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

Chapter 2
Materiel Solution Analysis (MSA) Phase

Version 3.0

July 2025

Office of the Under Secretary of Defense for
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Department of Defense Manufacturing and Quality Engineering Body of Knowledge (M&Q BoK)

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Principal Deputy Executive Director, Systems Engineering and Architecture
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M&Q BoK Chapter 2 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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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 identify 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.

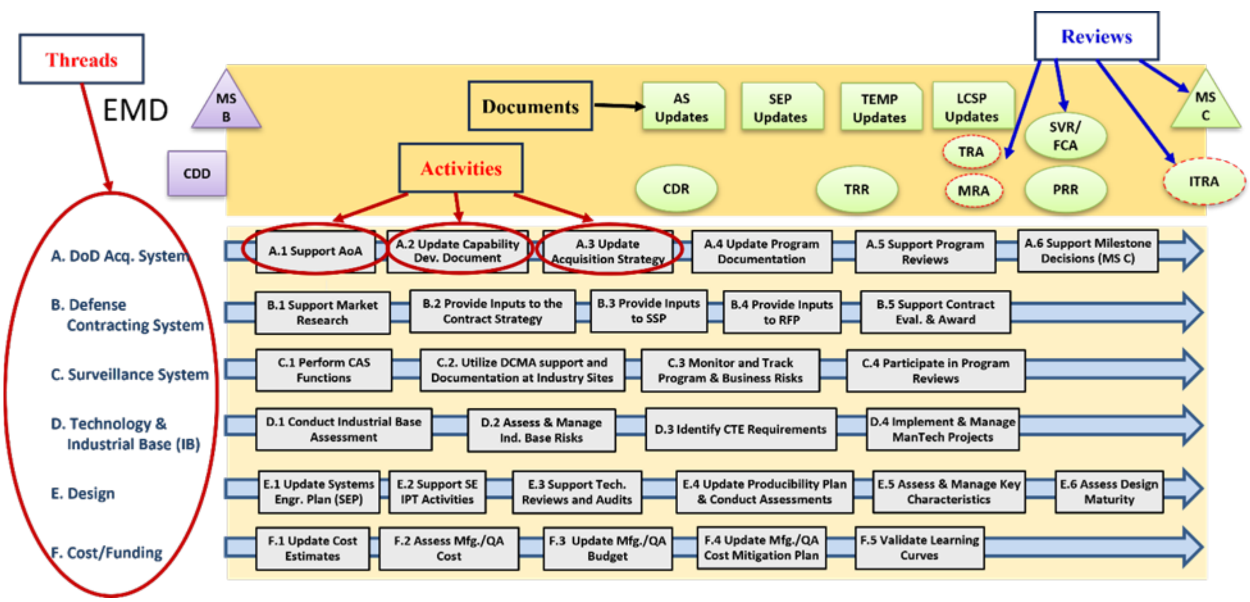
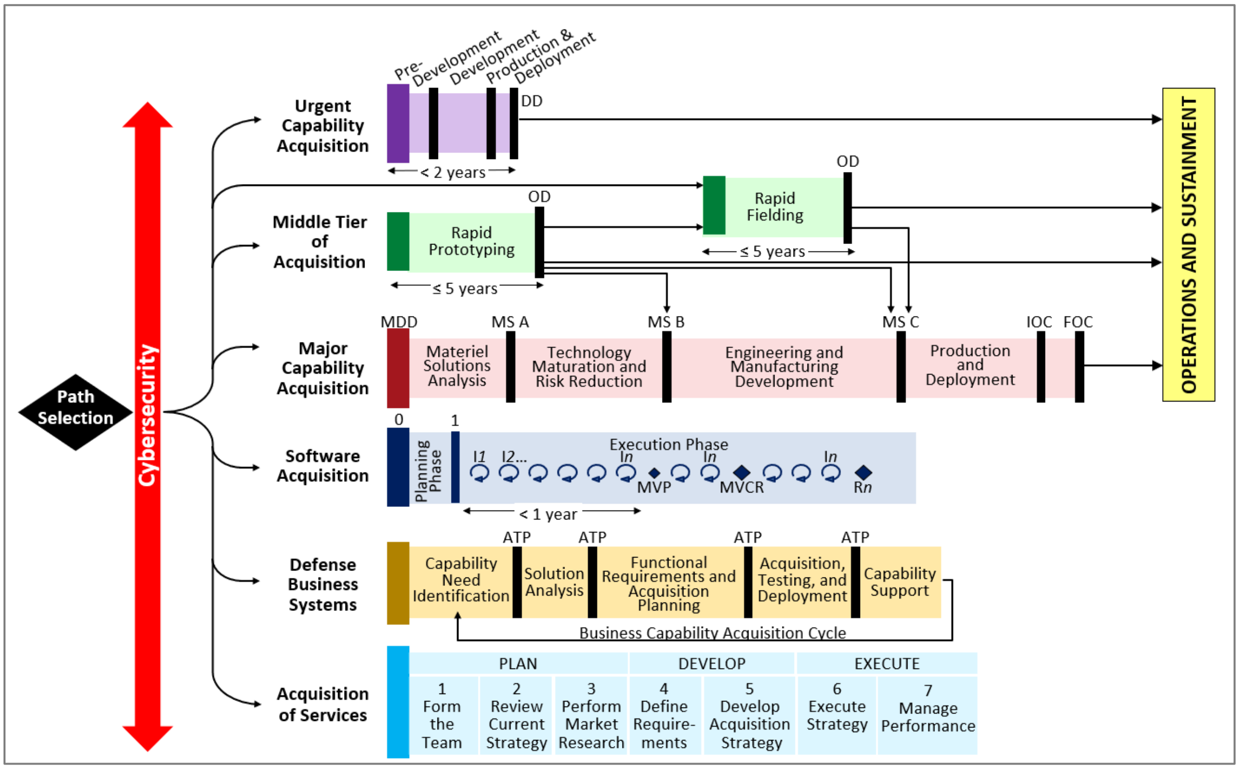


Figure 1. Sample Activity Chart

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) and 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.

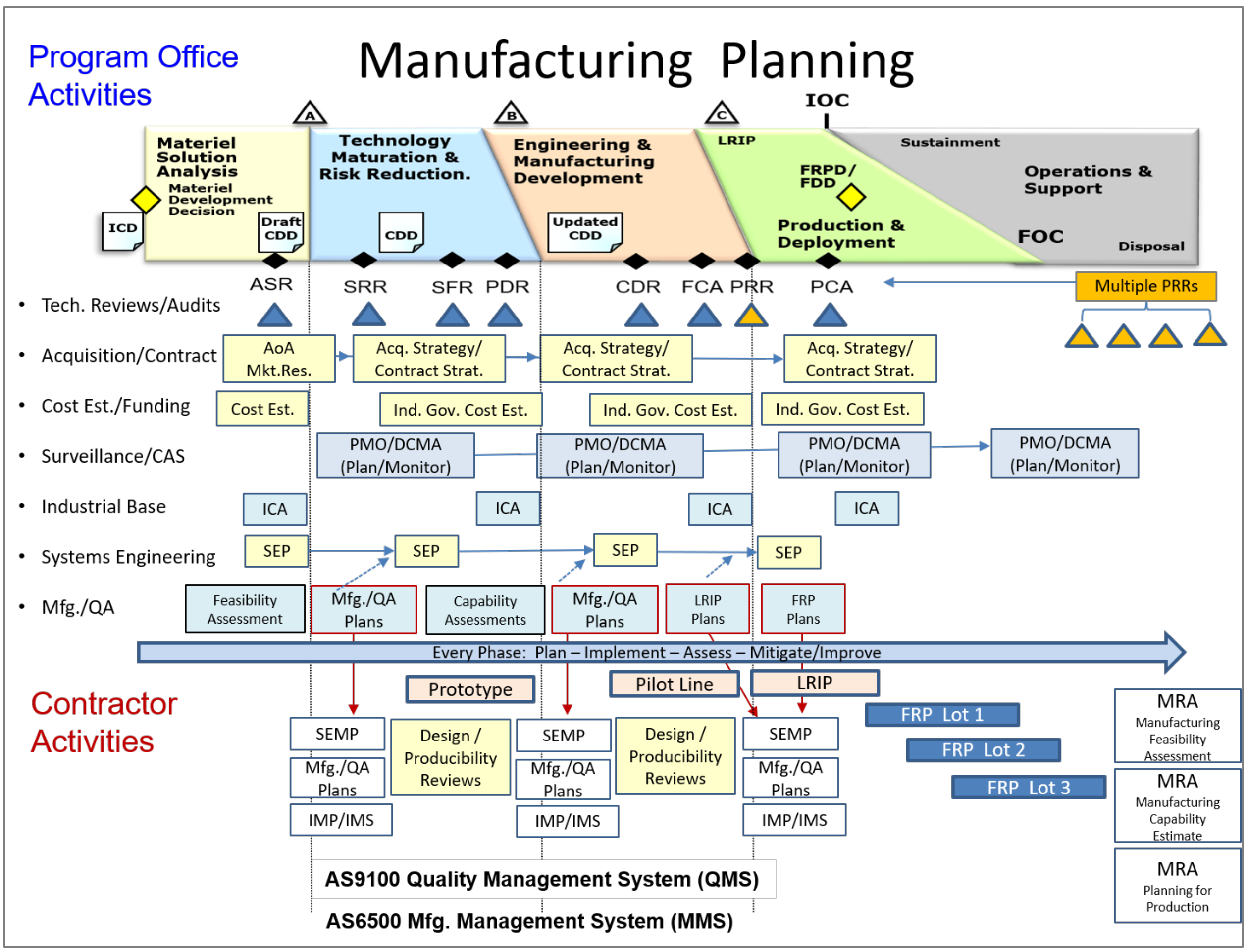


Figure 3. Typical Manufacturing and Quality Planning Activities

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 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 Manufacturing and Quality 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://www.cto.mil/sea/pg | Engineering Guidance
- Systems Engineering Plan (SEP) Outline https://www.cto.mil/sea/pg | Engineering Guidance
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://www.cto.mil/sea/pg | Risk Assessments
- 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://www.cto.mil/sea/pg

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 Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

2. Materiel Solution Analysis (MSA) Phase

Introduction

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

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.

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

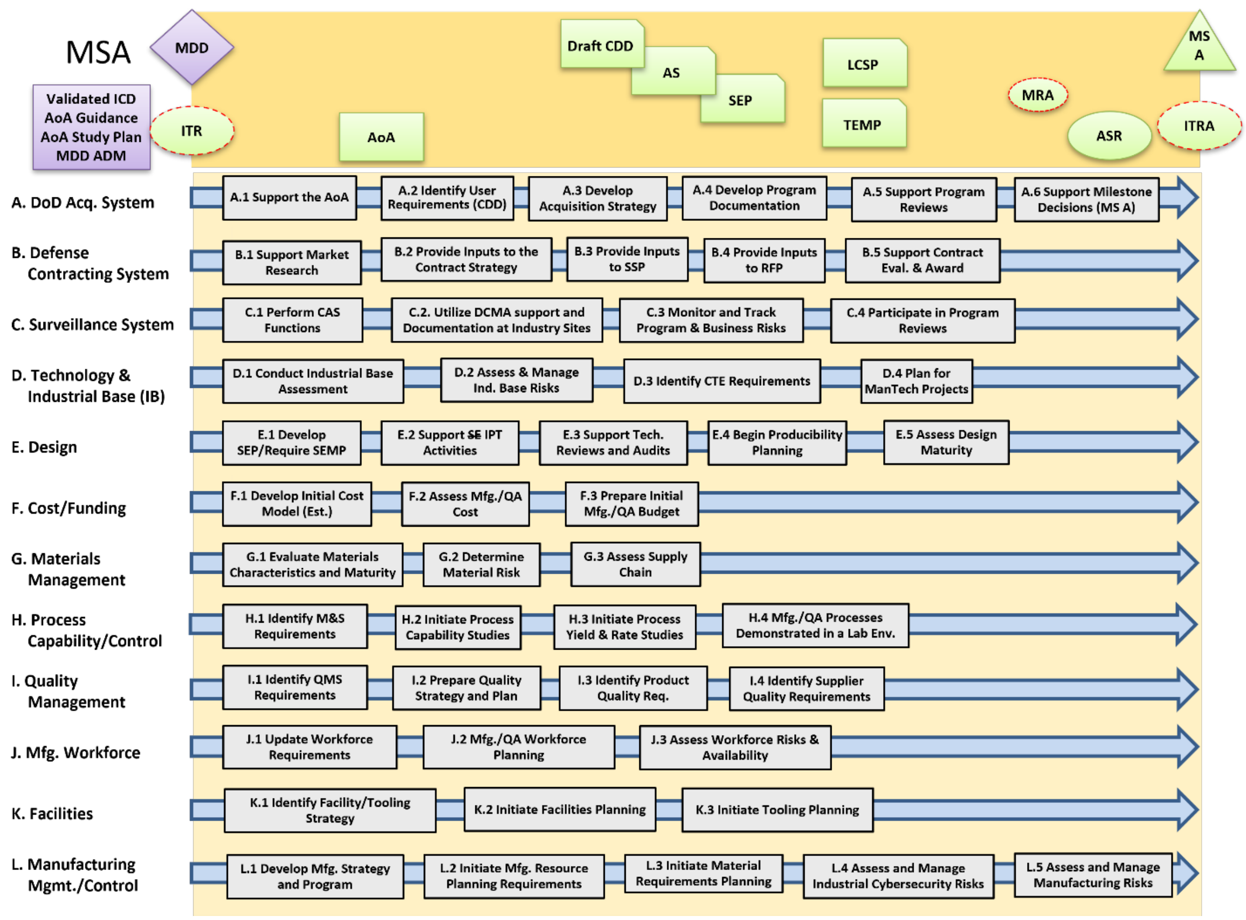


Figure 2-1. MSA Phase Manufacturing and Quality Activities

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

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

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

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

Manufacturing and Quality Objectives

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

- Conduct and complete the Analysis of Alternatives (AoA) with M&Q inputs needed to enable selection of a preferred materiel solution.
- Translate validated Key Performance Parameters (KPPs) and Key System Attributes (KSAs) into Key Characteristics (KCs) for M&Q.
- Conduct M&Q key trades for feasibility and affordability analyses; conduct risk, issue, and opportunity analyses; and plan for mitigations that impact cost, schedule, and performance.
- Develop M&Q goals for any needed development of critical enabling technologies.
- Translate the Initial Capabilities Document (ICD) with M&Q validation and verification analyses results into a draft Capability Development Document (CDD).
- Initiate the Test and Evaluation Master Plan (TEMP), the Systems Engineering Plan (SEP), and the Acquisition Strategy (AS) with inclusion of M&Q requirements.

The MSA phase specifies M&Q activities and tasks during early system development. The DoD Early Manufacturing and Quality Engineering Guide (https://www.cto.mil/sea/pg | Manufacturing and Quality) provides additional context for these activities within other early development activities (e.g., JCIDS, mission engineering, development planning, and systems engineering, digital engineering, acquisition planning). Increased M&Q practitioner involvement is encouraged during these early system development phases.

A. DOD ACQUISITION SYSTEM

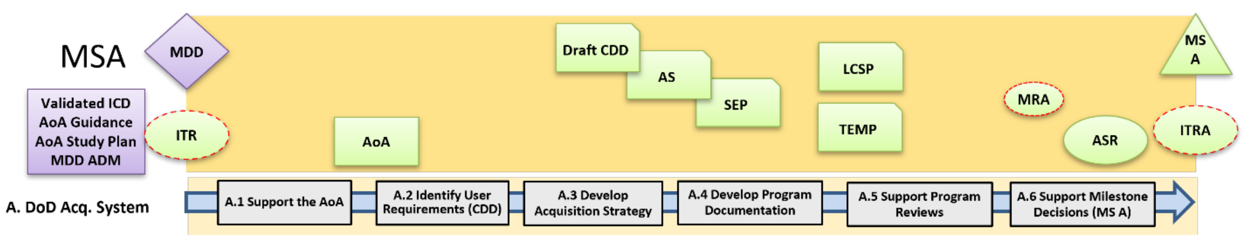


Figure 2-2. DoD Acquisition System Manufacturing and Quality Activities

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

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

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

A.1 Support the Analysis of Alternatives

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

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

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

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

Manufacturing and Quality Tasks

From an M&Q perspective during the AoA, each competing alternative under consideration is analyzed for its impact on industrial and manufacturing capabilities. The analysis uses the IBAs performed previously to determine the likelihood that a proposed materiel solution can be produced using existing manufacturing capabilities while meeting quality, rate, cost, and schedule requirements. The AoA also identifies new or high-risk manufacturing capability or capacity requirements if they are needed. The AoA should also identify critical technologies and the associated manufacturing process areas in each alternative requiring risk-reduction effort. The results of the analyses are used to quantify the differences between alternatives and select a preferred solution. At the close of the AoA, the program office takes ownership of the approach and conducts additional engineering analyses to support the development of the Acquisition Strategy and the SEP.

- Provide systems engineering support for addressing the following planning elements:
  - Capability needs architecture
  - System concept architecture
  - Key interfaces
  - Acquisition approach
  - Engineering/technical approach
  - Test and evaluation approach
  - Program management approach
  - Schedule
  - Resources
  - Risks
- Provide analyses of the M&Q requirements and feasibility contained in the draft CCD, and the preliminary CONOPS for the AoA:
  - Analyses should verify adequacy, relevance, and completeness
  - Analyses should identify and quantify M&Q risks
- Provide inputs to update to the AoA Study Plan and Study Guidance to include the following:
  - Critical technology elements (CTEs) associated with each proposed alternative, including technology maturity, integration risks, manufacturing feasibility, and technology maturation and demonstration
  - Lifecycle cost estimate and identified methodology including use of models and data, cost sensitivity, and identification of cost drivers and risks
  - Identification of study team and organization; M&Q personnel should be on this team
- Ensure IBAs and market analyses are updated for concepts included in the AoA (conduct if not previously accomplished):

  - IBAs should illustrate the differences between alternatives based on the industrial and manufacturing capabilities and the required resources during the AoA
  - Manufacturing feasibility should answer the question "Can it be built?"

- Ensure assessments of manufacturing feasibility for the AoA preferred concepts are up to date including engineering trade studies, early prototypes, models or data, and the industrial capabilities required to design, develop, manufacture, and maintain each (conduct if not previously accomplished):
  - Identify M&Q risks
    - Include materials, processes, and technology
    - Identify new or high-risk manufacturing processes or capacity requirements
  - Identify manufacturing, quality, materials, and unique requirements that are cost drivers for the AoA
  - Ensure the phase-by-phase requirements for M&Q skills and training are updated for the AoA preferred materiel solutions
  - Ensure the facilities and capital equipment requirements for each AoA preferred concept are updated
  - Ensure that each AoA preferred concept includes and is analyzed for quality management requirements
  - Ensure each AoA preferred concept includes and is analyzed for manufacturing management requirements
- Provide inputs to the AoA Final Report.
- 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
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Interactive MRL Users Guide (Checklist)

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Market Research Reporting Template
- Multi-Attribute Tradespace Exploration (MATE
- Pugh Matrix Template
- Quality Function Deployment Excel Spreadsheet
- Quality Function Deployment or House of Quality Matrix
- Requirements Traceability Matrix Template
- Requirements Verification Matrix
- Tailoring Worksheet for Materiel Solution Analysis Phase
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.84 Analysis of Alternatives
- Air Force Analysis of Alternatives (AoA) Handbook
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoD Market Research Guide
- SD-5 Market Research
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Pre-MDD Analysis Handbook
- Quality Function Deployment
- Requirements Traceability Matrix Guide
- DoD Technology Readiness Assessment Guide

A.2 Identify User Requirements

The Joint Capabilities Integration and Development System (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), in order 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).

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 Capabilities Development Document (CCD), Capabilities-Based Assessment (CBA). M&Q personnel may need to support the following CDD required Sections:

- Support the development of the Capabilities Development Document (CDD).
- Provide M&Q input on manufacturing feasibility and capability assessments.
- 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

- Support the assessment of how the proposed capability solution and its associated development performance attributes and other supporting data address the validated capability requirements and close or mitigate associated capability gaps.
- Support any technology readiness or other technical assessments in support of proposed material solutions.
- 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.
- Participate in the CBA or equivalent to provide manufacturing perspective on IB capability and manufacturing feasibility for both processes.
- Identify near-term opportunities that address user needs per the CCD 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.
- Cost Capability Analysis Guide suggests looking at capability development and requirements decisions:
    - What capability development requirements are the primary drivers of cost and schedule for this program?
    - How were the tradeoffs between cost, schedule, capability, and risk considered in determining these requirements’ measures? What are the cost/capability tradeoff opportunities?
    - How have affordability goals and constraints been included in the program and how will they be achieved?

Tools

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

Resources

- CJCSI 5123.01I, JCIDS Instruction
- 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
- Acquisition Requirements Roadmap Tool (ARRT) Suite
- AD/A5R Requirements Development Guidebook
- AFI 10-601 Operational Capability Requirements Development
- Manufacturing Readiness Level (MRL) Deskbook
- 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
- Quality Function Deployment (reference book)

A.3 Provide Inputs to the Acquisition Strategy

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. The strategy guides acquisition program execution across the entire system life cycle. It defines the relationship between the acquisition phases and work efforts, and key program events such as decision points, reviews, contract awards, test activities, production lot/delivery quantities, and operational deployment objectives. The strategy evolves over time and should continuously reflect the status and desired endpoint of the program.

Early systems engineering provides a foundation for the development of the Acquisition Strategy. The strategy is based on engineering analyses, trade studies, and preliminary system functional and performance requirements to meet a capability need. M&Q personnel need to be actively engaged in the development and update of numerous documents to include:

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

- Systems Engineering Plan (SEP)
    - Manufacturing Plan
    - Quality Plan

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

Manufacturing and Quality Tasks

- The Acquisition Strategy should address the following concerns:
    - Business Approach
    - Contracting Strategy (Type/Competition/Incentives)
    - SBIR/STTR Program Technologies
    - Market Research
    - Risk Management
    - Integrated Master Plan (IMP)/Integrated Master Schedule (IMS)
    - Product Support and Supportability Plan
        - ESOH
    - Industrial Base Considerations
    - Systems Engineering Plan
        - Manufacturing Plan
        - Quality Plan
        - Modular Open Systems Approach (MOSA)
- The Acquisition Strategy should emphasize and provide incentives for the important aspects of the program to include:
    - A market analysis and associated acquisition planning.
    - An assessment of the IB to support design, development, production, sustainment, or restart of an acquisition program.
    - An assessment of manufacturing feasibility to answer the question, "Can it be built?"
    - An initial M&Q strategy.

The Acquisition Strategy should include considerations such as:

- Competition: Competition can be a major contributor to reducing weapon system costs but can also be a major contributor to M&Q complexity and must be carefully planned.

- New manufacturing technologies: If required by the system concept, new manufacturing technologies will require specific plans for development, proofing, and transition of the technology to the eventual producer.
- Production rates and quantities: Rates and quantities play a major role in driving manufacturing cost as they will drive decisions on what production processes to use, types of tooling required, make-buy decisions, etc.
- Materials sourcing: Sources that are sole, single, fragile, or foreign sources, and those domestic sources that are vulnerable to foreign acquisition introduce risks to manufacturing.
- Contracting strategies: Acquisition Strategies and program planning should include M&Q technologies, facilities, investment incentives, risk mitigation efforts, etc.

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

- How risk areas will be addressed and minimized in the TMRR phase, on the path to full manufacturing capability in the P&D phase.
- What new manufacturing capabilities with a beneficial impact on the program will be addressed.
- The technical or manufacturing risks associated with the program and any critical technologies or manufacturing processes need to be matured and demonstrated in a manufacturing-relevant environment during the TMRR phase.
- The quality history of the item or system.
- Provide a summary of an updated M&Q IB capability analysis for the Acquisition Strategy, as required by DoDI 5000.02.
  - Provide inputs on the capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Provide inputs on IB capabilities, fragility, gaps, and risks for the Acquisition Strategy (e.g., key technologies, processes, components, etc.)
  - Provide the impacts and interdependencies of this acquisition on the National Technology Industrial Base (NTIB) and the analyses used to make this determination
  - Summarize M&Q impacts, how they will be managed, and the plan for future assessment, including frequency
  - Provide inputs for the government strategy and actions necessary to preserve the IB capabilities (e.g., incentivizing the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)
- Develop and provide a Manufacturing Strategy and a Quality Strategy to address the question “Can it be built?” The strategy should support the Acquisition Strategy development and include considerations of:

  - Competition and contracting strategies
  - New manufacturing technologies
  - Design (feasibility, producibility, KCs, risks, etc.)
  - Materials (characteristics, sourcing, risks, etc.)
  - Process, rates, and quantities (capabilities, control, risks, etc.)
  - Facilities, tooling, and workforce (including government-furnished equipment (GFE), special test equipment (STE), special inspection equipment (SIE), special requirements, etc.)
  - Management (quality, manufacturing, supply chain, risks, etc.)

- Provide M&Q inputs to Acquisition Strategy contracting strategy based on IB capabilities analyses, to support selection of a competitive award, a sole source award, or multiple source development (with down select for production contract) as the best course of action:
  - Include M&Q metrics to differentiate the value of each contract type such as performance, capacity, functional, economic, etc.
  - Include impacts on IB capabilities and risks that may result from different contract types (firm fixed price (FFP), fixed price incentive fee (FPIF), cost plus fixed fee (CPFF), etc.)
  - Determine prototyping approach for TMRR, either competitive, single, or prototyping of critical subsystems (statutory requirement for Major Defense Acquisition Program (MDAP) Acquisition Strategy, regulatory requirement for all other programs)

- Develop M&Q inputs to the Acquisition Strategy for the source selection approach that establishes and maintains access to competitive suppliers at the system, subsystem, and component level (e.g., requiring a modular open systems approach, alternative sources of supplies or services, etc.):
  - M&Q metrics to differentiate the value of each contract type to include performance, capability, capacity, affordability, etc.
  - Impacts and risks, issues, and opportunities that may result from different contract types (Firm Fixed Price (FFP), Fixed Price Incentive Fee (FPIF), Cost Plus Fixed Fee (CPFF), etc.)
  - Prototyping approach for EMD, either competitive, single, or prototyping of critical subsystems (statutory requirement for MDAP AS, regulatory requirement for all other programs)
  - Potential production approach for EMD and subsequent phases
  - Develop M&Q inputs that identify and address the sustainment of industrial capabilities, including manufacturing technologies and capabilities, and the maturation required during the TMRR and subsequent phases.
  - Provide M&Q inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystems, item, and component levels.

- Provide M&Q inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
  - Domestic alternatives through regeneration of prior capability
  - Creation of new capability for manufacturing products and processes
  - Lifetime buy of items at the subsystem and component levels

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

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

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

- Request DCMA inputs on strategies for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.

Tools

- Acquisition Strategy (AS) Outline Systems Engineering Plan (SEP) Outline
    - Manufacturing Plan
    - Quality Assurance Plan
- AS6500 Manufacturing Management System Checklist
- AS9100 Advanced Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Interactive MRL Users Guide (Checklist)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Group
- Initial Capabilities Document (ICD) Template
- Interactive MRL Users Guide (Checklist)
- Integrated Master Plan/Integrated Master Schedule: (i.e., Microsoft Project)
- Life Cycle Sustainment Plan Outline
- Test and Evaluation Master Plan Outline
- Technology Readiness Level (TRL) Assessment Checklist
- Risk Management Plan Template

Resources

- 10 USC 2431a. Acquisition Strategy
- FAR Part 7.105 Contents of Written Acquisition Plans
- Acquisition Plan Preparation Guide
- Acquisition Strategy Guide (DSMC)
- Acquisition Strategy Guide (NAVSEA)
- Systems Engineering Plan Preparation Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.6.6.1 Develop Acquisition Strategy
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- ISO 9001: Quality Management Systems
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Capabilities-Based Assessment (CBA) User’s Guide

- DCMA Industrial Analysis (DCMA-INST 401)
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- IEEE 15288-2014, Systems and Software Engineering
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Life Cycle Sustainment Plan Content Guide
- DoD Technology Readiness Assessment Guide
- TRA Deskbook
- Test and Evaluation Management Guide

A.4 Develop Program Documentation

Program Management Offices (PMOs) are faced with a myriad of program documents that they must create, update, and maintain because of statutory (law), regulatory or policy requirements. Often these documents are created in support of a Milestone A decision or at the initiation of a program. M&Q personnel need to actively support the development and update of many of these documents required during the MSA phase to include:

- Acquisition Strategy (covered under A2)
- Systems Engineering Plan (covered under E1)
- Contracting Strategy (covered under B2)
- Cybersecurity Strategy (covered under L4)
  - Industrial Security
- Product Support Strategy
- Acquisition Decision Memorandum (covered under A6)
- Acquisition Program Baseline
- Integrated Master Plan (IMP) and Integrated Master Schedule (IMS)
- Test and Engineering Master Plan (TEMP)
- Core Logistics Determination/Core Logistics and Sustaining Workloads Estimate
- Life Cycle Sustainment Plan (LCSP)
  - Product Support Strategy
- Environment, Safety and Occupational Health (ESOH) in Acquisition
  - Programmatic Environmental, Safety, and Health Evaluation (PESHE)
  - NEPA and NEPA Compliance Schedule
  - Hazardous Material Management Program

  - Pollution Prevention Program
  - System Safety and Health Program
- Capabilities Development Document (CDD) (covered under A2)
- Requests for Proposals (RFP) (covered under B4)
- Source Selection Plans (SSP) (covered under B3)

Manufacturing and Quality Tasks

- Request Program Documentation for the following items:
  - 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
  - Cost Data Summary Report DD Form 1921
  - Functional Cost-Hour Report (DD Form 1921-1) DI-FNCL-81566B
  - Long Lead Times Material Report DI-PSSS-82201
  - 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
  - Producibility Analysis Report DI-MGMT-80797A
  - Production Line of Balance (LOB) Status DI-MGMT-80034
  - Progress Curve Report DI-FNCL-81567C (DD Form 1921-2)
  - 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
  - Systems Engineering Management Plan (SEMP) DI-SESS-81785A
- Update the Acquisition Strategy.
- Update the Systems Engineering Plan.
- Update the Manufacturing Strategy and Quality Strategies.
- Initiate the M&Q Industrial Base (IB) capability analyses updates for inclusion in the Acquisition Strategy and the RFP to include inputs on:
  - IB capabilities, fragility, gaps, and risks for the Acquisition Strategy (e.g., key technologies and key and critical processes, parts, components, etc.)

  - Capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Impacts and interdependencies of this acquisition on the National Technology Industrial Base (NTIB) and the analyses used to make this determination
    - Include how they will be managed
    - Include plans for future assessments, including frequency
  - Government strategy and actions necessary to preserve the IB capabilities (e.g., incentives for the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)
- Provide M&Q inputs to Acquisition Strategy for a contracting strategy that supports selection of the best course of action through either a competitive award, a sole source award, or multiple source development to include:
  - M&Q metrics to differentiate the value of each contract type to include performance, capability, capacity, affordability, etc.
  - Impacts and risks, issues, and opportunities that may result from different contract types (Firm Fixed Price (FFP), Fixed Price Incentive Fee (FPIF), Cost Plus Fixed Fee (CPFF), etc.)
  - Prototyping approach for EMD, either competitive, single, or prototyping of critical subsystems (statutory requirement for MDAP AS, regulatory requirement for all other programs)
  - Potential production approach for EMD and subsequent phases
- Update M&Q inputs to the Acquisition Strategy for TMRR with a source selection approach that establishes and maintains access to competitive suppliers at the system, subsystem, and component level (e.g., requiring a modular open systems approach, alternative sources of supplies or services, etc.).
- Provide updated M&Q requirements as inputs for required technical reviews, production decisions, events, prototypes, and deliveries, including sub-tier subsystem, item, and components, to be included in the Acquisition Strategy based on:
  - Reports and data from DCMA
  - Analyses materials availability (lead-time and scale-up) and maturity (characterization)
  - Contractor data on rates and yields for M&Q
  - Analyses of M&Q maturity and projections
  - Reports on facilities, tooling, and workforce utilization
  - Updated capital equipment requirements
- Provide updated M&Q input and plans for the IMP/IMS including:
  - Schedule for any planned use of government-furnished special test equipment (STE), government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.).
  - Schedule impacts from the requirements for special materials and allotments, and the reasons for them if applicable

  - M&Q internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
  - Inputs on reviews down to the sub-tier level (including PDR, CDR, PRR, etc.), documentation inputs (e.g., draft CDD, TEMP, AS, SEP, PDR, etc.), production events, and deliveries
- Provide updated M&Q inputs and plans to the Test and Evaluation Master Plan (TEMP) including:
  - Demonstrations and assessments of capabilities of key subsystems and components
  - Demonstrations and assessments of production-related test activities and production processes
  - Assessment of the Quality in Design leading to producible and testable products
- Provide updated M&Q inputs and plans to the Core Logistics Determination/Core Logistics and Sustaining Workloads Estimate including:
  - By Milestone A, the DoD component will document its determination of applicability of core depot-level maintenance, repair capability requirements
- Provide updated M&Q inputs and plans to the Life Cycle Sustainment Plan (LCSP) including:
  - Inputs to the Product Support Strategy
  - Identify sustainment cost drivers
  - Identify sustainment technologies requiring development
  - Identify material availability concerns and risks
- Provide updated M&Q inputs and plans to the NEPA and NEPA Compliance Schedule including:
  - Environmental Impact Statement (EIS) developed and published
- Update the government Manufacturing Management and Quality Management approach for TMRR to include:
  - Changes in M&Q requirements
  - M&Q resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to M&Q organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
  - Changes to M&Q support organization required to meet program projected needs for TMRR and subsequent phases including:
    - Earned Value Management requirements
    - Cost control requirements
    - Data collection, reporting, and management
- Update the M&Q requirements for the TMRR contractor's Manufacturing Management System (MMS) and Quality Management System (QMS):

- Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
- If M&Q standards are not specified, develop requirements for program specific manufacturing management plan and quality management plan
- Identify M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle

- Update requirements for identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program:
  - Ensure a joint M&Q comprehensive Risk, Issue, and Opportunity Management Process that can identify, and tracking risks and associated mitigation plans is in place
- Analyze identified M&Q risks, issues, and opportunities, and associated mitigation plans for adequacy and completeness, and potential impacts on TMRR and subsequent phases to include:
  - Risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule
  - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
  - Required maturation of critical technologies and manufacturing processes to the appropriate level
  - M&Q cost and schedule impacts
- Update the M&Q support plan for an assessment of manufacturing readiness and the mandated independent assessment.
- Ensure other agencies are providing input on strategies (e.g., DCMA, Defense Logistics Agency (DLA), etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.
- Ensure M&Q updated inputs to the TEMP include the following:
  - M&Q updates and impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Planned significant activities indicated on the updated EMD program schedule
    - Manufacturing assessments
    - Long-lead or advanced procurements
    - Prototype builds
    - Projected lots or phases
    - Production Readiness Review
  - Updated inputs to the Risk, Issue, and Opportunity Management process and plans that include:
    - Industrial risks
    - Manufacturing risks
    - Quality risks
    - Engineering risks

    - Software risks
    - Production risks
    - Risk reduction and mitigation efforts
  - Updated Program Manufacturing Management Plan addressing software development and reuse
  - Updated M&Q inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
    - Compliance with Defense Federal Acquisition Regulation Supplement (DFARS), Program Protection Plan (PPP), International Trafficking in Arms Regulation (ITAR), etc.
    - Management of Controlled Unclassified Information
    - Technical approaches to cybersecurity and related M&Q security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
  - Updated Program Manufacturing Management Plan addressing each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
    - Manufacturing Management System
    - Design Analysis for Manufacturing
    - Manufacturing Risk Identification (including mitigation)
    - Manufacturing Planning
    - Manufacturing Operations Management
  - Updated inputs on the M&Q organization, billets and key assignments including:
    - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
  - Updated M&Q planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
  - Updated M&Q inputs to the configuration managed IMP/IMS including critical path

Tools

- Acquisition Strategy Outline
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- CDD Template
- ISO 9001, Quality Management System Checklist
- Interactive MRL Users Guide Checklist
- Life Cycle Sustainment Plan
- Manufacturing Maturation Plan
- Technology Readiness Level (TRL) Assessment Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center

- Integrated Master Plan/Integrated Master Schedule use MS Project
- Risk Management Plan Template
- SEP Outline updated to Version 4.1
  - Manufacturing Management Plan
  - Quality Assurance Management Plan
- TEMP Outline

Resources

- Acquisition Strategy Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- CDD Writing Guide
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities subpart 207.106 (S-70) of the Defense Federal Acquisition Regulation Supplement
- DoDD 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89 Test and Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- ISO 9001:2015, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- NIST 800-171, June 2015, Controls for Controlled Unclassified Information
- RFP Proposal Evaluation Guide
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline
- DoD Technology Readiness Assessment Guide

- Test and Evaluation Management Guide

A.5 Support Program Management Reviews

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

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

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

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

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

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

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

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

- Manufacturing
- RAM & Sustainment

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

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

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

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

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

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

Manufacturing and Quality Tasks

- Support the conduct of the ASR.
- Support the conduct of an MRA.
- Support the conduct of a TRA.
- Support the conduct of an ITRA.
- Support the conduct of an ILA.
- M&Q provides inputs and analyses to the ASR to support that the preferred materiel solution(s) resulting from the AoA have the best potential to be cost effective, affordable, operationally effective, and suitable, and can be developed to provide a timely solution to the need at an acceptable level of risk. M&Q representatives supporting the program IPTs will:

- Review, evaluate, and update the M&Q producibility assessments for the preferred system concept(s) for adequacy
- Review, evaluate, and update the comprehensive risk, issue, and opportunity assessment for completeness and adequacy of all M&Q risks and update mitigation plans (develop if not initiated):
  - Complete trade studies or technical demonstrations for manufacturing concept risk reduction
  - Incorporate producibility and manufacturing considerations that could impact program decisions (e.g., critical components, materials and processes, tooling and test equipment development, production testing methods, long lead items, and facilities/personnel/skills requirements)
- Review and evaluate the risks to M&Q associated with the use of a commercial off-the-shelf (COTS)/government off-the-shelf (GOTS)/non-developmental item (NDI) solution versus a new design
- Complete the M&Q input to the initial hazard analysis and/or the system safety analysis for the preferred solution(s)
- Assess the M&Q requirements of the draft CDD to verify that all KCs are traceable to user needs through preliminary system specifications, key assumptions, and constraints back to KPPs and KSAs (from JCIDS)
- Assess the results of the AoA materiel solution(s) to meet M&Q cost, schedule, and performance objectives
- Review, evaluate, and update the comprehensive M&Q plans that address critical items, parts, components, and prototypes to be developed and demonstrated, along with their cost, and critical path drivers
- Review risks associated with DMSMS and Obsolescence
- Provide M&Q inputs on the scope and planning of competitive prototyping of the materiel solution systems, subsystems, and components
- Provide M&Q inputs on the scope, planning, and resources needed for the initial end-item development
- Review Lessons Learned for M&Q drivers of system life cycle cost
- Provide inputs to the CARD that reflect realistic materiel solutions that meet the draft CDD within M&Q IB constraints including workforce estimates
- Review the timing and entry/exit criteria
- Review the Product Support Strategy

Tools

- Alternative Systems Review Checklist
- Army Acquisition Logistician's Assessment Checklist v.5
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974

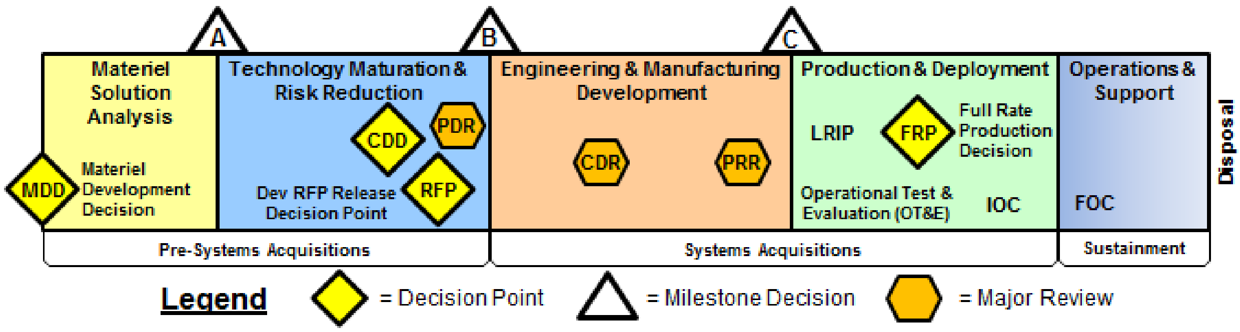
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist, v3
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Quality Status Report, DI-MGMT-82186
- Technical Readiness Assessment (TRA) Checklist

Resources

- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- ISO 9001:2015, Quality Management System
- Independent Logistics Assessment Guidebook
- Logistics Assessment Guidebook Tool
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

A.6 Support Milestone Decisions

Milestones are a point in time where a recommendation is made to the Milestone Decision Authority (MDA) about starting or continuing an acquisition program into the next Acquisition Phase. DoD Instruction 5000.02 establishes the milestones and Milestone Requirements “Operation of the Defense Acquisition System.”



The Milestone Decision Authority (MDA) is the overall executive sponsor responsible for any Major Defense Acquisition Program (MDAP). The MDA formally initiates each increment of an evolutionary acquisition program as required by DoD Instruction 5000.02 "Operation of the Defense Acquisition System." They determine if a program has met its phase exit requirement and can proceed into the next phase during a Milestone review in terms of cost, schedule, and performance. The Under Secretary of Defense (USD) (AT&L) is the MDA for all major Acquisition Category (ACAT) 1 program unless delegated. Program initiation may occur at Milestone B or C.

The MDA/DA is the program decision authority and specifies the decision points and procedures for assigned programs. The MDAs/Das will tailor program strategies and oversight, phase content, the timing and scope of decision reviews, decision levels based on the characteristics of the capability being acquired (including complexity, risk, and urgency) to satisfy user requirements. MDAs for MDAPs and major systems will approve, as appropriated, the acquisition strategy at all major decision points.

DoDI 5000.85 3.1. b Decision Reviews:

The purpose of decision reviews is to carefully assess a program's readiness to proceed to the next acquisition phase and to make a sound investment decision committing the Department's financial resources. Consequently, reviews will be risk and data focused to facilitate an examination of relevant questions affecting the decisions under consideration and allowing the MDA to judge whether the program is ready to proceed.

- The MDA is the sole and final decision authority. Staff members and staff organizations support and facilitate the MDA's execution of that authority.
- The Defense Acquisition Board (DAB) will advise the Defense Acquisition Executive (DAE) on critical acquisition decisions when the DAE, or designee, is the MDA. The DAE or designee will chair the DAB. An Acquisition Decision Memorandum (ADM) will document decisions resulting from reviews.
- Overarching Integrated Product Teams (IPTs) at the OSD level, and similar organizations within the DoD Components, are expected to collectively assist the MDA in making sound investment decisions for the department, and to ensure programs are structured and resourced to succeed. These organizations are not decision bodies and they and their leaders do not

supplant the authority of the PM, Program Executive Officer (PEO), or component acquisition executive (CAE), or DAE.

DAU's Milestone Requirements Matrix identifies mandatory statutory and regulatory documentation requirements. These requirements vary based on the type of acquisition being perused (Urgent Capability, Mid-Tier Acquisition, Major Capability, etc.). The requirements for Adaptive Acquisition Framework Document Identification (AAFDID) can be found on the DAU website: https://www.dau.edu/aafdid/Pages/MTA-Statutory-Regulatory-Requirements.aspx

M&Q personnel should be actively engaged in the organization and execution of numerous formal reviews and audits during this phase. The Milestone A review should include the following:

- Analysis of Alternatives
- Acquisition Strategy (AS)
- Cost Estimate (should include M&Q inputs)
- Should Cost Management (should include M&Q costs)
- Business Case Analysis
- Affordability Analysis (should include M&Q cost drivers)
- Approved Initial Capabilities Document
- Life-Cycle Sustainment Plan
- Programmatic Environmental, Safety and Occupational Health (ESOH) Evaluation (PESHE)
- Test and Evaluation Master Plan
- Program Risks (should include M&Q risks) and Risk Mitigation Activities
- Program Support Review was conducted using DAPS Methodology

Manufacturing and Quality Tasks

M&Q assurance managers should support the Milestone A decision by providing insight into various M&Q considerations. The goal of Milestone A is to determine if a program has met all its Exit Criteria and is mature enough to move into the TMRR Phase. Principal considerations include:

- Justification for and the affordability and feasibility of the preferred military solution.
- Identification of the technologies that must be matured during the TMRR phase.
- The scope of the capability requirement trade space and an understanding of the priorities within that trade space.
- Technical, cost and schedule risks, and the plans and funding to offset them during the TMRR phase.
- A proposed acquisition strategy, including intellectual property (IP), program protection, and exportability and acquisition planning.
- The test strategy.
- A life-cycle mission data plan for each intelligence mission data-dependent program (including cyber) and the projected threat and its impact on the materiel solution.

The maturity of the emerging technologies and manufacturing processes determines the path forward. Manufacturing and quality assurance (QA) managers need to assess and demonstrate manufacturing processes to the extent needed to verify that risk has been reduced to an acceptable level and are ready to move forward to the next phase.

- Support the Overarching Integrated Product Team (OIPT) in support of the Defense Acquisition Board (DAB),
- Support the Milestone A Decision and development of documentation.
- 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

Tools

- Acquisition Decision Memorandum (ADM) Materiel Development Decision (MDD) Template v1.4
- Acquisition Decision Memorandum (ADM) Milestone B Template
- Acquisition Decision Memorandum (ADM) Milestone C Template
- Milestone Decision Identification (DMID) Tool
- Cost and Affordability Analysis Tools (numerous)
- DCMA Industrial Capability Assessment Survey Form
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- Multi-Attribute Tradespace Exploration (MATE)
- Quality Function Deployment in excel
- Independent Technical Risk Assessment Checklist
- Integrated Master Plan/Schedule
- Earned Value Management Toolkit
- Milestone Template
- Life Cycle Sustainment Plan
- Market Research
- Pugh Template
- Navy PEO Milestone B Review Checklist
- Technology Readiness Assessment (TRA)
- Test and Evaluation Master Plan

- Transition to Production Assessment

Resources

- 10 USC 2366a MSAPs, Determination Required Before Milestone A
- DoDI 4245.7-M, Transition from Development to Production
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment (TRA) Guide
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- GAO Schedule Assessment Guide
- Life Cycle Sustainment Plan (*See* Product Support Manager Guide)
- Test and Evaluation Management Guide
- Cost and Affordability Analysis Guides (numerous)
- DoD Market Research Guide
- DCMA Instruction 3401, “Defense Indusial Base Mission Assurance”
- Pre-MDD Analysis Handbook

B. DEFENSE CONTRACTING SYSTEM

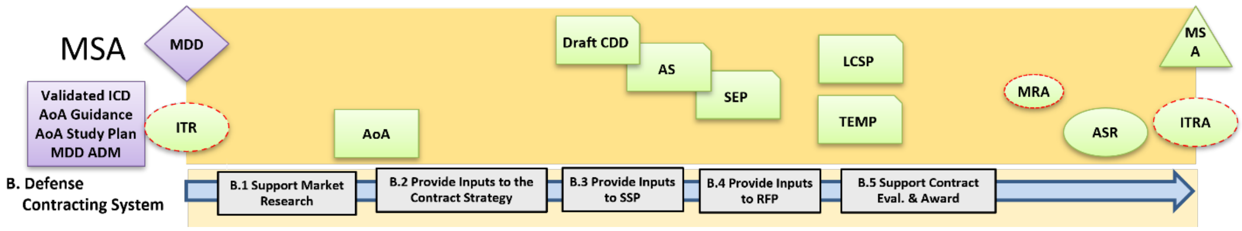


Figure 2-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

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

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

Each of the M&Q inputs to the RFP should note appropriate criteria and metrics to be met, included in the SSP, to ensure a fair and equitable source selection. The M&Q criteria and metrics should be coupled with appropriate award fee incentives, with processes and procedures, to reward successful management and execution, including incremental achievements of program goals. The criteria and metrics should also be used to incentivize domestic manufacturing and technology capability improvements that contribute to performance enhancement, schedule improvement, cost savings, etc.

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

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

- Market Research
- Contract Strategy
- Source Selection Plan
- Request for Proposal

- M&Q Inputs to the Contract (Sections C, E, L, and M) (refer to MIL-HDBK-245D)
- Contract Evaluation and Award

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

B.1 Provide Input to 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 use of recovered materials 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. Thorough market research needs to be conducted to determine whether or not small businesses are capable of satisfying the 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 in the following areas:
  - 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.
- Support the development of contracts, as appropriate.
- Identify and characterize materiel solutions resulting from the Sources Sought to support Requests for Information (RFI) activities and Industry Day events.
- Ensure the Request for Information (RFI) is open to alternative solutions.
- Analyze potential trade space to identify performance versus cost benefit discriminators for potential materiel solutions.
- Initiate planning for the M&Q efforts required during the next phase.

Tools

- Market Research 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 Input 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 adequacy of the contractors 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 risk of being able to achieve program performance requirements.
- Technical Risks is the risk of not meeting design, M&Q maturity dates and expectations.

The Contracting Cone outlines the full spectrum of available FAR and Non-FAR contract strategies. The interactive graphic below is available on the DAU website (Contracting Cone | Adaptive Acquisition Framework (dau.edu)).

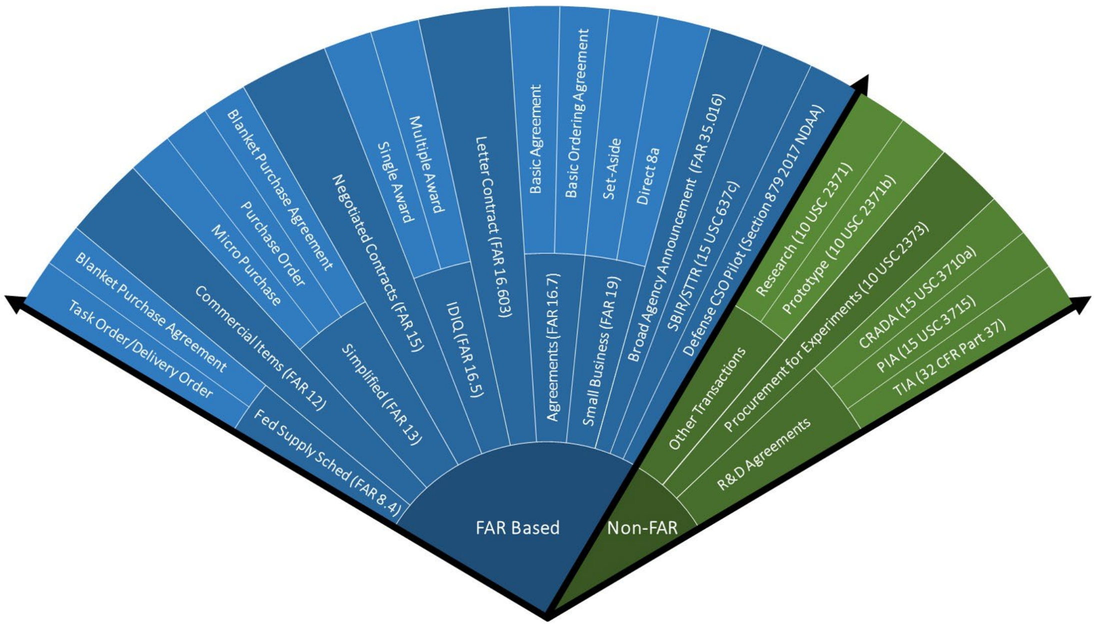


Figure 1-5. Contracting Cone

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.

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

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

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

Manufacturing and Quality Tasks

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
  - Co-production
- Develop M&Q entrance and exit criteria for technical reviews and decision points:
  - Specify metrics for partial achievements, incremental awards, penalties for failure to meet contract requirements, and achievement beyond expectations
- Support the development of contract incentives for early delivery of completed, comprehensive, and acceptable M&Q CDRLs, DIDs, and other program documentation to meet the requirements for timely government approval:
  - Specify metrics for partial achievement and penalties for failure to meet contract requirements
- Provide incentives for the achievement of M&Q specific thresholds, objectives, and sub-goals with respect to rate, schedule, performance, quality, etc.:
  - Specify metrics for partial achievements, incremental awards, and penalties for failure to meet contract requirements

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

Tools

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

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook
- Award Fee Guide, (Army, Navy, or Air Force guidance)
- Defense Production Act Title III (Manufacturing Technology Programs)
- DoDD 4400.01E, Defense Production Act Programs
- ISO 9001:2015, Quality Management Systems
- MIL-HDBK-896, Manufacturing Management Program Guide

B.3 Provide Input to the Source Selection Plan (SSP)

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

Manufacturing and Quality Tasks

- See Early Manufacturing and Quality Guide, Sections 2 and 3
- Support the drafting of the SSP and provide inputs and metrics.
  - Analyze the M&Q results from the AoA Study Guidance and the AoA as a basis for SSP requirements and metrics
  - Results from other relevant M&Q feasibility and IB studies to be used as additional data for SSP requirements and metrics
- Specify the criteria and metrics for evaluating the contractor's use of best practices for Manufacturing Management, Quality Management (e.g., AS6500, ISO 9001, AS9100, etc.), and Systems Engineering management (i.e., IEEE 15288):
  - Specify the criteria and metrics for evaluating the contractor's proposed processes, methods, and actions to address manufacturing feasibility, producibility, and quality risks associated with the proposed solutions
- Support SSP with appropriate criteria and metrics for submission, review, revision, and approval of CDRLs, DIDs, etc., to support M&Q processes.
- Specify M&Q criteria and appropriate metrics to be met for:
  - All milestones and technical reviews
  - M&Q reviews (including frequency of reviews)
  - Cost models and data (include cost-of-quality data)
  - Management processes for key and critical characteristics
  - Risk, issue, and opportunity identification, management, and mitigation program
  - Variability reduction program
  - Materials management process
  - Supply chain management program
  - Facilities, tooling, and test equipment plan
  - Workforce planning

- Specify the criteria and metrics for evaluating the contractor's:
  - Manufacturing and technology capability improvement plans and efforts.
    - Include cost sharing and incentive plans
  - Producibility efforts relevant to the solution.
    - Include cost sharing and incentive plans
  - Planning for IB risk management and mitigation
  - Plan to meet the exit criteria for TMRR phase
  - Strategy for acquisition of modern technology, production equipment, and production systems that increase productivity and reduce life cycle costs
    - Methods to encourage investment in U.S. domestic sources
- Specify the criteria and metrics for contractor support of independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment.

Tools

- 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
- Air Force Manufacturing Development Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Defense Federal Acquisition Regulation Supplement, Procedures, Guidance and Information, Subpart 215.3 – Source Selection
- IEEE 15288, Systems and Software Engineering
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs

- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management Systems
- PL 114-328, National Defense Authorization Act for 2017
- Source Selection Plan Guide

B.4 Provide input to the Request for Proposal (RFP)

The RFP is a document that solicits bids from vendors and provides an opportunity to communicate government requirements to the contractor for a specific proposal. Included within the RFP is the Statement of Work (SOW) which outlines the work to be performed and is a legally binding agreement. The RFP should identify the information required in the contractor's proposal and the criteria that will be used to evaluate the proposal, and the relative importance of those criteria. M&Q managers typically support the development of the RFP by identifying M&Q considerations and criteria for inclusion in the RFP and subsequent contract. The input to the RFP needs to be short and very succinct. These considerations need to ensure there is linkage between the ongoing M&Q considerations, warfighter requirements, and the evaluation factors and sub-factors. Evaluation factors often include cost or price, and quality of product or service, which include technical considerations, past performance, and others. 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.

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

Manufacturing and Quality Tasks

- 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

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

Resources

- Early Manufacturing and Quality Guide
- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- 10 USC 2366b
- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems

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

B.5 Support Contract Evaluation and Award

The evaluation phase begins when the government contracting office (CO) receives the offerors' proposals to the solicitation. In order 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.

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

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

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.
- <u>Supplier Management</u>. 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 for:
  - 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's past performance:
  - Review of the Past Performance Information Retrieval System (PPIRS)
  - Review contractor Past Performance Questionnaire
  - Review contractor Past Performance Citations
- Review of contractor plans for:
  - Project Management Plan
  - Manufacturing Management Plan
  - Quality Management Plan
  - Risk Management Plan
- Support contract negotiations:
  - Review of contractor cost and pricing
  - Compare to Independent Government Cost Estimate
- Support contractor selection:
  - 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:
  - Ensure quality
  - Ensure on time delivery
  - Manage subcontracts
  - Manage changes

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

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

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

Tools

- 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
- Award Fee or Incentive Fee Template

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
- Award Fee Guide, (Army, Navy, or Air Force guidance)

C. SURVEILLANCE SYSTEM

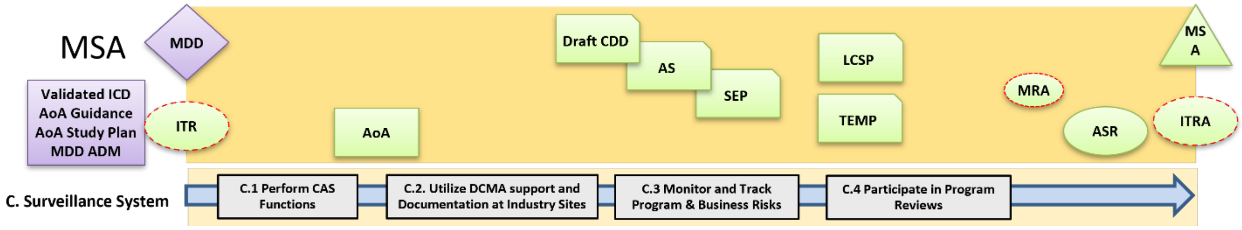


Figure 2-4. Surveillance System Manufacturing and Quality Activities

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

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

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

Often these activities may be performed under mutual agreement by the program office and the Defense Contract Management Agency (DCMA). In many cases these contractor surveillance activities may be performed by on-site program office contract administrators, delegated Service contract surveillance offices, or a variety of engineering support activities (i.e., supervisor of shipbuilding (SUPSHIP), or development command field activities). The activity managing the concept, or the Program Manager, should maximize the use of DCMA and engineering support activity at personnel contractor facilities where there is delegation of authority and expertise available. They should request the DCMA Contract Management Offices jointly support development of program support plans for all Acquisition Category I program contracts to ensure agreement on contract oversight needs and perspectives. M&Q managers play an integral and vital role in defining the total scope of contract administration. Program offices can delegate many CAS activities to DCMA as a best practice. Delegations may require a Memorandum of Agreement (MOA) or a Letter of Delegation (LOD). The program office should coordinate with DCMA on required support, provided there is adequate manpower and funding to support the proposed MOA/LOD.

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

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

C.1 Perform 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 during 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

- Track program status, program performance and actual or anticipated program problems:
  - Ensure timely submission of required reports (cost, schedule, performance, etc.)
  - Assess contractor reports (cost, schedule, performance, etc.)
- Assess and monitor industrial security program.
- Perform property administration:
  - Support 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:
  - Assess and monitor production capability and capacity
- Ensure timely reporting of potential and actual slippages 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:

  - 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 the monitoring of the contractor's financial condition.
- Support contract closeout procedures.

Tools

- AS9100 Checklist
- ISO 9001 Checklist
- AS6500 Checklist
- DCMA Program Support Plan per DCMA-ANX 205-02
- DCMA Pre-award survey (technical, production, quality, and financial)
- 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
- DCMA-INST-323, Data Collection and Analysis
- DCMA-INST-324, Product Examination
- DCMA-INST-325, Technical Reviews
- DCMA-INST-401, Industrial Analysis
- DCMA-INST-1102, Product Quality Deficiency Report
- DCMA-INST-1201, Corrective Action Process

- DCMA-INST-2301, Evaluating Contractor Effectiveness
- DCMA-INST-3101, Program Support
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment (TRA) Guide

C.2 Use DCMA Data and Support at Industry 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 sustainment. 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
- 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)
- QA Audits
- 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

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

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

Manufacturing and Quality Tasks

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

- Support the systems engineering process, trade studies, design, analyses, etc., using DCMA M&Q data from DCMA reports on:
  - Manufacturing and Quality System Analyses
  - Manufacturing and Quality Program and Product Analyses
  - Manufacturing and Quality Continuous Improvement and Analysis
  - Supply Chain System Analysis
  - Supply Chain Risk Assessment
- Support program assessments.
- Monitor manufacturing and production operations.
- Perform Quality inspections and monitor the contractors QMS.
- Provide engineering support and analysis.
- Conduct industrial analysis and monitor industrial cyber security programs.
- Support the management of government property.
- Support program cost assessments, and cost/financial reporting.
- Perform or support testing and first article inspections/tests.
- Recommend manufacturing investment programs required to mature emerging manufacturing technologies and industrial capabilities based in part on DCMA inputs.
- Request DCMA Contract Management Offices support development of M&Q to ensure agreement on contract oversight needs and perspectives with respect to:
  - Product support analysis
  - Software development
  - Counterfeit parts
  - Cybersecurity
- For manufacturing feasibility assessments of AoA concepts, request information and data input for similar products and manufacturing processes from DCMA in the following areas:
  - Manufacturing maturity
  - Status and readiness of industrial capabilities
  - Current available facilities and equipment
  - Workforce availability and training
  - Quality system processes and results
- Use DCMA M&Q data to analyze the M&Q requirements and feasibility for the AoA.
- Use DCMA M&Q data relevant for emerging technology maturity to develop and provide recommendations/rationale for the AoA preferred concepts.
- Use DCMA data to assist in identifying the manufacturing, quality, and/or supply chain risks for similar products and processes relevant for the AoA.
- Request and use DCMA M&Q data in support of the AoA to include data that supports the following analyses:

- Manufacturing System Analysis:
  - Supplier Surveillance
  - Production Planning and Control System
  - Material Management and Accounting System (MMAS)
- Manufacturing Program and Product Analysis:
  - Development Program-Specific Surveillance
  - Industrial Labor Relations
  - Past Performance
- Manufacturing Continuous Improvement and Analysis:
  - Surveillance of Supplier Continuous Improvement System
  - Supplier Performance Measurement
- Supply Chain System Analysis:
  - Materials Planning
  - Supplier/Sub-tier Qualification/Requirements Decomposition
  - Communication/Systems Integration
  - Continuous Improvement
  - Supplier Performance Measurement System and Surveillance Improvement
  - Data Analysis, Statistics, and Sampling
- Supply Chain Risk Assessment:
  - Risk Realization
  - Program/Platform/Sector Analysis and Modeling
  - Critical Item Risk
  - Capacity/Lead Time Analysis

Tools

- AS9100 Checklist
- ISO 9001 Checklist
- AS6500 Checklist
- DCMA Program Support Plan per DCMA-ANX 205-02
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Manufacturing Maturation Plan
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist)
- Technology Readiness Assessment Checklist

Resources

- FAR 42.11 Production Surveillance and Reporting
- DCMA Guidebook
- DCMA Manual 2303-01 Surveillance
- DCMA Manual 3101-01 Program Support
- DCMA-INST 401, Industrial Analysis
- 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 Risk Management
- DCMA-INST-221 Integrated Surveillance Plan
- DCMA-INST-302 First Article Inspection and Production Lot Testing
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-311 Process Review (QA)
- DCMA-INST-322 QA Audit
- DCMA-INST-323 Data Collection and Analysis
- DCMA-INST-324 Product Examination
- DCMA-INST-325, Technical Reviews
- DCMA-INST-401 Industrial Analysis
- DCMA-INST-1102 Product Quality Deficiency Report
- DCMA-INST-1201 Corrective Action Process
- DCMA-INST-1207 Effective Control of Nonconforming Material
- DCMA-INST-2301 Evaluating Contractor Effectiveness
- DCMA-INST-3101 Program Support
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- ManTech Strategic Plan
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment Guide

C.3 Monitor and Track Program and Business Risks

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Risks and issues can slow or delay a program, can add additional costs to a program, or can create field failures because of poor reliability.

Risk management is an integral part of program management and systems engineering. A program must align risk appetite with organizational capacity to manage and handle risks and apply informed judgment to allocate limited resources to the best effect. Sound judgment to achieve this balance is at the core of program management.

Risk management is an endeavor that begins with requirements formulation and assessment, includes the planning and conducting of a technical risk reduction phase if needed, and strongly influences the structure of the development and test activities. Active risk management requires investment based on identification of where to best deploy scarce resources for the greatest impact on the program's risk profile. PMs and staff should shape and control risk, not just observe progress and react to risks that are realized. Anticipating possible adverse events, evaluating probabilities of occurrence, understanding cost and schedule impacts, and deciding to take cost effective steps ahead of time to limit their impact if they occur is the essence of effective risk management. Risk management should occur throughout the lifecycle of the program and strategies should be adjusted as the risk profile changes

Program Managers (PMs) are responsible for prioritizing programmatic risks and mitigating them within program constraints. Program management is about the process of eliminating programmatic risk over the life of the program. Formal risk management is one tool to accomplish that objective. Top program risks and associated risk mitigation plans will be detailed in the program acquisition strategy and presented at all relevant decision points and milestones and should be accomplished at the system, subsystem, and component level.

Risk Management includes the following five risk areas:

- Risk Planning: Identify the program or contractors risk management process.
- Risk Identification: Identify what could go wrong.
- Risk Analysis: Identify what is the likelihood (probability) and consequence of the risk.
- Risk Mitigation: Identify how the risk with be mitigated (accept, avoid, transfer, or control).
- Risk Monitoring: Identify how the risk will be tracked and how the risk has changed over time.

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

Manufacturing and Quality Tasks

- Conduct risk planning, identification, analysis, handling, and monitoring.

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

Tools

- AS9100 Checklist
- ISO 9001 Checklist
- AS6500 Checklist
- Systems Engineering Plan (SEP) Outline
- Technical Readiness Assessments (TRAs) Checklist
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974,
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Manufacturing Maturation Plan
- Quality Status Report, DI-MGMT-82186
- Technical Readiness Assessment (TRA) Checklist
- Defense Technical Risk Assessment Methodology (ITRA criteria)
- Manufacturing Capability Assessment Worksheet
- Manufacturing Maturation Plan
- MDD Development Planning Templates
- System Capabilities Analytic Process (SCAP)
- Hazardous Material Assessment Template
- Interactive MRL Users Guide (Checklist)
- Preliminary Hazard List (PHL) See PHA checklist

Resources

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs

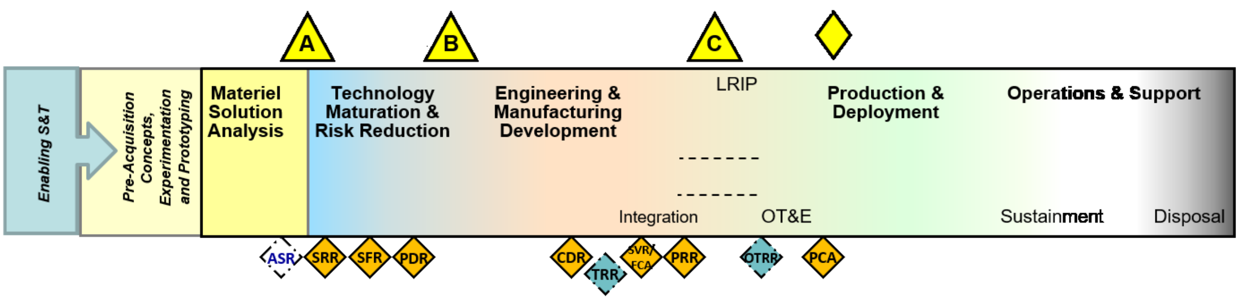
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.6 Risk Assessment
- AS9100, Quality Management Systems
- ISO 14001, Environmental Management
- ISO 9001, Quality Management System
- AS6500 Manufacturing Management System
- Manufacturing Readiness Level (MRL) Deskbook
- ESOH in Acquisition Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DCMA-INST-325, Technical Reviews
- DCMA-INST-3101 Program Support
- DCMA Manual 3101-01 Program Support

C.4 Participate in Program Reviews

DoD systems development requires a properly tailored series of technical reviews and audits provide key points throughout the system development to evaluate significant achievements and assess technical maturity and risk. DoDI 5000.85 and the Adaptive Acquisition Framework Document Identification (AAFDUD) Tool identifies the statutory and regulatory requirements for acquisition programs. Regardless of acquisition pathway, the PM, Systems Engineer, and Lead Software Engineer work to properly align the applicable technical reviews to support knowledge-based milestone decisions that streamline the acquisition life cycle and save precious taxpayer dollars. Technical reviews and audits allow the PM, Systems Engineer, and Lead Software Engineer to jointly define and control the program's technical effort by establishing the success criteria for each review and audit. A well-defined program facilitates effective monitoring and control through increasingly mature points.

Technical reviews of program progress should be event driven and conducted when the system under development meets the review entrance criteria as documented in the program's Systems Engineering Plan (SEP). An associated activity is to identify technical risks associated with achieving entrance criteria at each of these points (see the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs). Systems Engineering (SE) is an event-driven process based on successful completion of key events as opposed to arbitrary calendar dates. As such, the SEP should clarify the timing of events in relation to other SE and program events. While the initial SEP and Integrated Master Schedule (IMS) have the expected occurrence in the time of various milestones (such as overall system Critical Design Review (CDR)), the plan should be updated to reflect changes to the actual timing of SE activities, reviews, and decisions. Figure 3-1 of the SE Guidebook provides the end-to-end perspective and the integration of SE technical reviews and audits across all AAF pathways. Technical reviews should be tailored appropriately for other acquisition pathways.

The graphic below identifies all of the statutory and regulatory technical review and audit requirements by acquisition phase:



M&Q personnel need to support various contract administration and surveillance functions anytime that there is a contract and product to accept.

Manufacturing and Quality Tasks

- Support the Alternative System Review:
    - Review of the draft system performance specification
    - Assess the draft system performance specification against risk reduction efforts like prototyping
    - Review the key assumptions and constraints associated with the preferred solution
    - Review the results of any trade studies or technical demonstrations
    - Review any initial producibility assessments
    - Identify any technical risks and mitigation plans
    - Review the initial hazard analysis and system safety analysis for the preferred solution

Tools

- Alternative Systems Review Checklist
- Systems Engineering Plan (SEP) Outline
- Technical Readiness Assessments (TRAs) Checklist
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974,
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

- Technical Readiness Assessment (TRA) Checklist
- Defense Technical Risk Assessment Methodology (ITRA criteria)
- Manufacturing Capability Assessment Worksheet
- Manufacturing Maturation Plan
- MDD Development Planning Templates

Resources

- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- Air Force AoA Guide
- Air Force AoA Handbook
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.5.4 Technical Reviews
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.8.4 Technical Reviews
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 Technical Reviews and Audits
- Defense Technical Risk Assessment Methodology (DTRAM)\DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DCMA-INST-325, Technical Reviews
- DCMA-INST-3101 Program Support
  DCMA Manual 3101-01 Program Support Life Cycle

D. TECHNOLOGY AND INDUSTRIAL BASE

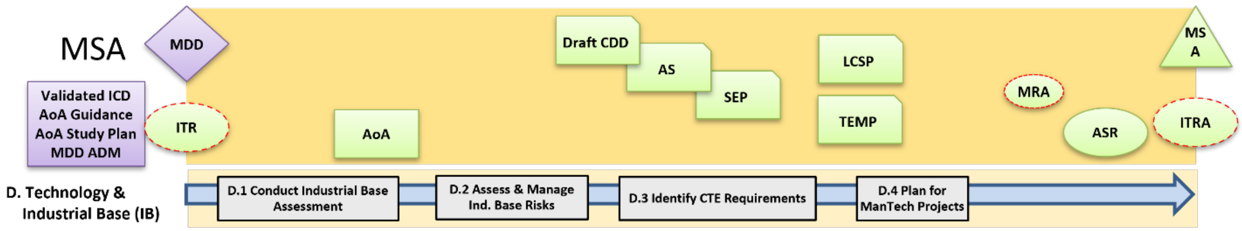


Figure 2-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC 4820 requires the Secretary of Defense to consider the National Technology and Industrial Base (NTIB) in the development and implementation of acquisition plans for each MDAP. The NTIB consists of the people and organizations engaged in national security and dual-use research and development (R&D), production, maintenance, and related activities within the United States, Canada, the United Kingdom, and Australia. All MDAP acquisition planning and plans should consider the following with regard to NTIB:

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

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

- Industrial Base Assessments (IBAs)
- Industrial Base Risks
- Critical Technology Elements (CTEs)
- ManTech Projects

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

D.1 Conduct Industrial Base Assessment (IBA)

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 can meet the needs for all their acquisition programs throughout their lifecycle. This analysis includes a look at the capability, capacity, and financial stability to perform and helps guide decision-making and the development and implementation of legislation, policy, and programs.

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

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

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

- Create an Industrial Base Study Plan.
- Identify the company, companies, or organizations to assess.
- Evaluate the capabilities required to produce the product:
    - Manpower (skills, training, certifications, and availability)
    - Materials (cost, properties, availability, etc.)
    - Machines (costs, availability, capability, capacity, etc.)
    - Methods (costs, availability, capability, capacity, etc.)
    - Measurement Systems (costs, availability, capability, capacity, etc.)
- Evaluate the capacity to produce the required amount of product:
    - Evaluate existing capacity of the 5Ms:
        - Design capacity
        - Effective capacity
        - Actual utilization
    - Forecast capacity demands (warfighter needs short and long term)

  - Identify alternative ways to modify capacity and achieve capacity goals:
    - Increase or surge
    - Decrease or shutdown
  - Evaluate financial and technological capacity alternatives
  - Select capacity alternatives most suited to strategic goals
- Identify demand (forecast how many are needed):
  - Qualitative Forecast (market research, expert opinion, historical, Delphi, etc.)
  - Quantitative Forecast (moving average, regression analysis, exponential smoothing, etc.)
- Identify supply (how many are available).
- Identify supply risks (sole source, single source, foreign source, etc.).
- Identify financial stability and risk to meet short- and long-term requirements.
- Identify industrial security concerns.
- Identify technical risks.
- Identify surge and mobilization concerns.
- Identify De-Mil and Smart Shutdown requirements.
- M&Q support the update of the IBAs for concepts included in the AoA (conduct if not previously accomplished) by:
  - Ensuring identification of relevant sources including identification of unique manufacturing capabilities that are not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
  - Determining the likelihood that a proposed materiel solution can be produced using existing manufacturing capabilities while meeting quality, production rate, and cost requirements
  - Ensuring the concept requirements and capabilities assessments are updated to include:
    - Identification of all known gaps, risks, and potential sources for key processes, technologies, and components
    - Identification of all potential and future M&Q needs inclusive of design, development, production, operation, sustainment, and eventual disposal
    - All technological developments, market trends, processes, environmental factors, and policies, etc., that could potentially impact M&Q of the preferred concepts
- Request updated DCMA industrial analysis data to support M&Q inputs to the AoA, including data that supports the following analyses:
  - Industrial Capability Assessments
  - Analytical Products
  - Defense Business and Economic Analyses
  - Acquisition Planning Support

- Ensure the M&Q focus of the IBAs is on the:
    - Capability to cost-effectively design, develop, produce, maintain, support, and restart the program (if necessary)
    - Approach to making production rate and quantity changes that support a response to contingency and support objectives
    - Vulnerability of supply chain (to include sole, single, fragile, foreign sources, foreign acquisition of domestic sources, and cybersecurity)
    - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
    - Potential obsolescence
    - Impact of external dependencies and integration
    - New and unique capabilities and processes
    - Actions necessary to mitigate existing IB gaps/risks and identify when a needed industrial capability could be lost
- Prepare the M&Q inputs to the IBA considerations summary report to summarize the results for inclusion in the Acquisition Strategy:
    - Recommend actions or investments that address risks to cost, schedule, performance, and qualitative considerations
    - Define and recommend how and when the actions would be incorporated into the budget and schedule and, if possible, identify budget offsets
    - If the required investment is greater than $10 million and is determined to affect more than one defense program, it must be coordinated within and across the Components per DoDI 5000.60

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- DD Form 2737 Industrial Capabilities Questionnaire
- SF 1405 Preaward Survey – Production
- Defense Industrial Base Assessment Survey OMB 0694-0119
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- AoA Study Plan Template
- Numerous M&S models are available for contractor and government use

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
- DCMA-INST 401, Industrial Analysis
- DCMA Instruction 3401, Defense Industrial Base Mission Assurance
- DoDD 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Assessments
- DoD 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 2 Industrial Base
- Manufacturing Readiness Level (MRL) Deskbook

D.2 Assess and Manage Industrial Base Risks

A healthy defense industrial base that provides the capability and capacity to produce weapon systems and other military hardware that is critical to maintaining U.S. national security objectives. The U.S. industrial base currently consists of over 200,000 companies. Mitigating risks—such as reliance on foreign and single-source suppliers—is essential for DOD to avoid supply disruptions and ensure that the industrial base can meet current and future needs.

Risk management is an integral part of program management and systems engineering. A program must align risk appetite with organizational capacity to manage and handle risks and apply informed judgment to allocate limited resources to the best effect. Sound judgment to achieve this balance is at the core of program management.

Risk management may be first introduced at a general level in the Acquisition Strategy and the Systems Engineering Plan, and the program risk management approach summarized in the Risk Management Plan (RMP). The RMP should:

- Explain how the program manages risks to achieve cost, schedule, and performance goals
- Establish the basic approach and risk management working structure
- Document an organized, comprehensive, and integrated approach for managing risks

- Define the goals, objectives, and the program office's risk management processes
- Define an approach to identify, analyze, handle, and monitor risks across the program
- Document the process to request and allocate resources (personnel, schedule, and budget) to mitigate risks
- Define the means to monitor the effectiveness of the risk management process
- Document the integrated risk management processes as they apply to contractors, subcontractors, and teammates.

Risk Management should be integrated with other program management tools such as the Work Breakdown Structure (WBS), Integrated Master Plan (IMP), and Integrated Master Schedule (IMS). It also discusses other techniques and metrics such as schedule risk analysis (SRA), cost risk analysis (CRA), performance risk analysis (PRA), and Technical Performance Measures (TPM). DoD has identified several sources of risks that should be addressed on a recurring basis to include:

- Lack of Competition
    - Shrinking Industrial Base (Consolidation and companies leaving the market)
    - Sole Source and Single Source
- Foreign Dependencies and Sources
- Material Shortages
    - Fragile Suppliers and Fragile Markets
    - Capacity Constrained Supplier Markets
    - Covid-19 and other factors
    - Lack of Visibility in the Supply Chain
- Diminishing Manufacturing Sources and Material Shortages
- Obsolescence and Counterfeit Parts
- Lack of Human Capital and Need for STEM
- Need for Modernization
- Data Rights and Intellectual Property
- Industrial Cybersecurity
    - ITAR (product and data security)
    - Industrial Control Systems (Distributed Control Systems (DCS), Programmable Logic Controllers (PLC), Supervisory Control and Data Acquisition (SCADA) systems, Specialized Industrial Computers (SIC), and Remote Terminal Units (RTU), etc.)

DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs provides guidance on proactively managing risks, issues, and opportunities in order 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 control)?
- Risk Monitoring: How has the risk changed (better, worse, or the same)?

Industrial base risk mitigation activities may be a result of a formal study or analysis or may be a result of routine oversight that identifies risk(s) or issue(s). Manufacturing and QA managers need to assist in the development and management of risk management strategies and implementation plans that include accepting, avoiding, transferring, or mitigating the risks and issues. Some risk mitigation activities may be implemented as "contingency plans" when a specific triggering event occurs. The level of detail in risk mitigation planning depends on the program life cycle phase and the nature of the risks to be addressed. However, there should be enough detail to allow an estimate of the effort required and technical scope needed based on system complexity.

Manufacturing and Quality Tasks

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

- New and unique capabilities and processes

Tools

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

Resources

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

D.3 Identify Critical Technology Element (CTE) 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 a 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.

The Technology Readiness Assessment (TRA) is a metrics-based process used to evaluate the maturity of technologies and their individual components (termed Critical Technology Elements). The process is as follows:

- Identify the CTE
- Assess the CTE
- Prepare and conduct the TRA
- Develop and manage the CTE Maturation Plan

Critical Technologies, Critical Technology Elements, Critical Enabling Technologies, and Critical Enabling Technologies (CTEs) are used interchangeably. These critical 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 to mature the CTE. Technology roadmaps traditionally look 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.

Additionally, CTEs were identified in the previous phase and assessed for feasibility, affordability, and supportability and for M&Q maturity. Plans to increase maturity were incorporated into the draft CDD, AS, SEP, and the RFP for the MSA phase. For TMRR, the identified M&Q process areas and process limitations requiring risk mitigation will be updated, including the hardware and the associated embedded software maturity and the cybersecurity risks and vulnerabilities to software and firmware. Implementation of risk reduction efforts in these areas should be initiated in this phase.

Manufacturing and Quality Tasks

- Identify the CTEs and assess the M&Q maturity for the AoA:
    - Include necessary hardware and the associated embedded software maturity

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

Tools

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

Resources

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

D.4 Plan for Manufacturing Technology (ManTech) Projects

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

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

Accelerating the flow of technology to the warfighter is one of the top priorities of DoD, services, and agencies. Technology transition involves the maturation of technologies to the point where they are proven to be mature and ready for insertion into a system or element. Manufacturing and QA managers as members of the Technical IPT need to support the analysis of maturity and the insertion of technologies into production programs.

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

ManTech programs should have the following:

- ManTech Program scope
    - Significantly enhances producibility and manufacturability
    - Beyond the acceptable risk for industry or a single program office
    - Defense-essential or defense-unique
- Joint Service warfighter impact
    - Multi-service, multi-system applications
    - Significant to war-fighting capability; solving a war-fighting problem
- Clear magnitude of impact
    - Capability, cost, cycle time, process yield improvement, faster time to implementation, number of systems impacted, positive return on investment (ROI), or other quantifiable merits
- Sound technical approach
- Key metrics for measuring manufacturing and project success identified
- Maturity at start no less than Manufacturing Readiness Level (MRL) 3
- Maturity at end is no less than MRL 4
- Clear transition and implementation path to warfighter or to the next funding agent

Manufacturing and Quality Tasks

- Develop plans for any identified gaps and high-risk manufacturing processes that require investment in ManTech or other manufacturing programs:
    - Analyze identified advanced manufacturing capabilities to confirm requirements
    - Analyze the gaps for potential manufacturing technology solutions that mitigate the risks

- Estimate M&Q cost, schedule, and performance impacts

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

Tools

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

Resources

- Air Force Technology Development and Transition Strategy Guidebook, Nov 2010

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development, and Investments
- DoD Directive 4200.15, ManTech
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment Guide

E. DESIGN

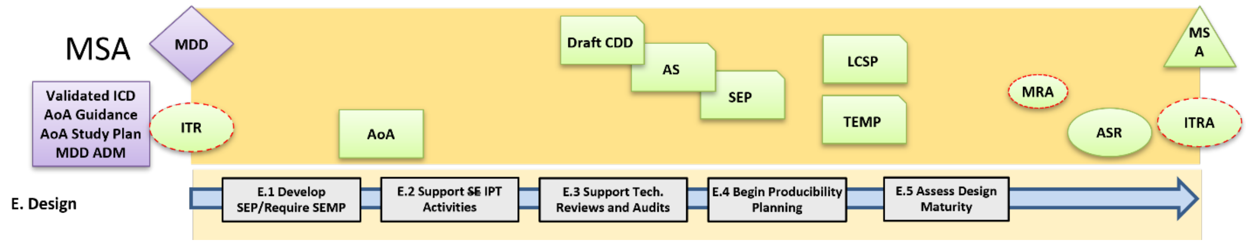


Figure 2-6. Design Manufacturing and Quality Activities

Introduction

DoD SE is a disciplined approach for the specification, design, development, realization, technical management, operation, and retirement of a weapon system. SE is an interdisciplinary and collaborative effort requiring close interaction with many disciplines to include operations, maintenance, logistics, test, production, quality, etc. The practice of SE is composed of 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 https://www.cto.mil/sea/pg.

Table 2-1. 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 of 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 through the use of 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 Develop Systems Engineering Plan

DoD Systems Engineering (SE) is a disciplined approach for the specification, design, development, realization, technical management, operation, and retirement of a weapon system. SE is an interdisciplinary and collaborative effort requiring close interaction with many disciplines to include operations, maintenance, logistics, test, production, quality, etc. SE accomplishes these activities by focusing on eight technical processes and eight technical management processes.

The systems engineering plan (SEP) is the blueprint for the execution, management, and control of the technical aspects of an acquisition program from conception to disposal. The SEP outlines how the systems engineering process is applied and tailored to meet objectives for each acquisition phase. The SEP is a "living" document that captures a program's current and evolving systems engineering strategy and its relationship with the overall program management effort. The SEP is updated as needed to reflect technical progress achieved to date and to reflect changes in the technical approaches stemming from the findings and results of the technical reviews, program reviews, acquisition milestones, or other program decision points.

The SEP should be included in the Request for Proposals (RFP) with an approved plan as either guidance or a compliance document and will be synchronized with the Acquisition Strategy. PMs should consider using Systems Engineering Management Plan, DI-SESS-81785A, as a CDRL item.

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

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

The Systems Engineering Management Plan (SEMP) is a document produced by a contractor that identifies their approach to systems engineering management based on contractual requirements (IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs). The SEMP is written in response to a government proposal which may include a DID for the SEMP (DI-MGMT-81024 SEMP).

Manufacturing and Quality Tasks

Support the development and updating of government planning documents:

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

Ensure the contractors Systems Engineering planning includes:

- Program Technical Requirements and Technical Approach.
- Technical Schedule, Timing, Milestones, and Schedule Risk Analysis:
    - Manufacturing Assessments
    - Technology Readiness Assessments
- Technical Risk, Issue, and Opportunity Management:
    - Technical/Technology Risks
    - Risk Identification, Reduction/Mitigation Plans
- Technical Structure and Organization:
    - Work Breakdown Structure
    - Government Program Office Structure
    - Contractor staffing
- Technical Specifications.
- Technical Baseline allows for requirements traceability, verification, and validation of the Preferred System Concept (PSC).
- Technical Performance Measures or how the program will use TPMs to measure progress, risks, and status:
    - Manufacturing Measures

  - Quality Measures
- Technical Activities and Products:
  - Technical Reviews along with M&Q criteria
  - Manufacturing Maturity Plans
  - Configuration Management
- Design Considerations:
  - Producibility Assessment and integration with other design activities
  - Design for Six Sigma (DFSS) and Design for Manufacturing and Assembly (DFMA)
  - Identification of key and critical manufacturing assembly and test processes to be evaluated and matured
  - Identify the need for and controls for Geometric Dimensioning and Tolerancing
- Integration of manufacturing risks in cost and manpower estimates.
- 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.

Ensure the following SEP related activities are conducted:

- Update the assessment of manufacturing feasibility for the preferred concept, if not completed; conduct an assessment, for inclusion in the SEP.
- Provide M&Q input to the SEP on all IB, design, manufacturing, production, and quality risks and risk reduction and mitigation efforts:
  - Identify critical technologies and M&Q process areas requiring risk reduction and mitigation efforts for the SEP, including the following activities:
    - Initial M&Q approaches for system requirements and system design concepts
    - M&Q trade studies
    - Potential M&Q solutions
  - Identify M&Q risks, issues and opportunities from existing architectures, capabilities, and external dependencies
  - Maintain up-to-date status on all key M&Q inputs to the SEP
- Provide M&Q plans and support to assist in development of the SEP and the program schedule based on the M&Q strategies in the Acquisition Strategy, to include:
  - Inputs on required M&Q products (e.g., assessment, metrics, etc.) for all systems engineering (SE) reviews
  - Inputs on specific and detailed M&Q entry and exit criteria metrics for technical reviews and MSA, TMRR, and subsequent phase decision points

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

Review the contractors SE Master Plan to ensure the following areas are addressed:

- Description of the technical effort and technical processes on what will be used, and how the processes will be applied using appropriate activities.
- Description of how digital data requirements will be met and how digital data will be managed.
- Description of how Technical Data Packages (TDPs) will be developed and managed.
- Description of how Product Manufacturing Information (PMI) will be developed and managed.
- Project structure to accomplish activities, information flow, and decision-making.
  - Organization of the development team, along with their physical location and facilities needs
- Resources required for accomplishing the activities.

- Project critical event objectives during any phase of a project's life cycle.
- Work product outputs of the processes and how the processes are integrated.
- Communication standards between project management engineering teams.
- Entry and exit criteria of work products during project phases.

Tools

- Acquisition Strategy Outline
- Acquisition Plan Preparation Guide template
- Systems Engineering Plan (SEP) Outline
- Systems Engineering Plan (SEP) DI-SESS-81785A
- Systems Engineering Management Plan, DI-SESS-81785A
- Interactive MRL Users Guide (Checklist)
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Manufacturing Maturation Plan
- Manufacturing Plan, DI-MGMT-81889A
- Quality Assurance Plan
- Quality Assurance Program Plan, DI-QCIC-81794
- Design for Six Sigma tools
- Integrated Program Management Report (IMPR) DI-MGMT-81861

Resources

- 10 USC 2431a Acquisition strategy
- Acquisition Strategy Guide, DSMC
- SEP Outline updated to Version 4.1
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- AS6500, Manufacturing Management Program ISO 9001:2015, Quality Management Program
- ISO 9001:2015, Quality Management Program
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896, Manufacturing Management Program Guide
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook
- DoD Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- 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
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline Defense Manufacturing Management Guide for Program Managers, Chapter 3.3.2 Systems Engineering Plan (SEP)

E.2 Support 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 (HSI), and System Safety) design considerations are addressed at the enterprise level. SE is typically structured as one or more integrated product teams (IPTs) that 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.

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

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 in order 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 (PMI) 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 are included in a 3D CAD model or file. PMI includes the following:
  - Bill of materials (BOM)
  - GD&T (Geometric dimensions and tolerances)
  - Surface finish
  - Weld symbols
  - Material specifications
  - Metadata & notes
  - History of engineering change orders
  - Legal/proprietary/export control notices
  - Other definitive digital data

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

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

The IPTs conduct systems engineering analyses to support the development of the Acquisition Strategy and the SEP. The MSA phase also provides the opportunity to influence system design and plan for production by evaluating technology opportunities and current practices against cost, schedule, and performance. The intent is to reduce technical risk, validate designs, validate cost estimates, evaluate manufacturing processes, and refine requirements. The PM is responsible for manufacturing, quality, and producibility risk identification and management throughout the program's life cycle. M&Q representatives will plan and conduct assessments of M&Q readiness and risk to be documented in the SEP.

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

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

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

Manufacturing and Quality Tasks

- M&Q IPT participants should review and assess the proposed approach to systems engineering and use of tools and best practices.
- Provide M&Q requirements based on analyses of system requirements and design concepts:
    - Identify capabilities and constraints based on the system specifications
    - Establish the required M&Q capabilities baseline
    - Identify M&Q affordability cost drivers and impact on schedule and performance
- 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.

- M&Q personnel should support the assessment of digital artifacts to perform manufacturing data analysis on:
    - Design specifications
    - Technical drawings
    - Design documents
    - Producibility analysis
    - Design optimization
        - Parameter Design
        - Tolerance Design
    - Geometric Dimensioning and Tolerancing (GD&T)
    - Product Life Cycle Management (PLM) data
    - 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
    - Process optimization
    - Energy optimization

- Provide input to design trade studies (i.e., functional and performance requirements) that include criteria concerning:

    - KPPs, KSAs, APAs, and evolving KCs

  - Manufacturing process capabilities, limitations, and concerns
  - Software and firmware development and re-use
  - Safety, handling, storage, and disposal considerations and restrictions
  - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
  - Manufacturing costs, materials, special tooling, and test equipment
  - Cost-effective and affordable designs to achieve performance and schedule while minimizing cost
  - Manufacturing capacity, workforce, and schedule impacts

- Participate in the design producibility process provides:

  - Identification products and processes that would benefit from producibility analyses (i.e., Design for Manufacturing (DFM)/Design for Assembly (DFA)
  - Monitoring and reporting on producibility process activities with respect to risks, issues, and opportunities
  - Integration of producibility with other design activities including software and firmware development and re-use
  - Participation in producibility design trade studies to include process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
  - Identification of innovative manufacturing technology opportunities

- Provide monitoring, reviewing, analyses, and reporting on multiple analyses as part of the FMECA process (e.g., DFMEA, PFMEA).
- Support Product Life Cycle Management (PLM) activities.
- M&Q IPT(s) participants provide design inputs and design support to:

  - Develop an initial view of system requirements and system design concepts
  - Formulate initial system solutions
  - Develop a system functional definition that incorporates the user needs
  - Perform engineering analyses
  - Conduct initial design trade studies including external dependencies
  - Create a system specification document
  - Develop preliminary system functional and performance requirements
  - Derive and document draft KPPs and KSAs
  - Plan modeling and simulation
  - Identify critical technologies, and conduct a manufacturing maturity assessment of the hardware and embedded software options
  - Identify and assess M&Q risks as part of identification and assessment of system level risks
  - Identify future design validation and verification requirements

- M&Q IPT(s) participants provide input and support to:

  - Program management reviews
  - Other program IPTs (e.g., Systems Engineering, Configuration Management, Risk Management, Producibility etc.)
  - The Acquisition Strategy, SEP, draft CDD, and the TEMP in preparation for and participation in the ASR

Tools

- Acquisition Plan Preparation Guide template
- Market Research Reporting Template
- Draft Capability Development Documents (CDD) Template
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Technology Readiness Assessment
- Producibility Assessment Worksheet (PAW)
- DCMA Industrial Capability Assessment Survey Form
- Design for Manufacturing and Assembly (DFMA)
- Test and Evaluation Master Plan (TEMP) Template
- Life Cycle Sustainment Plan (LCSP) Template
- PLM (digital) software tools include (E Design Threads):
  - Factory Layout Design
  - Plant Layout Design
  - Equipment and Layout Engineering
  - Machining and Tooling Design
  - Factory Simulation
  - Shop Floor Equipment Engineering
  - Ergonomic Simulation
  - Producibility Analysis

Resources

- 10 USC 144B, Sec 2366 and 2448
- Acquisition Strategy Guide, DSMC
- CJCSI 5123.01I, JCIDS Instruction
- CJCS JDIDS Manual
- CDD-CPD Writing Guide
- DoD Market Research Guide
- DCMA-INST-2303 Surveillance
- 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 5000.88, 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
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- Digital Engineering Body of Knowledge
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- 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 Guide
- Test and Evaluation Management Guide

E.3 Support Technical Reviews and Audits

Properly tailored technical reviews and audits provide key knowledge points to evaluate significant achievements and assess technical maturity and risk. DoDI 5000.85 and the Adaptive Acquisition Framework Document Identification Tool (AAFDIT) identify the statutory and regulatory requirements for acquisition programs. Regardless of acquisition pathway, the PM, Lead Systems Engineer, and other functional specialists work to properly align the applicable technical reviews to support knowledge-based milestone decisions that streamline the acquisition life cycle and save precious taxpayer dollars. Technical reviews and audits allow the PM, Lead Systems Engineer, and other functional specialists to jointly define and control the program's technical effort by establishing the success criteria for each review and audit. A well-defined program facilitates effective monitoring and control through increasingly mature points.

Technical reviews of program progress should be event driven and conducted when the system under development meets the review entrance criteria as documented in the SEP. An associated activity is to identify technical risks associated with achieving entrance criteria at each of these points (see the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs). SE is an event-driven process based on successful completion of key events as opposed to arbitrary calendar dates. As such, the SEP should clarify the timing of events in relation to other SE and program events. While the initial SEP and IMS have the expected occurrence in the time of various milestones (such as overall system CDR), the plan should be updated to reflect changes to the actual timing of SE activities, reviews, and decisions.

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

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

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

Manufacturing and Quality Tasks

Support the conduct of an Alternative System Review (ASR)

- Ensure adequate plans are in place to complete the necessary technical activities for the ASR.

- Ensuring results of all technical trade studies are captured in documents that are carried through to the next phase.
- Ensuring technical risk items are identified and analyzed, and appropriate mitigation plans are in place. This activity should include, for example, the identification of critical technologies and identification of key interfaces with supporting or enabling systems.

Conduct a feasibility assessment which includes:

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

Update assessments of manufacturing feasibility for the AoA preferred concepts including the industrial capabilities required to design, develop, manufacture, and maintain each.

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

Tools

- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Alternative System Review (ASR) Checklist
- Systems Engineering Plan (SEP) Outline
- Independent Technical Risk Assessment (ITRA)
- Technology Readiness Assessment (TRA) Checklist

Resources

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- DoD Engineering of Defense Systems Guidebook, Chapter 3 Technical Reviews and Audits
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-727, Design Guidance for Producibility
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- AS 9103, Variation Management of Key Characteristics
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 Technical Reviews and Audits
- 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
- DoD Technology Readiness Assessment (TRA) Guide

E.4 Begin Producibility Planning and Assessment

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.

The Producibility Plan should guide the design effort and describe activities that will be accomplished, the responsible organization, and the management controls that will be established to ensure successful accomplishment. M&Q managers should be updating the Producibility Plans with a focus on the realism, completeness and clarity of the planning accomplished by the contractor. 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).

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

Assess producibility considerations at technical reviews and audits (DoD Producibility Guide (Draft):

- Systems Requirements Review.
- System Functional Review.
- Preliminary Design Review.
- Critical Design Review.
- System Verification Review/Functional Configuration Audit.
- Production Readiness Review.
- Physical Configuration Audit.

Support the following Producibility activities:

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

        - Tolerance analysis
    - Costs, cost drivers, and controls
    - Material characterization and goals
    - KCs
    - Risk and risk mitigation planning
    - Prototypes
    - Learning curve projections
    - Planning for product and process measurements
    - Statistical Process Control (SPC)
    - Data and database management
    - Testing
- Ensure producibility planning is incorporated into the Manufacturing Management Plan and the Systems Engineering Plan.
- Support Product Life Cycle Management (PLM) activities.

Tools

- Producibility Engineering and Planning (PEP) Data Item Description
- Producibility Assessment Worksheet
- AS9100 Checklist
- ISO 9001 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline
- Design for Manufacture and Assembly (DFMA)
- 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
- Quality Functions Deployment (QFD)
- Critical Path
- Make/Buy Decision

- Fault Tree Analysis
- Design Failure Modes and Effects Analysis (DFMEA)
- Process Failure Modes and Effects Analysis (PFMEA)
- Design of Experiments (DOE)
- Preliminary Hazards List
- Pugh Matrix
- TRA Assessment Checklist
- Six Sigma and Lean Techniques

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
- Producibility Engineering Standard Practice Manual, U.S. Army Belvoir R&D Center
- 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
- Producibility System Guidelines, Missile Defense Agency
- Design for Manufacturability Handbook, Bralla
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning
- Acquisition Strategy Guide, DSMC
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook, Chapter 5.14.3 Producibility
- 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 Systems – Requirements for Aviation, Space, and Defense Organizations
- AS9103, Variation Management of Key Characteristics
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- AIAG Measurement Systems Analysis (MSA) Manual
- Manufacturing Readiness Level (MRL) Deskbook

- MIL-STD-1629A Failure Modes Effect and Critical Analysis
- SAE J1739-202101 Potential Failure Mode and Effects Analysis
- DoD Technology Readiness Assessment Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning (PEP)

E.5 Assess Design Maturity

Design maturity has not been a well-defined concept and there is not any DoD instruction, regulation, or other guidance covering maturity. Design maturity may be measured when a product design and associated product meets cost, schedule, and performance targets, and satisfies the user. These performance targets should be associated with KPPs, KSAs and TPMs. Design is an ongoing activity, from cradle to grave and thus should be assessed and managed along the way using the eight technical processes and eight technical management processes. Program problems impacting cost, schedule, and performance often have as a root cause, risks associated with immature designs.

Design is an ongoing activity, from cradle to grave and thus should be managed and assessed along the way using the eight technical processes and eight technical management processes. Immature designs often show up as cost, schedule, and performance problems that often result in field performance issues and higher production and maintenance costs.

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

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.

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 shall 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 systems are contained in a "common elements" appendix. Cost breakouts by WBS elements are useful to the program office and contractors in managing the program.

The WBS integrates technical, cost and schedule parameters, giving the PM a tool to:

- Ensure the traceability of all program activities.
- Identify significant risk drivers.
- Forecast cost and schedule performance.
- Develop corrective action plans as needed.

Current "Design Best Practices" include the use of numerous computer-aided software tools:

- Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM)
- Computer-Aided Process Planning (CAPP)
- Computer-Aided Three-Dimensional Interactive Application (CATIA)
- Design Failure Mode and Effects Analysis (DFMEA)
- Design for Manufacturing and Assembly (DFMA)
- Design for Six Sigma
- Design of Experiments (DoE)
- Modeling and Simulation Tools
- Failure Mode and Effects Analysis (FMEA)
- Process Failure Mode and Effects Analysis (PFMEA)
- Quality Function Deployment (QFD)

Design maturity assessments should occur at all program and technical reviews but especially at both the Preliminary Design Review (PDR) and Critical Design Review (CDR). Design maturity (completion) assessment should be reviewed during the Preliminary Design Review in the TMRR phase for prototypes with exit criteria identified and validated and the Allocated Baseline established. The PDR is conducted to ensure new technologies and manufacturing processes are mature enough to be integrated into the system. Design maturity (completion) should be reviewed during the Critical Design Review in the EMD phase for the system with exit criteria identified and validated and the system can meet its stated performance requirements within cost, schedule, and risks.

AS9103 is the industry standard and best practice for the identification and control of Key Characteristics (KCs). The standard requires the producer to identify KCs and control the manufacturing processes that directly influence the variation of those KCs. KCs should have a Capability Index (Cpk) of 1.33 or greater or as specified by the customer. The concept of identifying KCs is linked to the Pareto principle, which asserts that a small number of features will have the most significant impact on performance. M&Q managers should be involved in the identification and assessment of KCs early on during the development of the prototype design to see if the design and manufacturing can meet customer requirements and identify risks from not meeting those requirements. Often in the past, companies identified KCs only after experiencing cost problems, in the plant and in the field. Proactive or robust engineering would have contractors identifying KCs early in the design phase.

M&Q personnel need to support the Design IPT in evaluating design maturity by assuring that top-level performance requirements are defined and trade-offs in design options are assessed based on experimentation. These assessments may include an Alternative System Review (ASR)

Manufacturing and Quality Tasks

Design maturity should be promoted, assessed, and managed during the various acquisition phases during program or technical reviews and could include the following:

- Requirements are stable.
- Requirements definition complete.
- Requirements analysis complete.
- The following measures are established:
  - Measures of Effectiveness (MOE)
  - Key Performance Parameters (KPP)
  - Measures of Performance (MOP)
  - Technical Performance Measures (TPM)
- Requirements traceability down to the TPMs for the Preferred System Concept (PSC) and to the WBS configuration items.
- Technical planning is complete:
  - Eight Technical Processes
  - Eight Technical Management Processes
- Digital engineering best practices should be used to identify and optimize designs, manufacturing processes and controls, and life cycle cost models.
- Design considerations are integrated into the design effort in order to optimize operational effectiveness while balancing system performance, system availability, interoperability, and total system life-cycle cost.
- The design is stable:
  - Number of design changes
  - Design released to production
- Systems Engineering process are mature:
  - Systems Engineering Capability Model
- The Work Breakdown Structure (WBS) has been established (Program and Contract)

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

Tools

- Systems Engineering Plan (SEP) Outline
- Axiomatic Design Techniques
- Computer Aided Design (CAD)
- Computer Aided Manufacturing (CAM)
- Computer Aided Process Planning (CAPP)
- Computer Aided Three-Dimensional Interactive Application (CATIA)
- Design Failure Mode and Effects Analysis (DFMEA)
- Design for Manufacturing and Assembly (DFMA)
- Design for Six Sigma
- Design of Experiments (DoE)
- Modeling and Simulation Tools
- Failure Mode and Effects Analysis (FMEA) Process Failure Mode and Effects Analysis (PFMEA)
- Quality Function Deployment (QFD)
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Critical to Quality Tree
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- TRL Assessment Checklist
- 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

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook, Sample Format 4.5 Technical Maturity
- DoD Systems Engineering Plan Preparation Guide
- Digital Engineering Body of Knowledge
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ANSI/EIA Process for Engineering a System
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.5.1 Design Maturity Considerations
- Defense Manufacturing Management Guide for Program Managers, Chapter 11.7.2 Design Maturity
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Capability Maturity Model Integration (CMMI)
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- DoD Technology Readiness Assessment Guide

F. COST/FUNDING

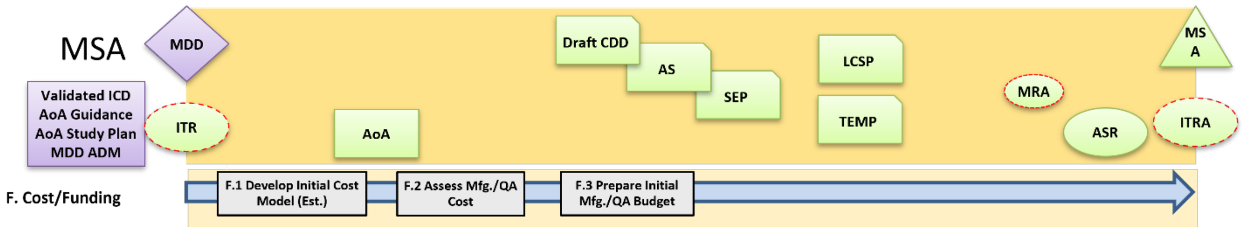


Figure 2-7. Cost and Funding Manufacturing and Quality Activities

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.

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 shall 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 systems are contained in a "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

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

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

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

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

F.1 Develop Initial Cost Model

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
  - DoDI 5000.73 Cost Analysis Guidance Procedures
- **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 Guide
  - 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 (above), 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

- Define the program to be used to prepare the cost estimate.
- 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.
- 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.
- 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.

- Initial Results and Iterations: The estimate or model now must be validated, and this process could include:
  - Cross-check: Tests 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.
  - Sensitivity: Tests the model's ability to estimate the impact on total cost by changing a specific cost driver.
  - 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.

Early in a program that model may be based on analogy when the system is still being defined and created. In reality, even these early models may have some very real data. For example, the warfighter may need a new missile, one that goes faster and farther. Parts of the missile may be new technology, and the basis of estimate may need to be analogy, but if the booster is an existing technology and is in production, for that part of the Work Breakdown Structure the program can use actual costs in their modeling.

Manufacturing and Quality Tasks

- Support the development and assessment of cost models:
  - AoA Cost Estimate
  - 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.
- The Cost Capability Analysis Guide suggests looking at capability development and requirements decisions:
  - What capability development requirements are the primary drivers of cost and schedule for this program?
  - How were the tradeoffs between cost, schedule, capability, and risk considered in determining these requirements' measures? What are the cost/capability tradeoff opportunities?
  - How have affordability goals and constraints been included in the program and how will they be achieved?
- 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.

- Provide M&Q inputs to update cost targets and error bands for proposed materiel solutions for the AoA:
  - Review the assumptions behind these targets
  - Prepare detailed M&Q process charts to ensure the validity behind cost targets
  - Identify and quantify M&Q cost variables
  - Quantify the uncertainties
- Update the cost estimates for the proposed materiel solutions for the AoA including estimates for:
  - KCs and key processes
  - Variability reduction needs
  - Manufacturing environment simulations
  - Cost/performance trade studies
  - M&Q capability requirements
  - Product and process validation requirements
  - Key supplier management
  - Producibility
  - Environmental compliance
  - Manufacturing systems security (physical, cyber, etc.)
- Upon completion of the AoA, develop M&Q inputs to initial cost models for the preferred solution:
  - Verify cost models include all M&Q process variables
  - Provide M&Q inputs to the CARD for the appropriate cost categories
  - Provide initial M&Q inputs (cost models estimates) to the ASR

Tools

- Interactive MRL Users Guide (Checklist) for the Cost/Funding thread
- Cost Analysis Requirements Description (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
- 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
- O&S Cost Management 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
- DoD Instruction 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
- DoD Directive 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

F.2 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, continues post-contract award to monitor contractor performance, and ends with contract closeout. 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 2-2. 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 Cost Data Reporting (CCDR) 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 to evaluate 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.

DCMA personnel may be called upon to support various cost assessments per the following:

- 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

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 Data Analysis Report (IPMDAR)

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:

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

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 variance 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.

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

- Validate all M&Q learning curves for the system and subsystems based on pilot line results, contractor and supply chain improvements, program progress to date to include:
  - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
  - Planning and scheduling
  - Throughput (yield and rates)
  - Labor efficiency and ergonomics
  - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
  - Materials handling, transportation, and storage (including WIP)
  - Supply chain changes
  - Standardization and common processes
- Identify the original cost estimate and compare it to the 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 manufacturing, quality, materials, and unique or specialized requirements and associated risks that are cost drivers for the AoA and update for the ASR:
  - Include assumptions on process, materials, rate, supplier quality, workforce, special handling, environmental compliance, security, etc., and quantify the cost driver uncertainties
  - Estimate the cost of quality for each concept
  - Estimate the cost of ESOH and HAZMAT requirements and risks
  - Estimate the cost and impact of testing requirements
- Identify producibility cost drivers and associated risks for the AoA and update for the ASR:
  - Estimate impact of producibility opportunities and risks on rates, process, throughput, etc.
  - Estimate cost of implementation for producibility improvements
- Provide updates to the CARD with the M&Q inputs for the ASR:
  - Provide M&Q cost sensitivity analyses updates
- 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
- Earned Value Management (EVM)
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Integrated Program Management Data Analysis Report (IPMDAR)
- Integrated Program Management Report (IMPR) DI-MGMT-81861
- Cost Data Summary Report
- DI-MGMT-81861B IPMDAR Data Item Description
- DoD Performance-Based Payments Tool
- Functional Cost-Hour Report
- Progress Curve Report, DD Form 1921-2
- 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
- *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

- O&S Cost Management 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 5000.04-M-1 Cost and Software Data Reporting Manual
- 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
- DoD Cost Estimating Guide
- Earned Value Management System (EVM) 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
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- Manufacturing Readiness Level (MRL) Deskbook

F.3 Prepare Initial Manufacturing and Quality 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.).

Budget estimates made near the end of the MSA phase need to be accurate enough to support the program through TMRR. M&Q managers need to support the review and update of M&Q budgets required to support daily manufacturing and QA and to support maturing technologies and processes.

Manufacturing and Quality Tasks

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

Tools

- Manufacturing Cost Estimating Worksheet
- Technology Readiness Level (TRL) Assessment Checklist
- Interactive MRL Users Guide (Checklist), Cost/Funding thread
- Manufacturing Maturation Plan

Resources

- 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
- O&S Cost Management Guide
- 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 5000.81 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

G. MATERIALS MANAGEMENT

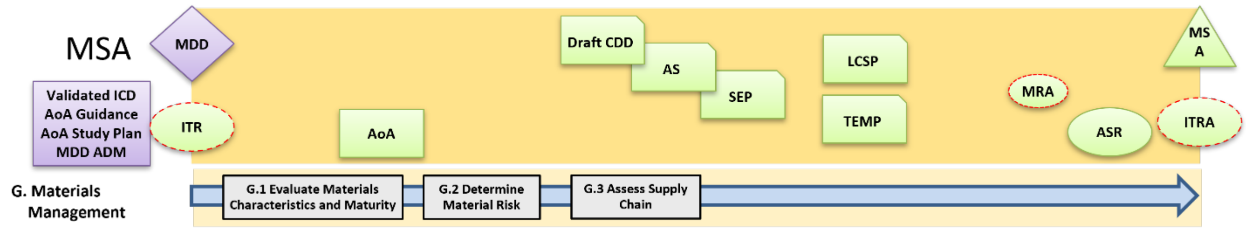


Figure 2-8. Materials Manufacturing and Quality Activities

Introduction

Material management is a core function of supply chain management, including the process for planning and controlling material requirements and material flow through the entire supply chain. Material management will require 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.

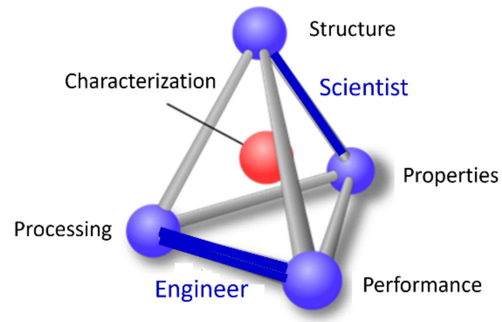
Material Management begins with customer requirements (demand signal), and this information flows throughout the supply chain, from the prime contractor, down many tiers, from raw materials, to fabrication, assembly, test, quality control, distribution and to the customer. The assessment of material requirements will identify the need for any additional research into mature materials and identify the properties, characteristics, and quality 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) and will focus on:

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

G.1 Evaluate Material Characteristics and Maturity



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. 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.

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

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

Manufacturing and Quality Tasks

M&Q personnel need to support the testing and assessment of material properties and characteristics:

- 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.):
    - Support experimentation such as Design of Experiments to identify key process characteristics
- Identify material properties against machine processes (turning, milling, grinding, drilling,

reaming, broaching, sawing, hobbing, cutting, sanding, molding, machining, etc.:

  - Support process capability studies

- Identify material properties for quality (inspection, testing, tolerancing, etc.).
- Analyze and update the contractor planning with respect to materials to include:
  - Material cost drivers
  - Emerging materials
  - Materials design requirements
  - Price stability, cost reduction and avoidance
  - Materials processes
  - Materials availability
  - Environmental factors and compliance
  - Supply chain
  - Processes and quality
  - Security, required special handling, cyber protection
  - Facilities, capital equipment, tooling, and test equipment
- Identify special handling requirements for:
  - Potential regulatory requirements
  - Hazardous materials and handling procedures
  - Security requirements (physical, cyber, etc.)
  - Transportation, storage, and shelf life
  - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
  - Disposal
- Identify and document appropriate metrics for evaluating materials against requirements (performance testing).
- Assess material capability to meet the threshold and objective requirements.
- Assess materials for potential product defects and foster improvements:
  - DMAIC – Define, Measure Analyze, Improve, and Control
- Identify additional research and development (R&D) and experiments required for materials validation and assessment of basic manufacturability or to advance the maturity of materials and processes.
- Update and evaluate material maturity and availability for selected AoA concepts:
  - Determine if the materials have been produced in a laboratory (or more mature) environment
    - Evaluate research and development (R&D) and experiments for validation of material manufacturability

    - Evaluate other ongoing programs for prior use of materials under consideration (DoD, Science and Technology (S&T), commercial, government, etc.)
  - Evaluate material properties, characteristics, and quality requirements for each concept against requirements
  - If new materials emerge or are identified, evaluate needed material properties and characteristics, and quality properties

- Provide M&Q support to evaluate the realism of projected lead times for materials (including hazardous) that are difficult to obtain or process.
- Assess M&Q requirements for material scale-up of selected AoA concepts.
- Perform M&Q volatility assessments for selected AoA concepts and identify:
  - Potential supply chain sources for critical materials
  - Hazardous materials for each concept
  - Special handling procedures that have been applied
- Determine if all M&Q special handling requirements have been identified:
  - Evaluate all materials for:
    - Potential regulatory requirements
    - Hazardous materials and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal

Tools

- Axiomatic Design Techniques
- Design for Six Sigma
- Design of Experiments Analysis
- Taguchi Loss Function Analysis (Robust Design)
- P-Diagram (Parameter Design Techniques)
- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- SD-19, Parts Management for DMSMS
- Design Failure Modes Effects Analysis (DFMEA)
- Process Failure Modes Effects Analysis (PFMEA)
- Failure Reporting and Corrective Action System (FRACAS)
- DMSMS Product Life Cycle Assessment (consult Defense Logistics Agency website)
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist) for the Materials Management thread

- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Supply Chain Management Risk Assessment Checklist
- TRL Assessment Questionnaire
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Lead Time Estimator
- Rough Cut Capacity Planning
- Checklist, Section Preservation (Handling, Storage, Packaging and Delivery)

Resources

- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- 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
- MIL-HDBK-727 Defense Technical Risk Assessment Methodology (DTRAM)
- AFRL-ML-WP-TR-2001-4027 Preliminary Material Properties Handbook
    - Various other Material Property Handbooks
- Materials Science and Engineering Handbooks (various)
    - ASM Handbooks
- DMSMS Guidebook, SD-22
- DoD 4140.1-R, Supply Chain Management Regulation
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- 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
- ISO 9001, Quality Management System
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- ESOH in Acquisition Guide
- 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 Guide

G.2 Determine Material Risk

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Material risks and issues can slow or delay a program, can add 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
  - 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.

The analysis of material risks should include addressing 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.

Material risk 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.

There are several ways the DoD can address material risks such as 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 risks)
- Finding foreign sources of supply
- Finding alternative or substitute parts
- Making a lifetime buy to meet all planned future needs
- Maintaining a current capability
- Developing an alternative solution
- 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 photopolymerization
- 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, 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 for the SRR and the SFR, and updates for the PDR.

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 materials maturity and availability M&Q risks for the AoA preferred solution that are:
    - New or critical materials in development
    - Developed in a lab environment, but are not immediately available
    - Readily available within 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
- Assess material scale-up M&Q risks for AoA preferred solution.
- Conduct an initial risk assessment of potential supply chain capability and capacity:
    - Include material risks for delivery times, manpower, quality, fragility, availability, etc., for the entire supply chain

  - Evaluate the materials management processes for gaps throughout the entire supply chain

- Assess material capability to meet the threshold and objective requirements.
- Assess military vulnerability or gaps that could result from the lack of reasonable material alternatives.
- Review and assess program and contractor Environmental, Safety and Occupational Health (ESOH) requirements for:
  - National Environmental Policy Act (NEPA) and NEPA Compliance Schedule
  - Programmatic Environmental Safety and Health Evaluation (PESHE)
  - System Safety
  - Hazardous Material Management Program
  - Pollution Prevention Program
- Identify all M&Q special handling risks including:
  - Potential regulatory requirements
    - Hazardous materials and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal
- Identify material risks from counterfeit electronic parts and materials (e.g., end items, components, parts, or assemblies).
- Conduct a comprehensive cost/schedule/technical risk assessment in support of the ASR and initiate mitigation plans for each risk.

Tools

- Checklist, Section Preservation (Handling, Storage, Packaging and Delivery)
- Design of Experiments Analysis
- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- Diminishing Manufacturing Sources and Material Shortages (DMSMS) Product Life Cycle Assessment—consult Defense Logistics Agency (DLA)
- Industrial Base Assessment Survey Form (DCMA Industrial Analysis Center)
- Interactive MRL Users Guide (Checklist), Materials Management thread
- 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

- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- AIAG Production Part Approval Process (PPAP) Manual
- DMSMS Guidebook, SD-22
- DoD 4140.01, DoD Supply Chain Materiel Management Regulation
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoD Market Research Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- SD-19, Parts Management for DMSMS
- SD-22 Diminishing Manufacturing Sources and Material Shortages
- Supply Chain Operations Reference (SCOR) Model
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Technology Readiness Assessment Guide

G.3 Assess the Supply Chain

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 (60-80%) of the program's components and subsystems coming from subcontractor, government, and other vendors or suppliers. This makes Supply Chain Management (SCM) a pivotal task.

Program problems often originate in the supply chain but may not manifest themselves until the component is integrated into the system. Program offices and contractors make efforts to identify and manage problems but only have visibility at the first tier and have little insight below that level. Manufacturing and QA managers need to routinely review and assess the contractors' supply chain and procurement activities and progress. The following is a short list of SCM concerns:

- SCM Management
  - Strategy, Vision, and Objectives
  - Performance Metrics

    - Perfect Order Fulfillment, SCM Cost, Supplier Quality, on-time delivery, etc.
  - Forecasting and Demand Management
  - Supply Chain Development
  - Continuous Improvement
- Supplier Selection and Make/Buy criteria and decisions
  - Lead Times
  - Critical sources of supply
  - Alternate sources
  - Visibility (especially below the 1st tier) and communication
  - Velocity (customer wait time, cycle times

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. Major SCM functions include:

- Demand Management (Forecasting, etc.)
- Procurement (Outsourcing, Make/Buy, Supplier Management, etc.)
- Industrial Production
- Inventory Management
- Transportation & Shipping
- Material Handling
- Storage and Distribution (Warehouse Management)
- Property Utilization
- Funds Control
- Data Processing (Information Systems, Data Integration, Analytics, etc.)
- Customer Relationship

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.

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole sources, 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.

Manufacturing and Quality Tasks

- Conduct an initial risk assessment of potential supply chain capability and capacity:
  - Include material risks for delivery times, manpower, quality, fragility, availability, etc., for the entire supply chain
  - Evaluate the materials management processes for gaps throughout the entire supply chain
- Assess the contractor’s Supply Chain Management (SCM) program for adherence to industry M&Q best practices to include:
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)
  - Manufacturing management standards (e.g., AS6500, MIL-HDBK-896, IEEE 15288, etc.)
  - Configuration management
  - Sourcing processes
  - Development of strategic partnerships with vendors and suppliers
  - Sub-contract management
    - Monitoring sub-tier compliance to contract M&Q requirements
    - Sub-tier supplier processes (e.g., configuration management, parts management, counterfeit parts management, electro-static discharge program, etc.)
    - Collaboration of information (especially quality and forecasting data)
  - Procurement processes (schedule, quantity, packaging, kitting, identification, quality)
  - Logistics and inventory management

    - Order Fulfillment (schedule, kitting, identification)
    - Warehouse Management (storage, schedule, kitting, packaging, environmental, security)
    - Transportation Management (methods, special handling, packaging, environment, identification)
    - Vendor Managed Inventory (schedule, quantity, packaging, kitting, identification, quality)
  - A robust risk, issue, and opportunity management process for integration of risks, criticality, obsolescence, sourcing

- Assess the contractor M&Q processes for compliance with or adherence to Company policy, process, and contracts, utilizing DCMA support (if available).
  - Contract Management with evidence of strong contracts and supplier interaction process with plans and schedule to reduce variability and lead times and associated impact on the critical path
  - Assess supply chain interdependencies with regards to other programs
  - Strategic Sourcing to minimize risks, criticality, and obsolescence
  - Supplier qualification, approval, and monitoring processes to include
    - Suppliers with known risks
    - Supplier parts usage and sources (i.e., GIDEP prohibited)
  - Requirements and data flow processes (two-way)
    - Program milestones and metrics (consistent with the IMS)
    - Demand Planning consistent with the IMS
    - Quality, safety, technical, and inspection requirements
    - Key and critical characteristics
  - Management of suppliers and sub-tier materials manufacturing processes and procedures, especially suppliers performing key and/or critical materials manufacturing processes impacting Key Characteristics (KCs)
  - Make or buy decision analysis processes
  - DMSMS management processes
  - Material waiver process (should only be utilized in limited circumstances)
  - Requirements for use of industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
  - Requirements for first article/qualification unit(s) (i.e., AS 9103)
  - Vendor survey requirements
  - Identification of Sub-tier supplier processes for embedded software and firmware risks, issues, and opportunities management including requirements:
    - For conducting Software Acceptance Test (SAT)/ Software Formal Qualification Testing (SFQT)

    - For performing surveillance of this activity

- Review and assess program and contractor Environmental, Safety and Occupational Health (ESOH) requirements for:
    - National Environmental Policy Act (NEPA) and NEPA Compliance Schedule
    - Programmatic Environmental Safety and Health Evaluation (PESHE)
    - System Safety
    - Hazardous Material Management Program
    - Pollution Prevention Program
- Establish potential supply chain quality management metrics for each of the concepts being considered.
- Establish supply chain quality management metrics for each of the concepts considered:
    - Perfect Order Fulfillment
    - On-time Delivery
    - Customer Order Cycle Time
    - Customer Wait Time
    - Supply Chain Response Time
    - Material Availability
    - Inventory Days of Supply
    - Inventory Turnover
    - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks

Tools

- AS6500, Manufacturing Management Systems
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- AS9100, Quality Audit Checklist
- AS9133, Supplier Audit Checklist
- AS9134 Supply Chain Risk Management Guidelines
- AS5553 Supply Chain Assessment
- NIST SP 800-53, Supply Chain Risk Management
- Critical to Customer Assessment
- Critical to Quality Tree
- Supply Chain Management Risk Assessment Checklist
- Lead Time Estimator
- DCMA Material Management and Accounting System Audit
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Materials thread
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- AS9103, Variation Management of Key Characteristics
- AS9133, Qualification Procedure for Aerospace Standard Parts
- AS6500, Manufacturing Management Program
- IAQG Supply Chain Management Handbook (SCMH)
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD 4140.01-R, Supply Chain Materiel Management
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- SD-19, Parts Management for DMSMS
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 15 Supply Chain Management
- MIL-HDBK-896A, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H. PROCESS CAPABILITY AND CONTROL

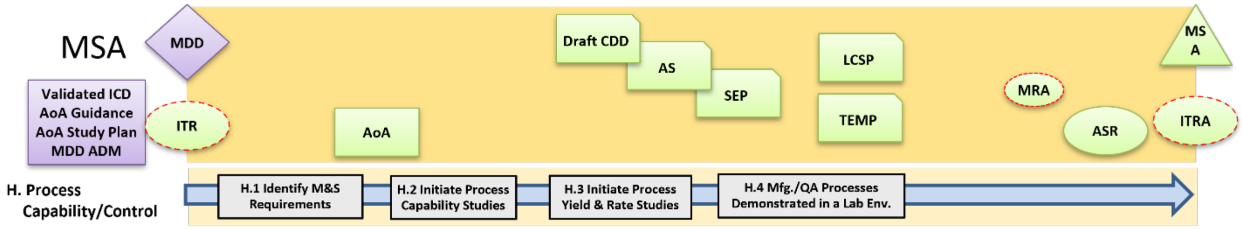


Figure 2-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with uniform, defect-free products that have 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 process variability of a given process or characteristic. Capability studies are used to assess the ability of a process to meet drawing or specification requirements. Typical measures include process capability (Cp/Cpk) and process performance (Pp/Ppk); X bar and R charts; control charts; and other statistical analysis tools.

As a best practice, M&Q personnel should analyze process capabilities for each key and critical manufacturing process. Personnel working on the SE IPT need to use statistical tools to identify where variation has the most impact, reduce variation, and make the process robust to design requirements. Process control studies and other tools can be used to identify upfront and early what the design requirements are, where processes must be made to be capable, and what that capability metrics or targets 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)

H.1 Identify Modeling and Simulation Requirements

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 test 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 test 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 opportunities to promote 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
        - Design Optimization
        - Tolerance/Parameter Design
        - Design Specifications and other Design Documents
        - Work Breakdown Structure
    - Manufacturing and Quality
        - Plant Design
        - Factory Flow Analysis
        - Material Planning
        - Process Planning
        - Manufacturing Simulation
        - Ergonomic Analysis
        - Tool Design
        - Dimensional Management
        - Geometric Dimensioning and Tolerancing
        - Bill of Materials
    - Operations and Sustainment
        - Product Life Cycle Management (PLM) Data
    - 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
- 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
- Plant Modeling and Simulation tools (e.g., FlexSim, SimFactory)
- Process Modeling Tools (e.g., Siemens PLM, Delmia)
- Product Life Cycle Management (PLM) (digital) software tools:
    - Factory Layout Design
    - Plant Layout Design
    - Equipment and Layout Engineering
    - Machining and Tooling Design
    - Factory Simulation
    - Shop Floor Equipment Engineering
    - Ergonomic Simulation
    - Producibility Analysis
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, etc.)
- 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

Resources

- DoD Directive 5000.59, DoD Modeling and Simulation Management
- DoDI 5000.97, Digital Engineering
- 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
- AS9100, Quality Management System
- AS9103, Variation Management of Key Characteristics
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896, Manufacturing Management Program Guide
- 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
- Early Manufacturing and Quality Engineering Guide
- 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
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Simulation Applications
- Modeling and Simulation Guidance for the Acquisition Workforce

H.2 Initiate Process Capability Studies

A process capability study is a measure of the inherent process variability of a given characteristic. Process capability studies are conducted to assess the ability of a process to meet the contractual specification. A process capability study uses data from a sample to predict the ability of a manufacturing process to produce parts that conform to the contract or specifications. This prediction enables organizations to "qualify" a new manufacturing process for production.

AS6500 requires organizations to analyze process capabilities for all critical processes, and to use statistical tools to reduce variation and calculate process capability indices as appropriate. In addition, organizations shall:

- Identify Cpk goals for critical manufacturing processes
- Provide process capability data to design engineers to utilize in the design stage
- Track and manage process capability data for improving low yields and foster continuous improvement to achieve yield targets

Important definitions include the following:

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

A process performance study is used to evaluate a manufacturing process and answers the question: "how did the process actually perform over a period of time?" This is a historical analysis that can still be used to drive process improvements.

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

- Cp (Process Capability)
- Cpk (Process Capability Index)
- Pp (Preliminary Process Capability)
- Ppk (Preliminary Process Capability Index),

The Cp and Cpk calculations use sample deviation or deviation mean within rational subgroups using limited or sample data. The Pp and Ppk calculations use standard deviation based on studied data (whole population). The Cp and Cpk indices are used to evaluate existing, established processes that are in statistical control and attempt to predict the ability of the process to produce conforming parts. The Pp and Ppk indices are used to evaluate actual performance with on-going processes in an attempt to determine how the process actually performed over time.

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

- Capability studies
- Yields and rates
- Process demonstrations

Typically, a process capability study follows these steps:

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

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

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

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

Manufacturing and Quality Tasks

- Initiate M&Q process capability studies based on the data from the preferred concept:
    - If no data is available, conduct necessary studies to generate the required data
    - Alternatively, use process capabilities of current or similar products to generate the required data
    - Analyze FMEA Templates (DFMEA and PFMEA)
- Analyze the impact of M&Q process capability on KCs that impact performance, reliability, and affordability.
- Analyze M&Q studies of existing processes to determine gaps in manufacturing capabilities as a risk and an impact on yields and rates:
    - Use modeling and simulation tools to perform an analysis of process capability to support yield and rate estimates, before actual manufacturing begins
    - Determine the need for new processes to meet requirements
    - Include time and resources required to mature these critical manufacturing processes
    - Incorporate sources of variations and plans to address the variation
    - Include additional data from existing, proposed, or similar processes from other projects and programs
- Based on analyses, update yield and rate estimates for the Acquisition Strategy and the SEP.
- Identify anticipated critical manufacturing processes when possible.
- Analyze the current state of process capability for critical M&Q processes for the preferred concept, identify potential gaps, and include the information in the Acquisition Strategy and the SEP.
- Identify and analyze the state-of-the-art manufacturing and production modeling and simulation approaches that support the preferred concept and include the information in the Acquisition Strategy and the SEP.
- Identify M&Q process capability goals and risks for the preferred concept from the manufacturing feasibility assessment, including risks to:
    - Critical M&Q processes

  - Potential cost and schedule impacts
  - Producibility
  - Special tooling
  - Testing and qualification
  - Environmental
  - Management (data, security, etc.)
- Identify opportunities to continuously improve processes using Lean\Six Sigma and other techniques

Tools

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

Resources

- 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
- ISO 9001 Quality management systems – Requirements
- AS6500 Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Systems Engineering Guidebook

- Defense Management Guide for Program Managers, Chapter 7.6.2 Determine Process Capability
- Defense Manufacturing Guide for Program Managers, Chapter 5.5.4 Seven Quality Control Tools
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program
- NAVSO P-3687, Producibility Systems Guidelines

H.3 Develop Process Yield and Rate Estimates

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 designs and process control activities to include continuous process improvement to identify and remove sources of variation. Yield is one measure of uniformity and is the percentage of products that are defect free and is usually described by the ratio of non-defective parts vs. total parts produced. An ideal process is one without any defects, no scrap, rework, or repair activities. Organizations often measure yield using one of the following measures:

- First Pass (throughput yield) is the number of units processed to specifications without rework (total units entering the process).
- Rolling Throughput Yield is a measure of yield at each process step.
- Final Yield is the measure of total yield or the total number of parts that passed inspection divided by the total number of parts produced.

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

AS6500 requires organizations to develop and implement Variation Reduction on all parts and processes that are considered to be key or critical characteristics. Variability reduction shall be used to achieve stable and capable critical manufacturing processes. Variability reduction requires the development and implementation of Process Control Plans that will include:

- Identify the types of data to be collected
- How the data will be collected, analyzed, and managed
- Identify the sources of variation on key and critical manufacturing processes
- How variation will be identified, assessed, managed, and controlled

  - Six Sigma, DMAIC, and other tools

M&Q personnel should develop and implement a Variability Reduction Program to identify and reduce product and process variability in order to achieve quality output at identified quality levels.

Important definitions include the following:

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

Statistical Process Control (SPC) is a technique that is used to control a process or production method and to foster continuous process improvement. SPC will include the investigation of process maturity for similar manufacturing processes to ensure that a process is both capable and in control. Processes are capable when they are producing products that meet the specification requirements of the technical drawing. Process capability is usually measured using either a Capability Index (Cp) or a Capability Index centered (Cpk). Process performance is usually measured using either Performance Index (Pp) or a Performance Index centered (Ppk). Contractors should be working to get their processes to be both capable and in control.

Statistical Process Control tools are used to determine if a process is in a state of statistical control (predictable). Typical process control tools include the X bar and R charts, plus many others. For each concept to be considered, a determination of the manufacturing process capability will be completed. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Critical and key manufacturing processes can also be identified during the assessment and analysis either through M&S or experimentation.

Manufacturing and Quality Tasks

- Collect up-to-date data from similar M&Q processes, and production line M&Q data for components and items as the basis for yield and rate analyses and estimating to validate "current as is" status:
  - Rate of quality processes (actual time to complete) vs. planned
  - Quality data actuals vs. estimated
  - Quality process yields actuals vs. planned
  - Changes in processes (actual vs. planned)
  - Cost of quality actuals vs. desired
- Assess potential impact on yields and rates, validate completeness of all related risk mitigation activities or acceptance of these risks (included in the joint Risk, Issue, and

Opportunity Management Process), including:
  - Key and critical manufacturing processes including embedding software (KCs)
  - Supply chain, materials, and sourcing, including multiple
  - Facilities, tooling, and equipment
  - Testing, test equipment, and in-process tests
  - System security, safety, and HAZMAT management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability, obsolescence, and sustainment
- Evaluate all yields and rates from current production activities for similar products against projected or required targets, goals, and projections:
  - Validate achievement of targets (e.g., pilot line, LRIP, etc.)
  - Refine yields and rates required for LRIP
  - Based on results of analyses develop and implement improvement plans as required
- Consider need for a Variability Reduction Program to improve yield rates and quality output:
  - Identify types of data to be collected
  - Identify how the data will be collected, analyzed, and managed
  - Identify potential sources of variation (FMEA) on key and critical manufacturing processes
  - Identify how variation will be identified, assessed, managed, and controlled
    - Six Sigma, DMAIC, and other tools

Tools

- AS9100 Checklist
- AS9103 Variation Management of Key Characteristics
- AS6500 Checklist
- Yield Rate Assessment
- Six Sigma/DMAIC process
- Statistical Process Control Charts
- Process Capability Study Worksheet (Cp and Cpk Assessment)
- First Pass Yield Estimates Worksheet
- Cause and Effect Diagram
- Pareto Analysis
- Histograms
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Systems

- AS9103, Variation Management of Key Characteristics
- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

H.4 Manufacturing Processes Demonstration in a Lab Environment

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.

M&Q engineering efforts should lead to a producible and testable system with the objective of achieving effective and efficient manufacturing processes with the necessary process controls to satisfy requirements with consistent, repeatable products while minimizing manufacturing costs.

During the MSA Phase, manufacturing processes should be demonstrated in a Lab environment and achieve an MRL 4 or greater to be considered mature.

Manufacturing and Quality Tasks

- Define and document the appropriate M&Q manufacturing 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
- Based on analyses and evaluations of M&S models, process demonstrations, production of components and items, and prototype builds, summarize, define, and finalize M&Q processes, process capabilities, and limitations for the TMRR Acquisition Strategy and SEP planning:
  - Refine process capability requirements for the TMRR phase
  - Develop plans to transition from a laboratory to a production relevant environment
  - Update models and simulations for use in TMRR with actual data to increase fidelity and confidence that the model and prototypes realistically represent the final product
- Conduct an MRL assessment and 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)
  - 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.)
- Based on government/contractor IPT interactions, define, and document the appropriate M&Q production relevant environment(s) to be used for process demonstrations and prototypes.

- Assess demonstrations of manufacturing processes in an environment with shop floor production realism present (e.g., actual production facilities, manufacturing personnel, using production tooling, processes, materials) incorporating factors such as:
  - Minimum reliance on laboratory resources
  - Environmental conditions (i.e., temperature, humidity, air quality)
  - Equipment (i.e., accuracy, calibration, age and condition, suitability, capacity, reliability)
  - Workforce (i.e., training, skills, and certifications)
  - Human factors (i.e., noise, vibrations, ergonomics)
  - Ability to meet the cost, schedule, and performance requirements of the EMD phase
- Evaluate demonstrations to determine environmental factors impacting the manufacturing of subsystems, items, and components:
  - Include ambient temperature, humidity, noise, vibrations, personnel skills levels, materials specifications, etc.
- Evaluate process demonstrations and production of prototypes for mitigation of M&Q risks.
- Evaluate and analyze yields and rates from process demonstrations and production of components and items for prototype builds:
  - Utilize results as inputs to improvement plans
- Collect data from process demonstrations and production of components and items for prototype builds to support verification, validation, and authentication of M&S processes.
- Assess manufacturing readiness by conducting an MRL assessment to support PDR and the Milestone B decision process:
  - Support the Technology Readiness Assessment, if conducted
  - Support identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment
- 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 component targets should use MRL criteria and metrics for that phase
- 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

- AS9145 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment 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, for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Studies (C_p and C_{pk} assessments)
- Producibility Assessment Worksheet (PAW)
- Statistical Process Control Charts
- 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, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- ISO 9001, Quality Management System
- 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
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook

I. QUALITY MANAGEMENT

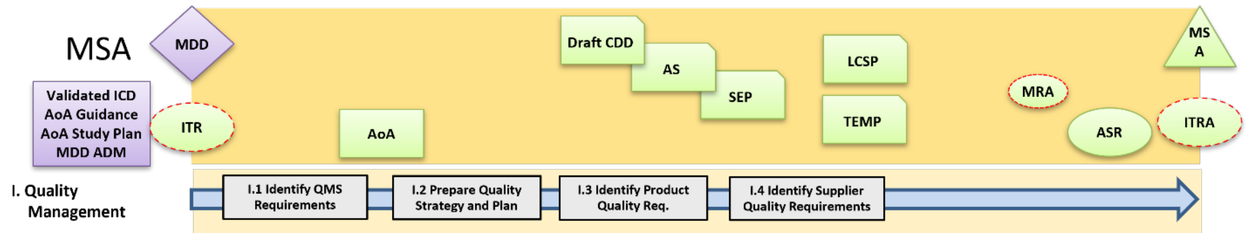


Figure 2-10 Quality Management Manufacturing and Quality Activities

Introduction

Quality is the degree to which material attributes, performance features, and characteristics of a product satisfy a given need. Quality may apply to a product, process, or system and may be physical, sensory, behavioral, temporal, ergonomic, or functional.

Quality management is 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 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.

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

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

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

I.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 that focuses on the results, in relation to the quality objectives, to satisfy user 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

- Analyze the preferred concepts for quality management system requirements, and document them in the AoA and SEP:
  - The quality management requirements should include:
    - Quality management system requirements
    - Management responsibility requirements
    - Resource management requirements
    - Product realization requirements (e.g., risk management, design, and development, purchasing, etc.)
    - Measurement, analysis, and improvement requirements
  - Alternatively, the quality management requirements can be met by adherence to established standards (e.g., AS9100, ISO 9001, etc.):
    - Include M&Q management lessons learned
    - Include industry best practices
- Specify the quality management contract requirements to be met by the contractor or government entity as appropriate:
  - Ensure these requirements are put on contract for the preferred concepts
  - Provide requirements for quality management responsibilities and personnel within the IPT
  - Provide quality management requirements and metrics
- 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 the industry's 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

- Review, update, and analyze quality management metrics for the preferred concept from the AoA Study Guidance:
    - Verify that the frequency the metrics are reviewed is commensurate with quality risks
    - Processes for management, control, and monitoring of KPPs, KSAs, and KCs, CSIs, and CAIs, and their integration into the QMS.
- Support the assessment of the following AS9100 QMS requirements:
    - 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 System Analysis (metrology and calibration)
- Conduct a process audit of the contractor’s QMS including assessment of:
    - Quality processes and supply chain quality including:
        - Identification, control, and auditing of critical manufacturing processes
        - Role and participation of DCMA (contractor and supply chain)
        - KCs control and management
        - Acceptance testing including software
        - In-process and final inspection functionality
        - Statistical process controls, rates, and yields (and management of same)
        - Execution of and adherence to quality plans including control plans and quality improvement plans

  - Certification processes (e.g., flight safety, man-ratings, etc.)
  - Continuous process improvement results
  - Software quality assurance results
  - Management of quality data to include digital data
  - 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

- Ensure the organization's QMS system is striving for continuous product and process improvement using proven Lean/Six Sigma concepts, tools, and practices.
- Contact DCMA for input on QMS evaluation of potential contractors and suppliers for the preferred concept.
- Request DCMA support and assistance to assess adequacy and completeness of contractor and supply chain QMSs application to system, subsystems, items, and components.

Tools

- AS9100, 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 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
- Lean/Six Sigma Tools and Techniques

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102 First Article Inspection
  - AS9103 Variation Management of Key Characteristics

  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance

- ISO 9001, Quality Management System (QMS) – Requirements
- FAR 46.202 Types of Contract Quality Requirements
- FAR 52.246-11 Higher-level Contract Quality Requirements
- AFMC Instruction 63-145, Manufacturing and Quality (Draft)
- 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
- 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
- Manufacturing Readiness Level (MRL) Deskbook

I.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, organizations can use a Quality Strategy 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 the 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 for 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 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 should 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.

Advanced Product Quality Planning (APQP) is a structured approach to product and process design. This framework consists of a standardized set of quality requirements (AS9145 APQP/PPAP) that enables suppliers to design a product that satisfies the customer that is comprised of five steps or phases:

- Plan & Define
- Product Design and Development
- Process Design and Development
- Product and Process Validation
- Production Feedback

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 program's Quality Plan;
    - 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
- 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

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

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.

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. MSA evaluates features such as stability, linearity, and bias testing. MSA of tools such as Design of Experiments (DOE), Gage R&R, ANOVA, Statistical Process Control (SPC), and Failure Mode Effects Analysis (FMEA) assess the measurement process and characterizes its uncertainty and variability. MSA may assess causes of variation of repeated measurements as well as between similar gages, between operators, under different usage environments, and changes over time. MSA may allow for understanding of the measurement variation relative to that of the associated parts or processes.

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

- Personal and product safety
- Producibility and Inspectability
- Process for calibration and metrology
- 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

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

- 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
    - 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 the requirements for controlling quality data, including digital data, and managing data end-to-end

- Analyze product quality requirements for the AoA preferred concept:
  - Identify product acceptance methods and determine sampling plans as appropriate
  - Incorporate new quality technologies and process state of the art into product quality requirements
  - Analyze the need for unique product quality requirements (i.e., specific product characteristics)
  - Analyze product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks

- 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
  - Conduct Measurement System Analysis (MSA) to identify the amount of variation that exists within a measurement system
  - Conduct Gage T&T studies to quantify the amount of variation in the measurement system in order to assess repeatability and reproducibility
  - 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
    - Ensure Geometric dimensioning and tolerancing (GD&T) is a system used by engineers and manufacturers for defining and communicating engineering tolerances
    - Support the requirements process to include the allocated and functional designs
- Measurement traceability to include 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:
    - 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 in using Lean/Six Sigma and other techniques

Support the assessment of the following AS9100 product quality requirements:

- Design control and drawing control.
- Product Identification and Traceability (AS9132).
- Inspection and Testing.
- Product/Process Metrics.
- Control of Customer Supplied Product.

- Product Acceptance.
- Qualification Procedures for Standard Parts (AS9133).
- First Article Inspection/ Test (AS9102).
- Control of Non-conforming Material (AS9131).
- Manage Key/Critical Characteristics (AS9103).
- Variation Management (AS9103).
- Control of Inspection, Measurement, and Test Equipment (Metrology/Calibration).
- Measurement System Analysis.
- Gage T&T Studies.
- Handling, Storage, Packaging, Marking, Preservation and Delivery.
- Continuous Improvement, Lean/Six Sigma.
- Analyze potential solutions and processes that could address product quality needs:
  - Analyze identified quality technologies (i.e., metrology technologies) that could improve product quality
  - Analyze potential solutions or processes to improve the product quality of low-yield processes and components
- Contact DCMA personnel to capture input on potential contractors and supplier quality performance against quality requirements for similar products or processes.
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements.
- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards.

Tools

- AS9100 Quality Audit Checklist
  - 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 Audit Checklist
- Critical to Customer Assessment
- Critical to Quality Tree
- QA Surveillance Template
- Independent Technical Risk Assessment Checklist

- Interactive MRL Users Guide (Checklist) for the Quality Management thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- AS9100, Quality Management System – Aerospace
  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
- 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 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- AIAG Measurement Systems Analysis (MSA) Manual
- SAE J1739 Potential Failure Mode and Effects Analysis (Design FMEA, Process FMEA)
- AIAG APQP Manual
- IAQG Aerospace APQP Manual
- ASME Y14.5 Dimensioning and Tolerancing
- DoD Systems Engineering Guide
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-STD-1916 DoD Test Method Standard
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge
- Defense Technical Risk Assessment Methodology (DTRAM)
- 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-80756
- Quality Assurance Program Plan DI-QCIC-81794
- Quality Assurance Provisions (QAP) DI-SESS-80789A

I.4 Identify Supplier Quality Requirements Analysis

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. DoD the prime contractors often deliver the final defense product, but increasingly, they do so through the management of their supply chain, which is rooted in both commercial and military supplies. Adding to the complexity is the fact that on many large weapon system programs the prime contractor is often the integrator, with (60-80%) of the program’s components and subsystems coming from subcontractor, government, and other vendors or suppliers. This makes Supply Chain Management (SCM) a pivotal task.

Supply chain quality management is the process of developing and executing a supplier quality program that ensures that products are delivered on time, to the right place, in the right count and condition, at the agreed upon price in time to meet the customers’ requirements (production).

Supplier quality management begins early in product design and development and continues throughout the life cycle of the system or product. Supplier quality goes beyond lowest price to include identifying “best value” subcontractors and vendors that have a history of providing quality products and services, with low nonconformance rates and rapid response to problems.

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole sources, 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.

Program problems often originate in the supply chain but may not manifest themselves until the component is integrated into the system. Program offices and contractors make efforts to identify and manage problems but only have visibility at the first tier and have little insight below that level.

Manufacturing and QA managers need to routinely review and assess the contractors' supply chain and procurement activities and progress. The following is a short list of SCM concerns:

Supply Chain considerations per AS9133 and 9134:

- Subcontractor Selection and Management (Make/Buy decisions)
    - Lead Times, Defect-free product delivery, etc.
- Flow-down of Requirements for subcontractors and vendors
- Evaluation of subcontractors and vendors QMS and product quality
- Supply chain and quality metrics
    - Perfect Order Fulfillment, SCM Cost, Supplier Quality, on-time delivery, etc.
- Customer support, return policy, and satisfaction
- SCM risk management guidelines (AS9134)
- QMS for stock distributors

Special Supply Chain considerations include:

- First article inspection
- Product traceability
- Preservation, packaging, handling, storage, and delivery of products
- Sole Source/Single Source
- Foreign Source
- Counterfeit Parts
- Diminishing Manufacturing Sources and Material Shortages
- Obsolescence
- International Traffic in Arms Regulation (ITAR)
- Cybersecurity
- Quality Audits
- Nonconforming Material Control
- Corrective and Preventive Action

In general, major, and critical suppliers will have the same quality requirements as the prime, Thus if the prime contractor is operating under ISO 9001 or AS9100, then the next level down may also have the same requirement flowed down to them. Ensure that the appropriate contract quality requirements flow down to the subcontractors and vendors, and that the prime contractor is actively managing and controlling risks at their subcontractor and vendor facilities as appropriate.

M&Q personnel need to support the assessment of contractor supply chains and ensure that quality requirements are flowed down throughout the supply chain as appropriate.

Manufacturing and Quality Tasks

- Assess the contractor's Supply Chain Management (SCM) program for adherence to industry M&Q best practices to include:
    - Quality management standards (e.g., ISO 9000, AS9100, etc.)
    - Manufacturing management standards (e.g., AS6500, MIL-HDBK-896, IEEE 15288, etc.)
    - Configuration management (e.g., MIL-HDBK-61B)
    - Contracting and subcontract management
- Assess the contractors' Purchasing system (Make/Buy Decisions):
    - Has a Quality Management System that is compliant with best practices (AS9100, ISO 9001, etc.)
    - Has a quality policy with goals
    - Meets or addresses the twenty-one elements of an ISO 9001:
    - Meets ESOH and Safety statutory and best practice requirement
- Specify and Flow-down Quality Requirements.
- Evaluate Subcontractor and Vendor QMS.
- Evaluate Subcontractor and Vendor Product Quality.
- Analyze the supply chain quality management requirements for the preferred concept:
    - Analyze the need for focused supplier quality management requirements (e.g., a supplier Quality Assurance Plan)
    - Analyze the need for a stand-alone supplier Quality Management Plan for the supply chain
    - The quality management requirements for the supply chain should include:
        - Quality management system requirements
        - Management responsibility requirements
        - Resource management requirements
        - Product realization requirements (e.g., risk management, design, and development, purchasing, etc.)
        - First Article Inspection if required
        - Measurement, analysis, and improvement requirements
    - Quality management requirements for the supply chain can be met by adherence to established quality standards (e.g., AS9100, ISO 9001, etc.)
        - Include M&Q management lessons learned
        - Include industry best practices
    - Analyze and update supply chain quality management metrics for the preferred concept.
- 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
- Conduct Measurement System Analysis (MSA) to identify the amount of variation that exists within a measurement system
- 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

- Establish supply chain quality management metrics for each of the concepts being considered for incoming quality inspection, including the identification of acceptable quality levels (AQLs):
  - Perfect Order Fulfillment
  - On-time Delivery
  - Customer Order Cycle Time
  - Customer Wait Time
  - Customer Satisfaction
  - Supply Chain Response Time
  - Material Availability
  - Inventory Days of Supply
  - Inventory Turnover

    - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks

- Analyze the impact of quality technologies and process state-of-the-art for impacts on the quality management of the supply chain.
- Analyze potential solutions, tools, and techniques that could address quality management requirements of the supply chain:
    - Incorporate quality technologies (i.e., metrology technologies) that could improve the supply chain quality programs
    - Incorporate potential solutions (e.g., materials, machines, training, etc.) to improve low-yield processes and components and lower variability to meet supply chain quality requirements
- Contact DCMA personnel for input on the analysis of potential supply chain quality management systems.
- Ensure quality and manufacturing requirements are included in the contracts of proposed suppliers and in appropriate agreements with other agencies, e.g., the DCMA.
- Ensure that the assessment of potential supplier's quality management (in the lower supply chain) for each concept being considered includes DCMA input.
- Ensure quality and manufacturing requirements are included in the contracts of proposed suppliers and in appropriate agreements with other agencies (e.g., DCMA).
- Identify, assess, and manage supplier QA concerns such as DMSMS, Obsolescence, Counterfeit Parts, etc.

Tools

- AS9100, Quality Audit Checklist
    - AS9133, Supplier Audit Checklist
    - AS9134 Supply Chain Risk Management Guidelines
    - AS5553 Supply Chain Assessment
- ISO 9001, Quality Audit Checklist
- Corporate Supplier Quality Questionnaire
- Critical to Customer Assessment
- Critical to Quality Tree
- Supply Chain Management Risk Assessment Checklist
- Lead Time Estimator
- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist), Quality Management thread
- Manufacturing Maturation Plan
- Quality Management Plan
- Systems Engineering Plan (SEP) Outline

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102 First Article Inspection
  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
- ISO 9001 Quality Management Systems
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- AIAG Measurement Systems Analysis (MSA) Manual
- AS6500, Manufacturing Management Program
- IAQG Supply Chain Management Handbook (SCMH)
- MIL-STD-1535B Supplier QA
- DoD 4140.01-R, Supply Chain Materiel Management
- NIST SP 800-53, Supply Chain Risk Management
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- 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
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- 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

J. MANUFACTURING WORKFORCE

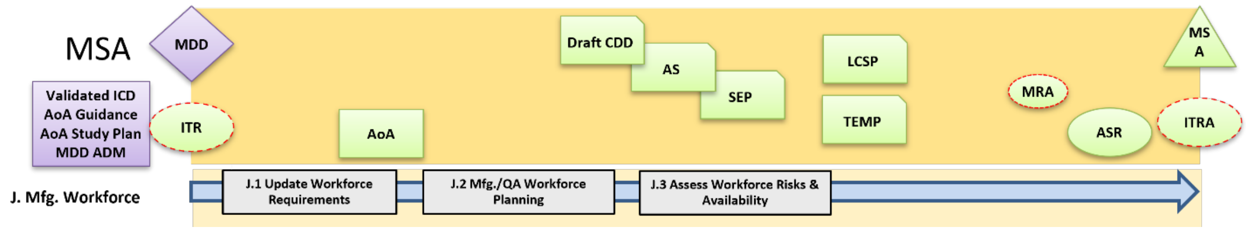


Figure 2-11. Manufacturing Workforce Manufacturing and Quality Activities

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; a moderate to severe skills shortage in their overall workforce; and 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 their ability to expand operations or improve productivity.

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

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

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

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

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

J.1 Update Workforce Requirements

Workforce requirements planning provides quantitative inputs to program planning. Contractors workforce planning should identify and 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 in order 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)
- Understanding of Advanced Manufacturing (AM) methodologies used to improve manufacturing processes and products
- Understanding of Additive Manufacturing technologies to include 3D printing

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.

Manufacturing workforce is one of the 5Ms (manpower, machines, materials, methods, measurement) that needs to be addressed on an ongoing basis, especially early in the MSA phase as alternative solutions are identified, thus uncovering new manufacturing processes and workforce skills. M&Q personnel need to support the identification of workforce skills, training, and availability requirements based on the identified factory floor processing requirements (manpower).

Manufacturing and Quality Tasks

- Conduct an analysis of the supply of workforce:
  - Identify industry and sector M&Q workforce competencies:
    - Technical competencies
    - Academic competencies
    - Advanced manufacturing
    - Additive manufacturing
    - Lean/Six Sigma and CPI
  - Identify workforce requirements by job/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 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's 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 the 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 the 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 knowledge gaps and expertise needed:

  - 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?

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

  - Workforce requirements (technical and operational)
  - Processes that require certifications (i.e., special skills)
  - Sources and shortages of qualified personnel based on processes, education, location, precision requirements, etc.

- Update requirements by phase for M&Q skills and training for preferred materiel solutions for the AoA:

    - Identify additional or new skills required
        - Include associated training requirements
    - Determine staffing requirements for skills, experience, certification levels, education levels, ramp-up, and attrition
- Include M&Q workforce requirements in the Acquisition Strategy and the SEP as appropriate.

Tools

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

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
- Early Manufacturing and Quality Engineering Guide
- Digital Engineering Body of Knowledge
- Defense Manufacturing Management Guide for Program Managers, Chapter 6 Manufacturing Planning

- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- Manufacturing Resource Planning (MRP II)
- Manufacturing Readiness Level (MRL) Deskbook

J.2 Manufacturing and Quality Workforce Planning

M&Q Workforce management covers a wide range of business processes that are used to ensure that the organizations workforce is strategically allocated, the right people, in the right place, at the right times, and doing the right things in order to maximize business performance, increase organizational competency, and satisfy the customer.

Workforce skills identification and plans provide inputs to program planning. Workforce planning should align the skills required to meet program objectives based on the scope of the effort required to develop, field, and sustain the system. To determine the scope of the M&Q workforce plans necessary for the system, the following considerations should be analyzed and understood, including the IMP/IMS, production plan, the Work Breakdown Structure (WBS), the contractor's make/buy plans, M&Q processes, and procedures, the risks, issues, and opportunities and other associated plans.

Workforce planning and management executes the results of the workforce requirements planning process and focuses on:

- Forecasting of Workforce Demand is dependent on Production/Sales Demand (Forecasting Models: Quantitative or Qualitative)
- Staffing and Scheduling to meet planned production requirements
    - Workforce Competency/Skills Identification
    - Employee Turnover/Attrition Rates
    - Job Security
- Recruiting (Hiring) and Onboarding
- Competency Management (Training and Development, initial and ongoing)
- Performance Management and Analytics
- Time and Attendance Tracking
    - Absence Management (Rates)
    - Overtime Management (Rates)
- Pay and Benefits
    - Competitive Pay?
    - Competitive Benefits (Vacation and Leave Planning)?
- Compliance Management
    - Regulatory Compliance (Number of Documented Compliance Complaints)
    - Health and Safety (Reportable Safety Incidence)

Human resources (Human Capital) are a valuable asset. Therefore, a strategic business plan must ensure that the selection of employees for each task is appropriate, as well as compatible with the selected product, delivery schedule, and competency level.

Workforce management and planning includes the following goals:

- Reduce labor costs
- Develop employees
- Respond to changing customer needs
- Improve quality and productivity
- Improve employee retention
- Improve safety and compliance

M&Q personnel need to support the identification of workforce skills, training, and availability requirements based on the identified factory floor processing requirements (manpower).

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

Manufacturing and Quality Tasks

- Initiate M&Q planning, as an input to program management planning, to address M&Q skill sets, production workforce availability requirements, and risks for this phase.
- Planning should address:
    - Human resource policies, processes, and procedures to include forecasting, recruiting, training, scheduling, and compensation
    - Current labor market impacts on availability, stability, capabilities, and training to meet M&Q workforce requirements
    - Mitigation needs for
    - Mitigation plans for critical shortages of qualified personnel based on processes, location, precision requirements, etc.
- Plans for acquisition and training of new personnel.
- Plans for project ramp-up or ramp-down.
- Plans for workforce attrition:
    - Workforce skills requirements based on contractor's production plans and make/buy decisions for internal and/or outsourcing of workforce skills
- Skillsets and capabilities by category by schedule:
    - Training and/or certification requirements (e.g., certified welders, skilled machine programmers or operators, etc.)
    - Potential impacts from labor relations, surges, competition, etc.

  - Volatility of demand and impact on workforce requirements
  - Current level and forecasting for training, certifications, and education
  - Capacity and capability to train, certify, etc.
  - Manufacturing machinery and equipment improvements and changes (e.g., programming and operation, maintenance, calibration, and repair, etc.) impact on workforce
  - ManTech demonstrations, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
  - Facility relocations, and changes (e.g., location, improvements and expansion, lay-out changes, etc.)
  - Tooling improvements and changes (e.g., operation and maintenance, safety, security, cleanliness, acoustics, HVAC, and environmental controls, etc.)
  - Quality requirements changes and additions (e.g., inspections, equipment operation, maintenance, calibration, etc.)
  - New materials and technologies impact on workforce ability to address processing, testing, and acceptance
  - Environmental, safety, and health requirements changes impact on workforce
  - Impacts of regulatory requirements (e.g., special handling, security, HAZMAT, environmental needs, storage requirements, etc.) on the workforce
  - Incorporation of appropriate workforce lessons learned for processes, tools, and techniques for manufacturing workforce strategy
  - Planning for digital engineering requirements and activities
  - Development of M&Q metrics to measure performance

- Assess contractor M&Q workforce management and plans for this phase to include:

  - Synchronization with the SEP, the IMP/IMS, and the Subcontractor Management Plan
  - Consistency with the contractor’s Manufacturing Plan
  - Staffing rate requirements for production environment
  - Workforce skills availability (i.e., number of trained capable workers)
  - Workforce stability (e.g., labor force age, turnover rate, labor force sustainability, etc.)
  - Special skills certification and training requirements

Tools

- Workforce Planning Tools (SAP/Oracle/MRPII)
- Manufacturing Resource Planning (MRPII)
- Interactive MRL Users Guide (Checklist), Workforce thread
- Manufacturing Maturation Plan
- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management

- Critical Path Template
- Milestone Chart
- Gantt Chart
- Forecasting and Regression Analysis
- Learning Curve Estimator
- Line of Balance Template
- Route Sheet Analysis
- Shop Floor Manufacturing Plan Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)
- Work Measurement Analysis

Resources

- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9100, Quality Management System
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- Digital Engineering Body of Knowledge
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Resource Planning (MRP II)
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook, Workforce thread
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.7.12 Personnel Planning
- Defense Manufacturing Management Guide for Program Managers, Chapter 14.5.5 The Future of Manpower

J.3 Identify and Manage Workforce Risks and Availability

M&Q Workforce management covers a wide range of business processes that are used to ensure that the organizations workforce is strategically allocated, the right people, in the right place, at the right times, and doing the right things in order to maximize business performance, increase organizational competency, and satisfy the customer.

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

- Workforce skills availability (how many are needed and are there enough people?)
- Workforce skills capability (do they have the right training, skills, abilities, and certifications?)

Manufacturing USA estimates that by 2028 manufacturers will need to fill 4.6 million jobs, which indicates a mismatch between the supply of workers and the demand for them. This gap in the workforce supply is driven in part by the aging workforce, rising technical requirements, and the lack of a training pipeline for training new members of the workforce. Manufacturing organizations need to address these gaps if they are to meet their production demands.

The Program Management Office (PMO) should identify any manpower risks. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Manufacturing Readiness Assessments, Industrial Capabilities Assessments, trade-off studies, tooling plans, make- or-buy plans, manufacturing plans, and bills of material. Important output include actions to reduce or manage remaining risks. Provide an assessment of manufacturing processes, including critical skills availability, identify the steps needed to progress from one manufacturing environment to the next, and eventually to a Pilot Line, LRIP, and FRP.

M&Q personnel need to support the identification of potential workforce skills, training, and availability requirements based on an identified emerging material and processes. The need for assessing and managing manufacturing risks during the various acquisition phases is discussed below.

Manufacturing and Quality Tasks

- Assess manufacturing workforce risks:
    - Required workforce availability has been forecasted by monthly requirement against the production requirements
    - Required workforce is available, by labor skill category, to meet planned production requirements
    - Required workforce skills, training, and certifications have been forecasted by monthly requirement against production requirements
    - Required workforce training and certification have been planned for by monthly requirement against production requirements
    - Have any new or emerging skills been identified that need to be assessed for availability and training
    - Union agreements have been reviewed to ensure workforce/schedule availability

- Develop workforce plans to achieve production requirements.
- Document personnel skills development to meet appropriate quality and rate targets.
- Assess and manage workforce attrition to ensure production workforce skill sets and availability to meet production goals.
- Assess potential disruptive activities that could impact workforce availability (natural disasters, pandemics, changes in technologies, strikes, plant closures, etc.).

Tools

- Workforce Planning Tools (SAP/Oracle/MRP II)
- Manufacturing Resource Planning (MRPII) Assessment
- Independent Technical Risk Assessments (ITRAs)
- Technology Readiness Assessment
- Interactive MRL Users Guide (Checklist), Manufacturing Workforce thread
- Manufacturing Maturation Plan
- DCMA Production Planning and Control (PPC) Checklist
- AS6500 Manufacturing Management Assessment
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Forecasting and Regression Analysis
- Make/Buy Decisions
- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Milestone Chart
- Gantt Chart
- Route Sheet Analysis
- Critical Path Template
- Critical Chain Project Management
- Capacity Planning Worksheet
- Line of Balance Assessment
- Line of Balance Template
- Learning Curve Estimator
- Work Measurement Analysis
- SWOT Analysis (Strengths, Weaknesses, Opportunities and Threats)

Resources

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- AS6500, Manufacturing Management Program

- Manufacturing Plan, DI-MGMT-81889A
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9100, Quality Management System
- ISO 9001, Quality Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Technology Readiness Assessment Guide
- Independent Technical Risk Assessment Framework for Risk Categorization
- DoDI 5000.88, Engineering of Defense Systems
- AFI 63-145, Manufacturing and Quality Management
- DoDI 5000.60H, Defense Industrial Capabilities Assessment
- DCMA Instruction 204 Manufacturing and Production
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.7.12 Personnel Planning
- Defense Manufacturing Management Guide for Program Managers, Chapter 14.5.5 The Future of Manpower

K. FACILITIES

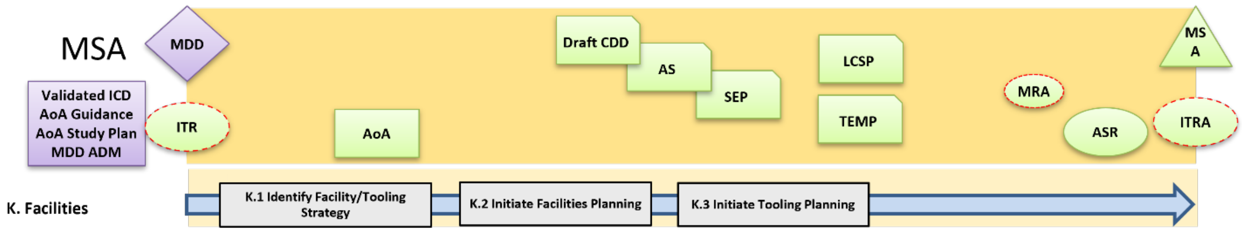


Figure 2-12. Facilities Manufacturing and Quality Activities

Introduction

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

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

This thread (Facilities) requires an analysis of the capabilities and capacity (Prime, Subcontractor, Supplier, Vendor, and Maintenance Repair and Overhaul facilities) of the proposed production facility. Capabilities and capacities are key risks areas that drive facility concerns in manufacturing. This thread (Facilities and Tooling) will focus on the following sub-threads as required:

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

K.1 Identify Facility and Tooling Strategy

Facilities and Tooling (special tooling, special test equipment, and special inspection equipment) is often a significant cost and schedule driver, and major influence on product quality outcomes. The B1 program for example had over $1B in tooling, and the lead times for facility and tooling development was over a year. Because of this programs and organizations need a Facility/Tooling Strategy to help guide their decisions, investments, and other actions aimed at achieving long term goals and business strategies. One strategy is to begin the development of facilities and long-lead tooling well in advance of the contract for the next phase. Contractor M&Q managers need to develop a strategy for implementing a facility and tooling plan and for reducing risk in the implementation of a facility and tooling program with program office M&Q personnel monitoring these activities and risks. Facility and Tooling Strategies should focus on the following:

- Facility design includes addressing the product/process structure intersection to identify the type of facility required (job shop, batch processing, assembly line, continuous flow line, etc.)
- Facility design includes a floor layout that supports material handling and flow:
  - Static material flow analysis using tools such as Value Stream Mapping (VSM)
    - Bottleneck Analysis (Theory of Constraints)
  - Dynamic Simulation of Material Flow
  - Lean Plant Layout improves flow by identifying waste and going to a Pull system

  - Flow analysis identifies constraints and bottlenecks
- Facility design includes Security (Physical and Cyber)
- Facility design includes safety and ergonomics
- Facility design includes environmental considerations (heating, cooling, lighting, etc.)
- Facility design includes areas for receiving and inspection, storage, kitting, fabrication, assembly, final inspection and testing, and shipment
- Equipment design includes addressing reliability, right size, total productive maintenance, and set-up reduction (SMED)
  - Monuments (large pieces of equipment often shared among product lines)
  - Flexibility and Modularity
  - Accuracy and Repeatability
  - Total Preventive Maintenance
  - Energy Efficiency
  - Safety and Ergonomic Design
  - Key metric is Overall Equipment Effectiveness (OEE) which is measured and managed
- Tooling design includes jigs, fixtures, gauges, dies, molds, patterns, etc., that are used to support fabrication and assembly operations. Tooling design should address the following considerations:
  - Mistake proofing (Poke Yoke)
  - Point of use
  - Repeatability
  - Flexibility
- Types of Tooling:
  - Prototype tooling is used to develop and test products for form, fit, and function often on experimental designs and prototypes. Sometimes referred to as soft tooling.
  - Bridge tooling is used on pilot lines as a way of supporting ramping up to low-rate or full rate production
  - Production tooling is tooling that is robust and can support long-term production requirements (rate and quantity). Also referred to as hard tooling.

Strategies often include:

- Vision and Mission
- SWOT Analysis
- Goals, Objectives, and Priorities
- Action Plans and Owners
- Measure Performance and Develop Mitigation Plans

Manufacturing and Quality Tasks

- Develop a Manufacturing Strategy (Acquisition Strategy and SEP) for facilities and tooling to include:

  - Identification and selection of the production facility
  - Availability of industrial base to support production (facilities and tooling)
  - Surge capability to meet anticipated rates and/or fluctuating demand
  - Environmental and safety factors
  - Security requirements for facilities (physical and cyber)
  - Design, fabrication, and control of tooling and test equipment
  - Decisions on the mix of "soft" and "hard" tooling
  - Procurement of commercial or existing tooling
  - Identification of any unique tooling required to support production
  - Planning for M&Q ManTech initiatives for new tools

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

- Update the M&Q funding estimates required for capital equipment, tooling, and test equipment for preferred concepts.

Tools

- Acquisition Strategy Template
- Systems Engineering Plan (SEP) Outline
    - Manufacturing Plan
    - Quality Assurance Plan
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- AS9100 Quality Management System Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Bottleneck Analysis (Theory of Constraints)
- Critical Chain Project Management
- Plant Design and Facility Layout Software Evaluation Tools

Resources

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- FAR/DFAR 52.245.17, Special Tooling
- FAR/DFAR 52.245.18, Special Test Equipment
- P.L. 110-417, Section 815, program documentation must include the review cycle for assessing tool retention across the life of the system.
- Defense Manufacturing Management Guide for Program Managers, Chapter 6, Manufacturing Planning
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.7.13 Facility Planning
- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5, Elements of a Manufacturing Strategy
- Manufacturing Readiness Level (MRL) Deskbook
- NIST Guide to Industrial Control Systems (ICS) Security
- AS6500, Manufacturing Management Program
- MIL-HDBK-896A, Manufacturing Management Program Guide
- Digital Engineering Body of Knowledge
- AS9100, Quality Systems – Aerospace
- ISO 9001, Quality Management System
- Systems Engineering Plan Preparation Guide
- IEEE15288, Best Practices for Using System Engineering Standards

- IEEE15288.2, Standard for Technical Reviews and Audits on Defense Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- Risk, Issue, and Opportunity Management Guide
- Defense Technical Risk Assessment Methodology (DTRAM)

K.2 Initiate Facility Planning

Contractor manufacturing facilities planning and assessment includes an analysis of the capabilities and capacity of the production facilities to develop, produce, 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 should address the following areas:

- Facility Production System
  - Job Shop
  - Disconnected Line
  - Connected Line
  - Continuous Flow
- Plant design, construction, and management (Floorplans, utilities, etc.)
- Workflow Analysis (Factory Simulation)
- 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
  - Identify M&Q funding estimates required for capital equipment, tooling, and test equipment for the preferred concept from the facilities and tooling planning
  - 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 for phase specific production efforts 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 facility plans that include a floor layout that supports material handling and flow:
  - Material flow analysis using such tools as Value Stream Mapping (VSM)
    - Bottleneck Analysis (Theory of Constraints)
  - Lean plant analysis and layout improves flow by identifying waste and going to a Pull system
  - Flow analysis identifies constraints and bottlenecks

- 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 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
- DoDI 5000.97, Digital Engineering
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge
- Defense Manufacturing Management Guide for Program Managers, Chapter 6, Manufacturing 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

K.3 Initiate Tooling Planning

Tooling is designed and developed to aid in the manufacture of parts or components, or to support assembly operations. Tooling includes jigs, dies, fixtures, molds, patterns, taps, gauges, other equipment, and manufacturing aids. Special tooling, special test and special inspection equipment are included under the broad definition of tooling. Production tools may be developed and used for a one-time or short production run or may need to be developed to withstand the robust environment of long-term rate production.

The Department of Defense permits contractors to acquire capital equipment to include Tooling, 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 that is specific to a DoD program. These tools and test equipment can be expensive and take a long time to procure, to include developing, testing, proving and then maintaining. The program office and contractors may want to develop general guidelines or plans for the development and procurement of tooling and test equipment, especially special tooling and test equipment that is needed for the program and for the management and assessment of the tooling and test equipment.

- Special Tooling, per FAR 2.1.1, includes jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items including foundations and similar improvements necessary for installing special tooling, and 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.
- Special Test Equipment, per FAR 2.101, means 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 foundations and similar improvements necessary for installing special test equipment, and standard or general-purpose items or components that are interconnected and interdependent so as to become a new functional entity for special testing purposes.
- Special Inspection Equipment: Is included in the above definition under special test equipment.
- Tool/Test/Inspection equipment design: The contractor should describe documented processes to ensure release, acceptance, identification, security, access and change control of tool design and tool inspection datasets. Tooling datasets should have traceability to current authority engineering and derivative tooling dataset sources. The engineering authority dataset(s) should be identified on the tool design when applicable.
- The supplier should ensure that when Tool Design responsibility is at a sub-tier supplier, 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 should be dimensionally accepted and periodically validated to the authority design at a frequency determined to ensure accuracy and repeatability of the tool before use.

There are several issues related to contractor investment om tooling, 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. The need for M&Q personnel involved in conducting tooling planning and assessments during the various acquisition phases is discussed below.

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

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

Manufacturing and Quality Tasks

- Identify tooling requirements used for the development or production of supplies or parts or to the performance of functions for the program to include:
    - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
    - Requirements for identification, calibration, frequency, and traceability to international or national measurement standards
    - Requirements for collection, monitoring, and maintenance of data and a register for validation purposes
    - Assess industrial cybersecurity and operational technology concerns for tooling and test equipment
    - Requirements for safeguarding tooling from adjustments, damage, or deterioration
- Develop and implement a Tooling Plan for specialized tooling whose use is limited to the development or production of supplies or parts or to the performance of functions for the program including jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items including foundations and similar improvements necessary:
    - Limited quantity or soft tooling
    - Rate quantity or hard tooling
    - Necessary for development (pilot)
    - Necessary for production (LRIP/FRP)
    - Necessary for Operations and Sustainment support
    - Identify as Government Furnished Equipment (GFE), if appropriate
- Derive M&Q funding estimates that are needed for capital equipment, tooling, and test equipment for the preferred concept of the facilities and tooling planning.
- Perform a M&Q assessment of the contractor’s and supply chain tooling, test, and inspection equipment resources provided for:
    - Suitability for the specific type of monitoring and measurement activities required
    - Maintenance and accountability to required standards with appropriate documentation

Tools

- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Risk Assessment Report DI-SESS-81974

- DCMA Production Planning and Control Risk Assessment Checklist
- SF 1432 Special Tooling and Special Test Equipment Inventory Worksheet
- 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)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management

Resources

- FAR Part 45 – Government Property
- DFARS 252.245-1 Government Property
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- 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
- 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

L. MANUFACTURING MANAGEMENT AND CONTROL

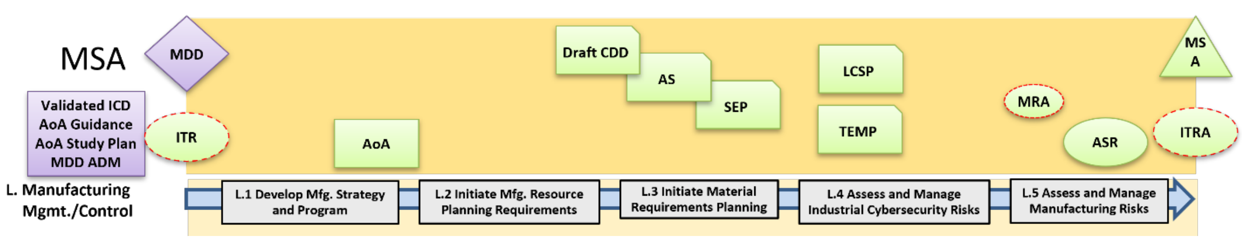


Figure 2-13. Manufacturing Management and Control Manufacturing and Quality Activities

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 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 production 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

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

L.1 Develop Initial Manufacturing Strategy

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 of time. 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 as a way 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
- GFP and component breakout approach

A Manufacturing Management Program (System) is an integrated collection of people, processes, policies, information systems, and other tool that are required in order 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 Product Quality Planning (APQP) is a structured approach to product and process design. This framework consists of a standardized set of quality requirements (AS9145 APQP/PPAP) that enables suppliers to design a product that satisfies the customer that is comprised of five steps or phases:

- Plan & Define
- Product Design and Development
- Process Design and Development
- Product and Process Validation
- Production Feedback

Advanced Manufacturing (AdM) 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 innovative materials and emerging capabilities enabled by the physical and biological sciences. Advanced manufacturing includes additive manufacturing, artificial intelligence, robotics, and advanced composite materials.

Beginning in MSA, after the preferred concept is determined, the PM and program office develop the Manufacturing Strategy and should begin detailed planning for manufacturing. Before the Materiel

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

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).
- Develop appropriate manufacturing management strategy inputs with references based on the best practices from AS6500 for inclusion in the Acquisition Strategy and the SEP.
- Develop the initial Manufacturing Strategy, as a subset of the Acquisition Strategy, and ensure the Manufacturing Strategy addresses M&Q considerations for:
    - IB Risk Identification and Mitigation
    - Enabling/critical technologies and constraints
    - New and emerging manufacturing technologies
    - ManTech projects
    - Design and producibility
    - Use of digital data
    - Key and critical characteristics
    - Modular Open Systems Approach (MOSA)
    - Rate and schedule (includes processes, tooling, make/buy, etc.)
    - 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 contracting development (e.g., dual source, co-production, etc.)
    - Intellectual Property rights (including deliverables and associated license rights over the entire product life cycle)
    - Quality Strategies and Planning
    - Processes and capability control

- Process, rates, and quantities (including reference to Economic Order Quantity and the affordability targets, capabilities, control, risks, etc.)
- Workforce planning
- Facilities, tooling, and test equipment (including GFE and assets)
- Environmental Safety and Occupational Health (ESOH)
  - Update NEPA and NEPA Compliance Schedule
  - Update the Hazardous Material Management Program (NAS 411)
  - Update the Pollution Prevention Program (DODI 4715.4)
  - Update the Programmatic Environmental Safety and Health Evaluation (PESHE)
  - Update the System Safety and Health Program (MIL-STD-882E)
- Cybersecurity to include industrial security
  - Security parameters (physical and cyber) for both hardware and software
- Manufacturing maturity and progress against M&Q goals required for each technical review (ASR, SRR, PDR, Critical Design Review (CDR), and other appropriate reviews)
- Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
- Supportability and sustainment
- Use of priorities, allocations, and allotments, and justification
- Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
- Parts, materials, and processes (PM&P)

- Ensure that the Manufacturing Strategy also addresses:
  - Manufacturing tools and techniques to improve efficiency and eliminate waste such as Lean
  - Manufacturing assessments to support program milestone decision points and major design reviews with appropriate exit criteria
  - Manufacturing metrics for the program with a specified review cycle of metrics commensurate with risks
- Ensure the Manufacturing Strategy (and Acquisition Strategy) includes establishing appropriate agreements, delegations, and contracts with other agencies, e.g., DCMA.
- Draft an initial program Manufacturing Management Plan that addresses each key area of the strategy for incorporation into the SEP that includes details from the analyses. In accordance with AS6500, the plan should address:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management
- Ensure each AoA preferred concept is analyzed for manufacturing management requirements

(to be incorporated into the RFP):

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

- Update the government Manufacturing Management and Quality Management approach for TMRR to include:
  - Changes in M&Q requirements
  - M&Q resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to M&Q organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
  - Changes to M&Q support organization required to meet program projected needs for TMRR and subsequent phases including:
    - Earned Value Management requirements
    - Cost control requirements
    - Data collection, reporting, and management
- Update the M&Q requirements for the TMRR contractor's Manufacturing Management System (MMS) and Quality Management System (QMS):
  - Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - If M&Q standards are not specified, develop requirements for program specific manufacturing management plan and quality management plan.
  - Identify M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- Update requirements for identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program:

  - Ensure a joint M&Q comprehensive Risk, Issue, and Opportunity Management Process that can identify, and tracking risks and associated mitigation plans is in place
- Analyze identified M&Q risks, issues, and opportunities, and associated mitigation plans for adequacy and completeness, and potential impacts on TMRR and subsequent phases to include:
  - Risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule
  - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
  - Required maturation of critical technologies and manufacturing processes to the appropriate level
  - M&Q cost and schedule impacts
- Update the M&Q support plan for an assessment of manufacturing readiness and the mandated independent assessment.
- Ensure other agencies are providing inputs on strategies (e.g., DCMA, Defense Logistics Agency (DLA), etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality:
  - Updated inputs to the Risk, Issue, and Opportunity Management process and plans that include:
    - Industrial risks
    - Manufacturing risks
    - Quality risks
    - Engineering risks
    - Software risks
    - Production risks
    - Risk reduction and mitigation efforts
- Review, update, and analyze manufacturing management metrics for the preferred concept from the AoA Study Guidance:
  - Verify the frequency that the metrics are reviewed is commensurate with manufacturing risks
- Specify the manufacturing management requirements to be met by the contractor (in the RFP) or government entity (in the SEP) as appropriate:
  - Provide requirements for manufacturing management responsibilities and personnel within the IPT
  - Provide manufacturing management requirements and metrics
  - Metrics

Tools

- 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

- Acquisition Strategy Guide (DSMC)
- Acquisition Strategy Guide (NAVSEA)
- Systems Engineering Plan Preparation Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.6.6.1 Develop Acquisition Strategy
- 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
- DoDI 5000.97, Digital Engineering
- NIST Guide to Industrial Control Systems (ICS) Security
- IEEE 15288 Technical Reviews and Audits

L.2 Initiate Manufacturing Resource Planning

A Manufacturing Management System (MMS) is used by organizations 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 considering the "5Ms" (manpower, machines, materials, methods, and measurements) at each workstation to identify manufacturing resource requirements and constraints. Manufacturing planning and controls 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 in order 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 support production smoothing, improve throughput and efficiency.
- **Manufacturing Execution System (MES)**: Establishes the 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 sets 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 against planned production. Tracks manufacturing key performance indicators (KPIs) to enable management action based on performance measures. Examples of manufacturing KPIs include:
        - Production Volume: Track the quantities that you are able to 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 unit costs over time
        - Maintenance Costs: Evaluate your equipment costs over time

During the MSA phase the program office has identified several alternative solutions and M&Q managers need to understand the M&Q impacts of these potential solutions.

Manufacturing and Quality Tasks

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

- Identify manufacturing resource planning requirements.
- Description of how Product Manufacturing Information (PMI) will be developed and managed.
- Description of how digital information will be developed and managed.
- Manufacturing resource planning needs are assessed, analyzed, and validated.
- Manufacturing resource planning requirements for potential systems or concepts identified.
- Identify manufacturing production operations approach:
    - Make to Order (Pull)
    - Make to Stock (Push)
    - Assemble to Order
    - Engineer to Order
- 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 capacity requirements planning 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
- 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
- Execute the Manufacturing Execution System (MES):
  - 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)
- 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
- Bill of Material Assessment
- 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)
- Assembly Chart
- Operations Process Chart
- Route Sheet
- Line of Balance Assessment
- Input/Output Analysis
- Make/Buy Decisions
- 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, Chapter6 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
- DoDI 5000.97, Digital Engineering
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge

L.3 Initiate Material Requirements Planning

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/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 in order 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 these requirements to procurement operations and the extended supply chain. Material planning uses the bill of materials (BOM) to identify all of the items that go into building one end item and the master production schedule to calculate how many of each of the BOM elements that need to be on hand to support planned 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 more profit. Reducing material encourages some industries to consider ‘Just in Time (JIT)’ strategies that require small levels of inventory. However, JIT requires careful planning and complete communication to maintain production schedules. JIT should only be considered when there is a clear demand signal and short lead times.

Typical roles in Materials Requirements Planning 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 in order to achieve material management goals and objectives:

- Lower prices of materials and increase competition
- Lower storage and inventory costs
- Lower overall cost of materials
- Standardized parts
- Economic make/buy decisions
- Continuous supply of material
- Favorable supplier relations
- Consistent quality
- Reduce or eliminate counterfeit parts
- Reduce use of DMSMS and Obsolescent parts

- Reduce or eliminate sole source, single source, or foreign source vendors

During the MSA Phase, organizations should look at the proposed concepts and analyze them to understand potential MRP requirements.

Manufacturing and Quality Tasks

M&Q personnel need to support the identification and management activities needed for Material Requirements Planning for AoA concepts being considered:

- Create a Master Production Schedule based on actual and forecasted orders.
- Identify all of the items in the Bill of Materials.
- 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.

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
- Line of Balance Status Report DI-MGMT-80034
- Make/Buy Decisions
- Long Lead time Material Report, DI-PSSS-82201
- Materials Requirements Planning (MRP) Assessment
- Systems Engineering Management Plan, DI-SESS-81785A
  - Manufacturing Plan Inputs
  - Manufacturing Plan, DI-MGMT-81889A
  - Quality Plan Inputs
  - Quality Assurance Program Plan, DI-QCIC-81794
- 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
- DFAR 242.72 Contractor Material Management and Accounting System
- Bill of Materials
- Inventory Records
- Master Production Schedule
- AS5553, Counterfeit Electronic Parts
- AS6174, Counterfeit Material
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.10.2 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

L.4 Assess and Manage Industrial Cybersecurity Management Risk

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 systems (MES) support 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.
- Carry the contract clause into 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, 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 Cybersecurity Risks
- 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. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the AAF.

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

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

During the MSA phase, manufacturing operations cybersecurity capabilities and cyber-vulnerabilities should be evaluated. OT cybersecurity approach and requirements for the preferred materiel solution considered as part of AoA. OT cybersecurity risks in the anticipated industrial base have been assessed. Identify impacts of cybersecurity measures on manufacturing processes for preferred materiel solutions. Potential supply chain OT cybersecurity and vulnerability risks identified.

- 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 assess security controls
  - Review and assess 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

- OT Cybersecurity development efforts initiated.
- OT cybersecurity reporting procedures developed.
- Cybersecurity measures assessed for impacts on producibility and manufacturability.
- Supply chain OT cybersecurity and vulnerabilities assessed, and mitigation plans developed.
- Cybersecurity requirements for OT systems plans have been identified (production equipment, tooling, STE/SIE, etc.).
- Workforce trained in cybersecurity (see DoD Cyber Workforce Qualifications Matrix).
- Complete information analysis.
- Conduct initial Critical Program Information (CPI) analysis as a part of the Program Protection Plan (PPP):
    - May include an analysis of components, design, manufacturing processes, critical technologies, system and subsystem capabilities and vulnerabilities, and any other information that provides a distinctive operational capability
- Conduct initial Trusted System Networks (TSN) analysis:
    - May include a criticality analysis, threat assessment, and vulnerability assessment at the critical subsystems, configuration item, and component levels, and at critical suppliers
- Utilize digital engineering to support the development, implementation, and management of industrial cybersecurity programs and procedures.
- Conduct System Security Engineering (SSE)/ Systems Engineering (SE) tradeoffs.
- Establish a Cyber Security IPT and select Security Controls.
- Assess manufacturing operation cybersecurity capabilities and cyber vulnerabilities.
- Assess OT cybersecurity approach and requirements for the preferred materiel solution considered as part of AoA.
- Assess OT cybersecurity risks in the anticipated industrial base.
- Assess cybersecurity risks on measures for manufacturing processes of preferred materiel solutions.
- Assess potential supply chain OT cybersecurity and vulnerability risks.
- Identify, assess, and report cybersecurity incidents.
- Minimize and mitigate cybersecurity risks on OT infrastructure.

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (CALIT), DAU
- CISA Industrial Cybersecurity Checklist, Appendix F

- NIST Security Plan Template
- Cybersecurity Strategy ADDM Template
- Interactive MRL Users Guide (Checklist), Cybersecurity 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
- Trusted Systems and Networks (TSN) Analysis Guide
- Digital Engineering Body of Knowledge
- 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 5200.39, Critical Program Information Identification and Protection within RDT&E
- DoDI 5000.97, Digital Engineering
- DoDI 5200.44, Protection of Mission Critical Functions to Achieve Trusted System and Networks (TSN)
- DoDI 8500.01 Cybersecurity
- DoDI 8510.01, Risk Management Framework for DoD Systems
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- DoD 5220.22-M, National Industrial Security Program
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge
- ASME Y14.41, Digital Product Definition Data Practices
- MIL-STD-31000B, Technical Data Package
- DoD Technology and Program Protection Guidebook

- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle

L.5 Assess and Manage Manufacturing 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 much 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.

In addition to formal risk assessments, M&Q personnel must perform Independent Schedule Assessments. The M&Q workforce is expected to have their fingers on the pulse of the manufacturing / production lines and be able to provide the Program Manager with our assessment of the build and delivery schedule. M&Q managers may assess these risks through deliverable schedule/quality/supplier metrics, on-line access to contractor ERP systems, independent M&S, IMS schedule risk assessments, DCMA inputs, and close relationships with our contractor counterparts. See AFLCMC/EZSM Acquisition Manufacturing and Quality Assurance Process Guide

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 in order 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 control)?
- 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 production problems.

Manufacturing and Quality Tasks

- Ensure each AoA preferred concept is analyzed for manufacturing management requirements:
  - The manufacturing management requirements can be met by adherence to established standards (i.e., AS6500) as incorporated by contract requirements
  - Alternatively, manufacturing management requirements should at a minimum include:
    - Manufacturing management system requirements
    - Design analysis for manufacturing requirements
    - Manufacturing risk identification requirements
    - Manufacturing planning requirements (e.g., supply chain, materials, cost, workforce)
    - Manufacturing operations management requirements

    - Analyze the impacts of technology and process state of the art on manufacturing management
    - Request DCMA inputs on manufacturing management system evaluations of potential contractors and suppliers for the preferred concept(s).
    - Analyze relevant manufacturing management lessons learned and best practices among programs and across centers

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

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.

Utilize DCMA's Manufacturing Systems Risk Assessment processes to assess the following:

- Production Planning and Control (PPC) Checklist.
- Work Measurement.
- Producibility
- Defense Priorities and Allocation Systems.

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 Manufacturing Management 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
- Technology Readiness 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
- 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 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

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^{3}I	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.

10 USC 144B, Weapon Systems Development and Related Matters
https://uscode.house.gov/view.xhtml?path=/prelim@title10/subtitleA/part4/chapter144B&edition=prelim

10 USC 2304, Contracts: Competition Requirements
https://www.govinfo.gov/content/pkg/USCODE-1995-title10/pdf/USCODE-1995-title10-subtitleA-partIV-chap137-sec2304.pdf

10 USC 2305, Contracts: Planning, Solicitation, Evaluation and Award Procedures
https://www.govinfo.gov/content/pkg/USCODE-2012-title10/pdf/USCODE-2012-title10-subtitleA-partIV-chap137-sec2305.pdf

10 USC 2334, Independent Cost Estimate and Cost Analysis
https://www.law.cornell.edu/uscode/text/10/2334

10 USC 2337, Life-cycle Management and Product Support
https://www.govinfo.gov/content/pkg/USCODE-2015-title10/pdf/USCODE-2015-title10-subtitleA-partIV-chap137-sec2337.pdf

10 USC 2430, Major Defense Acquisition Program Defined
https://www.law.cornell.edu/uscode/text/10/2430

10 USC 2431a. Acquisition Strategy
https://www.law.cornell.edu/uscode/text/10/2431a

10 USC 2431b, Risk Management
https://www.govinfo.gov/content/pkg/USCODE-2015-title10/pdf/USCODE-2015-title10-subtitleA-partIV-chap144-sec2431b.pdf

10 USC 2435, Acquisition Program Baseline
https://www.govinfo.gov/content/pkg/USCODE-2010-title10/pdf/USCODE-2010-title10-subtitleA-partIV-chap144-sec2435.pdf

10 USC 2438, Performance Assessments
https://www.govinfo.gov/content/pkg/USCODE-2010-title10/pdf/USCODE-2010-title10-subtitleA-partIV-chap144-sec2438.pdf

10 USC 2440, Technology and Industrial Base Plans
https://www.govinfo.gov/app/details/USCODE-2011-title10/USCODE-2011-title10-subtitleA-partIV-chap144-sec2440

10 USC 2445b, Cost, Schedule, and Performance Information
https://www.govinfo.gov/content/pkg/USCODE-2011-title10/pdf/USCODE-2011-title10-subtitleA-partIV-chap144A-sec2445b.pdf

10 USC 2448b, Independent Technical Risk Assessments
https://www.govinfo.gov/content/pkg/USCODE-2016-title10/html/USCODE-2016-title10-subtitleA-partIV-chap144B-subchapIII.htm

10 USC 2501, National Security Strategy for NTIB
https://www.govinfo.gov/app/details/USCODE-2015-title10/USCODE-2015-title10-subtitleA-partIV-chap148-subchapII-sec2501

10 USC 2502, National Defense Technology and Industrial Base Council
https://www.govinfo.gov/app/details/USCODE-2010-title10/USCODE-2010-title10-subtitleA-partIV-chap148-subchapII-sec2502

10 USC 2503, Analysis of the Technology and Industrial Base
https://www.govinfo.gov/app/details/USCODE-2011-title10/USCODE-2011-title10-subtitleA-partIV-chap148-subchapII-sec2503

10 USC 2504, Annual Report to Congress
https://www.govinfo.gov/app/details/USCODE-2010-title10/USCODE-2010-title10-subtitleA-partIV-chap148-subchapII-sec2504

10 USC 2505, NTIB Periodic Defense Capability Assessments
https://www.govinfo.gov/app/details/USCODE-2006-title10/USCODE-2006-title10-subtitleA-partIV-chap148-subchapII-sec2505

10 USC 2521, Manufacturing Technology Program
https://www.govinfo.gov/content/pkg/USCODE-2010-title10/pdf/USCODE-2010-title10-subtitleA-partIV-chap148-subchapIV-sec2521.pdf

48 CFR 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
https://www.law.cornell.edu/cfr/text/48/252.204-7012

Acquisition Process/Acquisition Strategy
www.acqnote/acquisitions/acquisition-strategy

Acquisition Requirements Roadmap Toolsuite (ARRT) Cost Estimating Guide, DAU
www.acqnote/acquisitions/acquisition-strategy
https://content1.dau.edu/DAUMIG_SAM_185/content/resources/ARRT_Home.html

Acquisition Strategy Guide, 4th Edition, DSMC, Dec 1999
http://www.acqnotes.com/Attachments/DSMC%20Acquisition%20Strategy%20Guide.pdf

Adaptive Acquisition Framework
https://aaf.dau.edu

Adaptive Acquisition Framework Guidebooks and References
https://aaf.dau.edu/guidebooks
Cost Estimating
Cybersecurity
Engineering
Human Systems Integration
Intellectual Property
Intelligence
International Acquisition
IT and Business Systems
Program Management
Program Protection
Sustainment
Test and Evaluation

AFI 10-601, Operational Capability Requirements Development
https://static.e-publishing.af.mil/production/1/af_a3_5/publication/afi10-601/afi10-601.pdf

AFI 63-141, Manufacturing and Quality Management, Dec 2020
https://static.e-publishing.af.mil/production/1/saf_aq/publication/afi63-141/afi63-141.pdf

AFI 63-145, Manufacturing and Quality Management, Dec 2020
https://static.e-publishing.af.mil/production/1/saf_aq/publication/afi63-145/afi63-145.pdf

AFI 65-508, Cost Analysis Guidance and Procedures, Air Force
https://static.e-publishing.af.mil/production/1/saf_fm/publication/afi65-508/afi65-508.pdf

AFLCMC/EZSM Acquisition Manufacturing and Quality Assurance Process Guide
Note: Only available to Air Force personnel on AFLCMC SharePoint

AFMC Instruction 63-145, Manufacturing and Quality
https://static.e-publishing.af.mil/production/1/saf_aq/publication/afi63-145/afi63-145.pdf

AFMC Instruction 23-113, Pre-Award Qualification of New or Additional Parts Sources
https://static.e-publishing.af.mil/production/1/afmc/publication/afmci23-113/afmci23-113.pdf

AIAG Measurement Systems Analysis (MAS) Manual
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SF 1404 Preaward Survey of Prospective Contractor – Technical
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-technical

SF 1405 Preaward Survey of Prospective Contractor – Production
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-technical

SF 1406 Preaward Survey of Prospective Contractor – Quality Assurance
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-quality-assurance

SF 1407 Preaward Survey of Prospective Contractor – Financial Capability
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-financial-capability

SF 1408 Preaward Survey of Prospective Contractor – Contractor Accounting System
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-financial-capability

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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.

Acquisition Decision Memorandum (ADM) MDD Template
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-Materiel-Development-Decision-(MDD)-Template-v1-4

Acquisition Decision Memorandum (ADM) MDD Template, Milestone A
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-MS-A-Template-v1-4

Acquisition Decision Memorandum (ADM) MDD Template, Milestone B
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-MS-B-Template-v1-4

Acquisition Decision Memorandum (ADM) MDD Template, Milestone C
https://www.dau.edu/tools/t/Acquisition-Decision-Memorandum-(ADM),-MS-C-Template-v1-4

Acquisition Logistician's Assessment Checklist (Army)
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiRsPqKmdXtAhULlKwKHZ_lBX4QFjAAegQIAxAC&url=https%3A%2F%2Fwww.dau.edu%2Fcop%2Flog%2FDAU%2520Sponsored%2520Documents%2FArmy%2520Acquisition%2520Logistician%2520s%2520Assessment%2520Checklist%2520V5.0.doc&usg=AOvVaw2wved2qLjb0ZMNM6cyiBzL

Acquisition Logistics: An Assessment Tool (NAVSO P-3690)
https://www.dau.edu/cop/log/DAU%20Sponsored%20Documents/NAVSO%20P%203690%20ILA%20Asess%20Tool%20Sep%2001.pdf

Acquisition Plan Preparation Guide template
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjYzKf-p7TsAhVIT6wKHYfvA8oQFjAAegQIBBAC&url=http%3A%2F%2Fwww.acqnotes.com%2FAttachments%2FAcquisition%2520Plan%2520Preparation%2520Guide.doc&usg=AOvVaw1yKslG_VAKiWoUuIxnBO2C

Acquisition Strategy (AS) Outline
https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf

Acquisition Strategy Template
https://www.dau.edu/tools/t/Acquisition-Strategy-Template-v2-4

Alternative System Review (ASR) Checklist
http://acqnotes.com/acqnote/tasks/alternative-systems-review-2

Analysis of Alternatives (AoA) Study Plan Template
https://www.dau.edu/tools/t/Analysis-or-Alternatives-(AoA)-Study-Plan-Template-v2-0

AoA Study Guidance Template
https://www.dau.edu/tools/t/Analysis-or-Alternatives-(AoA)-Study-Guidance-Template-v1-0

AoA Study Plan Template
https://www.dau.edu/tools/t/Analysis-or-Alternatives-(AoA)-Study-Plan-Template-v2-0

AS5553 Counterfeit Electronic Parts: Avoidance, Detection, Mitigation, and Disposition
Internet Search

AS6500 Manufacturing Management Program Checklist
Internet Search

AS9100 Quality Management System Checklist
Internet Search

AS9100 Quality Audit Checklist
Internet Search

AS9103 Variation Management of Key Characteristics Assessment
Internet Search

AS9133 Qualification Procedure for Standard Products (Supplier Audit) Checklist
Internet Search

AS9134 Supply Chain Risk Management Guidelines
Internet Search

AS9137 Advanced Quality Assurance Procedure (AQAP) Checklist
Internet Search

AS9145 Requirements for Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP) Checklist
Internet Search

Assembly Chart
Internet Search

Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
http://www.dodmrl.com/DI-SESS-81974.pdf

Automated Requirements Roadmap Tool (ARRT) Suite, DAU
https://www.dau.edu/tools/t/Acquisition-Requirements-Roadmap-Tool-(ARRT)-Suite

Award Fee Plan Checklist
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Award Fee Plan Template
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Award Fee Sample Rating Definitions
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Award Fee Sample Evaluation Criteria
https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

Benchmarking
Internet Search

Bill of Material Assessment
Internet Search

Bill of Material Data Item Description - DI-PSSS-81656B
https://www.dau.edu/cop/dmsms/Lists/Tools/DispForm.aspx?ID=48&ContentTypeId=0x0100AE321BA2819FFD499A441F9A8F574C1600A3866BA66DC4B546AF0E2614A20E809A

Bottleneck Analysis (Theory of Constraints)
Internet Search

Capability Development Document (CDD) Template
http://acqnotes.com/acqnote/acquisitions/capability-development-document-cdd

Capabilities-Based Assessment (CBA) Tool, DAU
https://www.dau.edu/tools/t/CBA-Tool

Capability Development Document (CDD) Template
http://acqnotes.com/acqnote/acquisitions/capability-development-document-cdd

Capacity Assessment Worksheet
Internet Search

Cash Flow Tool for Evaluating Alternative Finance Arrangement
https://www.acq.osd.mil/dpap/policy/policyvault/USA005332-10-DPAP.pdf

Cause and Effect Diagram
Internet Search

Contractor Purchasing System Review (CPSR)
Note: User must register on the DCMA 360 portal to get access

Cost Analysis Requirements Description (CARD) Guidance (see CAPE website for tools)
http://acqnotes.com/acqnote/careerfields/cost-analysis-requirements-description

Cost Analysis Requirements Description (CARD) Template
https://www.dau.edu/tools/t/Cost-Analysis-Requirements-Description-(CARD)-Template-v1-3

Cost Estimating Technique – Analogy
http://acqnotes.com/acqnote/careerfields/cost-estimating-methods

Cost Estimating Technique – Parametric
http://acqnotes.com/acqnote/careerfields/cost-estimating-methods

Cost Estimating Technique – Engineering
http://acqnotes.com/acqnote/careerfields/cost-estimating-methods

Cost Estimating Technique – Actuals
http://acqnotes.com/acqnote/careerfields/cost-estimating-methods

Cost/Schedule Control System Criteria (C/SCSC) Reference Guide – DTIC
https://apps.dtic.mil/dtic/tr/fulltext/u2/a258445.pdf

Cost/Schedule Control System Criteria (C/SCSC) Guide and Checklist – DTIC
https://www.secnav.navy.mil/rda/OneSource/Documents/CEVM/Tools%20and%20Examples/DOD%20Guides/BowmanInterpretiveGuide1.pdf

Cost of Quality (CoQ) Estimates
Internet Search

Critical Chain Project Management
Internet Search

Critical Design Review (CDR) Checklist
http://acqnotes.com/acqnote/acquisitions/critical-design-review

Critical Path Template
Internet Search

Critical to Customer Template
Internet Search

Critical to Quality Tree Template
Internet Search

Cyber Security Assessment see Cyber Security Assessment see Cybersecurity & The Acquisition Lifecycle Integration Tool (CALIT)
https://www.dau.edu/tools/t/Cybersecurity-and-Acquisition-Lifecycle-Integration-Tool-(CALIT)

DMCA Engineering Surveillance Plan
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-207.pdf

DCMA Industrial Capability Assessment Survey
Note: User must register on the DCMA 360 portal

DCMA Manufacturing and Production Surveillance Plan
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-204.pdf

DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
Note: User must register on the DCMA 360 portal

DCMA Material Management and Accounting System (MMAS) Audit
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-211.pdf

DCMA Pre-Award Survey System (PASS) review
https://www.dcma.mil/WBT/pass/

DCMA Pre-Award Survey (SF 1403)
https://www.gsa.gov/reference/forms?search_keyword=SF%201403

DCMA Pre-Award Survey – Technical (SF 1404)
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-technical

DCMA Pre-Award Survey – Production (SF 1405)
https://www.gsa.gov/reference/forms?search_keyword=SF%201405

DCMA Pre-Award Survey – Quality Assurance (SF 1406)
https://www.gsa.gov/reference/forms?search_keyword=SF%201406

DCMA Pre-Award Survey – Financial Capability (SF 1407)
https://www.gsa.gov/reference/forms?search_keyword=SF%201407

DCMA Pre-Award Survey – Contractor Accounting System (SF 1408)
https://www.gsa.gov/reference/forms?search_keyword=SF%201407

DCMA Production Planning and Control Risk Assessment Checklist
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-204.pdf

DCMA Program Assessment Report
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-MAN-3101-02.pdf

DCMA Program Support Plan (DCMA-ANX 205-02)
Note: *User must register on the DCMA 360 portal*

DMCA QA Surveillance Plan
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-309.pdf

Design Failure Modes and Effects Analysis (DFMEA)
Internet Search

Design for Affordability
Internet Search

Design for Manufacture and Assembly (DFMA)
Internet Search

Design for Performance
Internet Search

Design for Producibility
Internet Search

Design for Six Sigma (DFSS)
Internet Search

Design of Experiments (DoE)
Internet Search

Design of Experiments (DoE) Analysis
Internet Search

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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

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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

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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

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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

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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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