics

Manufacturing and Quality Tasks

- Develop or update an M&Q Facilities Plan that includes:
  - Identify the facilities and capital equipment requirements to support the planned development of technologies, prototypes, and production activities within required lead times
  - Identify planned rate and quantity requirements to support capacity and capability requirements for the facilities and needed for facility enhancements
  - Develop mitigation plans based on impacts to 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)
  - Identify unique or specialized M&Q facility requirements for transportation, handling, and storage equipment
  - Identify and plan for new facilities to be constructed to mitigate M&Q gaps in current facility capability or capacity
- Identify requirements for M&Q investments and funding with associated schedules to support the need for increased capabilities or capacity
  - Assessment and mitigation of M&Q environmental and safety factors and impacts
  - Identify any requirements for security of M&Q facilities (physical and cyber)
- Identify the quantitative and qualitative demands of 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

- Assess the contractor's manufacturing management plans for facilities including plans, utilization, and any relocation/consolidation, program schedules, and manufacturing maturity requirements for adequacy, compliance, and impact to the contract to include:
    - Identify 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
    - Assess 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.
    - Identify any planned relocation and/or consolidation of production facilities, tooling, and production lines impacts to schedule and costs
    - Identify impacts to schedule and costs from planned changes to increase manufacturing maturity (i.e., manufacturing technology)
    - Identify any planned Lean/Six Sigma activities to improve quality and reduce costs
    - Identify any environmental and safety factors or requirements
    - Identify any security requirements for M&Q facilities (physical and cyber)
    - Request DCMA support for facility assessments to include data and assistance for these efforts

Tools

- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Risk Assessment Report DI-SESS-81974
- Manufacturing Maturation Plan
- AS6500 Manufacturing Management System Checklist
- AS9100 Quality Management System Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Factory Simulation and Layout Software Tools (various)
    - Production System Planning tools
    - Ergonomic tools
    - Process Planning & Workflow tools
    - Virtual Factory tool
- Bottleneck Analysis (Theory of Constraints)
- Gantt Charts
- Critical Chain Project Management

Resources

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- AS6500, Manufacturing Management Program
- MIL-HDBK-896A, Manufacturing Management Program Guide
- AS9100, Quality Systems – Aerospace
- ISO 9001, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- IEEE15288, Best Practices for Using System Engineering Standards
- IEEE15288.2, Standard for Technical Reviews and Audits on Defense Programs
- NIST Guide to Industrial Control Systems (ICS) Security
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.7.13 Facility Planning
- DCMA-INST-204 Manufacturing and Production
- Defense Technical Risk Assessment Methodology (DTRAM)
- 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
- Early Manufacturing and Quality Engineering Guide

J.2 Identify Tooling, Special Tooling, Test, and Inspection Equipment

The Department of Defense often permits contractors to acquire capital equipment to include 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 which 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.

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 utilized, the transition from limited life to rate tools and the degree of similarity between production test equipment and depot test equipment to be required. In addition, the tooling and test equipment must be properly identified, maintained, calibrated, and entered into a property management system with periodic (annual) audits.

Special tooling includes all jigs, dies, fixtures, molds, patterns, taps, gauges, other equipment and manufacturing aids, all components of these items, and replacement of these items, which are of such a specialized nature that without substantial modification or alteration their use is limited to the development or production of particular supplies or parts thereof or to the performance of particular services. It does not include material, special test equipment, facilities (except foundations and similar improvements necessary for installing special tooling), general or special machine tools, or similar capital items.

Special test equipment includes either single or multipurpose integrated test units engineered, designed, fabricated, or modified to accomplish special purpose testing in performing a contract. It consists of items or assemblies of equipment including standard or general-purpose items or components that are interconnected and interdependent to become a new functional entity for special testing purposes. It does not include material, special tooling, facilities (except foundations and similar improvements necessary for installing special test equipment), and plant equipment items used for general plant testing purposes.

Tooling, special tooling, special test equipment, and special inspection equipment should include:

- Tool/Test/Inspection equipment design - The contractor will describe documented processes to ensure release, acceptance, identification, security, access and change control of tool design and tool inspection datasets. Tooling datasets will have traceability to current authority engineering and derivative tooling dataset sources. The engineering authority dataset(s) will be identified on the tool design when applicable.
- The supplier will ensure that when Tool Design responsibility flows down to sub-tier suppliers, the supplier will approve the sub-tier supplier.
- Traceability - All digitally defined special tooling and physical inspection media (check fixtures, templates, etc.) will be identified and traceable to the engineering authority dataset, tool design dataset and any tool inspection datasets.
- Inspection - These tools and tooling media will be dimensionally accepted and periodically validated to the authority design at a frequency determined to ensure accuracy and repeatability of the tool before use.

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
  - Assess industrial cybersecurity and operational technology concerns for tooling and test equipment
- 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 to be considered.

Tools

- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Risk Assessment Report DI-SESS-81974
- SF 1432 Special Tooling and Special Test Equipment Inventory Worksheet
- Plant Design and Facility Layout Software Evaluation 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
- Rough Cut Capacity Planning Spreadsheet

Resources

- FAR Part 45 – Government Property
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition ProgramsAS6500, Manufacturing Management System
- Manufacturing Readiness Level (MRL) Deskbook
- AS6500, Manufacturing Management System
- MIL-HDBK-896A, Manufacturing Management Program Guide

- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5.7 Tooling and Test Equipment, and Chapter 9.4.7 Other Costs (Tooling and Test Equipment)
- DCMA-INST-204 Manufacturing and Production
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 4275.5, Acquisition and Management of Industrial Resources
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- DoDI 5000.97, Digital Engineering
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge

K. MANUFACTURING MANAGEMENT AND CONTROL

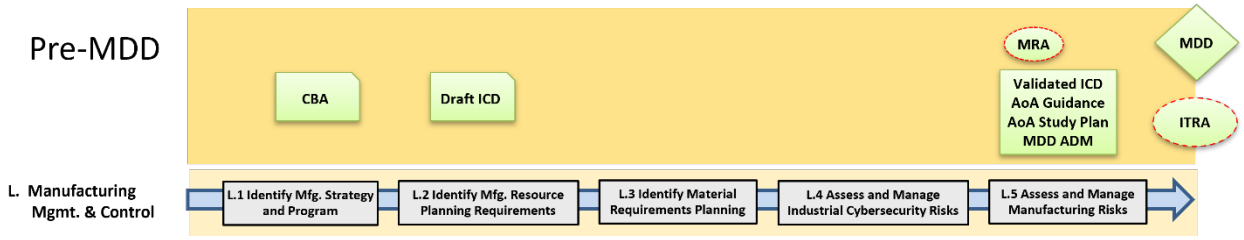


Figure 1-15. Manufacturing Management and Control Activities

Introduction

Manufacturing is concerned with the conversion of raw materials and/or components into products or finished goods. This conversion is accomplished through a series of manufacturing procedures and processes. Manufacturing management includes such major functions as manufacturing planning, cost estimating and scheduling; engineering; fabrication and assembly; installation and checkout; demonstration and testing; product assurance, and shipment. Manufacturing considerations can begin as early as pre-MSA in which technical managers (system engineers, manufacturing, quality, etc.) assess the "manufacturing feasibility" associated with the current product or manufacturing approach.

Programs that require manufacturing will need to support manufacturing planning and control activities and may require that a manufacturing management system be put in place to support planned activities. The use of a comprehensive manufacturing management system will support the timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risks and issues throughout the program life cycle. Meeting this objective is best accomplished by including industry best practices and standards (i.e., AS6500, Manufacturing Management Program) in the contracts with industry.

The purpose of manufacturing planning is the identification of resources and integration into a structure that provides the capability to achieve objectives. Manufacturing planning should include:

- A Manufacturing Strategy
- A Manufacturing Management Program (per AS6500 and MIL-HDBK-896)
- Material Management System (Material Requirements Planning)
- Manufacturing Resource Planning
- Manufacturing requirements in contracts
- Appropriate agreements with other agencies (e.g., DCMA)
- Manufacturing assessments to support program decision points and major design reviews
- Manufacturing metrics and reviews at a frequency commensurate with manufacturing risks
- Manufacturing risk management

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.

This thread (Manufacturing Management) requires an analysis of the orchestration of all elements needed to translate the design and transform materials into an integrated and fielded system (meeting Program goals for affordability and availability). This thread will focus on the following sub-threads as required in each phase:

- Manufacturing Strategy and Program
- Manufacturing Resource (Management) Planning
- Material Requirements (Management) Planning
- Assess and Manage Industrial Cybersecurity
- Assess and Manage Manufacturing Risks

K.1 Identify Manufacturing Strategy and Program

A Manufacturing Strategy should be developed as part of the Systems Engineering Plan and Acquisition Strategy. These plans and strategies will be used to support the development and production of an affordable program. and includes considerations such as manufacturing voids, deficiencies, and dependencies on critical foreign source materials. The strategy is a detailed plan for assuring timely and cost-effective production of an item which meets all operational effectiveness and suitability requirements. The strategy must be developed in consonance with program engineering, contracting, test, and logistics strategies, considering current and projected constraints, risks, and opportunities in the industrial-technological base.

A good manufacturing strategy is one that supports design, technology, and manufacturing maturation and gradually builds factory floor capabilities to rate production and then holds production at a steady state for an extended period. Some program strategies that involve manufacturing focus on affordability and cost efficiency and include co-production, where major WBS elements are given out to other countries to reduce cost and risk on the host nation. The manufacturing strategy should include competition to reduce risks and to reduce weapon system cost.

The manufacturing strategy may include some of the elements listed below.

- Capability to Produce
- Capacity to Produce (Rate and Quantity)
- Material Availability
- Critical Manufacturing Technologies
- Manufacturing Investments
- Producible Designs

- Mature Processes
- Special Tooling, Special Test Equipment, and Special Inspection Equipment
- Manufacturing Skills
- Manufacturing Plan
- Quality Assurance Plan

For each element in the strategy, decisions must be made early in the acquisition process to ensure that the required actions are taken in a timely manner. Tradeoffs are made, often within the context of the development of the program acquisition strategy based upon the following:

- Level of production competition
- Type of production competition
- Role of producibility engineering and planning
- Quality assurance approach
- Manufacturing process proofing
- Role of industrial modernization incentives program
- Manufacturing technology insertion
- Lean/Six Sigma implementation

A Manufacturing Management Program (System) is an integrated collection of people, processes, policies, information systems, and other tools that are required to plan, execute, and manage manufacturing operations, including those at supplier facilities. The best practice for manufacturing management in the industry is AS6500 Manufacturing Management Program. Even if not called out on contract, the requirements of AS6500 are worth reviewing while assessing a contractor's manufacturing management program. Refer to MIL-HDBK-896, Manufacturing Management Program Guide for the implementation of AS6500 on DoD programs.

Organizations should establish, document, manage, and continuously improve on their Manufacturing Management Program (System) in accordance with AS6500 Manufacturing Management Program or other approved best practices that meet the essential requirements of AS6500. Organizations should document how, when, and by whom each requirement of AS6500 is to be accomplished and identify the roles and responsibilities for each requirement of AS6500. The requirements of AS6500 are applicable in all phases of acquisition and may be tailored as required.

Advanced Manufacturing (AM) is defined as the innovation of improved manufacturing methods for manufacturing existing products, and the production of new products enabled by advanced technologies. Source: National Strategy for AM, National Science and Technology Council. AM "refers to new ways to manufacture existing products and the manufacture of new products resulting from advances in technology. Advanced Manufacturing depends on the use and coordination of information, automation, computation, software, sensing, and networking, making use of cutting-edge materials and emerging capabilities enabled by the physical and biological sciences. Advanced

manufacturing includes additive manufacturing, artificial intelligence, robotics, and advanced composite materials. M&Q personnel should consider requirements to implement AM where it makes sense.

DoD organizations should implement AS6500 or other best commercial practice as a contract requirement.

Manufacturing and Quality Tasks

- Support the development of the Acquisition Strategy (AS).
- Support the development of the Systems Engineering Plan (SEP).
- Support the identification, development, and implementation of advanced manufacturing methods.
- Support the identification, development, and implementation of additive manufacturing technologies.
- Develop the initial Manufacturing Strategy, if appropriate, and ensure the Manufacturing Strategy addresses M&Q considerations for:
    - IB risk mitigation
    - Enabling/critical technologies and constraints
    - ManTech projects
    - Design and producibility
    - Technical data and digital engineering considerations
    - 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
- 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 contractors and suppliers for each concept being considered.

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

- 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.
- 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
    - Design and materials reproducible
    - Critical and key M&Q processes
    - Processes stable and in control
    - Tolerances achievable
    - Special tooling requirements
    - Special skills requirements (training, certification, etc.)

  - Test and demonstration requirements for new materials and processes
  - Supply chain capable and in place
  - Alternate design approaches
  - Schedule achievable (cycle times, lead times, critical path, etc.;)
  - 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
- 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 contractors and suppliers for each concept being considered.

Tools

- Acquisition Strategy Outline
- Systems Engineering Plan (SEP) Outline
- Systems Engineering Management Plan DI-SESS-81785A
  - Manufacturing Plan, DI-MGMT-81889A
  - Quality Assurance Program Plan, DI-QCIC-81794
- AS6500 Assessment
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- Work Breakdown Structure

Resources

- 10 USC 2431a. Acquisition Strategy
- FAR Part 7.105 Contents of Written Acquisition Plans
- Acquisition Strategy Guide (DSMC)
- Acquisition Strategy Guide (NAVSEA)
- Systems Engineering Plan Preparation Guide

- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition ProgramsAS6500, Manufacturing Management System
- Manufacturing Readiness Level (MRL) Deskbook
- Defense Manufacturing Management Guide for Program Managers, Chapter 4 Manufacturing Strategy
- DoD Systems Engineering Guidebook
- Digital Engineering Body of Knowledge
- IEEE 15288 Technical Reviews and Audits

K.2 Identify Manufacturing Resource Planning and Scheduling Requirements

A Manufacturing Management System (MMS) is used to identify and 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. Many companies utilize advanced planning and control software systems (MRP, MRP II, and ERP) to manage their material and manufacturing planning activities. Smaller companies that do not have these high-end software tools still need to plan and execute their manufacturing program and may do so using less sophisticated paper-based practices. Program office personnel need to be able to understand various manufacturing systems and be able to evaluate contractor performance and risk in this area.

Manufacturing planning includes elements of manufacturing engineering and industrial engineering.

- Manufacturing Engineering: Concerned with determining the best facilities, equipment, machinery required to produce a product. Manufacturing engineers focus on the technical and mechanical aspects of engineering processes in manufacturing.
- Industrial Engineering: Concerned with factory floor efficiency by looking at how manpower, machines, and processes work together. Industrial engineers focus on assessing and enhancing organizational procedures related to manufacturing processes. Evaluating machine components to identify ways to help their teams improve efficiency and quality control standards of a production line may be a part of their duty.

Manufacturing resource planning is about understanding everything it takes to produce the items required by the contract, on time, on budget, and with the right quality and performance features. It includes considerations of capacity planning, production scheduling, performance measures, cost reporting, quality reporting, and labor reporting.

Capacity planning calculates factory floor workload at all the “5Ms” (manpower, machines, materials, methods, and measurements) to identify manufacturing resources and constraints at the prime

contractor and throughout the supply chain. Manufacturing planning and control are developed at several levels:

- **Strategic:** Establishes the Master Production Schedule (MPS) on the front end to reconcile demand management with material planning and capacity planning. Capacity planning at this level is a rough-cut estimate of the rate of work planned vs capabilities at critical resources and bottleneck operations to ensure that the capacity will be available to meet the MPS.
- **Mid-Level:** Establishes Capacity and Material Plans and sees the development of the Capacity Requirements Plan (CPR) at critical work centers. CPR identifies overload and underload conditions in order to production smoothing, improve throughput and efficiency.
- **Manufacturing Execution**: Establishes the back-end execution of production plans to include shop floor scheduling and control and vendor scheduling and control to support production at four levels:
    - Scheduling: Establishes the workflow (routings, sequences, operations, setup, manpower, machines, queues, movement, cycle times, etc.) for the products, collects production data, and optimizes the production process and authorization to produce through order release. Ensures that the required materials, tooling, personnel, and information are available to support fabrication and assembly and set the start and finish dates for each job.
    - Dispatching: Implements the schedule for production and authorizes the release of job orders to the shop floor. Dispatching sequences the jobs based on prioritizations rules (First In, First Out; Customer Priority; Shortest Processing Time; Longest Processing Time, etc.).
    - Monitoring: Establishes real-time monitoring and control of production processes down to the components in the system to assess progress as measured against planned production. Identifies problem areas, allowing managers the opportunity to initiate corrective actions. Tracks manufacturing key performance indicators (KPIs) provide evidence of efficiency and effectiveness. Examples of manufacturing KPIs include:

        - Production Volume: Track the quantities that you can produce
        - Production Downtime: Analyze and optimize your maintenance
        - Production Costs: Monitor the costs implied in production
        - Overall Operations Effectiveness (OOE): Evaluate your operational efficiency
        - Overall Equipment Effectiveness (OEE): Assess the scheduled efficiency
        - Capacity Utilization: Maximize the use of your capacities
        - Throughput: Measure your production capabilities
        - First Pass Yield: Monitor your production quality
        - Scrap Rate: Track the amount of failed units
        - Right First Time: Understand the performance of your production process
        - Asset Turnover: Acknowledge your assets in relation to your revenue
        - Unit Costs: Track and optimize your units' costs over time
        - Maintenance Costs: Evaluate your overall equipment costs

Note that pre-MDD there may not be a need for the development and execution of manufacturing resource planning and control. If there is a need, then consider the following manufacturing and quality tasks.

Manufacturing and Quality Tasks

M&Q personnel need to identify and plan for anticipated manufacturing resources that will be required to support production if there is a production program.

- Identify manufacturing resource planning requirements.
- Manufacturing resource planning needs are assessed, analyzed, and validated.
- Manufacturing resource planning requirements for potential systems or concepts identified.
- Identify long-term manufacturing resource planning requirements:
  - Conduct a rough-cut capacity plan to analyze available resources
  - Identify and quantify key resources (5Ms)
  - Identify the Bill of Materials (BOM)
  - Extend the BOM against the Master Production Schedule
  - Identify manufacturing resource gaps (over capacity/overload workstations)
  - Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- Support Product Lifecycle Management (PLM) activities and the ability to manage end-to-end, design-to-delivery processes using various software tools to access critical data in real time, not only at the prime contractor but up and down the supply chain.
- Identify mid-term manufacturing resource planning requirements:
  - Conduct a capacity requirements plan to analyze available resources
  - Identify and quantify key resources (5Ms)
  - Identify the Bill of Materials (BOM)
  - Extend the BOM against the Master Production Schedule
  - Identify manufacturing resource gaps (under and over capacity workstations)
  - Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- Identify short-term manufacturing resource planning requirements (production execution):
  - Conduct shop floor execution of production against available resources
  - Schedule the activities (routings or workflow)
  - Dispatch the work, release the production order to the floor
  - Monitor the workflow and take corrective action on potential or real problems
  - Identify and quantify key resources (5Ms)
  - Identify the Bill of Materials (BOM)
  - Extend the BOM against the Master Production Schedule
  - Calculate utilization rates

  - Calculate or identify lead times
  - Calculate Overall Equipment Effectiveness rates
  - Identify constraints or bottlenecks
  - Identify manufacturing resource gaps (under and over capacity workstations)
  - Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- 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
- 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
- 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 contractors and suppliers for each concept being considered.

Tools

- AS6500 Assessment
- Interactive MRL Users Guide (Checklist) Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline
- Systems Engineering Management Plan, DI-SESS-81785A
  - Manufacturing Plan, DI-MGMT-81889A
  - Quality Assurance Program Plan, DI-QCIC-81794
- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- Product Life Cycle Management (PLM) (digital) software tools include:
  - Factory Layout Design

  - Plant Layout Design
  - Equipment and Layout Engineering
  - Machining and Tooling Design
  - Factory Simulation
  - Shop Floor Equipment Engineering
  - Ergonomic Simulation
  - Producibility Analysis
- Manufacturing Execution System (MES) software tools:
  - Production Planning and Scheduling
  - Work Order Management
  - Inventory Management
  - Equipment and Asset Management
  - Quality Management and Statistical Process Control
  - Process Management
  - Resource Allocation
  - Product Tracking
  - Data Collection and Analysis (Manufacturing KPIs)
- Bill of Material Assessment
- Assembly Chart
- Operations Process Chart
- Route Sheet
- Line of Balance Assessment
- Input/Output Analysis
- Make/Buy Plan
- Work Breakdown Structure

Resources

- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- AIAG Production Part Approval Process (PPAP) Manual
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- Bill of Materials
- Parts List
- Process Plans and Route Sheets
- Assembly Charts and Operations Process Chart

- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Defense Manufacturing Management Guide for Program Managers, Chapter 6 Manufacturing Planning
- Defense Manufacturing Management Guide for Program Managers, Chapter 13 Manufacturing Controls
- AFI 63-145, Manufacturing and Quality Management
- Manufacturing Resource Planning (MRP II) software

K.3 Identify Material Requirements Planning and Management

Material requirements planning and management is a core function of manufacturing management and supply chain management and involves the planning and execution of procurement programs that are needed to meet the material requirements for production programs of a company or organization. These requirements include initiating, controlling, and regulating the flow of material while simultaneously assessing input variables like demand, design, availability, quality, supply chain, socio-political environment, delivery schedules, and workstation and production systems capacities.

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.

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 function of an MRP system is to ensure that the right materials are in 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 concerned with three types of material inventories:

- Raw Materials: Raw materials and components are the basic building blocks for the company.
- Work-in-Progress (WIP): WIP is made up of materials, components, subassemblies, and assemblies that are in the process of being produced but no final inspection or acceptance.
- Finished Goods: Finished goods have been inspected and accepted and are awaiting delivery.

Material planning begins with material managers determining the amount of material required to meet planned production operations. The amount of material is dependent on what, how much, and when (demand signal) the material is needed to meet the production schedule and plans for the replenishment.

Material planning creates inventory levels for each type of item (raw material, work in progress or finished goods), and communicates requirements to procurement operations and the extended supply chain. Material planning uses the bill of materials (BOM) to identify all the items that go into building one end item and the master production schedule to calculate how many of the BOM elements that need to be on hand to support production. Material managers then look at existing inventories of all of the BOM end items and issues procurement orders for any items not on hand and schedules deliveries to support the production schedule.

Material planning directly affects profits as the lower the inventories, the lower the cost of production and the greater the profit. Reducing material cost has caused some industries to consider 'Just in Time (JIT)' strategies that require small levels of inventory. However, this still requires careful planning to maintain without impacting production schedules and there are other material or inventory strategies to consider and should only be considered when there is a clear demand signal and short lead time.

Typical roles in Materials Management include inventory analysts, inventory control managers, materials managers, material planners, and expediters as well as hybrid roles like buyer/planners. M&Q managers need to support the various material management functions and activities to achieve material management goals and objectives:

- Lower prices of materials and increase competition
- Lower storage costs
- Lower overall cost of materials
- Standardized parts
- Economic make/buy decisions
- Lower inventories and higher inventory turnover
- Continuous supply of material
- Favorable supplier relations
- Consistent quality
- Reduce or eliminate counterfeit parts
- Reduce or eliminate sole source, single source, or foreign source vendors

During Pre-MDD there may or may not be a need to develop or implement an extensive MRP system.

Manufacturing and Quality Tasks

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

- Create a Master Production Schedule based on actual and forecasted orders.
- Identify all the items in Bill of Materials (BOM).
- Identify the inventory status of all items on the BOM required for production.
- Identify material requirements by assessing the Bill of Materials (BOM) against the Master Production Schedule, and current inventory on hand.

- Identify what to Make vs. what to Buy items in the BOM.
- Develop and implement a supplier sourcing process with evaluation criteria for Buy items:
    - Past performance
    - Ability to meet capacity and schedule requirements
    - Financial stability of vendor
    - Ability to provide technical support
    - Adequacy of vendor quality management system
    - Total part cost including warranty costs
- Create and issue purchase orders to support planned production.
- Develop inventory control and management processes.
- Assess availability and quality of materials to be used for each production requirement:
    - Assess the maturity (technical and characterization) of material sources, essential raw materials, special alloys, composite materials, etc.
    - Assess material risks such as counterfeit parts, DMSMS and Obsolescence, corrosion, etc.
    - Understand alternatives to preferred materials for each materiel solution or production requirement
- Assess all aspects of tasks in materiel availability:
    - 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
- Identify Material Requirements key performance measures:
    - Perfect Order Fulfillment
    - Delivery On-time Performance
    - Inventory days of supply
    - Inventory turnover
- 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.
- Identify material requirements by assessing the Bill of Materials, Master Production Schedule, and current inventory on hand.
- 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:
    - 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

- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control Thread
- Manufacturing Maturation Plan
- AS6500 Assessment
- DCAA Materials Management Audit Program and Checklist
- DCMA MSRA Production Planning and Control (PPC), Material Requirement Planning Checklist
- Materials Requirements Planning (MRP) Assessment
    - Bill of Material Assessment
    - Master Production Schedule
    - Inventory Assessment
    - Supplier/Supply Chain Assessment
- Production Plan
- Line of Balance Assessment
- Make/Buy Decisions
- Long Lead time Material Report, DI-PSSS-82201
- 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
- Work Breakdown Structure

Resources

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- Material Management and Accounting System – Audit Program

- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)
- DFAR 242.72 Contractor Material Management and Accounting System
- Bill of Materials
- Inventory Records
- AS5553, Counterfeit Electronic Parts
- AS6174, Counterfeit Material
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.10.q Material Requirements Planning
- DFAR 242.72 Contractor Material Management and Accounting System
- DoDI 5000.88, Engineering of Defense Systems
- Early Manufacturing and Quality Engineering Guide

K.4 Assess and Manage Industrial Cybersecurity Risks

The integration of Information Technology (IT) and Operational Technologies (OT) is helping manufacturing organizations to improve productivity and efficiency. However, it has also provided malicious actors (nation states, criminals, insider threats, etc.) the ability to exploit cybersecurity vulnerabilities. Once malicious actors gain access, they can harm an organization by compromising data or system integrity, hold industrial control systems (ICS) and/or OT systems ransom, damage ICS machinery, or cause physical injury to workers.

Operational technologies and Industrial Control Systems can include:

- Enterprise resource planning (ERP) system supports functional management resources within an enterprise, and control process performance.
- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution system (MES) supports the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers.
- Programmable Logic Controllers (PLCs)
- Supervisory Control and Data Acquisition (SCADA) Systems
- Distributed Control Systems (DCS)

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 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.

Industrial cybersecurity is concerned with the ability of organizations to securely create, manage, control, and share information digitally. While the management and exchange 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. Current digital environments are complex and made up of many systems with digital threads that connect government program offices to industry, prime contractors to subcontractors, laboratories to program offices, within an organization, etc. This digital thread includes design data in the form of model-based designs, model based systems engineering, shop floor machines that use the design data to manufacture products, and the cloud to share data with suppliers, retailers, and other service organizations.

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.*"

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 Industrial Cybersecurity Risks
- Industrial Cybersecurity Planning and Management (Execution)

Contractor M&Q personnel need to identify and manage industrial cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities with program office M&Q personnel assessing contractor performance and risks in this area. Industrial cybersecurity references the software, hardware, practices, personnel, and services deployed to protect operational technology infrastructure, people, and data. OT/ICS includes:

- Programmable Logic Controllers (PLCs)
- Supervisory Control and Data Acquisition (SCADA) Systems
- Distributed Control Systems (DCS)

Industrial cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the acquisition framework in what is called the Industrial Internet of Things (IIoT).

M&Q personnel need to develop and execute industrial cybersecurity planning for system concepts to identify 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.

During Pre-MDD OT cybersecurity requirements for system concepts should be identified and OT cybersecurity vulnerabilities of potential manufacturing facilities identified.

M&Q personnel need to utilize the DoD MRL Cybersecurity Criteria using the Interactive MRL Users Guide and MRL Matrix L3 Manufacturing OT Cybersecurity.

Manufacturing and Quality Tasks

- Support development of cybersecurity contract requirements.
- Support reviews and assessments of contractor industrial cybersecurity Program for Operational Technology (OT) or Industrial Control Systems (ICS).
- Support reviews and assessments of contractor industrial cybersecurity risks:
    - Identify Industrial Cybersecurity Risks and vulnerabilities
    - Review and assessment of security controls
    - Review and assessment of contractor industrial control systems to include:
        - Manufacturing Executions Systems (MES)
        - Programmable Logic Controllers (PLCs)
        - Supervisory Control and Data Acquisition (SCADA) Systems
        - Distributed Control Systems (DCS)
        - Machines and workstations
    - Support Industrial Cybersecurity testing to include annual penetration testing
    - Manage and mitigate Industrial Cybersecurity Risks
- Identify cybersecurity requirements for potential concepts:
    - Request cyber threat information, assess threats, and develop a Cyber Protection Plan
    - OT cybersecurity requirements for system concepts identified

  - OT cybersecurity vulnerabilities for potential manufacturing facilities identified
  - Identify and train cross-functional cybersecurity personnel and teams
  - Develop and implement an Industrial Cybersecurity charter and program
  - Identify specific ICS policies and procedures
  - Develop and implement an ICSA Security Risk Management Framework
    - Define and inventory all ICS assets
    - Develop a security plan for ICS systems
    - Perform ICS risk management
    - Define and implement ICS risk mitigation controls
    - Provide ICS security training and raise Cybersecurity awareness for all involved
- Identify potential OT cybersecurity vulnerabilities of potential manufacturing facilities.
- Utilize digital engineering to support the development, implementation, and management of industrial cybersecurity programs and procedures.
- Identify, assess, and report cybersecurity incidents.
- Assess the impact of International Traffic in Arms Regulation (ITAR) on program.

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (CALIT), DAU
- CISA Industrial Cybersecurity Checklist, Appendix F
- Cybersecurity Strategy ADDM Template
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control Thread
- Manufacturing Maturation Plan
- 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
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- NIST SP 800-37, Risk Management Framework for Information Systems and Organizations
- NIST SP 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST SP 800-171, Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations
- NIST SP 1800-10, Protecting Information and System Integrity in Industrial Control System Environments
- NIST GCR 19-22, Formalizing ISA-95 Level 3 Control with Smart Manufacturing System Models
- Critical Manufacturing Sector Security Guide, CISA

- Digital Engineering Body of Knowledge
- DoDI 8500.01, Cybersecurity
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.83, Technology and Program Protection to Maintain Technological Advantage
- DoDI 5000.90, Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoDI 5000.97, Digital Engineering
- DoDI 5200.39, Critical Program Information Identification and Protection within RDT&E
- DoDI 5200.44, Protection of Mission Critical Functions to Achieve Trusted System and Networks (TSN)
- DoD 5220.22-M, National Industrial Security Program
- DoDI 8510.01, Risk Management Framework for DoD Systems
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- DoD Technology and Program Protection Guidebook
- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle

K.5 Assess and Manage Manufacturing Management Risks

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Manufacturing problems that have led to cost overruns, schedule delays, and field failures, sometimes at the expense of the warfighter. Today's manufacturing environment, though improved, still has many problems. Manufacturing risk assessments can be performed in a variety of forms (PRRs, MRAs, MFAs, PCRs, ITRAs, etc.) using a variety of processes and procedures and should be an on-going activity in all phases of acquisition.

The following common production risks areas can affect cost, schedule, and performance if the program office is not proactive in managing them. M&Q managers need to assess and manage the following (some are addressed in other threads and sub-threads):

- Emerging Technologies
- The Industrial Base
- Industrial Cybersecurity
- Intellectual Property
- Design/Producibility
- Cost Drivers and Cost Estimating
- Funding for Maturing the Manufacturing Processes
- Materials Availability and Environmental Impacts
- Environmental Safety and Occupational Health (ESOH)
- Make/Buy Decisions
- Supply Chain Management

- Process Capability and Control
- Production Verification
- Quality Management/Supplier Quality Management
- Manufacturing Management and Workforce
- Facilities Availability
- Special Tooling and Test Equipment
- Diminishing Manufacturing Sources and Material Shortages (DMSMS) and Obsolescence
- Corrosion Control
- Counterfeit Parts
- Configuration Control
- Human Capital/Workforce Availability

DCMA's Manufacturing Systems Risk Assessment are used to determine the frequency and detail of periodic key process manufacturing related surveillance activities. Mandatory systems and processes requiring surveillance in Resident Offices per DCMA Instruction 204, include:

- DCMA Production Planning and Control (PPC) Checklist includes:
  - Demand Management looks at how demand forecasts are calculated, and customer orders managed
  - Resource Requirements Planning looks at long term needs for facilities, manpower, and machines
  - Aggregate Planning looks at long term levels of production (mix of production and volume)
  - Rough Cut Capacity Planning looks at critical resources to ensure the feasibility of meeting the master production schedule
  - Material Requirements Planning looks at time phased plans for all component parts, raw materials, sub-assemblies, and assembly activities required to produce all products to the master production schedule
  - Capacity Requirements Planning looks at conducting capacity checks of production plans that have been generated from the material requirements plan
  - Shop Floor Controls looks at executing the production plan by ensuring documentation, materials, and tooling are present, and that orders are released to the floor according to the material requirements plan, establishes priority control of material flows, and monitors shop order performance
- Work Measurement is used to measure factory efficiency, methods improvement, and cost/schedule reporting (DoD 5010.15.1-M Standardization of Work Measurement)
  - Standards Development requires contractors to develop labor standards that quantify the amount of time it should take a qualified worker, with the right parts and tools, to perform a task (could include actual hours, standard hours, learning curves, etc.).
  - Standards Maintenance
  - Standards Usage
- Producibility:

  - Producibility Infrastructure Establishment
  - Process Capability Determination
  - Producibility Measurement
- Defense Priorities and Allocation System
  - Contract Review and Order Acceptance
  - Requirements Flow-Down
  - Delay Notification
  - Preferential Scheduling

Manufacturing risk management is based on an understanding of the reasons why systems have not or will not meet manufacturing and quality targets and a determination of the associated impact on cost, schedule, and performance throughout the life cycle. Risk assessments highlight areas needing management attention and help ensure successful execution and transition of the program/project into the next phase. When targets are not met, the program should develop and implement a Manufacturing Maturation Plan (MMP) to ensure the appropriate level of maturity will be achieved at the next decision point.

DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs provides guidance on proactively managing risks, issues, and opportunities to assist program offices to achieve cost, schedule, and performance objectives throughout the program's life cycle. The Guide outlines the risk management process as follows:

- Risk Planning: What is the risk management process? And how has it been working?
- Risk Identification: What can go wrong?
- Risk Analysis: What is the likelihood (probability of occurrence) and the consequence (impact to cost, schedule, performance, etc.) of the risk?
- Risk Mitigation: What can be done to mitigate the risk (accept, avoid, transfer, or mitigate)?
- Risk Monitoring: How has the risk changed (better, worse, or the same)?

Contractor M&Q managers need to support the identification and management of manufacturing risks with program office M&Q personnel assessing contractor performance and risks in this area. Assessing manufacturing risk is a constant activity focused on production risk areas but often focused on specific. Assessing manufacturing risk is a constant activity focused on production risk areas but often focused on specific production problems.

Manufacturing and Quality Tasks

Manufacturing Feasibility Assessments are performed early in the life cycle when competing design concepts are being considered. The assessments are conducted to identify potential manufacturing constraints and risks and the capability of the contractor to execute the manufacturing efforts.

Assessments should be made regarding each competing design alternative under consideration, and they should:

- Identify the required production processes and manufacturing techniques not currently available and the risks associated with the development of manufacturing technologies, the probability of meeting the need dates and possible contingency actions.
- Identify potential impact of critical and long lead time material and production equipment, the probability of meeting the need dates and possible contingency actions.
- Provide production feasibility, design performance, cost, and schedule impact analyses to support trade-offs among alternatives.
- Provide cost and production schedule estimates to support management reviews.
- Determine an efficient rate of production and rate acceleration curve.
- Make recommendations for anticipated production testing and demonstration efforts, including specific requirements for production run demonstrations using production tooling, test equipment, and manufacturing equipment.
- Develop methods of conserving critical and strategic materials and of reducing reliance on foreign sources.
- Identify potential production bottlenecks and limiting factors to rate production.

DCMA's Production Planning and Control (PPC) Checklist can be used to assess manufacturing management in the following areas:

- Production Planning and Control:
  - Assess Demand Management (looks at forecasting customer orders):
    - Is the demand signal clear, consistent and predictable (unclear is high risk and requires greater inventory)
    - Is the manufacturing lead time long (long lead times are high risks and require advanced planning)
  - Assess Resource Requirements Planning (looks at long term needs for facilities, manpower, and machines):
    - Production requirements are translated into measures of capacity such as labor hours, machine hours, etc.
    - Production resource requirements are evaluated against available resources
    - Shortfalls are identified and managed
    - Bottlenecks and constraints are identified and managed
  - Assess Aggregate Planning (looks at long-term levels of production):
    - Assess the mix of production and volume
    - Determine the levels of production, staffing, inventory, and overtime over the long term
    - Meet production with inventory, or overtime, or using a pull system
  - Assess the Master Production Schedule:
    - Identify what is to be made by date and quantity

  - Assess Rough Cut Capacity Planning (look at critical resources to ensure the feasibility of meeting the master production schedule):
    - Identify the capacity of critical manufacturing resources
    - Assess the capacity of critical manufacturing resources against the Master Production Schedule
  - Assess Material Requirements Planning:
    - Assess time phased plans for all component parts, raw materials, sub-assemblies, and assembly activities required to produce all products to the master production schedule
  - Assess Capacity Requirements Planning
    - Conduct capacity checks of production plans that have been generated from the material requirements plan
    - Determine job completion times for each work center using fixed lead times, then assess loading over time.
  - Assess Shop Floor Controls:
    - Ensure documentation, materials, and tooling are present, and that orders are released to the floor according to the material requirements plan
    - Establish priority control of material flows
    - Monitors shop order performance
- Assess Work Measurement:
  - Standards Development requires contractors to develop labor standards that quantify the amount of time it should take a qualified worker, with the right parts and tools, to perform a task. (could include actual hours, standard hours, learning curves, etc.)
  - Standards Maintenance
  - Standards Usage
- Assess the use of the Defense Priorities and Allocation System (DPAS)
- Assess the impact of Diminishing Manufacturing Sources and Material Shortages (DMSMS) and Obsolescence on manufacturing performance

Assessments should be made for each production environment, and then manage these risks:

- Identify the required production processes and manufacturing techniques not currently available and the risks associated with development of manufacturing technologies, the probability of meeting the need dates and possible contingency actions.
- Identify potential impact of critical and long lead time material and production equipment, the probability of meeting the need dates and possible contingency actions.
- Provide production feasibility, design performance, cost, and schedule impact analyses to support trade-offs among alternatives.
- Provide cost and production schedule estimates to support management reviews.
- Determine an efficient rate of production and rate acceleration curve.

- Make recommendations for anticipated production testing and demonstration efforts, including specific requirements for production run demonstrations using production tooling, test equipment, and manufacturing equipment.
- Develop methods of conserving critical and strategic materials and of reducing reliance on foreign sources.
- Identify potential production bottlenecks and limiting factors to rate production.

Tools

- 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
- Independent Technical Risk Assessments (ITRAs)
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control Thread
- Manufacturing Maturation Plan
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- AS6500 Assessment
- DCMA Production Planning and Control (PPC) Checklist
- Production Surveillance Plan Flowchart
- Production Surveillance Flowchart
- Development Surveillance Flowchart
- Over and Above Surveillance Flowchart
- Time and Material Surveillance Flowchart
- Physical Progress Reviews Flowchart
- Performance Based Payment Support Flowchart
- Continuous Improvement Opportunities Flowchart
- Industrial Labor Relations Flowchart
- Line of Balance Assessment
- Make/Buy Decisions
- Materials Requirements Planning (MRP) Assessment
- Manufacturing Resource Planning (MRPII) Assessment
- Master Production Schedule
- Production Plan
- Inventory Assessment
- Supplier/Supply Chain Assessment

Resources

- AS6500, Manufacturing Management Program
- 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
- Manufacturing Readiness Level (MRL) Deskbook Manufacturing Resource Planning (MRP II)
- DoDI 5000.60H, Defense Industrial Capabilities Assessment
- DCMA Instruction 204 Manufacturing and Production
- DCMA Instruction 326, Risk Assessment
- DCMA Manual 2303-01, Surveillance – Assess Risk
- AFI 63-145, Manufacturing and Quality Management
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Acquisition Program Support (DAPS) Methodology
- Independent Technical Risk Assessment Framework for Risk Categorization
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.6 Risk Assessment
- Defense Manufacturing Management Guide for Program Managers, Chapter 17.4 Assessment of Manufacturing Readiness
- Defense Manufacturing Management Guide for Program Managers, Chapter 17.8 The MRL Assessment
- Defense Manufacturing Management Guide for Program Managers, Chapter 17.9 The Manufacturing Management Maturation Plan
- DoD Technology Readiness Assessment (TRA) Guide
- SD-22 Diminishing Manufacturing Sources and Material Shortages
- DoD Corrosion Prevention and Control Guidebook
- DoDI 5000.67 Prevention and Mitigation of Corrosion on DoD Military Equipment and Infrastructure
- Overarching DoD Counterfeit Prevention Guidance
- Counterfeit Materiel Process Guidebook, Department of Navy
- ITAR Law: Arms Export Control Act of 1976
- USC 22 Subchapter M International Traffic in Arms Regulation
- MIL-HDBK-61 Configuration Management Handbook

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Appendix A: Abbreviations and Acronyms

AAF	Adaptive Acquisition Framework
AAFDIT	Adaptive Acquisition Framework Document Identification Tool
ADM	Acquisition Decision Memorandum
AdM	Advanced Manufacturing
AFRL	Air Force Research Laboratory
AIAG	Automotive Industry Action Group
A_m	Materiel Availability
AM	Additive Manufacturing
ANSI	American National Standards Institute
A_o	Operational Availability
AoA	Analysis of Alternatives
APA	Additional Performance Attributes
APB	Acquisition Program Baseline
APQP	Advanced Product Quality Planning
AQL	Acceptable Quality Level
ARL	Army Research Laboratory
ARRT	Acquisition Requirements Roadmap Tool Suite
AS	Acquisition Strategy
ASME	American Society of Mechanical Engineers
ASR	Alternative Systems Review
ASTM	American Society for Testing and Materials
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

C/SCSC	Cost and 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
CAPP	Computer-Aided Process Planning
CARD	Cost Analysis Requirements Description
CAS	Contract Administration Services
CBA	Capabilities-Based Assessment
CC	Critical Characteristic
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
CO	Contracting Officer
COE	Center of Excellence
COMSEC	Communications Security
CONOPS	Concept of Operations
COSSI	Commercial Operations and Support Savings Initiative
COTS	Commercial Off-the-Shelf

CP	Critical Part
Cp/Cpk	Process Capability/Process Capability Index
CPAR	Contractor Performance Assessment Report
CPC	Corrosion Prevention and Control
CPFF	Cost Plus Fixed Fee
CPI	Continuous Process Improvement
CRI	Cost Reduction Initiative
CSDR	Cost and Software Data Reporting
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
DCAPE	Director of Cost Assessment and Program Evaluation
DCMA	Defense Contract Management Agency
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
DMMG	Defense Manufacturing Management Guide
DMS	Diminishing Manufacturing Sources
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
DPM	Defective Parts Per Million
DSS	Design for Six Sigma
DT&E	Developmental Test and Evaluation
DTC	Design to Cost
DTRAM	Defense Technical Risk Assessment Methodology
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
5Ms	Manpower, Machines, Materials, Methods, Measurement
FA	First Article
FAI	First Article Inspection
FAR	Federal Acquisition Regulation
FAT	First Article Test
FCA	Functional Configuration Audit
FDD	Full Deployment Decision
FFP	Firm Fixed Price
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
FPIF	Fixed Price Incentive 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
ILA	Independent Logistics Assessment
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOC	Initial Operational Capability

IP	Intellectual Property
IPMDAR	Integrated Program Management Data Analysis Report
IPS	Integrated Product Support
IPT	Integrated Product Team
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
KMP	Key Manufacturing Process
KPP	Key Performance Parameter
KSA	Key System Attribute
LCC	Life Cycle Cost
LCSP	Life Cycle Sustainment Plan
LFT&E	Live-Fire Test and Evaluation
LOB	Line of Balance
LOD	Letter of Delegation
LRIP	Low-Rate Initial Production
M&Q	Manufacturing and Quality
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
MOP	Measure of Performance
MOSA	Modular Open Systems Approach
MP	Mission Profile
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	Measurement System Analysis
MSA	Materiel Solution Analysis
MSRA	Manufacturing Systems Risk Assessment
MTA	Middle Tier Acquisition
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
MTTR	Mean Time to Repair
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
O&M	Operations and Maintenance
O&S	Operations and Support
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
OIPT	Overarching Integrated Product Team
OMB	Office of Management and Budget
OMS/MP	Operational Mode Summary/Mission Profile
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
P&D	Production and Deployment
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
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
PMO	Program Management Office
PMP	Parts, Materials, and Processes

PMR	Program Management Review
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
PPIRS	Past Performance Information Retrieval System
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
PSC	Preferred System Concept
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
R&M	Reliability and Maintainability
RAM	Reliability, Availability, Maintainability
RCM	Requirements Correlation Matrix
RCT	Requirements Correlation Table
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RFI	Request for Information

RFP	Request for Proposal
RFP DP	Request for Proposal Release Decision Point
RFV	Request for Variation
RIO	Risk, Issues and Opportunities
RMBoK	Reliability and Maintainability Body of Knowledge
S&T	Science and Technology
SAE	Society of Automotive Engineers
SAR	Safety Assessment Report
SAT	Software Acceptance Test
SCAP	System Capability Analytic Process
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
SE&A	Systems Engineering and Architecture
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	System Security Engineering
SSN	Sources Sought Notice
SSP	Source Selection Plan
ST	Special Tooling
STE	Special Test Equipment
STEM	Science, Technology, Engineering, and Math
SUPSHIP	Supervisor of Shipbuilding
SVR	System Verification Review
SWOT	Strengths, Weaknesses, Opportunities, and Threats
T&E	Test and Evaluation
TAPP	Technology Area Protection Plan
TBD	To Be Determined
TDP	Technical Data Package
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
USC	United States Code
USD(R&E)	Under Secretary of Defense for Research and Engineering
V&V	Verification and Validation
VCRM	Verification Cross-Reference Matrix
VOLT	Validated Online Lifecycle Threat
VR	Variability Reduction
VSM	Value Stream Mapping

WBS	Work Breakdown Structure
WIP	Work in Progress
WIPT	Working Integrated Product Team

Appendix B: References

Resources identified in the 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.

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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.

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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.

2.10. Value Management

The contractor shall establish and maintain a Value Management Program to apply Value Engineering/Value Analysis techniques to continuously review and analyze systems, projects, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with required levels of performance, reliability, quality, or safety. Value improvement solutions shall be considered for formal submission of Value Engineering Change Proposals (VECPs) to reduce Government contract costs. The contractor may use SD-24 and FAR 52.248 as additional guidance for value management and VECPs.

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. Value Engineering Change Proposals

FAR Part 48 prescribes policies and procedures for using and administering value engineering (VE) techniques in contracts. FAR Part 52.248-1 encourages contractors to propose changes in the form of Value Engineering Change Proposals (VECP) that can reduce the life cycle costs of projects while maintaining performance and quality standards.

Regarding FAR VE guidance:

1. VECP Defined: The VECP must generate net acquisitions savings and must change the instant contract to implement. Reference 52.248-1 (b) (2) for restrictions to the type of change.

2. Contract Thresholds: The requirement to include the standard 52.248-1, the Incentive Clause, in contracts is based on the simplified acquisition threshold. FAR 52.248-1 may also be included in contracts of lesser value. Refence FAR 48.2 for exceptions to clause inclusion.

3. Contract Types: The VE incentive or mandatory clauses may be used in contract types such as incentive, fixed price, and cost reimbursement..

4. VE Voluntary Approach: If an accepted VECP is under the Incentive Clause (standard 52.248-1), the contractor uses its own resources to develop/submit VECPs. Guidance for the sharing arrangement in this scenario recommends a greater percentage of net acquisition shares to the contractor.

5. VE Mandatory Approach: If an accepted VECP is under the Program Requirements (mandatory) Clause (modified 52.248-1), the Government is required to pay for specific value engineering program efforts. Guidance for the sharing arrangement in this scenario recommends a greater percentage of net acquisition shares to the Government. Alternate I is the mandatory program and covers the entire contract. Alternative II is a mix of the voluntary and mandatory with a Scope of Work (SOW) defining the specific requirement allowing more flexibility. The objective of the Requirements Clause is to ensure that the contractor's value engineering effort is applied to areas of the contract that offer opportunities for considerable savings consistent with the functional requirements of the end item of the contract. Reference 48.101 (b) (2) for details.

4.6. 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.

4.7. 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.

4.8. 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.

4.9. 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

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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.

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