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

Chapter 6
Operations and Support (O&S) Phase

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Approved by

Principal Deputy Executive Director, Systems Engineering and Architecture

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M&Q BoK Chapter 6 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.

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

The BoK includes 6 chapters:

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

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

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

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

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

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

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

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

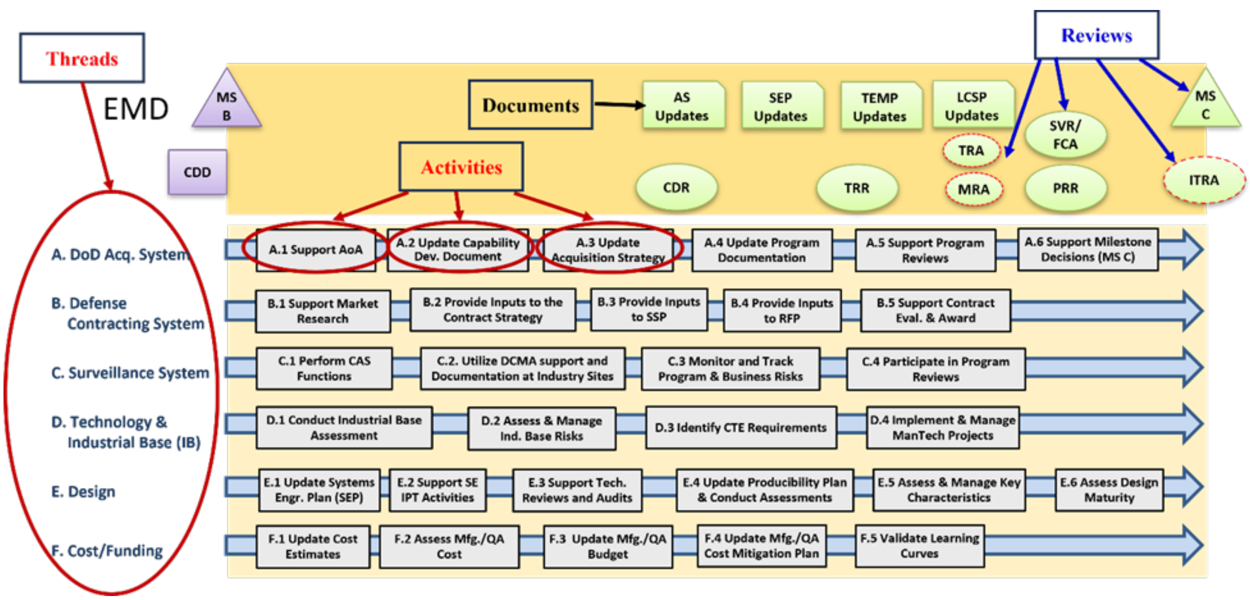
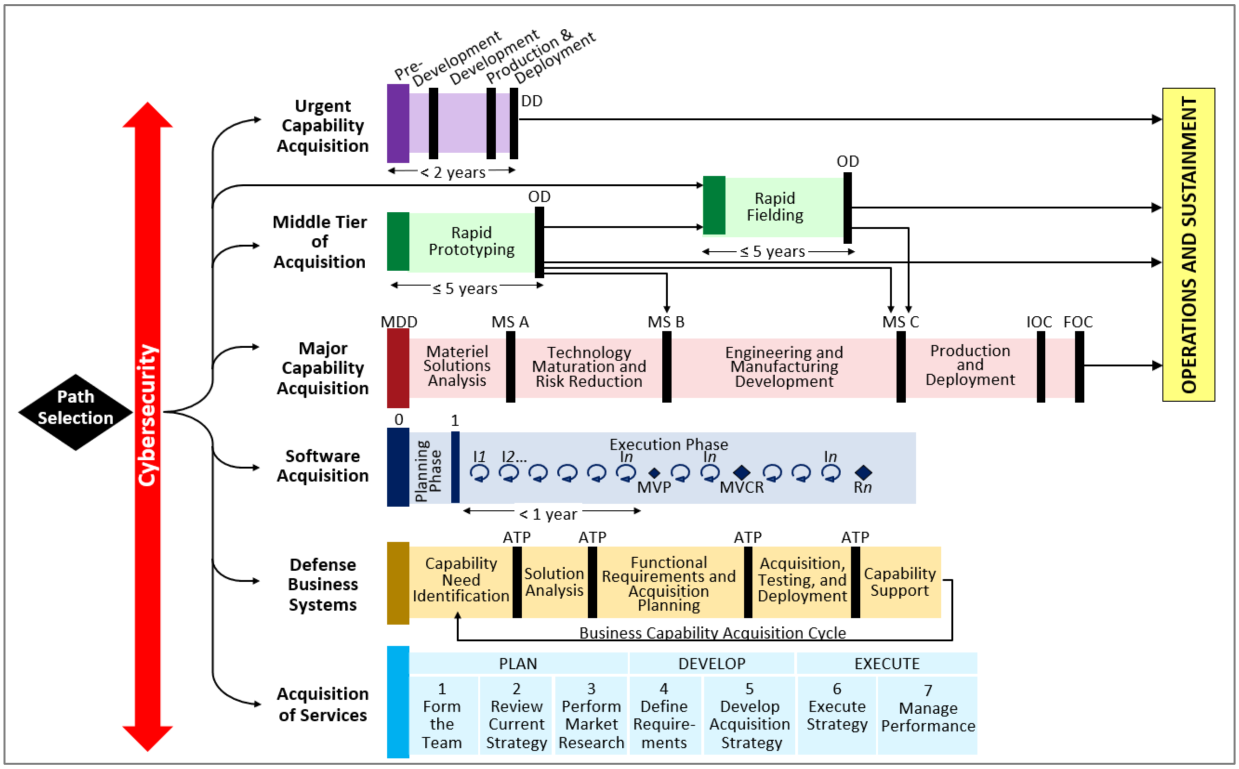


Figure 1. Sample Activity Chart

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

This BoK follows DoDI 5000.02, Operation of the Adaptive Acquisition Framework (AAF), and 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 to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

M&Q planning, control, and management activities represent an important and central effort that begins early in the life cycle (Pre-Materiel Development Decision (MDD) and/or Materiel Solution Analysis (MSA) phases) and continues throughout the life of a program 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.

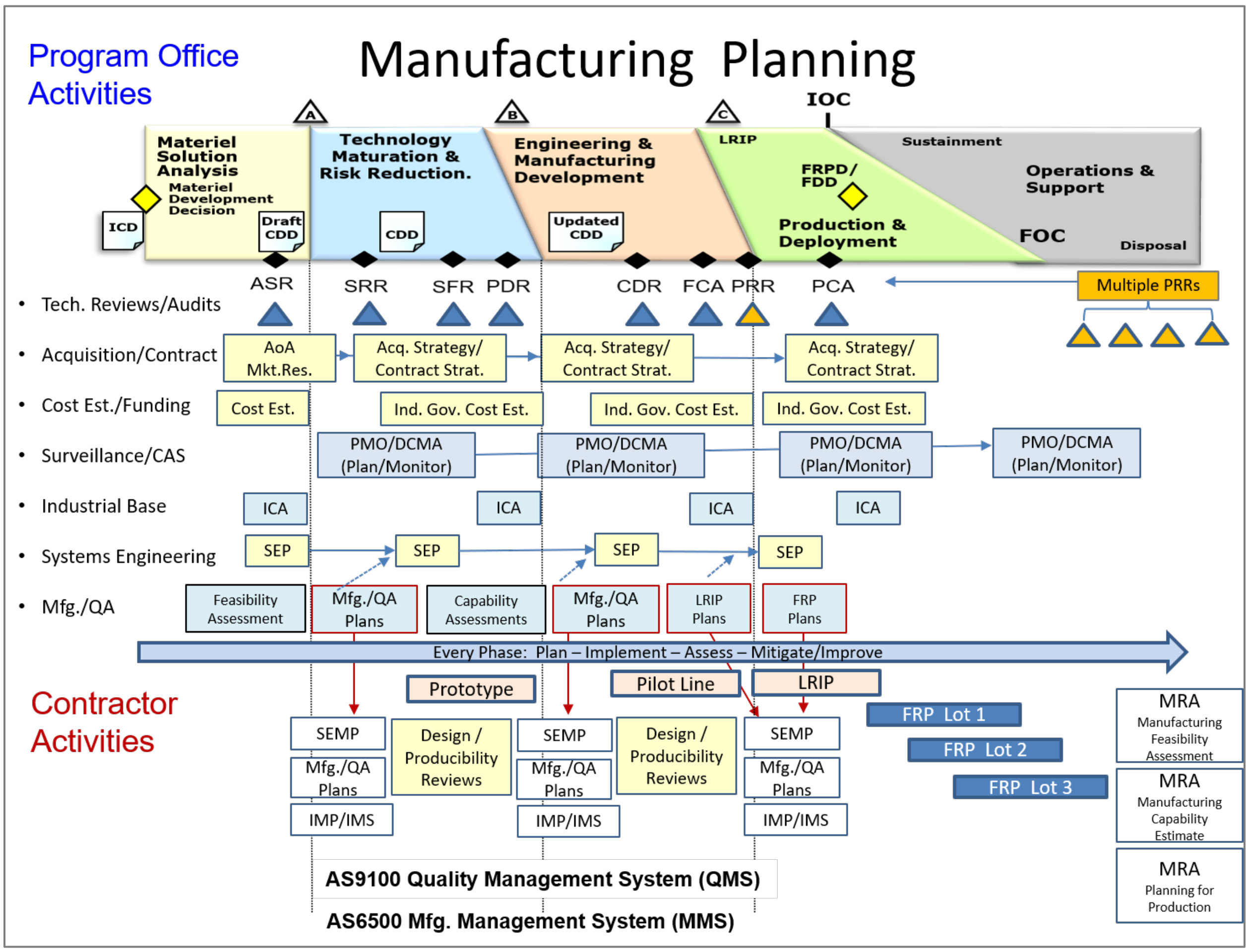


Figure 3. Typical Manufacturing and Quality Planning Activities

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 a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

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

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

6. Operations and Support (O&S) Phase

Introduction

During the Operations and Support (O&S) phase, the Program Manager (PM) executes the Life Cycle Sustainment Plan (LCSP)/Product Support Strategy to satisfy materiel readiness and provide operational support. The O&S phase includes two major efforts: **Sustainment** (of operational systems) and **Disposal.** The LCSP, prepared by the PM and approved by the Milestone Decision Authority, is the basis for the activities conducted during this phase. Following the Production and Deployment (P&D) phase, production operations may shift from the prime contractor to government owned and operated facilities such as depots; arsenals; shipyards; maintenance, repair, and overhaul (MRO) facilities; or other industrial operations. In some cases, system sustainment activities are accomplished at contractor facilities.

Many manufacturing and quality (M&Q) activities in this phase have a logistics focus such as supply, inventory, transportation, or maintenance and repair. This Body of Knowledge (BoK) focuses on DoD program office O&S activities such as management of system upgrades and modification as part of DoD Directive 5000.01, The Defense Acquisition System, as opposed to logistics "shop floor" functions such as Figure 6-1 illustrates typical program office M&Q activities of the O&S phase.

Sustainment

During this phase, the PM will deploy the product support package and monitor its performance according to the LCSP, which may include time-phased transitions between commercial, organic, and partnered product support providers. The PM will ensure the program has appropriate resources; will acquire the necessary intellectual property (IP) deliverables and associated license rights, tools, equipment, and facilities to support each level of maintenance; and will establish necessary organic depot maintenance capability in compliance with statute and the LCSP.

- A successful program meets the sustainment performance requirements, remains affordable, and continues to seek cost reductions by applying should-cost management and other techniques throughout this phase. Doing so requires close coordination with the warfighting sponsor (i.e., user), resource sponsors, and materiel enterprise stakeholders, along with effective management of support arrangements and contracts. During O&S, the PM will measure, assess, and report system readiness using sustainment metrics and will implement corrective actions for trends diverging from the required performance outcomes defined in the Acquisition Program Baseline (APB) and LCSP.
- Over the system life cycle, operational needs, technology advances, evolving threats, process improvements, fiscal constraints, plans for follow-on systems, or a combination of these influences and others may warrant revisions to the LCSP. When revising the LCSP, the PM will revalidate the supportability analyses and review the most current product support requirements, senior leader guidance, and fiscal assumptions to evaluate product support changes or alternatives and determine best value.

Disposal/Demilitarization (DeMil)

- The O&S phase ends when the program is at the end of its useful life. The system will be demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment.

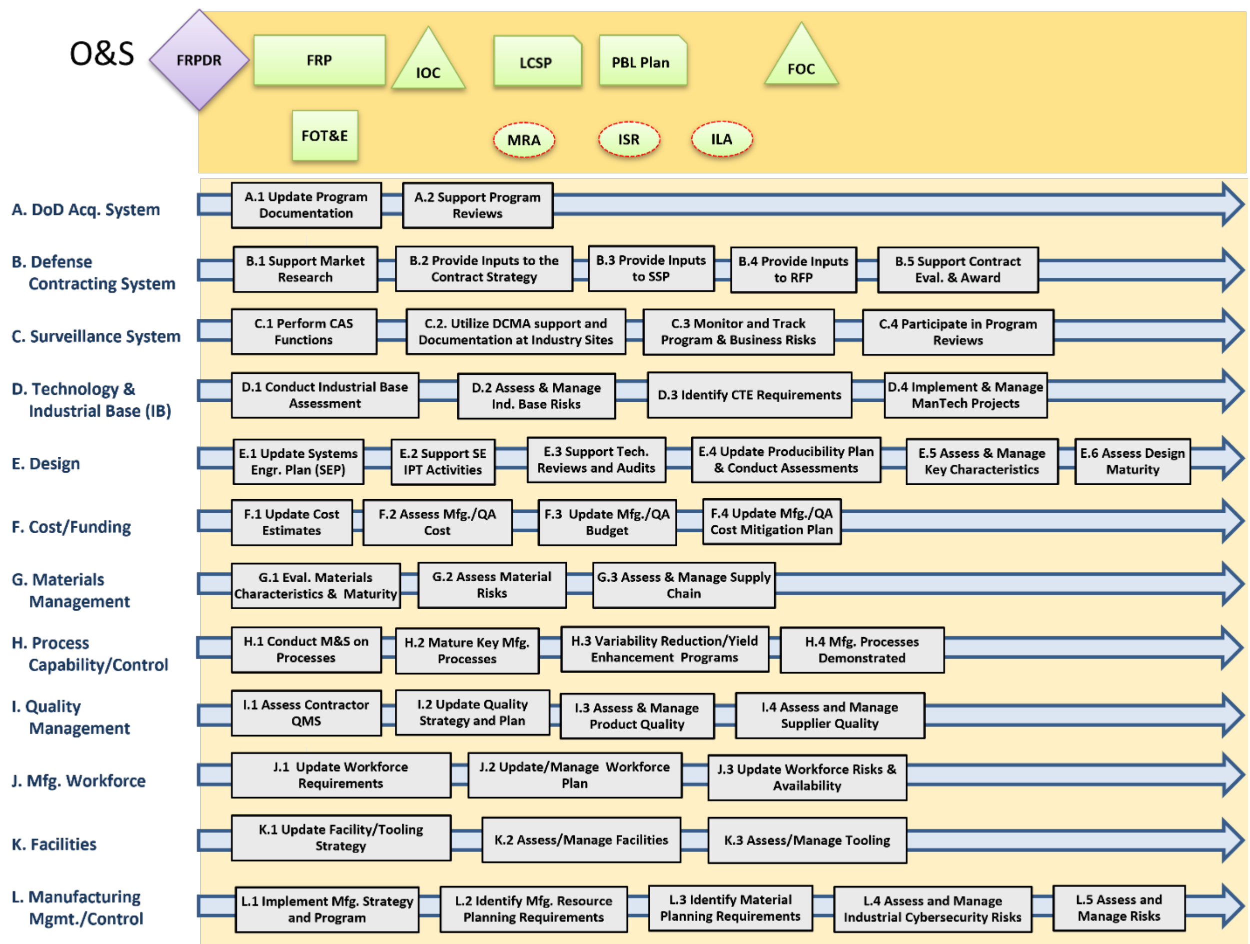


Figure 6-1. O&S Phase Manufacturing and Quality Activities

Key Program Phase Reviews, Documentation, and Activities

The O&S phase begins after the Production and Deployment milestone decision supported by the program's LCSP. Life cycle sustainment planning begins as early as the Materiel Solution Analysis (MSA) phase and is updated in every phase all the way through the O&S phase. The LCSP helps the PM develop a complete and detailed product support package, resulting in product support arrangements. The package consists of product support elements needed to achieve sustainment requirements and the set of arrangements that programs establish with organic and commercial sustainment providers. The backbone of the product support package is the Integrated Product Support (IPS) Elements as detailed in the IPS Element Guidebook. These 12 elements can be grouped into three areas that cover the full range of life cycle functions:

- Life cycle management
  - Product Support Management
  - Supply Support
  - Packing, Handling, Storage, and Transportation (PHST)
  - Maintenance Planning and Management
- Technical management
  - Design Interface
  - Sustaining Engineering
  - Technical Data
  - Computer Resources
- Infrastructure management
  - Support Equipment
  - Training and Training Support
  - Manpower and Personnel
  - Facilities and Infrastructure

A major focus during the sustainment effort of the O&S phase is identifying root causes and resolutions for safety and critical readiness degrading issues. These efforts include participating in trade studies and decision making relative to changes to the product support package, process improvements, modifications, upgrades, and future increments of the system. All these changes need to consider the operational needs and the remaining expected service life, interoperability or technology improvements, parts or manufacturing obsolescence, aging system issues, premature failures, changes in fuel or lubricants, and Joint or Service commonality.

- Key Program Documentation
  - System Safety Analysis (MIL-STD-882E)
  - Programmatic Environmental, Safety and Occupational Health Evaluation (PESHE)
  - National Environmental Policy Act (NEPA) and NEPA Compliance Schedule
  - Systems Engineering Plan (SEP)
  - Life Cycle Sustainment Plan (LCSP)
  - Product Support Strategy (PSS)
  - Reliability Centered Maintenance Analysis
  - Requests for Proposals (RFPs)
  - Source Selection Plans (SSPs)
- Key Program Reviews
  - Independent Logistics Assessment (ILA)
  - Manufacturing Readiness Assessment (MRA)

  - In-Service Review (ISR)

Manufacturing and Quality (M&Q) Objectives

During the O&S phase, program offices collect service use data, user feedback, failure reports, and discrepancy reports to assess sustainment performance. The program often will define and execute a series of improvements because of a Preplanned Product Improvement, a value engineering proposal, or modifications/upgrades to meet warfighter needs. When the product is competitive with similar products, these improvements are often driven by the action of competitors. The challenge in this phase is to integrate these changes into the production system with minimal disruption and cost. The changes introduced reflect both improvements in the ability of the product to meet the original design objective and extensions of capability to meet increased performance objectives.

M&Q considerations during the O&S phase should include the following:

- Continued production of units being fielded
- Updates/product improvements often tied to block upgrades
- Changes to the supply chain
- Items maturing (Diminishing Manufacturing Sources and Material Shortages (DMSMS)/ Obsolescence/Counterfeit Parts)
- Changes to rate and quantity of items being produced; need to ensure a source of supply
- Items manufactured for spare parts (different configurations)
- Improvements to a contractor's Manufacturing Management System or Quality Management System (QMS)
- Impacts of Continuous Process Improvement (CPI) due to Lean Six Sigma/total ownership cost or other improvement activities
- Environmental considerations (environment, safety, and occupational health (ESOH)/Occupational Safety and Health Administration (OSHA)/National Environmental Policy Act (NEPA) and Programmatic Environmental, Safety and Occupational Evaluation (PESHE), requirements and risks
- Need to be able to maintain fielded items (data/technical information availability)
- Manage total life cycle costs/affordability (M&Q elements)
- End of life management (demil and disposal)
  - Collection/storage/disposal of hazardous materials and/or waste
  - Decontamination
  - Disassembly
  - Materials processing
  - Safety precautions
  - Transportation of the system to and from the disposal site

The O&S phase often overlaps with the P&D phase for many years, since O&S activities begin when the first system is fielded, and production can run for many years after Initial Operational Capability

(IOC). O&S ends when a system is demilitarized and disposed of. Manufacturing and QA activities often change as production sometimes moves from a prime contractor to government owned and operated facilities, such as depots and MRO facilities. Key activities during this phase include:

- Continuation of Full-Rate Production (FRP)
- Performance-Based Logistics (PBL) implementation continues
- Updates to the Sustainment contract
- Updates to intelligence/counterintelligence products
- Disposal and demil at the end of its useful life

A. DOD ACQUISITION SYSTEM

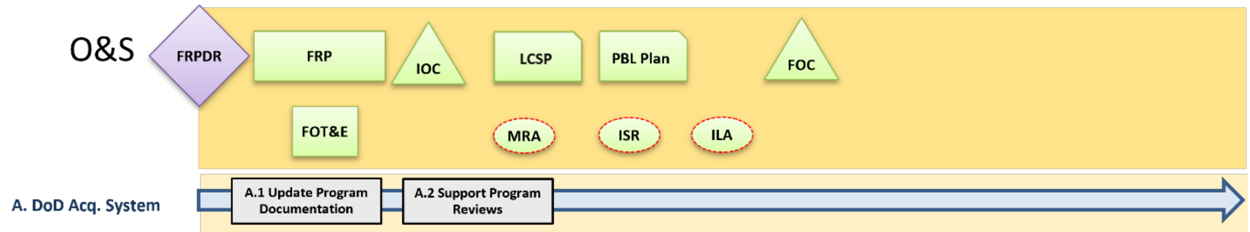


Figure 6-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

Sustainment planning, including the requirements in 10 USC 2337, must be an integral element of the capability requirements and acquisition process from inception. The PM, with the support of the Product Support Manager (PSM), will:

- Develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and will lead to a product support package to achieve and sustain warfighter requirements.
- Initiate system modifications, as necessary, to improve performance and reduce ownership costs, consistent with the limitations prescribed in 10 USC 2244a.
- Begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components, as required by DoDM 4160.28, Defense Demilitarization: Program Administration, with sufficient lead-time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.

The LCSP is updated at each milestone and specified decision points to reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

The PM will integrate the product support design into the overall design process and will assess enablers that improve supportability, such as diagnostics and prognostics, for inclusion in the system performance specification. As the design matures, the PM will ensure that life cycle affordability is a factor in engineering and sustainment trades.

The following information sources provide important inputs to the O&S phase systems engineering process and should contain manufacturing considerations:

- Systems Engineering Plan (SEP)
- Programmatic Environmental, Safety and Occupational Evaluation (PESHE)
- Life Cycle Sustainment Plan (LCSP)

Manufacturing and quality tasks during the O&S phase focus on producing spare parts/ subsystems/systems to keep the production articles operating and initiating system modifications to improve performance and reduce ownership costs.

Manufacturing should help develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and leads to a product support package that will achieve and sustain warfighter requirements.

- Manufacturing should begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components with enough lead-time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.
- Manufacturing should initiate/support system modifications, as necessary, to improve performance and reduce ownership costs.
- Manufacturing will also be concerned with several related issues to include:
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
  - Obsolescence
  - Counterfeit parts
  - Corrosion prevention and control
- Manufacturing should provide updates that reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

Several technical reviews could occur during this phase:

- Independent Logistics Assessment (ILA)
- Manufacturing Readiness Assessment (MRA)
- In-Service Review (ISR)

The Independent Logistics Assessment (ILA) is a multi-disciplined product and process assessment to ensure that the fielded system is operationally employed with well-understood and managed risk. This review is intended to characterize in-service technical and operational health of the fielded system by providing an assessment of risk, readiness, technical status, and trends in a measurable form that will substantiate in-service support budget priorities. Normally ISRs occur at numerous points in the O&S phase. They are typically initiated before, and in support of, the initiation of the following fiscal year(s) O&S budget requirements determination process.

During the sustainment effort of the O&S phase, systems engineering processes support ISRs including identifying root causes and resolutions for safety and critical readiness degrading issues. This effort includes participating in trade studies and decision making relative to the best resolution (e.g., changes to the product support package, manufacturing process improvements, modifications, upgrades, and future increments of the system), considering the operational needs and the remaining expected service life.

There may be a need to conduct a Manufacturing Readiness Assessment (MRA) to support ongoing risk assessment activities.

Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, joint or Service commonality, etc., may all indicate the need for a system upgrade(s) or process improvements.

- The program should measure, assess, and report manufacturing readiness.
  - The major review during the O&S phase is the ISR
  - During O&S reviews, the manufacturing team should measure, assess, and report manufacturing readiness using metrics and should implement corrective actions for trends diverging from the required performance outcomes
  - The manufacturing team should provide information on quality, manufacturing/ production, engineering, and software-related issues, deficiencies, or risks
- Manufacturing analysis supports the depot source of repair decision and must include detailed requirements for core depot-level maintenance and repair capabilities, and associated sustaining workloads required to support such requirements.

During O&S, the PM will measure, assess, and report system readiness using sustainment metrics and will implement corrective actions for trends diverging from the required performance outcomes defined in the Acquisition Program Baseline and LCSP.

The PM will ensure sustainment factors are fully considered at all key life cycle management decision points, and that appropriate measures are taken to reduce O&S costs by influencing system design early in development, developing sound product support strategies, and addressing key drivers of cost.

The PM should be aware of changing production capability as the transition from production to spare parts provisioning will severely reduce opportunities for future spares procurement if production facilities are changed to accommodate a new product line, material needs change, or new tooling for special purpose machines are installed. If extended production runs did not provide a spare parts inventory, the cost of parts produced later could be significantly higher than the original procurement. Conditions that drive up spare parts prices include:

- Smaller order quantity requirements
- Orders for earlier configuration units that require special documentation
- Parts requiring special purpose tooling
- Unique or scarce material requirements
- Lack of production capability can be due to several factors: Out of business, discontinued facilities, lack of available production capacity, etc.
- Special handling, packaging, and shipping requirements

A.1 Update Program Documentation

Manufacturing and QA personnel need to be actively engaged in the development and update of numerous documents, to include:

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

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

Manufacturing and Quality Tasks

- Request the following Program Documentation:
  - 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

- Support updates to the Acquisition Strategy and other program documentation, as necessary.
- Support the development and implementation of the Product Support Strategy (PSS) as detailed in the twelve step Product Support Model.
- Ensure M&Q inputs for the O&S phase documents and activities evolve from the P&D phase to include:
  - Manufacturing Strategy and Plan
  - Quality Strategy and Plan
  - Test and Engineering Master Plan (TEMP)
  - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
  - Life Cycle Sustainment Plan (LCSP)
  - Capability Development Document (CDD)
  - Requests for Proposals (RFP)
  - Source Selection Plans (SSP)
- Sustainment requirements should be finalized to support sustainment contracts and the LCSP.
- Support the development of the Product Support Package (PSP) to include the following 12 elements:
  - Product Support Management
  - Design Interface
  - Sustaining Engineering
  - Maintenance Planning and Management
  - Supply Support
  - Support Equipment
  - Technical Data
  - Training and Training Support
  - Manpower and Personnel
  - Facilities and Infrastructure
  - Packaging, Handling, Storage, and Transportation (PHS&T)
  - Computer Resources

- Support the development of the Product Support Strategy.
- Support the development of the Product Support Requirements.
- Prepare the M&Q inputs to the Product Support Strategy and Requirements:
    - Manufacturing support to system and product support package design trades
    - Manufacturing support to test and evaluation (T&E) planning
    - Manufacturing support in defining performance metrics for product support contracts and organic support requirements
    - Manufacturing support to logistics requirements, workload estimates, and logistics risk assessment
    - Manufacturing support to integrate the product support design into the overall design process, and assess enablers that improve supportability, such as diagnostics and prognostics, for inclusion in the system performance specification
    - Manufacturing support that helps ensure life cycle affordability is a factor in engineering and sustainment trades
    - Produce spare parts/subsystems/systems to keep the production articles operating and initiate system modifications, to improve performance and reduce ownership costs.
    - Manufacturing should initiate/support system modifications, as necessary, to improve performance and reduce ownership costs
    - Manufacturing should support cost estimating associated with system modifications
- Manufacturing should help develop and implement an affordable and effective performance-based product support strategy. The product support strategy will be the basis for all sustainment efforts and leads to a product support package that will achieve and sustain warfighter requirements.
- Manufacturing should help to assess field R&M data to evaluate the impact of M&Q activities on field failures. Assess R&M using Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA) and Process Failure Modes and Effects Analysis (PFMEA).
- Manufacturing should begin demilitarization and disposal planning, including demilitarization and controlled inventory item coding of system, subsystems, or components with enough lead time before the disposal or retirement of the first asset to reduce costs and risks and to ensure compliance with statutory and regulatory requirements.
- Monitor related issues including the following:
    - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
    - Obsolescence
    - Counterfeit Parts
    - Corrosion Prevention and Control
- Provide updates that reflect the increased maturity of the product support strategy, any changes in the corresponding product support package, current risks, and any cost reduction activities.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Industrial Base Assessment Survey Form Defense Contract Management Agency (DCMA) Industrial Analysis Center
- Interactive MRL Users Guide (Checklist)
- ISO 9001, Quality Management System Checklist
- Life Cycle Sustainment Plan Outline
- Manufacturing Maturation Plan
- Product Support Strategy Development Tool, Defense Acquisition University (DAU)
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- 10 USC 2337, Life-Cycle Management and Product Support
- DoD Product Support Managers Handbook
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems–Aerospace
- CJS JCIDS 3170.01, JCIDS System
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities
- DoD HCI Style Guide, Human Computer Interaction (HCI)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDM 4160.28, Defense Demilitarization: Program Administration
- Guide to Environment, Safety, and Occupational Health (ESOH) in the Systems Engineering Plan (SEP)
- ISO 9001, Quality Management System
- DoD Systems Engineering Guidebook
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- MIL-STD-1472, DoD Design Criteria Standard: Human Engineering
- NIST 800-171, Controls for Controlled Unclassified information
- Performance-Based Logistics (PBL) Guidance
- Product Support Manager Guidebook
- Technology Readiness Assessment Guidance

A.2 Support Program Management Reviews

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

- Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)
- In Service Reviews (ISRs)
- Independent Logistics Assessments (ILAs)
- Industrial Capabilities Assessments (ICAs)
- Follow-on Test and Evaluation (FOTE)
- Full-Rate Production (FRP) Decision

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

Sources of data used to assess and manage industrial, and manufacturing readiness include technical reviews and audits, Program Status Reviews, pre-award surveys, Manufacturing Readiness Assessments, Industrial Base Assessments, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

10 USC Section 2448b requires that Independent Technical Risk Assessments (ITRAs) be conducted in support of milestone and production decisions for Major Defense Acquisition Programs (MDAPs). ITRAs will be conducted for all MDAPs prior to Milestone A, Milestone B, and Milestone C approval and before an FRP decision.

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

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

The ISR is a multidisciplined assessment to characterize the in-service health of the deployed system and enabling system elements (training, user manuals, documentation, etc.). Risk management activities in the course of the ISR include risk assessment of operational hazards, product baseline integrity, supply chain status, determination of acceptable operational hazard risk, and in-service usage/support risk.

Manufacturing and Quality Tasks

- Provide M&Q assessments in support of the Independent Logistics Assessment (ILA) by assessing:
  - Product Support Management
  - Design Interface
  - Sustaining Engineering
  - Supply Support
  - Maintenance Planning and Management
  - Packaging, Handling, Storage, and Transportation (PHS&T)
  - Technical Data
  - Support Equipment
  - Training and Training Support
  - Manpower and Personnel
  - Facilities and Infrastructure
  - Computer Resources
  - Environment, Safety, and Occupational Health (ESOH)
- Provide M&Q assessments in support of the ISR:
  - System Hazard Risk Assessment
  - Operational Readiness assessment of system impacts from M&Q risks
  - Cost, schedule, and budget assessments from M&Q risks
  - Budget estimates in support of future M&Q activities
  - Current and Future Operational Risk and Systems Assessment of the impact of M&Q on reliability, maintainability, and operational readiness
- Support Follow-on Test and Evaluations (FOT&E) and review test reports.
- Support Independent Technical Risk Assessments if conducted.
- Support Technical Readiness Level Assessments of conducted.
- Provide M&Q assessments in support of Manufacturing Readiness Assessments (MRA):
  - Assessments of the 12 threads
- Provide M&Q support of Industrial Base Assessments.
- Provide support to the Full Rate Production Decision:
  - Manufacturing processes are under control
  - Product performance and reliability are acceptable
  - Sustainment and support systems are acceptable
  - System affordability has been assessed and is acceptable

  - o System sustainment has been assessed and is acceptable

Tools

- Army Acquisition Logistician's Assessment Checklist
- DoD In-Service Review (Checklist)
- Independent Logistics Assessment Checklist (DLA)
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- Technology Readiness Level Assessment (Checklist)
- Independent Technical Risk Assessment
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Industrial Capabilities Assessment (Checklist)

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- ISO 9001, Quality Management System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level Deskbook
- DOD Technology Readiness Assessment Guide
- Independent Logistics Assessment Guidebook
- Logistics Assessment Guidebook Tool
- DoD Product Support Managers Handbook
- Defense Technical Risk Assessment Methodology

B. DEFENSE CONTRACTING SYSTEM

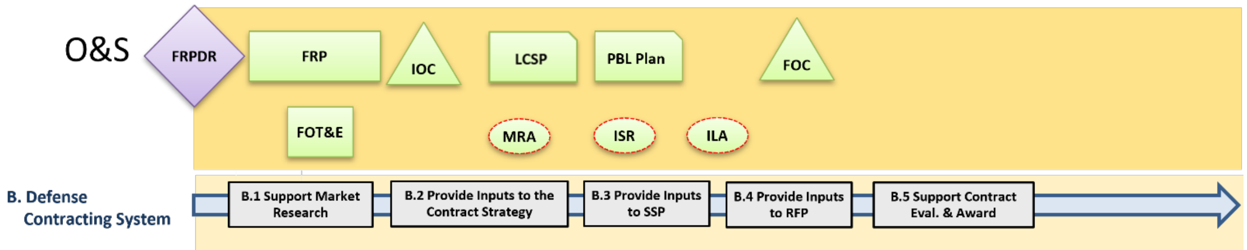


Figure 6-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

DoD contracting requirements and activities are required by various statutory and regulatory requirements to include the FAR/DFAR and by many DoD, Service and Agency regulations, policies, and guidance documents.

The contract is the vehicle used to establish a formal relationship between the government and a prime contractor. Government business processes include the business strategy or acquisition strategy, contracting approach, contracting strategies, contract language, and financial strategies. M&Q personnel will participate in all phases of the development of Engineering and Manufacturing Development (EMD) RFP, Source Selection Plan (SSP), and Award Fee incentive criteria.

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 (Section C, E, L and M) (refer to MIL-HDBK-245E)
- Contract Evaluation and Award

Market Research is a pre-solicitation activity that involves the evaluation of the market's ability to satisfy the user needs. M&Q personnel need to support market research to identify suppliers and evaluate potential sources and opportunities to assess the risks associated with these opportunities. During this phase, programs are often faced with Diminishing Manufacturing Sources and Material Shortages (DMSMS), obsolescence, counterfeit and other supply chain issues, making the finding of alternative sources a priority. Market Research can be conducted at the weapon system, subsystem, component, or part level and during any phase,

The Request for Proposal (RFP) is the primary opportunity for M&Q personnel to make inputs and should be based on M&Q risks, issues, and opportunities discovered during the O&S phase. Typical areas to be included in the proposal include industry best practices for manufacturing management, quality management, and systems engineering. Other areas to be addressed by M&Q include design and producibility, trade studies, M&Q technology investments, competition, materials (availability, counterfeit, and/or long-lead), data management, quality processes (capability studies), and M&Q reporting and control. This list and other details should be addressed in the Statement of Work (SOW) and/or the Statement of Objectives (SOO).

The RFP should include the following from an M&Q perspective:

- Manufacturing Management and Control
- Design Development and Demonstration
- Quality Management and Systems (best practices)
- M&Q Costs
- Industrial Base
- Process Control and Capability (best practices)
- Materials, Workforce, Facilities, and Tooling
- Risk, Issues, and Opportunity Management

A well-written RFP is critical to the success of the source selection. There should be consistency between the requirements documents, Source Selection Plan (SSP), and RFP. The acquisition team must ensure a clear linkage between the requirements and evaluation factors to maximize the accuracy and clarity of the RFP.

Manufacturing and quality personnel should support the PM in the development of an RFP based on the supportability analyses contained in the LCSP and review of the most current product support requirements, senior leader guidance, and fiscal assumptions to evaluate product support changes or alternatives and determine best value.

After the Full-Rate Production decision, the LCSP will focus on finalizing the sustainment metrics, integrating sustainment considerations with design and risk management activities, and refining the execution plan for the design, acquisition, fielding, and competition of sustainment activities.

The RFP needs to consider that at the end of a system's useful life, that system may need to be demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment.

Life cycle sustainment for information systems may be provided via multiple approaches, including Service-level agreements, support agreements, performance work statements, and enterprise services. Where feasible and as approved by the MDA, programs may employ portfolio-level documents to satisfy their LCSP requirements. COTS and GOTS products used as intended will normally be supported via standard warranties and support agreements. Effective life cycle sustainment requires continuous monitoring to ensure investments are maintained at the right size, cost, and condition, to include vulnerability management, to support warfighter and business missions and objectives.

The necessary intellectual property (IP) deliverables and associated license rights, consistent with and integrated with the program IP Strategy.

COTS and GOTS products used as intended will normally be supported via standard warranties and support agreements. Effective life cycle sustainment requires continuous monitoring to ensure investments are maintained at the right size, cost, and condition, to include vulnerability management, to support warfighter and business missions and objectives.

The relationship between government and contractor is a critical area. The Program Management Office (PMO) and M&Q managers should strive to create and maintain close teaming arrangements with their counterparts. This will enable better communication and enhanced respect between both parties.

Performance tracking within the SOO/SOW and RFP should focus on technical and business measures that will help to assure program success (cost, schedule, and performance). Cost performance measures should focus on affordability and total life cycle costs, schedule performance measures should focus on the Integrated Master Plan/Schedule. Adherence to both may be found in Earned Value Management (EVM) if required. Technical performance should be assessed using technical measures that are derived from the Measures of Effectiveness (MOEs), Key Performance Parameters (KPPs), Measures of Performance, and Technical Performance Measures (TPMs). Manufacturing and QA-related TPMs should support the achievement of Sustainment Supportability Measures.

Manufacturing and quality personnel should support an integrated product support capability implementing the program's mix of government and industry providers supported by appropriate analyses as included in 10 USC 2337 – Life-cycle management that focuses on:

- Maximize competition to make the best possible use of available DoD and industry resources at the system, subsystem, and component levels; and
- Maximize value to the DoD by providing the best possible product support outcomes at the lowest operations and support cost.

Manufacturing and QA personnel should be working to identify cost, schedule, and TPMs. TPMs are often derived from mission needs or MOEs, KPPs, and Measures of Performance. These measures can then be related to and tracked by an Earned Value Management System (if applicable), and the Integrated Master Plan/Schedule.

A successful program meets the sustainment performance requirements, remains affordable, and continues to seek cost reductions by applying should-cost management and other techniques throughout the O&S phase. Doing so requires close coordination with the warfighting sponsor (i.e., user), resource sponsors, and materiel enterprise stake holders, along with effective management of support arrangements and contracts.

During Full-Rate Production, manufacturing should focus on how sustainment performance will be measured, managed, assessed, and reported; and the necessary actions to adjust the product support package to ensure continued competition and cost control while meeting warfighter mission requirements. After Initial Operational Capability (IOC), the LCSP is the principal document governing the system's sustainment. Programs will update the plan whenever there are changes to the product support strategy, or every 5 years, whichever occurs first, supported by appropriate analyses, sustainment metrics, sustainment costs, system components or configuration (hardware and software), environmental requirements, and disposal plans or costs.

Manufacturing and QA should support programs to update the plan whenever there are changes to the product support strategy, or every 5 years, whichever occurs first, supported by appropriate analyses, sustainment metrics, sustainment costs, system components or configuration (hardware and software), environmental requirements, and disposal plans or costs. Performance-based payment events should be used as effective M&Q measures. This activity involves the assessment of how efficiently the contractor is producing products, primarily through the evaluation of work measurement data. It also includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.

During production and into sustainment, manufacturing should support performance-based payment events such as award fees, manufacturing/production incentives, and learning curve analysis

B.1 Provide Input to Market Research

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

Market Research can be either Strategic or Tactical:

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

Market Research is intended to determine and help:

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

Market Research is a primary means of determining the availability and suitability of commercial items and the extent to which the interfaces for these items have broad market acceptance, standards-organization support, and stability. In addition, market research is important in seeking small business capabilities. Thorough market research needs to be performed 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.
- Identify market data such as the number of suppliers in the market and market share.
- Identify potential suppliers (name, size, and annual sales).

- Identify and assess business Practices (e.g., ISO 9001, etc.).
- Identify and assess production capability and capacity.
- Identify and assess ability to surge/mobilize.
- Identify and assess distribution capabilities (preservation, packaging, handling, storage, and transportation).
- Identify the availability of commercial items.
- Identify 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 inputs for sources sought activity, as appropriate.
- Support the development of contracts, as appropriate.
- Identify and characterize materiel solutions resulting from the Sources Sought to support. Requests for Information (RFI) activities and Industry Day events.
- Ensure the Request for Information (RFI) is open to alternative solutions.
- Analyze potential trade space to identify performance versus cost benefit discriminators for potential materiel solutions.
- Initiate planning for the M&Q efforts required during the next phase.

Tools

- Market Research Methods – DAU
- 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 at the DAU website [Contracting Cone | Adaptive Acquisition Framework (dau.edu)].

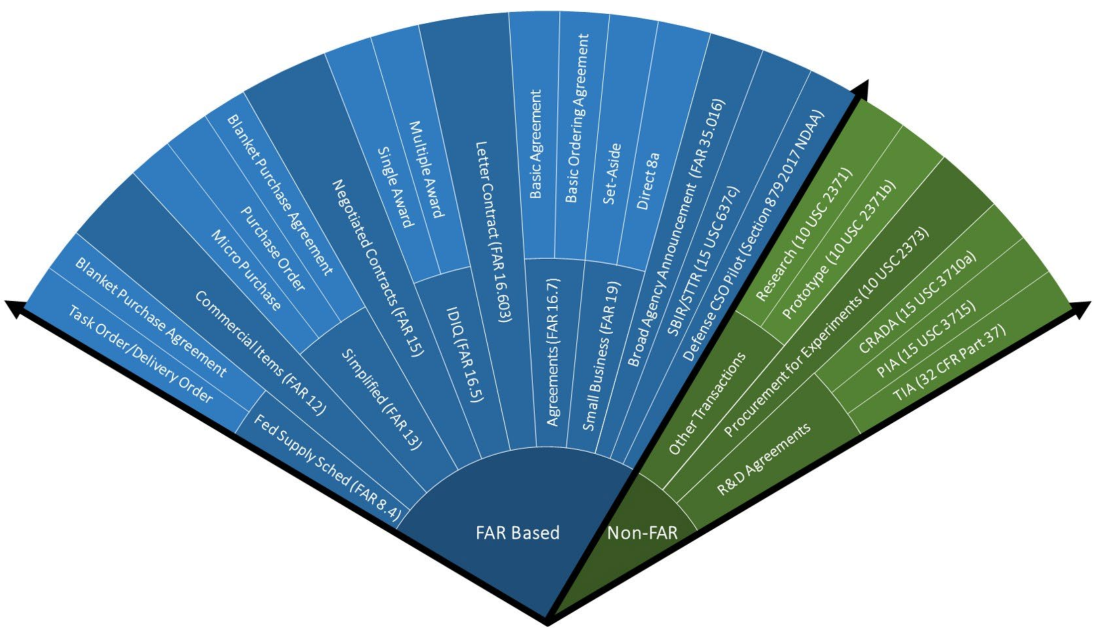


Figure 1-5. Contracting Cone

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 and provide M&Q input to the contract in the form of award or incentive fee Criteria, appropriate to the contract type and consistent with the Acquisition Strategy, which specify program goals and address the necessary M&Q (including supply chain) cost, schedule, and performance improvements (to include progress against goals, partial progress, recovery, and penalty) in the areas of:
  - M&Q CDRLs, DIDs, etc. (e.g., timely submission and approval)
  - Compliance with cyber-threat protection and industrial security requirements (e.g., PPP, DFARS 252.204-7012, NIST 800-82, etc.)
  - M&Q industrial base risk mitigations to schedule goals (#/%, milestones)
  - Manufacturing readiness progress (MRL assessments) against targets
  - Assessments of lower tier supply chain for manufacturing readiness and maturity in advance of the System maturity targets (#/%)
  - M&Q risk and issues mitigations complete (schedule/#)
  - Manufacturing and producibility projects planned and implemented (#/%)
  - Progress of learning curves (% to goals) including rates, yields, variability, process times, re-work, and repair, etc.
  - M&Q systems operations (production line, tooling, equipment, ManTech insertion, etc.) performance to goals (schedule/ %)
  - Key and critical manufacturing process capability improvements and variability reduction (i.e., C_{pk} improvements on key and critical processes beyond contract)
  - KC maturation and management to goals (% to goal and schedule progress)
  - Technical Performance Measures (TPMs) (% progress to schedule)
  - Manufacturing processes and advanced manufacturing capability improvement, and implementation (#/% to goals)
  - Materials characterization schedule improvements in additional environments beyond contract requirements (time)
  - Management of CSIs and CAIs to requirements
  - Process Capability improvement (Cpk value to goals)
  - Quality improvement projects planned and completed (#/% to goals)
  - Quality improvement positive trends (acceleration of improvements %)
  - Exceeding quality improvement goals
  - Variation and Variability reduction efforts (yields/rates/trends)
  - Manufacturing improvement projects implemented (#/% to goals)
  - Parts and materials management against appropriate M&Q goals (e.g., availability, capacity, sourcing, standardization, etc.) (#/%)
  - Facilities and equipment utilization (% to plan)
  - Workforce development and management to plan (e.g., hiring, training, and reductions) (#/% to plan)
  - Testing completion to schedule (% successfully completed) and testing improvements and positive trends (%)

  - Testing and demonstration beyond contract requirements (include test reductions)
  - Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
  - Manufacturing Plan progress against completion (cost and schedule)
  - Cost sharing when goals are not met must also be specified.
  - Improvements in schedule (e.g., increased slack time, expedited development, early delivery, or just-in-time implementation, etc.)
  - Quality Management System compliance to best practices and/or contract requirements (# to standard)
  - Quality Plan progress against completion (cost and schedule)
  - Quality costs and cost reduction (including cost of quality) (schedule/#/%)
  - M&Q safety system requirements (% compliance)
  - Systems Engineering management compliance to best practices for M&Q technical processes, technical management processes, and essential specialty engineering (# to standard)
  - Performance to IMP/IMS (schedule)
  - Progress toward meeting LRIP exit criteria
  - Predictive and pro-active maintenance and modernization of facilities, tooling, and equipment (including GFE)
  - Investments in modern manufacturing methods, software, and equipment including ManTech and other investments (cost share %)
  - Qualification and investments in additional sources within the U.S. IB ($)

- Develop M&Q entrance and exit criteria for technical reviews and decision points:
  - Specify metrics for partial achievements, incremental awards, penalties for failure to meet contract requirements, and achievement beyond expectations
- Support the development of contract incentives for early delivery of completed, comprehensive, and acceptable M&Q CDRLs, DIDs, and other program documentation to meet the requirements for timely government approval:
  - Specify metrics for partial achievement and penalties for failure to meet contract requirements
- Provide incentives for achievement of M&Q specific thresholds, objectives, and sub-goals with respect to rate, schedule, performance, quality, etc.:
  - Specify metrics for partial achievements, incremental awards, and penalties for failure to meet contract requirements
- Specify thresholds for the adoption and effective implementation of industry best practices in M&Q (e.g., AS6500, ISO 9001, AS9100. etc.):
  - Develop program-specific metrics that measure progress
  - Specify incentives for exceeding thresholds

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

Tools

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

Resources

- FAR Subpart 16.4, Incentive Contracts
- DoD Guidance on Using Incentive Contracts
- DoD/NASA Incentive Contracting Guide
- Air Force Award Fee Guide
- Navy Award Fee Guide
- Army Award Fee Guide
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)
- AS6500, Manufacturing Management Program
- DoD Systems Engineering Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide

B.3 Provide Inputs to the Source Selection Plan

FAR 15.101, in the Best Value section, states that an agency can obtain best value in negotiated acquisitions by using any one or a combination of source selection approaches. The Source Selection Plan (SSP) is a key document that specifies how the source selection activities will be organized, initiated, and conducted 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 to 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 Integrated Product Team (IPT), should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Support the development of the SSP. The Source Selection Authority should approve the SSP before the final solicitation is issued. The SSP should include the following as a minimum:
    - Introduction: Background and Objectives
    - Source Selection Process
    - Source Selection Organization (source selection team should include M&Q)
    - Security (data, communications and personnel)
    - Pre-solicitation Activities
    - Major Source Selection Events including Visits
    - Evaluation Factors and Sub-factors (should include some M&Q)
    - Evaluation Procedures
- Review the SSP against the Acquisition Strategy.
- Ensure manufacturing inputs to the Sustainment SSP include:
    - Manufacturing and QA evaluation criteria,
    - Technical Data Rights and Manufacturing Process Data Rights,
    - Intellectual property (IP) deliverables and associated license rights.
- Ensure the SSP describes the following data requirements:
    - The management approach to managing data acquired with other than unlimited rights.
    - The management approach for management data (i.e., data that is not software or technical data). It should include how contractor data needing protection will be identified, marked, and managed.
    - How the data deliverables will be reviewed for unjustified or non-conforming markings. It should include the process the program will follow to question or challenge contractor assertions or markings

  - The data deliverables specified in the RFP or contract, including the technical data, computer software documentation, and management data items.
  - The approach for maintaining the software and its documentation once software maintenance is transferred from the Original Equipment Manufacturer. It should include the contract provisions being put into place that will allow for a cost-effective migration.
  - The degree to which data will be acquired to support future competitions. It should include the logic by which these elements were selected; the alternative solutions considered; and the criteria by which the decision to procure technical data was made.
  - The extent to which priced options and associated source selection criteria will be used to acquire additional licenses.
  - The intended use of other mechanisms such as deferred ordering, deferred delivery, and the use of withholding or incentives specific to performance in data management.
  - How the use of an integrated digital environment and the repository system factors into the data strategy.
  - Any required interfaces to government data systems or repositories, and how those requirements will be satisfied.
  - The digital format standards to be used and why they were selected. The process (i.e., business case analysis, adherence to DoD Component policy, etc.) used to determine the deliverable form/format for all deliverables should be included.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- ISO 9001, Quality Management System Checklist
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- Source Selection Plan Template

Resources

- DoD Product Support Managers Handbook
- Air Force Contract Sustainment Support Guide
- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DoD Systems Engineering Guidebook
- DAU AcqNotes website
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities
- DoD Source Selection Procedures
- FAR Subpart 15.3 Source Selection
- IG5315.303 Source Selection Plan Guide
- ISO 9000, Quality Management System

B.4 Provide Input to the Request for Proposal

The Request for Proposal (RFP) is a document that solicits bids from vendors and provides an opportunity to communicate to the contractor the government's requirements 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 for inclusion in the REP and subsequent contract. The input to the RFP needs to be short and very succinct. M&Q should consider the warfighter requirements and evaluation factors and sub-factors with an emphasis on Sustainment. Evaluation factors often include cost or price, and quality of product or service, which includes technical, past performance and others. 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 to 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 input

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

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

Manufacturing and Quality Tasks

- See Early Manufacturing and Quality Guide, Sections 2 and 3
- Support writing of the RFP and participate in RFP review teams
- Analyze M&Q results
- Specify requirements for the contractor to describe 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 process:
  - 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 System Checklist
- AS9100, Quality Management System Checklist
- IG5315.204-5(b) Section L Guide and Template
- IG5315.204-5I Section M Guide and Template
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- ISO 9001, Quality Management System Checklist
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- DCMA Pre-Award Survey System (PASS)
- SF 1403 DCMA Pre-Award Survey General
- SF 1404 DCMA Pre-Award Survey Technical
- SF 1405 DCMA Pre-Award Survey Production
- SF 1406 DCMA Pre-Award Survey Quality Assurance
- SF 1407 DCMA Pre-Award Survey Financial Capability

Resources

- Early Manufacturing and Quality Guide
- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- Air Force Contract Sustainment Support Guide
- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DoD 5000.60-H, DoD Handbook: Assessing Defense Industrial Capabilities
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- MIL-HDBK-245E, Preparation of Statement of Work
- SD-15 Performance Specification Guide
- DI-IPSC-81431 System/Subsystem Specification Data Item Description
- DI-SDMP-81484A, Detail Specifications Data Item Description
- DI-SDMP-81465A, Performance Specification Data Item Description
- DI-SDMP-81493, Program Unique Specification Document Data Item Description
- MIL-STD-961, Defense and Program-Unique Specifications Format and Content
- MIL-HDBK-245E, Preparation of Statement of Work
- IG5315.204-5(c) Section M Guide
- ISO 9000, Quality Management System
- ISO/IEC/IEEE 15288, System and Software Engineering IG5315.204-5(b) Section L Guide
- MIL-HDBK-29612-1A Guidance for Acquisition of Training Data Products and Services
- AFMC Inst 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-Award Survey Guide
- Pre-Award Survey User's Manual

B.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."

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

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

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 assure 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.
- Result in effective root cause analyses and corrective actions.

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

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

A pre-award survey may be conducted on a proposed contractor to assess the ability of the prospective contractor to perform under the terms of the proposed contract. A pre-award survey typically requires an on-site visit to the contractors 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:
  - The overall technical proposal is adequate and addresses the scope, deliveries, and schedules required by the RFP.
  - The contractor's technical approach in the proposal is based upon sound engineering concepts.
  - The contractor provides adequate information to support specific quantities of labor and materials.

  - The contractor's proposal contains an adequate description of its basis for direct labor hours, including sufficient rationale for engineering judgment and projections from prior work completed on similar programs.
  - The contractor provides adequate explanation for factored labor hours.
  - The contractor's proposal provides supporting data to justify proposed material, scrap, rework, attrition, or other factors.
  - The contractor provides reasonable rationale for special tooling and test equipment to establish that the proposed items are required for the program
- Support the review of contractor past performance:
  - Review the Past Performance Information Retrieval System (PPIRS)
  - Review contractor Past Performance Questionnaire
  - Review contractor Past Performance Citations
- Review contractor plans:
  - Project Management Plan
  - Manufacturing Management Plan
  - Quality Management Plan
  - Risk Management Plan
- Support contract negotiations:
  - Review 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

- Develop and provide M&Q input to the contract in the form of Award or Incentive Fee Criteria, appropriate to the contract type and consistent with the Acquisition Strategy, which specify program goals and address the necessary M&Q (including supply chain) cost, schedule, and performance improvements (to include progress against goals, partial progress, recovery, and penalty) in the areas of:
  - M&Q CDRLs, DIDs, etc. (e.g., timely submission and approval)
  - Compliance with cyber-threat protection and industrial security requirements (e.g., PPP, DFARS 252.204-7012, NIST 800-82, etc.)
  - M&Q Industrial Base risk mitigations to schedule goals (#/%, milestones)
  - Manufacturing readiness progress (MRL assessments) against targets

- Assessments of lower tier supply chain for manufacturing readiness and maturity in advance of the System maturity targets (#/%)
- M&Q risk and issues mitigations complete (schedule/#)
- Manufacturing and producibility projects planned and implemented (#/%)
- Progress of M&Q learning curves (% to goals) including rates, yields, variability, process times, re-work, and repair, etc.
- M&Q systems operations (production line, tooling, equipment, ManTech insertion, etc.) performance to goals (schedule/ %)
- Key and critical manufacturing process capability improvements and variability reduction (i.e., C_{pk} improvements on key and critical processes beyond contract)
- Key Characteristics maturation and management to goals (% to goal and schedule progress)
- Technical Performance Measures (TPMs) (% progress to schedule)
- Manufacturing processes and advanced manufacturing capability improvement, and implementation (#/% to goals)
- Materials characterization schedule improvements in additional environments beyond contract requirements (time)
- Management of CSIs and CAIs to requirements
- Process Capability improvement (Cpk value to goals)
- Quality improvement projects planned and completed (#/% to goals)
- Quality improvement positive trends (acceleration of improvements %)
- Exceeding quality improvement goals
- Variation and Variability reduction efforts (yields/rates/trends)
- Manufacturing improvement projects implemented (#/% to goals)
- Parts and materials management against appropriate M&Q goals (e.g., availability, capacity, sourcing, standardization, etc.) (#/%)
- Facilities and equipment utilization (% to plan)
- Workforce development and management to plan (e.g., hiring, training, and reductions) (#/% to plan)
- Testing completion to schedule (% successfully completed) and testing improvements and positive trends (%)
- Testing and demonstration beyond contract requirements (include test reductions)
- Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
- Manufacturing Plan progress against completion (cost and schedule)
- Manufacturing cost (Δ$), cost reduction (%/$), and cost avoidance
- Cost sharing when goals are not met must also be specified.
- Improvements in schedule (e.g., increased slack time, expedited development, early delivery, or just-in-time implementation, etc.)
- Quality Management System compliance to best practices and/or contract requirements (# to standard)

  - Quality Plan progress against completion (cost and schedule)
  - Quality costs and cost reduction (including cost of quality) (schedule/#/%)
  - M&Q safety system requirements (% compliance)
  - System Engineering management compliance to best practices for M&Q technical processes, technical management processes, and essential specialty engineering (# to standard)
  - Performance to IMP/IMS (schedule)
  - Progress toward meeting LRIP exit criteria
  - Predictive and pro-active maintenance and modernization of facilities, tooling, and equipment (including GFE)
  - Investments in modern manufacturing methods, software, and equipment including ManTech and other investments (cost share %)
  - Qualification and investments in additional sources within the U.S. IB ($)

Tools

- 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/Incentive Fee Plan
- Aware Fee Template, USAF

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
- Air Force Award Fee Guide
- Army Award Fee Guide
- DoD Guidance on Using Incentive Contracts, Mar 2016
- DoD/NASA Incentive Contracting Guide
- FAR Subpart 16.4 Incentive Contracts
- Navy Award Fee Guide
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)

C. SURVEILLANCE SYSTEM

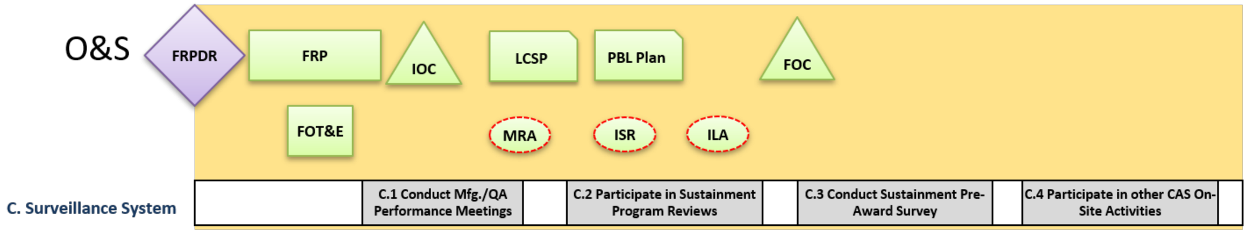


Figure 6-4. Surveillance System Manufacturing and Quality Activities

Introduction

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

Often these activities may be performed under mutual agreement by the program office and DCMA. In many cases these contractor surveillance activities may be performed by on-site program office contract administrators, delegated Service contract surveillance offices, or a variety of engineering support activities (i.e., supervisor of shipbuilding (SUPSHIP), development command field activities).

The PM and PMO should use to the extent possible available personnel from DCMA to provide onsite contract administration services (CAS) and functions in accordance with FAR 42.302(a) or DFAR subpart 242.3. Typical CAS functions involving engineering, M&Q can provide program offices with timely, value-added analysis, acquisition insight, and early confirmation of progress and risk reporting. CAS functions include but are not limited to:

- Pre- and Post-award contract actions
- Cost and financial surveillance
- Property administration
- Supply chain management
- Safety and Environmental Health
- Engineering
- Production
- Quality

CAS functions may be delegated to the DCMA using a Memorandum of Agreement (MOA) or Letter of Delegation (LOD). DCMA-INST-205, Major Program Support and FAR 42.302(a) Contract Administration Functions outlines how DCMA personnel can be used to support program office requests. Their support may be dependent upon manpower availability and funding.

Many M&Q functions may have moved from prime contractor facilities to government owned and operated facilities such as depots and MROs where CAS surveillance may not be available. This does not mean that oversight functions as outlined in the FAR/DFAR are not still appropriated.

Oversight of contracting actions will continue during the O&S phase. Sometimes contractors go out of business or for other reasons the program changes contractors. If so, it is important to gain a thorough understanding of their capability, capacity, and financial stability using a pre-award survey.

Major oversight functions include the need for regular status meetings, program reviews, the need for pre-award surveys (as appropriate) and other CAS oversight functions and activities. Manufacturing and QA oversight should be based on contract requirements (AS6500, AS9100, etc.).

Over the system life cycle, operational needs, technology advances, evolving threats, process improvements, fiscal constraints, plans for follow-on systems, or a combination of these influences and others may warrant revisions to the LCSP.

Major Defense Acquisition Programs (MDAPs) undergo Independent Logistics Assessments (ILAs) before Milestones B and C and the Full-Rate Production Decision to assess the adequacy of the product support strategy and to identify features likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs. The reviews focus on sustainment planning and execution, including the core logistics analyses and establishment of organic capabilities.

After IOC, the DoD Components will continue to conduct ILAs at a minimum interval of every 5 years. Assessments will focus on the weapon system-level product support performance in satisfying warfighter needs, meeting sustainment metrics, and providing best-value outcomes. They must specifically assess O&S costs to identify and address factors resulting in growth in O&S costs and adopt strategies to reduce such costs. Results will inform LCSP and analyses updates.

Each DoD Component will establish its criteria for independence and will provide (1) guidance to ensure consistency within the respective Component and (2) the scope of the assessment for key acquisition decision points. At a minimum, these reviews will be chartered by the Component Acquisition Executive (CAE) and conducted by logistics, program management, and business experts from outside the program office. Each DoD Component will establish its criteria for independence and will provide guidance to ensure consistency within the respective Component and the scope of the assessment for key acquisition decision points. At a minimum, these reviews will be chartered by the

CAE and conducted by logistics, program management, and business experts from outside the program office M&Q experts should participate in this activity.

The In-Service Review (ISR) is a multidisciplined product and process assessment to ensure that the fielded system is operationally employed with well-understood and managed risk. This review is intended to characterize in-service technical and operational health of the fielded system by providing an assessment of risk, readiness, technical status, and trends in a measurable form that will substantiate in-service support budget priorities.

C.1 Conduct Manufacturing and QA Performance Meetings

Compliance with a standard such as AS6500 Manufacturing Management Program, or ISO 9001 Quality Management System, or AS9100 Quality Systems, does not guarantee product or service quality. These standards are management system standards that identify requirements for processes within an organization, describe expected tasks and outcomes, and explain how the processes and tasks integrate to produce required inputs and outputs. Standards are meant to enable the organization to develop a set of processes that, if done by qualified persons using appropriate tools and methods with appropriate leadership involvement, will enable a capability for delivering high quality products or services. These standards can provide a basis for developing and managing a manufacturing or quality program and for assessing compliance with those standards.

Programs achieve product or service quality by implementing a strategic plan to integrate all business and technical functions, resulting in the consistent application of proven, capable processes within an organization. Managers must ensure that all management systems are working toward the same goals and are not creating conflicting or dysfunctional behavior. Implementing a standard is of little use if the financial system rewards delivery of non-conforming products and services. Because everything a contractor does should be related to the quality of its products or services, a contractor's quality management system should be the basis for integrating all other management systems within an enterprise.

Manufacturing and Quality Tasks

- Support the contractor's government/contractor status meetings to ensure the contractor is performing according to contract requirements:
    - At the prime contractor facility
    - At key/critical subcontractors and suppliers
- Ensure the contractor has established and implemented a Material Management and Audit System (MMAS).
- Ensure the contractor has established and implemented a Government Property Control System.
- Support regular (weekly/monthly) contractor status meetings:

  - Manufacturing management concerns per contract requirements (AS6500).
  - Quality concerns per contract requirements (AS9100, ISO 9001, etc.).

Tools

- Army Acquisition Logistician Assessment Checklist
- DAU Logistics Assessment Guidebook, Appendix A: Integrated Product Support Element Assessment Criteria (checklist)
- Interactive MRL Users Guide (Checklist
- Manufacturing Maturation Plan
- Material Management and Accounting System checklist
- Navy Government Property Compliance Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program
- ASA(ALT) Independent Logistics Assessments (ILA) Policy Memorandum
- DoD Systems Engineering Guidebook
- DOD Technology Readiness Assessment Guide
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-309, Government QA Surveillance Planning
- DFARS 245, Government-Furnished Property
- DoD Logistics Assessment Guidebook
- DoDI 4161.02, Accountability and Management of Government Contract Property
- FAR Part 45.1 Government Property
- Guidebook for Contract Property Administration,
- Independent Logistics Assessment
- Independent Logistics Assessment Handbook (Navy)
- ISO 9001, Quality Management System
- Material Management and Accounting System (MMAS) Audit Program
- SECNAVINST4105.1C, Independent Logistics Assessment and Certification Requirements
- DoD Product Support Managers Handbook

C.2 Participate in Sustainment Program Reviews

The technical reviews and audits are necessary systems engineering (SE) activities performed to assess technical progress within a program, relative to contractual requirements and developmental maturity. Technical reviews of program progress should be event-driven and conducted when the system under development meets the review entrance criteria as documented in the Systems Engineering Plan (SEP). The technical reviews and audits should include participation by subject matter experts who are independent of the program (i.e., peer review), unless specifically waived by the SEP approval authority as documented in the SEP. Acquisition milestones and SE technical reviews and audits serve as key points throughout the life cycle to evaluate significant achievements and assess technical maturity and risk. During the O&S phase the program will be faced with the need to conduct many program and technical reviews to include:

- Independent Logistics Assessment (ILA)
- In-Service Review (ISR)
- Manufacturing Readiness Assessment (MRA)

Manufacturing and Quality Tasks

- Support Independent Logistics Assessments (ILAs) at a minimum of every 5 years:
    - Assess O&S costs and address factors resulting in growth in O&S costs and adopt strategies to reduce such costs
    - Assess M&Q considerations that might impact sustainment activities
        - Assessments at prime and subcontractor levels
- Support the ISR to ensure the fielded system is operationally employed with well-understood and managed risk. The ISR should include the following considerations as appropriate:
    - Review quality, manufacturing, engineering, and software-related issues, deficiencies, and/or risks during program reviews
    - Assess System Operational Risk and System Readiness have been quantified and related to current O&M and procurement budgets
    - Review any time-phased transitions between commercial, organic, and partnered product support providers
    - Ensure data rights and IP deliverables and associated license rights, tools, equipment, and facilities are acquired to support each of the levels of maintenance that will provide product support; and will help establish necessary organic depot maintenance capability
    - Identify features that are likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs
    - Assess sustainment planning and execution, to include the core logistics analyses and establishment of organic capabilities
    - Review and assess Performance-Based Logistics (PBL) planning, development, implementation, and management during Sustainment
    - Review and assess product obsolescence and the likelihood of future redesign to upgrade system capability to include Diminishing Manufacturing Sources and Material Shortages (DMSMS) and obsolescence
    - Review and assess program office shutdown activities as needed
    - DCMA should be used to support sustainment reviews
- Conduct a Manufacturing Readiness Assessment as appropriate.

Tools

- Army Acquisition Logistician's Assessment Checklist
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Technology Readiness Assessment Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DoD Systems Engineering Guidebook
- DOD Technology Readiness Assessment Guide
- DoD Product Support Managers Handbook
- DoD Independent Logistics Assessment Guidebook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Independent Logistics Assessment Handbook (Navy)
- ISO 9001, Quality Management System
- NAVSO P-3692, ILA Handbook

C.3 Conduct Sustainment Pre-Award Survey

A pre-award survey may be required per FAR 9.106 and is an evaluation of a prospective contractor's capability to perform under the terms of a proposed contract. During the O&S phase some subcontractors may leave the business, and a new subcontractor may be validated, or there may be a significant system update that may require a pre-award survey and a first article inspection. It typically requires an on-site visit to the prospective contractor's facility and could be an assessment of their technical, production, quality, and financial capabilities. Manufacturing and QA managers need to support assessments at the contractors' facilities and should involve the support by DCMA personnel stationed at the facility.

Manufacturing and Quality Tasks

- Support the evaluation of a proposed contractor's capability and capacity by performing a pre-award survey.
- Support DCMA personnel on the following surveys:
  - Technical (SF 1404)
  - Production (SF 1405)
  - Quality (SF 1406)

  - Financial (SF 1407)

- Support the evaluation of Technical Capability; Production Capability; Quality; Packaging; Flight Operations/Safety; Technical documentation; Configuration Management; and Software Capability.
- Support revisions and system modifications over the system life cycle, as may be driven by operational needs, technology advances, evolving threats, process improvements, fiscal constraints, and plans for follow-on systems.
- Support taking appropriate measures to reduce operating and support costs by influencing system design early in development, developing sound product support strategies, and addressing key drivers of cost.
- Support independent logistics assessments to assess the adequacy of the product support strategy, and to identify features that are likely to drive future operating and support costs, changes to system design that could reduce costs, and effective strategies for managing such costs.
- Support sustainment planning and execution, to include the core logistics analyses and establishment of organic capabilities.

Tools

- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- SF 1404 Pre-Award Survey – Technical
- SF 1405 Pre-Award Survey – Production
- SF 1406 Pre-Award Survey – Quality Assurance
- SF 1407 Pre-Award Survey – Financial Capability

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DCMA Pre-Award Survey Guidebook
- ISO 9001, Quality Management System

C.4 Participate in Other CAS On-Site Activities

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DFAR subpart 242.3 identifies 71 Contract Administration Services (CAS) functions that need to be accomplished and managed. Contractor surveillance is defined by several FAR and DFAR clauses. Many CAS activities fall under the umbrella of production or quality surveillance activities. Manufacturing and QA managers play an integral and vital role in the total scope of contract administration. Most program offices delegate many CAS activities to DCMA as a best practice.

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

Manufacturing and QA personnel may be called out to perform some or all the following functions:

- Provide input to the development of a Memorandum of Agreement (MOA) between the program office and the government contract administration activity.
- Attend/participate in Post-Award Orientation Conference (PAOC).
- Provide independent program status of cost, schedule, and technical performance.
- Conduct Flight Operations, if applicable.
- Support Requests for Variation (RFVs) Material Review Board (MRB) proposals for Use-As-Is (UAI) and repair non-conformances.
- Verify supplier complies with contractual Special Packaging Instructions (SPIs) for end item systems and spares.
- Perform Government Contract Quality Assurance (GCQA), to include Inspection and Acceptance, of production quantities.
- Verify Surveillance Critical Designator (SCD) (FAR 42.11) applied to the contract is the correct designator.
- Perform government surveillance of the supplier's Material Management and Accounting System (MMAS).
- Verify Beyond Economical Repair (BER) requests.
- Perform evaluation of Over and Above (O&A) requests.
- Perform Physical Progress Reviews (PPRs) to support Progress Payments.
- Perform Estimates to Completion (EAC) when requested.
- Provide delivery delay notices to the customer.
- Validate/verify Performance Base Payment requests.
- Provide support to customer priority delivery requests.
- Support of Failure Reporting, Analysis and Corrective Action System (FRACAS).
- Support assessment of field failures.

Tools

- DCMA Manufacturing and Production Surveillance Plan
- DMCA Engineering Surveillance Plan
- DMCA Program Support Plan
- DMCA QA Surveillance Plan
- Interactive MRL Users Guide (Checklist)

- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DCMA-INST-204, Manufacturing and Production
- DMCA-INST-205, Program Support
- DMCA-INST-207, Engineering Surveillance
- DMCA-INST-309, Government Contract QA Surveillance Planning
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- ISO 9001, Quality Management System

D. TECHNOLOGY AND INDUSTRIAL BASE

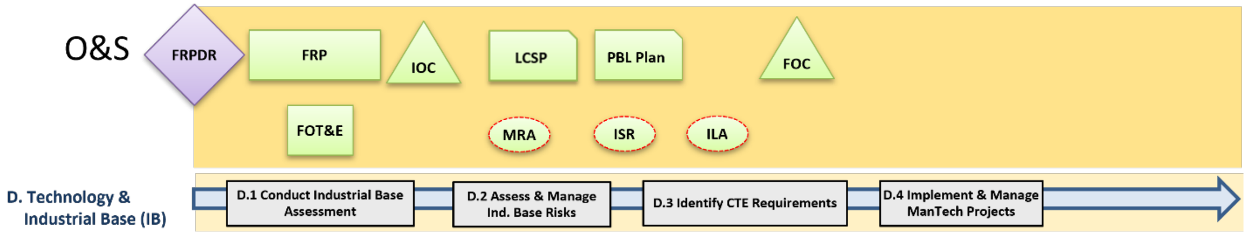


Figure 6-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC 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. Acquisition planning and plans must include considerations of the NTIB for all MDAPs, for example:

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

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

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

The O&S phase is characterized by ongoing production and sustainment operations. The PM should continue assessing the industrial base to ensure there will be a source of material for future development, production, and sustainment. The potential loss of design or manufacturing capabilities at planned cost and schedule is the major program risk during the O&S phase.

The update of earlier phase assessments will serve as a baseline as the system evolves. It will document the manufacturing capabilities required for the Acquisition Strategy and facilitate the updates of M&Q

inputs to the Systems Engineering Plan (SEP) and Request for Proposal (RFP) documents. The IB topic areas that should be assessed include:

- Industrial base sources relevant to the program, the contractor, and the contractor's supply chain
- M&Q processes and techniques
- Design producibility risks, issues, and opportunities
- Cyber risks and vulnerabilities to M&Q information and data
- Impacts of materials (e.g., critical, long-lead, etc.)
- Supply disruption risks, issues, and program impacts from critical and strategic materials
- Availability and capability of production machinery, equipment, and tooling
- Development requirements and planned production rates
- Industrial capabilities risks, issues, and opportunities (e.g., single points of failure, fragile suppliers, sole and single sources, etc.)
- Resilience of critical defense industrial base capabilities
- Procurement surges and contractions

D.1 Conduct/Update Industrial Base Assessment and Analyses

During the Operations and Support phase program management is responsible for incorporating industrial base assessments, including capacity and capability considerations, into acquisition planning and execution. Having documented industrial base considerations in the Acquisition Strategy and identified industrial capability problems, the program should initiate an IB mitigation plan that addresses current and future M&Q risks. The plan should address M&Q capabilities that should be maintained throughout program life cycle; mitigate obsolescence, business fragility, supply chain vulnerability, material availability; and address impacts of external dependencies, new and unique capabilities, military vulnerabilities, and rate and quantity changes.

10 USC – Section 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. Acquisition planning and plans shall include considerations of the NTIB for all MDAPs. These considerations should include:

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

In addition, public law requires major defense acquisition programs to conduct an analysis of the capabilities of the national technology and industrial base to develop, produce, maintain, and support the program, including consideration of the following factors related to foreign dependency:

- The availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment for the sustained production of systems fully capable of meeting the performance objectives established for those systems; the uninterrupted maintenance and repair of such systems; and the sustained operation of such systems.
- The identification of major systems and items available only from sources outside the national technology and industrial base.
- The availability of alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base; and an analysis of any military vulnerability that could result from the lack of reasonable alternatives.
- The effects on the national technology and industrial base that result from foreign acquisition of firms in the United States.

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 and helps guide decision-making and the development and implementation of legislation, policy, and programs.

The program office as a member of the Integrated Product Team (IPT) should conduct an IBA or update previous IBAs to satisfy the requirements of 10 USC 4820 and DFAR Subpart 207.1.

Manufacturing and Quality Tasks

- Conduct industrial base assessments as needed, or when they are in danger of being lost.
- Address product and process technology obsolescence, replacement of limited-life items, regeneration options for unique manufacturing processes, and conversion to performance specifications at the subsystem, component, and spares levels.
- Determine whether government alternative action is required to preserve the industrial capability per DoD Handbook 5000.60H, which could include:
    - Take no action
    - Buy from a foreign source
    - Find/develop an alternative source
    - Lifetime buys
    - Smart Shutdown
    - Maintain the current capability

- Identify DoD investments needed to create and maintain access to competitive suppliers for critical areas at the system, subsystem, and component level:
  - Identify ManTech projects
  - Initiate ManTech projects
- Support assessments of the capabilities of the industrial base to support the development, production and sustainment of weapon systems used by U.S. defense forces.
- Support industrial base assessments, which could include the following concerns:
  - Capability to develop, produce, and sustain a capability
  - Capacity to develop, produce, and sustain a capability
  - Financial stability to develop, produce, and sustain a capability
- Support assessments of the ability to meet post-production operational needs (spares, etc.).
- Support assessments related to:
  - Technology obsolescence
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
  - Counterfeit parts
  - Replacement of limited-life items
  - Regeneration options for unique manufacturing processes
  - Conversion to performance specifications at the subsystems, component, and spares levels

Tools

- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- DD Form 2737 Industrial Capabilities Questionnaire
- Defense Industrial Base Assessment Survey OMB 0694-0119
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan

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 Instruction 401, Industrial Analysis
- DCMA Instruction 3401, Defense Industrial Base Mission Assistance

- DoDI 5-000.60, Defense Industrial Base Assessments
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Defense Manufacturing Management Guide for Program Managers, Chapter 2 Industrial Base
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition

D.2 Assess and Manage Industrial Base Risk

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.

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 programs 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 same)?

During O&S, industrial base and technology risk assessment and management considerations must continue to be an integral part of program management and are key to the success of the program through development, production, and sustainment.

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 risk 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.)

Manufacturing risk resolution involves assessing risks through formal technical reviews and in demonstrating the manufacturing capability and maturity. Manufacturing technology development needs to be accomplished in a phased approach to define and demonstrate capabilities. The EMD developer should have demonstrated that the required advanced processes or material capabilities were achievable in a production relevant environment. The objective of the ManTech program is to improve performance while reducing acquisition costs by developing, maturing, and transitioning advanced manufacturing technologies. These ManTech projects or other projects must be implemented in time to support production. The focus is on providing a reasonable expectation that the advanced manufacturing materials and processes, required in EMD and production, can be achieved.

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 controlling 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.

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

When there is an indication that industrial capabilities needed by DoD are endangered, an additional analysis is required as the basis for determining what if any DoD action is required to preserve an industrial capability (*see* DoDD 5000.60 and DoD 5000.60H). Along with this analysis come the identification of risks and the development and implementation of risk mitigation activities.

The risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule is a major risk during this phase.

- Manufacturing and QA personnel should consider industrial surge requirements and capability for operationally expendable items such as munitions, spares, and troop support items. These are surge candidates and should receive close attention and specific planning, to

include the use of contract options.
- Manufacturing and QA personnel should identify production bottlenecks at both the prime and sub tier supplier levels for high use/high volume programs in an asymmetric warfare construct. Consider surge capability in evaluation criteria for contract award.
- If M&Q analysis indicates that industrial capabilities are in danger of being lost to include DMSMS and Obsolescence, the DoD Components should determine whether government action is required to preserve the industrial capability.
- Conduct industrial base risk mitigation.

During the O&S phase the industrial base may include depots, MROs, and other organic activities. There are several manufacturing risk areas for the PM during the O&S phase to include:

- Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Obsolescence
- Counterfeit parts
- Insertion of new technology
- Smart shutdown
- Demilitarization and disposal

DoD investments may be needed to create and maintain access to competitive suppliers for critical areas at the system, subsystem, and component level. When the analysis indicates that industrial capabilities needed by DoD are in danger of being lost, the Components should determine whether government action is required to preserve the industrial capability. They should address product technology obsolescence, replacement of limited-life items, regeneration options for unique manufacturing processes, and conversion to performance specifications at the subsystem, component, and spares levels.

Manufacturing and Quality Tasks

- Conduct assessments of contractor risk planning and management processes:
  - Review assigned roles, responsibilities, and authorities
  - Review processes and procedures
  - Review risk analysis criteria for likelihood and consequences
  - Review traceability of risks to technical requirements and program objectives
- Review contractor identified risks:
  - Identify where in the WBS or process element the risk occurred
  - Identify potential root causes of the risks
- Review contractor risk analysis process:
  - Review contractor assessment of likelihood of occurrence and Impact

- Develop and implement Industrial Base risk mitigation activities per DoD 5000.60H, Chapter 5, Identify and Evaluate Alternative Actions. These risk mitigation plans should address the following:
    - Identify which M&Q capabilities should be maintained throughout the life of the program.
    - Mitigate product or process technology obsolescence, lifetime replacement, or regeneration of items projected to go out of production.
    - Address the approach to making production rate and quantity changes that support a response to contingency and support requirements including surges.
    - Mitigate the vulnerability of the supply chain (to include sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources).
    - Address the availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment (required to include the availability of alternatives for obtaining such items from within the NTIB.
    - Address the risks introduced by new and unique capabilities and processes.
- Support the development of Acquisition Strategies that consider industrial surge requirements and capability for operationally expendable items such as munitions, spares, and troop support items.

Tools

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

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
- Executive Order 15860 Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60, Defense Industrial Assessments

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and Evaluate Alternative Actions
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Defense Technical Risk Assessment Methodology (DTRAM)
- MRL Deskbook, Chapter 5.2 Development of a Manufacturing Maturation Plan
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

D.3 Identify/Update Critical Technology Element (CTE) Requirements

Typically, the program is very mature in the O&S phase but may still require R&D of new technologies to keep weapon systems current with new threats. As a result, the program is constantly looking at emerging threats and emerging capabilities. If there is a gap between requirements and capabilities, then the program may initiate a manufacturing technology (ManTech) development effort to close that gap.

Much of the technology that will be incorporated into the system should be matured during this phase for inclusion or insertion. M&Q should be working closely with the design engineers to evaluate the maturity and feasibility of each new system technology. New system technologies are prone to producibility issues that make them high risk and these technologies may require new manufacturing technologies. Manufacturing technology gaps should be addressed with plans and budget for development, initiation, and insertion points identified along with cost, schedule, and performance impacts. Contractor agreements to utilize completed or successful manufacturing technology projects are essential.

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 being 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.

A systematic process that assesses the maturity of Critical Technology Elements (CTEs) is a DoDI

5000.02 requirement for all acquisition programs. In completing the development of a system or incremental capability, one of the key tasks is to mature Critical Manufacturing Processes (CMPs) associated with KCs, and therefore with CTEs. Manufacturing process demonstrations include affordable and executable manufacturing processes, system fabrication, production of prototypes and first articles that demonstrate system integration, interoperability, supportability, safety, and utility. The focus of demonstrations is on risk reduction in a pilot line environment.

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 that CTE Technology roadmaps traditionally look at:

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

Manufacturing USA and other organizations support the development and advancement of over 700 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 EMD, 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

- Update and assess the identified CTEs for feasibility, affordability, and supportability and for M&Q maturity:
  - Identify mature alternative components or subsystems for each immature CTE
  - Develop plans for increasing CTE M&Q maturity and mitigating associated risks:
    - Update plans to improve and/or maintain maturity from the draft CDD, AS, and SEP (if available)
    - If manufacturing processes need to be updated or developed, plan and budget for the effort to mitigate manufacturing risk
    - Include integration risks associated with the updated CTEs from trade studies
    - Include updates for CTE interdependencies and associated risks
- Update the identified M&Q process areas and process limitations requiring risk mitigation:
  - Include necessary hardware and the associated embedded software maturity
  - Include cybersecurity risks and vulnerabilities (software and firmware)
- Support the Technology Readiness Assessments that benchmark technology risks:
  - Determine the degree of M&Q risks in development
  - Conduct in depth analyses of the M&Q risks associated with the design as needed
  - Develop plans for recommended M&Q risk mitigations to be conducted
  - Implement plans to improve CTE M&Q maturity
- Support the identification of the required Technology Readiness Levels (TRLs) to be achieved for each CTE at each systems engineering milestone (e.g., Critical Design Review (CDR), Production Readiness Review (PRR), etc.).
- Update assessments and analyses of emerging technologies to determine capability of current manufacturing technology, processes, and infrastructure to support system development:
  - Analyze the need (determine gaps) for new manufacturing technologies, processes, and infrastructure
  - Identify required risk mitigation efforts with cost and schedule impacts
- Perform manufacturing technology trade studies that include an assessment of how new and emerging technology might impact product design requirements, affordability, and manufacturing capabilities.
- Update the assessment of identified high risk manufacturing process areas necessary for the program that require investments in ManTech programs:
  - Estimate cost, schedule, and performance impacts

Tools

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

- Independent Technical Risk Assessment Checklist/DTRAM
- Producibility Assessment Worksheet
- Pugh Matrix
- Technology Readiness Assessment (TRA) Checklist
- TRL Calculator

Resources

- Defense Acquisition Program Support Methodology
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- DoD Technology Readiness Assessment (TRA) Guide

D.4 Implement and Manage Manufacturing Technology Projects

Accelerating the flow of technology to the warfighter is one of the top priorities of DoD, services, and agencies. 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.

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 warfighting capability; solves a warfighting 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) 7
- Maturity at end no less than MRL 8
- Clear transition and implementation path to warfighter or to the next funding agent

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.

Based on funding, schedule, and implementation progress, ManTech projects should be updated and managed to achieve program objectives. Projects should address and reduce risks, improve M&Q processes, and improve cost and schedule performance. ManTech projects should be completed, integrated, and demonstrated on a pilot line at the appropriate contractor and/or supply chain facilities.

During the O&S phase, M&Q personnel should focus on continually analyzing risks and identifying risk mitigation measures needed to sustain a reliable, technologically superior, affordable, and resilient defense industrial base. DoDI 5000.60 provides policy and identifies responsibilities for assessing defense industrial capabilities. These assessments ensure that the industrial capabilities needed to meet current and future national security requirements are available and affordable. The industrial base assessment will be used to determine if a specific industrial capability is required to meet DOD needs, and if any action should be taken to ensure the continued availability of the capability.

The effectiveness of actions or investments made in areas of manufacturing capability, obsolescence, fragility, capacity, and resilience to address M&Q industrial base risks to cost, schedule, and performance should be assessed and validated. These results should be incorporated into the joint Risk, Issues, and Opportunity Management System in support of LRIP and Production and Deployment phase. Additionally, the updated M&Q inputs should be included in the industrial base Capabilities Considerations Summary Report for Milestone C.

M&Q managers as members of the Technical IPT need to implement ManTech projects that have been identified in previous studies and gap analysis. ManTech implementation must be managed and completed in a timely fashion to be integrated into the system. ManTech projects focus on efforts to enhance the producibility and manufacturability of defense essential and unique processes or components.

Manufacturing and Quality Tasks

- Manage manufacturing technology projects to plan to ensure that the technologies are inserted into a system or element as appropriate:
    - Review cost, schedule and performance goals and metrics
- Conduct demonstrations of completed ManTech projects to industry in the appropriate facility.
- Implement, monitor, and track manufacturing technology projects at contractor/ subcontractor facility for effectiveness and performance:
    - Demonstrate manufacturing technology development solutions in a production representative environment
    - Continue manufacturing technology efforts for validation on the Pilot Lines
- Update program manufacturing technology plans, including approved and funded ManTech proposals, which should address:
    - Risk reduction manufacturing process areas
    - Improvements in manufacturing processes (cost and schedule)
    - Resulting quality improvements (e.g., Cpks, yields, rates, etc.)
    - Other source manufacturing technology efforts (e.g., Title III, PTACs, MEPs, NIST, etc.)
    - Demonstrations of completed manufacturing technology projects to industry in the appropriate facility
    - Contractor/subcontractor level of participation in the project
    - Scheduled manufacturing technology project insertion at the contractor/subcontractor facility
    - Relevant data collected to support insertion (e.g., DCMA, Title III, etc.)
    - Identified high-risk manufacturing process areas
    - Identified risks and issues with associated event-based mitigation plans
    - Identified manufacturing technology efforts to be funded other sources
    - Any new or emerging manufacturing technology gaps
    - Scheduled completion of manufacturing technology efforts to support program
    - Contractor/subcontractor participation in the project
    - Relevant data to support the plan (e.g., DCMA, Title III, etc.)

    - Review other program portfolios for potential alternatives/solutions (e.g., ManTech, Title III, DARPA, Procurement Technical Assistance Centers (PTAC), Manufacturing Extension Program (MEP), National Institute of Standards and Technology (NIST), etc.)
- Execute approved and funded manufacturing technology projects.
- Monitor and track progress of projects against the goals (e.g., process improvement, quality improvement, etc.)
- Monitor ongoing DoD/Service ManTech projects for potential applicability to program needs.

Tools

- Army ManTech Proposal Rating spreadsheet
- ManTech Phase I project questionnaire
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Independent Technical Risk Assessment Checklist
- Technology Readiness Level Calculator
- TRL Assessment Checklist

Resources

- Defense Production Act, Title III
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Service ManTech guidance (e.g., Air Force Technology and Transition Strategy Guidebook)
- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development, and Investments
- DoD Technology Readiness Assessment (TRA) Guide

E. DESIGN

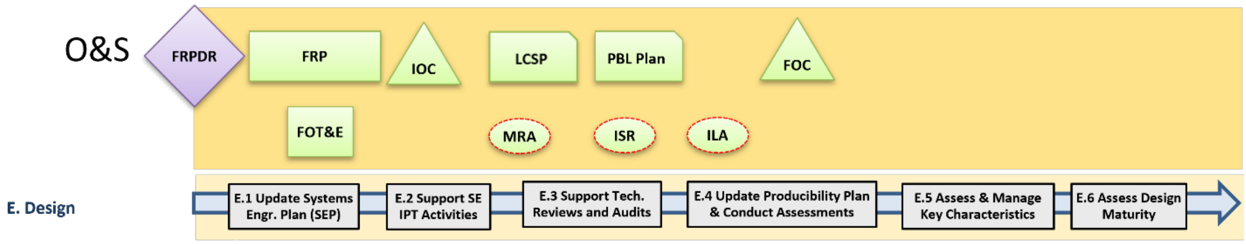


Figure 6-6. Design Manufacturing and Quality Activities

Introduction

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

Table 6-1. 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

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

Manufacturing and quality personnel participation in the program's systems engineering process as a part of the IPTs is critical to succeeding in producibility and affordable system with acceptable risks. Manufacturing and quality industry best practices are integral to design and development efforts in both Manufacturing Management System (MMS) and Quality Management System (QMS) requirements (e.g., AS6500, ISO 9001, AS9100, etc.). The program should integrate M&Q into the product design and development process and engage M&Q expertise throughout the entire life cycle of a system to include the O&S phase. Analyses of design alternatives through trade studies, producibility analyses, and manufacturing feasibility based on program requirements need to be conducted, with results incorporated into the design.

During the O&S phase, M&Q should be assessed to support all sustainment activities and concerns. Sustainment activities supporting system operations should address two major efforts: life cycle sustainment and disposal. This includes continued production and design activities associated with product improvement, technology refresh, life-extension modifications, value engineering activities, and capability enhancements. It should be noted that during the O&S phase design, Product improvement includes the procurement, installation, retrofit, modernization, upgrade, or rebuild of a component or subsystem of a weapon system platform or major end item that would improve the reliability, availability and maintainability, extend the useful life, enhance safety, lower maintenance costs, or provide performance enhancement of the weapon system platform or major end item."

One of the roles of M&Q personnel is to "influence the design." It must be noted that M&Q personnel are not design engineers and thus their role is a supporting role. They need to assess the design to ensure that the design is manufacturable and inspectable/testable. The existing factory floor is a "capability," and a design that cannot be produced on the existing factory floor either requires a design change to match the existing factory floor capability or M&Q personnel must develop new processes that will ensure that the design can be build that results in uniform, defect-free products that are affordable.

Designs should be stable and mature prior to going into production, with design changes limited to those required for continuous improvement. All Key Characteristics should be stable and under control per appropriate quality standards. Any significant design changes should be assessed for maturity prior to release to production.

Contractors and production organizations during the O&S phase may be experiencing the following:

- Ongoing production (no design impact)
- Ramp up or ramp down in production (no design impact)
- Production of spares (no design impact)
- Design changes to meet changing requirements or for continuous improvement
- Changing requirements could indicate a significant design change
- Continuous improvement may involve “tweaking” of the design or manufacturing processes

M&Q activities can be taking place at contractor facilities or at government depots, MRO facilities, or other forms of government facilities. M&Q personnel should advocate continuous improvement. They have numerous opportunities to do so, such as during teleconferences, Program Management Reviews, and fact findings. The effort is not confined to contractors, as personnel can encourage internal improvements at depots and within the program office.

E.1 Update the Systems Engineering Plan (SEP) and Systems Engineering Master Plan (SEMP)

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 is a government document that 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 systems engineering strategy and its relationship with program management efforts. The SEP is updated to reflect changes in the technical approaches stemming from the results of the technical reviews, program reviews, acquisition milestones, or other program decision points. M&Q managers, as members of the SE IPT, should be providing input into the SEP.

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).

The development of the Manufacturing and QA Plan and Strategy should include assessing manufacturing readiness to support the design process and should be integrated into the SEP. A robust, well characterized, and capable factory floor will help to enable the facilities ability to meet the design intent while delivering uniform, defect free product that is affordable. The first consideration is a need to understand the current manufacturing capabilities to see if they match up against the design requirements so that a plan for the enhancements of capabilities where there is a gap between the design and factory floor capabilities.

The manufacturing strategy should include the criteria for determining which production processes will require proofing and the timing of such proofing activity. These processes are often identified during a manufacturing risk assessment or during the design as Key Characteristics. Process proofing can make a major contribution to risk reduction, but it may involve cost and/or potential schedule impacts during the development phase. Maturing manufacturing processes should be documented in a formal Manufacturing Maturation Plan.

Manufacturing and Quality Tasks

- Manufacturing and QA personnel need to support the development and update of the Systems Engineering Plan (SEP) using the following information sources provide important inputs to the Production and Deployment phase systems engineering process:
  - Acquisition Program Baseline
  - Systems Engineering Plan (SEP)
    - Manufacturing Plan
    - Quality Plan
  - Test and Evaluation Master Plan (TEMP)
  - Life-Cycle Sustainment Plan
  - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
  - Programmatic Environmental, Safety, and Occupational Health Evaluation (PESHE)

Manufacturing must assess the detailed production designs, processes, WBS, and schedules must be transitioned from Full-Rate Production to a schedule and rate that can be used to produce spares during sustainment. In addition:

- 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 must assess new analytical methods, tools, and processes for analyzing production schedules against spare parts manufacturing.
- Manufacturing should support developing an overarching WBS framework to identify "smart shutdown" tasks. This would stop Full-Rate Production efforts and change over to a limited spares production capability.
- The planning, execution, and control of the production phase activities require that the work be divided into manageable tasks that are compatible with the existing manufacturing and performance measurement systems. Often, the WBS used during the development phases will not be appropriate for the production phase or for sustainment. Consequently, the contractor should, as a basis for production planning, identify and develop the WBS to be used. While this may differ from the EMD structure, the two should be such that production phase costs can be related to the development WBS, and the sustainment costs can be related to the production costs. This is critical for those programs that have used a design-to-unit production cost management approach during development.
- The objective of the O&S phase is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. When the system reaches the end of its useful life, the department should dispose of it.
- During the O&S phase, systems engineering processes support sustainment efforts using In-Service Reviews (ISRs). ISRs include the identification of root causes of field and other problems, and the development of mitigation strategies for safety and critical readiness on these problems that are degrading performance. Mitigation activities could include participation in trade studies and decision making (e.g., changes to the product support package, manufacturing process improvements, modifications, upgrades, and future increments of the system), considering the operational needs and the remaining service life. Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, Joint or Service commonality, etc. may all indicate the need for a system upgrade(s) or process improvements.
- The last activity associated with the operations and support acquisition phase is disposal. Early systems engineering processes should include and inject disposal requirements and considerations into the design processes that facilitate disposal.

M&Q personnel should ensure that the SEP contains the following manufacturing considerations:

- 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
    - Identification of key and critical manufacturing assembly and test processes
- Integration of manufacturing risks in cost and manpower estimates

Review the contractors SEMP 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.
- Project structure to accomplish activities, information flow, and decision-making:
    - Organization of the development team, along with their physical location
- Identification of Resources.
- Description of Project.
- Description of Work.
- Identification of Communication channels.
- Project structure to accomplish activities, information flow, and decision-making:
    - Organization of the development team, 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.
- Perform assessments and identification of M&Q risks, issues, and opportunities (e.g., technology, manufacturing, cybersecurity, software development, and sustainment) including mitigation.
- Perform and evaluate opportunities to promote DMSMS resilience and the proactive assessment of parts obsolescence risk when selecting parts.
- Communication standards between project management engineering teams.
- Entry and exit criteria of work products during project phases.
- 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

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 SEMP (DI-MGMT-81024 SEMP)
- Interactive MRL Users Guide (Checklist), Design thread
- 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
- Technology Readiness Assessment Checklist
- Integrated Program Management Report (IMPR) DI-MGMT-81861

Resources

- 10 USC 2431a Acquisition strategy
- Acquisition Strategy Guide, DSMC
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- 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, Technical Reviews and Audits on Defense Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Digital Engineering Body of Knowledge
- ASME Y14.5 Dimensioning and Tolerancing
- ASME Y14.41, Digital Product Definition Data Practices
- MIL-STD-31000B, Technical Data Package
- NISTIR 7749, Model Based Enterprise Technical Data Package Requirements
- SD-19, DMSMS Guidebook
- SD-22, Parts Management Guide
- DOD Technology Readiness Assessment Guide
- Manufacturing Readiness Level (MRL) Deskbook
- 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. M&Q personnel, as members of the SE IPT, should participate in the eight technical processes and eight technical management processes.

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 16 processes: eight technical management processes and eight technical processes. These 16 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.

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. A 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.

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 a 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 is included in a 3D CAD model or file. PMI includes the following:
    - Bill of materials (BOM)
    - 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 the ability 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

Major programs are organized around core design teams, usually comprised of 20-50 of the contractor’s best engineers. This core design team makes 90-95 percent of all critical decisions with most design decisions made prior to production. If M&Q are not one of their primary concerns, then these considerations will be delegated to secondary teams or not accomplished until late in the program causing serious problems with cost, schedule, and performance.

The PM and Technical team need to ask M&Q questions and ask them often. The contractor will follow the government's lead. If the government shows concern for these areas in the development of the design and integration with M&Q, then the contractor receives the message and will show concern. Manufacturing and QA personnel must participate with the Design IPT in the development and review of the design and design documentation.

Major design updates can occur during the O&S phase as programs bring on new capabilities and technologies. Programs are organized around a core design team, usually composed of 20-50 engineers. This core design team makes 90-95 percent of all critical decisions with most design decisions made prior to production. If M&Q are not one of their primary concerns, these considerations will be delegated to secondary teams or not accomplished until late in the program, causing serious problems with cost, schedule, and performance.

The PM and technical team need to ask M&Q questions and ask them often. The contractor will follow the government’s lead. If the government shows concern for these areas in the development of the design and integration with M&Q, then the contractor receives the message and will show concern. Manufacturing and QA personnel must participate with the Design IPT in the development and review of the design and design documentation.

Manufacturing and Quality Tasks

- Participate in the Systems Engineering process along with other members of the Design Integrated Product Team (IPT).

- Ensure adherence to appropriate M&Q requirements and best practices.
  - AS6500 Manufacturing Management Program and AS9100 Quality Management Program
  - Identify and assess opportunities to promote advanced manufacturing technologies and techniques
- 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)
  - 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
- Support and participate in ongoing Design IPT activities that demonstrates:
  - Producibility has been assessed and integrated with other design activities.
  - Key and critical manufacturing assembly and test processes have been identified, evaluated, and matured.
  - All risks (technology, manufacturing, software development, and sustainment) have been assessed.

  - Metrics and data to assess, monitor, manage and control the transition process have been developed.
  - Manufacturing and quality engineers participate in engineering IPTs.
  - Identify and assess opportunities to promote advanced manufacturing technologies and techniques

- Develop and implement formal digital engineering processes, practices, tools and guidance into systems engineering IPT activities throughout the life cycle of a program and integrate these activities into the programs' plans and schedules.
- Provide inputs to any design trade studies.
- Provide inputs into the Producibility Program and processes that impact producibility.
- Review current design best practice includes digital engineering, digital twins, and defining the authoritative source of program data. This includes use of computer-aided design (CAD) and computer-aided manufacturing (CAM).
- Provide inputs to any engineering trouble analysis on factory floor problems (FTA, FMEA, PFMEA, etc.) or on field failures (FRACAS, etc.).

Tools

- Interactive MRL Users Guide (Checklist) for the Design thread
- Life Cycle Sustainment Plan outline
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline
- 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
- IMP/IMS template
- Test and Evaluation Master Plan (TEMP) template
- Life Cycle Sustainment Plan (LCSP) template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Technology Readiness Assessment Checklist

Resources

- AS9100, Quality Management Program
- AS9103, Variation Management of Key Characteristics
- AS6500, Manufacturing Management Program
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H Assessing Defense Industrial Capabilities
- 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
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- Digital Engineering Body of Knowledge
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Defense Acquisition Guidebook, Chapter 4 – Life Cycle Sustainment
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- Life Cycle Sustainment Plan (LCSP) memo
- MRL Deskbook
- DOD Technology Readiness Assessment Guide
- Systems Engineering Plan (SEP) Outline

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.

During the O&S Phase there may be no formal technical reviews, however there may be an opportunity to conduct an In-Service Review (ISR), and Manufacturing Readiness Assessment (MRA). The ISR is A multi-disciplined product and process assessment to ensure the system under review is operationally employed with well-understood and managed risk. This review is intended to characterize the in-service technical and operational health of the deployed system. It provides an assessment of risk, readiness, technical status, and trends in a measurable form. M&Q personnel should be actively engaged in these technical reviews and audits as appropriate.

Manufacturing and Quality Tasks

- Develop and implement formal digital engineering processes, practices, tools and guidance into systems engineering IPT activities throughout the life cycle of a program and integrate these activities into the programs' plans and schedules.
- M&Q personnel should support the conduct of any ISRs, and concerns include:
  - Status of any modernization activities on the system, subsystem, components or equipment
  - Status of any funding that may impact M&Q activities
  - Any concerns or risks associated with DMSMS, obsolescence, or counterfeit parts
  - Concerns with technical data on aging systems
  - Configuration management on managing fleets of systems of different configurations
  - Material readiness that may be impacted by M&Q operations
  - Operational readiness that may be impacted by M&Q operations at OEM sites
  - Supply chain considerations that may impact operational requirements

- M&Q personnel should support the conduct of the MRA, and the following concerns:
  - See MRA checklist
- M&Q personnel should support the conduct of the TRA (if any), and the following concerns:
  - See TRA checklist

- Ensure that production equipment is maintained, and this translates to a high overall equipment effectiveness (OEE) rate and is accounted for in determining the availability of the equipment and contingency plans.

Tools

- In-Service Review (ISR) Checklist
- Technology Readiness Assessment (TRA) Checklist
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan

Resources

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook, Chapter 3 Technical Reviews and Audits
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- ISO 9001:2015, Quality Management System
- 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
- Technology Readiness Assessment (TRA) Guidance

E.4 Update Producibility Planning and Conduct Assessments

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 engineering and planning (PEP) program should be defined contractually and contain specific tasks and measurable performance that will support an orderly transition. PEP progress should be tracked by means of production readiness reviews required before initial or full production decisions. The objective of a transition plan is to provide visibility of how well each activity is being executed. Progress should be regularly compared against the transition plan.

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 a 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.

During this Phase, the PM should conduct producibility assessments to reduce manufacturing risk and demonstrate producibility prior to FRP. A strong producibility emphasis early in design will minimize the time and cost required for successful transition to production and will ensure that production items are more reliable and dependable.

Manufacturing and Quality Tasks

- Complete producibility assessments.

- Utilize producibility tools, techniques, procedures, and associated metrics that include:
    - State-of-the-art Modeling and Simulation software
    - Failure Modes and Effects Analyses (FMEA)
        - Fault Tree Analysis (FTA)
        - DFMEA
        - SFMEA
        - PFMEA
    - Design for Manufacture and Assembly (DFMA)
    - Design of Experiments (DOE)
    - Design for Six Sigma
    - Quality Function Deployment (QFD)
    - Advanced Product Quality Planning (APQP)
    - Production Part Approval Process (PPAP)
    - Benchmarking
    - Design guides
    - Interdependencies and integration analyses
    - Tolerance analyses
    - Requirements validation analyses
    - Trade studies on alternative product and process designs
    - Product complexity analyses
    - Safety analyses
    - Manufacturing process analyses
    - Quality and quality process analyses
    - Measurement System Analysis
    - Costs, cost drivers, and controls analyses
    - Materials characterization and availability
    - Prototyping of components, items, subsystems, competitive, etc.
    - Learning curve goals and projections
    - Product and process measurements utilizing Statistical Process Control (SPC)
    - Data and database management
    - Testing
- Provide input into the Life Cycle Sustainment Plan (LCSP):
    - The LCSP should contain requirements for a Producibility Plan
- Provide input to the Product Support Strategy (PSS).
- Provide input into producibility/design reviews, systems engineering, and trade studies for Sustainment planning.
- Review contractor/governments plans for producibility planning.

- Ensure the producibility plan describes how design engineers will apply producibility principles.
- Identify specific producibility engineering techniques (Design for Manufacturing and Assembly (DFMA), Design for Reliability and Maintainability, Design for Six Sigma (DFSS), DfX, etc.) that the contractor could use to enhance producibility outcomes.
    - Advanced Product Quality Planning (APQP)
    - Production Part Approval Process (PPAP)
- Support the identification and management of key characteristics (KCs).
- Support the identification of producibility risks and issues.
- Assess producibility considerations at the following technical reviews and audits (DoD Producibility Guide, Draft):
    - Production Readiness Review
    - Physical Configuration Audit
    - Manufacturing Readiness Assessment
    - Technology Readiness Assessments

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 Manufacturing and Assembly (DFMA)
- CAD/CAM software
- Physical Configuration Audit Checklist
- Quality Function Deployment (QFD)
- Critical Path
- Make/Buy Decision
- Fault Tree Analysis
- Failure Modes and Effect Analysis (FMEA)
- Process Failure Modes and Effects Analysis (PFMEA)
- Design Failure Modes and Effects Analysis (DFMEA)
- Preliminary Hazards List
- Pugh Matrix
- Technology Readiness Assessment Checklist

- Six Sigma and Lean Techniques

Resources

- 10 USC 144B, Sec 2366 and 2448
- DoD Producibility 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-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
- 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
- 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
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896A, Manufacturing Management Program Guide
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- AS9103, Variation Management of Key Characteristics
- ASTM E2782-17 Standard Guide for Measurement Systems Analysis
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1629A Failure Modes Effect and Critical Analysis
- SAE J1739, Potential Failure Mode and Effects Analysis (FMEA) including Design (Design FMEA), and Processes (Process FMEA)
- DoD Technology Readiness Assessment (TRA) Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning (PEP)

E.5 Manage Key Characteristics

A characteristic is a dimension or a physical, chemical, electrical, mechanical, or visual feature of a part defined by design data. A characteristic must be measurable, either directly or indirectly, and either variable or attribute data types. Characteristics, per AS9100/EN-9100/JISQ 9100, are defined as:

- *Key Characteristics for a part, subassembly, of system ate those selected geometrical, material properties, functional and/or cosmetic features, which are measurable, whose variation control is necessary for meeting Customer requirements and enhancing Customer Satisfaction.*
- *Key Characteristics for a process are those selected measurable parameters of a process whose control is essential to manage variation of part or system Key Characteristics.*

The organization which provides engineering drawings, specifications, or purchase order/contract requirements is responsible for identifying and managing KCs. KCs apply to all levels of parts within an assembly, and to any organization responsible for producing the design. In addition, those organizations are required to flow down the requirement to identify, manage, and control KCs to subcontractors who produce design characteristics. In addition to KCs, you should be aware of:

- Critical: A critical characteristic is defined by AS6500 as a characteristic that is likely, if defective, to create or increase a hazard to human safety, or to result in failure of a system to perform a required function.
- Significant: Significant characteristics are defined as feature, dimension, or note that anticipated variation could affect principal fit, function, durability, customer satisfaction, or manufacturability.

Key and critical product characteristics and features are the output of key and critical M&Q processes. Consequently, to achieve program goals it is important for the contractor to identify these early in the system design and development effort and then control these characteristics during production. Key and significant characteristics are identified and defined in DFMEA and PFMEA and have a relation with the cause and effect of potential failure modes.

AS6500 defines a critical manufacturing process as a process that creates or affects a key or critical characteristic. KCs and critical characteristics and the associated manufacturing processes may be produced or accomplished at a sub-tier supplier. Both the contractor and the program office should have a top-level understanding of KCs.

AS9103 is the industry best practice of the identification and control of Key Characteristics and requires the producer to maintain documentation of Key Characteristics and control those manufacturing processes that directly influence variation of those Key Characteristics. Key Characteristics should be capable and have a Cpk of 1.33 or greater or as specified by the customer.

The concept of identifying key characteristics is linked to the Pareto principle, which asserts that a small number of features will have the most significant impact on performance.

Products perform better when there is less variation on the key and critical characteristics. M&Q personnel may be called to support the identification and management of key characteristics. Contractors and organizational design activities should be identifying key product characteristics on engineering drawings and specifications. A strong emphasis early in the design phase on:

- Configuration control,
- Key and critical characteristics processes,
- Risks, issues, and opportunities (RIO) management,
- M&Q capabilities, feasibility, and producibility, contribute to reduce the time and cost required for successful transition to production.

Organizations responsible for identifying, managing, and controlling KCs should follow the following management stages:

1. Understand KC and required performance
2. Plan for a manufacturing process that will produce acceptable performance
3. Operate the process to generate data
4. Analyze the data to identify appropriate action
5. Take action to improve
6. Continue to monitor performance

M&Q program personnel should monitor and assess the maturity of KCs and critical characteristics, as well as the associated M&Q processes, and risk and issues mitigation activities. The correctness, adequacy, and completeness of key and critical processes for KCs and critical characteristics should be verified as part of this monitoring and assessment of maturity to include the closure of post-PDR M&Q mitigation measures.

Manufacturing and Quality Tasks

- M&Q personnel will assess technical processes based on assessments of manufacturing feasibility, capability analyses, producibility, and KC analyses, in accordance with industry best practices (e.g., AS6500, AS9100, etc.) and assess readiness for the CDR (per IEEE 15288).
- 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.
- Design KCs have been identified, are being tracked and managed, and mitigation plans developed.
- All KCs are controlled in LRIP to appropriate quality levels.
- Support the identification and management of Key Characteristics to ensure that they are under control.
- The manufacturing process should be identified, documented, and put under statistical control.
- Process capability (i.e., Cpk) studies should be accomplished to demonstrate process maturity.
- Key Characteristics (KC) risk issues should be identified, and mitigation plans developed and put into place.
- Key Characteristics should be assessed to ensure that they are attainable based upon production demonstrations.
- Process producibility improvements should be ongoing.
- All KCs should be controlled in FRP to appropriate quality levels.
- A Manufacturing Readiness Assessment should be conducted to assess KCs.
- Manufacturing processes should be re-assessed as needed for capability to test and verify potential influence on Operations and Support.

Tools

- Interactive MRL Users Guide (Checklist), Design thread
  - Critical to Quality Tree
  - Failure Mode and Effects Analysis
  - Process Capability Analysis Worksheet
  - Producibility Assessment Checklist
  - Technology Readiness Level (TRL) Assessment Checklist

- Manufacturing Maturation Plan
- AS9100 Checklist
- AS6500 Checklist
- Systems Engineering Plan (SEP) Outline
- Design for Manufacturing and Assembly (DFMA)
- Quality Function Deployment (QFD)
- Fault Tree Analysis
- Failure Modes and Effect Analysis (FMEA)
- Process Failure Modes and Effects Analysis (PFMEA)
- Design Failure Modes and Effects Analysis (DFMEA)
- Physical Configuration Audit Checklist
- Producibility Assessment Checklist
- Technology Readiness Level Assessment Checklist
- Technology Readiness Assessment Calculator

Resources

- 10 USC 144B, Sec 2366 and 2448
- DoD Producibility/Manufacturability Guide (Draft)
- NAVSO P-3687, Producibility System 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-727, Design Guidance for Producibility
- Producibility System Guidelines, Missile Defense Agency
- Design for Manufacturability Handbook, Bralla
- AS9100, Quality Assurance Management
- AS9103, Variation Management of Key Characteristics
- AS9102 First Article Inspection Requirements
- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- 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
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.5.1.12 Key Characteristics
- SAE J1739, Potential Failure Mode and Effects Analysis (FMEA) including Design (Design FMEA), and Processes (Process FMEA)
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis
- DoD Technology Readiness Assessment (TRA) Guide

E.6 Assess Design Maturity

Design maturity has not been a well-defined concept and nor is any DoD instruction, regulation, or other guidance, nor is program maturity. Design maturity may be measured when a product design and associated product meets cost, schedule, and performance targets, and satisfies the user. Performance targets should be associated with MOEs, MOPs, KPPs, KSAs and TPMs. These performance measures can be evaluated during product demonstrations using various validation or testing techniques, and during major program or technical reviews or audits.

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 separate "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.

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

- Requirements process structured and complete:
  - Requirements management process documented in the SEP
  - Stakeholder requirements definition complete
  - Requirements analysis complete (see requirements roadmap worksheet)
  - Requirement changes managed
- The following inputs to the SE requirements process have been established and mapped to:
  - Measures of Effectiveness (MOE)
  - Key System Attribute (KSA)
    - Measures of Performance (MOP)
  - Key Performance Parameters (KPP)
  - Technical Performance Parameters (TPMs)
- Requirements Correlation Table (RCT) or Requirements Correlation Matrix (RCM) established:
  - Key Performance Parameters (KPP)
  - Technical Performance Parameters (TPMs)
- Requirements traceability complete from the TPMs for the Preferred System Concept (PSC) and to the WBS configuration items:
  - Bi-directional
  - Utilizing appropriate traceability matrix
- Technical planning is complete:
  - Eight Technical Processes
  - Eight Technical Management Processes
- Systems Engineering processes are mature:
  - Systems Engineering Capability Model

- 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.
- Requirements are stable
- The design is stable:
  - Number of design changes
  - Design released to production
- The Work Breakdown Structure (WBS) has been established (Program and Contract)
- Configuration management used to manage:
  - Functional Baseline using the Functional Configuration Audit around the time of the PDR
  - **Allocated Baseline (see CDR)**
  - Product Baseline using the Physical Configuration Audit. System level prior to the Full Rate Production Decision
- Contractor utilizes appropriate engineering tools and processes to create a mature and producible design

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)

The design should be stable and mature as the product moves into the O&S phase and may be considered mature when the number and type (Class I and Class II) of engineering change traffic is tapering off and when the drawing packages have been released to manufacturing. The configuration of the item should be stable as should be the requirements.

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

Manufacturing and Quality Tasks

- Support the assessment of the design's stability.
- Encourage contractors to continually improve their processes and products and change from rate production to limited production of spares.
- Monitor field failures and the potential for design changes due to a variety of problems (Field Failure Reports, etc.).

Tools

- Integrated Master Plan/Integrated Master Schedule assessment
- Acquisition Program Baseline (APB) Template
- 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
- Technology Readiness Assessment Checklist
- Fault Tree Analysis (FTA)
- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- Tolerance Design

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Plan Preparation Guide
- AS6500, Manufacturing Management Program

- MIL-HDBK-896, Manufacturing Management Program Guide
- DCMA-INST-204, Manufacturing and Production
- AS9100, Quality Management Program
- ISO 9001, Quality Management System
- AS9103, Variation Management of Key Characteristics
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- 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
- 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
- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- MIL-STD 882E, System Safety
- Capability Maturity Model Integration (CMMI)
- MRL Deskbook
- Engineering of Defense Systems Guidebook
- DoD Systems Engineering Guidebook
- MIL-HDBK-727, Design Guidance for Producibility
- MIL-STD-881, Work Breakdown Standard
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis
- DoD 4245.7-M, Transition from Development to Production, Chapter 3 – Design
- NAVSO P-3687, Producibility Systems Guidelines
- Design for Six Sigma Memory Jogger
- Principles and Guidelines for Design for Manufacturing and Assembly
- Taguchi Robust Design/Six Sigma Guide
- DoD Technology Readiness Assessment (TRA) Guide

F. COST AND FUNDING

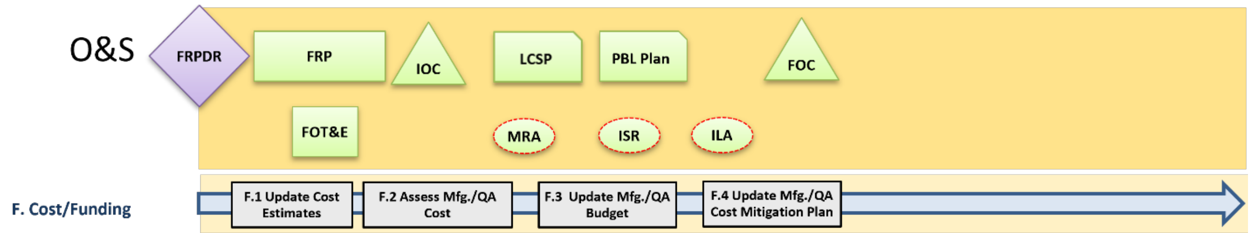


Figure 6-7. Cost and Funding Manufacturing and Quality Activities

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 separate "common elements" appendix. Cost breakouts by WBS elements are useful to the program office and contractors in managing the program.

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

- Contract Performance Dataset (CPD)

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

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

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

F.1 Update Manufacturing and Quality Cost Estimate

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 produce 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

A cost analysis requirements description (CARD) is used to formally describe the program for the purpose of preparing the DoD Component Cost Estimate and the Independent Cost Estimate. M&Q cost estimating is a process used to predict life cycle manufacturing costs based upon the capabilities and processes to produce and support the components of a system. M&Q specialists within the program predict system costs using the results of trade studies and probable process yields. M&Q should-cost inputs should be provided to the Cost Analysis Requirements Document (CARD) to update it for consistency with the approved system specification.

Work Breakdown Structure and Estimate Structure

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

Cost Estimating Process

1. Define the program to be used to prepare the cost estimate.
2. Identify the basis for the cost estimate to include the scope (level of detail), framing assumptions, ground rules, calendar years to express costs, life-cycle phases to be estimated, level of detail, need for what-if analysis, and anything else that influences how the estimate is performed, as well as the schedule for the completion of the cost estimate.
3. Cost data or elements: Data is the heart of the estimate and must include the identification, validation, normalization, and analysis of quality data influence all of the remaining steps in the cost estimating process.
4. Methods/Models: The selection of the best cost/schedule estimating methods. The estimating methods address a variety of applicable influences such as the effects of weight, volume, and power; quantities produced (learning curve and rate effects); quantities per year; phasing; and many others. The time and availability of data required to implement the method is a consideration when selecting methods.

5. Initial Results and Iterations: The estimate or model now must be validated, and this process could include:
    a. Cross-check: 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.
    b. Sensitivity: Tests the model's ability to estimate the impact on total cost by changing a specific cost driver.
    c. What-if Analysis: Tests the model's ability to estimate the impact of changing a variety of cost drivers that define a specific alternative.

Cost Estimating Techniques

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

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

Manufacturing cost estimates for the production phase are normally based on the assumption that the design is complete, that the manufacturing processes are known, stable and in control, and manufacturing operations will be accomplished as planned. The same hold true for the O&S phase. However, the O&S phase may see several changes to the P&D model.

- Full-Rate Production may not continue, and if it stops and the contractor is only producing spares, then the unit cost may go up.
- Work may be done at a public or private organization

Typically, in any industry, materials and labor are the two biggest manufacturing cost drives. Another major factor is rate and quantity. During the O&S phase several changes often take place that impact costs, such as changes to rate and quantity as the contractor's original rate from Full-Rate Production goes down, and most of their production is in support of spares. There may also be changes to the supply chain as contractors either move in and out of business or contractors look for lower prices and higher quality.

During this phase should-cost management and other techniques will be used continuously to control and reduce costs. Employ a should-cost management and analysis approach to identify and implement system and enterprise sustainment cost reduction initiatives. Should-cost targets will be established and reviewed periodically based on analysis of acquisition sustainment costs and O&S cost element drivers. PMs will capture product support metrics and cost data in DoD Component- and DoD-level information systems, and track performance against should-cost targets.

Any deviation from these assumptions could cause a growth in cost. As such, time and conformance measures can give some indication of potential or real cost aberrations since there is normally a direct correlation between late delivery or conformance problems and cost.

M&Q cost estimates for the O&S phase are normally often based on actual costs that were experienced during the Production and Operations phase, the costs associated with Full-Rate Production (FRP). Cost associated with FRP should be well known, however, during the O&S phase, the contractor may not be producing product or spares at the same rate and the contractor may not be in Full-Rate Production, so the cost may be higher. Or the O&S costs are now associated with depot-level work, and because the throughput is lower and thus the cost per unit to remanufacture may be higher.

Detailed cost estimates need to be established or updated. Costs could be related to contractor or depot/MRO activities and products. Historical cost estimates based on Full-Rate Production quantities may not be appropriate for the O&S phase.

During the O&S phase, the manufacturing cost estimate should be based upon application of detailed manufacturing standards and learning curves to the operations being performed and adjusted, as necessary, by realization factors or actual costs. At this phase learning should be flat and may even go up as rates and quantities may go down or as system updates are being made.

Manufacturing and Quality Tasks

- Establish cost models for the O&S phase based on the planned rates and quantities:
  - Cost Analysis Requirements Description (CARD)
  - 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:
  - Cost estimate includes all life cycle costs (sustainment, disposal, and demil)
  - 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

- 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.
- Review and assess the work allocation by a contractor or the government, and at a production facility or at an organic activity (depot, arsenal, shipyard, fleet readiness center, or MRO).
- Assess whether DoD investments are going to be needed to create or enhance certain critical industrial capabilities.
- Track expenditures and estimate to complete using approved techniques such as Earned Value Management System analysis, or its predecessor Cost/Schedule Control System (C/SCS) during sustainment operations.
- Help develop sustainment performance requirements to include metrics such as:
  - Learning Curves
  - Work Measurement
  - Line of Balance
  - Manufacturing Cycle Times
- Cost/Schedule Control Systems Criteria (C/SCSC) or Earned Value Management (EVM). This includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.
- Assess contractor performance where progress or performance-based payments are in effect:

  - During production and into sustainment, manufacturing should support performance-based payment events such as award fees, manufacturing/production incentives, and learning curve analysis
- Encourage contractors to continually improve their processes and products during regular program meetings, formal program reviews, fact-finding activities, etc.

Tools

- Interactive MRL Users Guide (Checklist), Cost thread
- Cost Analysis Requirements Description (CARD) template
- Program Office Estimate (POE) ADDM Template
- Acquisition Requirements Roadmap Tool (ARRT) Cost Estimating Worksheet
- Joint Agency Cost Estimating Development Handbook
- DCAAM 7640.1 DCAA Contract Audit Manual, Chapter 9 Audit of Cost Estimates and Price Proposals
- ONR Cost Proposal Worksheet
- DARPA Cost Proposal Worksheet
- Contract Audit Manual, Chapter 9 Audit of Cost Estimates and Price Proposals
- Earned Value Management (EVM)
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Funds Management Platinum Card
- Analogy and Parametric Estimating Techniques
- Manufacturing Cost Estimating Worksheet
- *See* CAPE website for tools http://www.cape.osd.mil/

Resources

- 10 USC Section 2334 Independent Cost Estimation and Cost Analysis
- 10 USC 2337a Assessment, Management, and Control of Operating and Support Cost for Major Weapon Systems
- 10 USC 2337, Life-cycle management and product support (b)(2)
- 10 USC 2336a, b and c MDAP Submissions to Congress for Milestone A, B and C
- DoD Cost Estimating Guide
  - Department of the Army Cost Analysis Manual
  - AFI 65-508 Cost Analysis Guidance and Procedures
  - DON Cost Estimating Guide
  - Missile Defense Agency Cost Estimating and Analysis Handbook
  - DoD Operations and Support Cost Estimating Guide
- Air Force Life-Cycle Management Center Standard Process for Cost Capability Analysis
- DCMA-INST-213 Technical and Pricing Support

- DCMA-INST-120 Pricing and Negotiation
- DCMA-INST-123 Cost Monitoring
- DCMA-ANX-213-01 Technical Support to Negotiations
- DoDI 5000.01, The Defense Acquisition System
- DoDI 5000.02 Operation of the Adaptive Acquisition Framework
- DoDI 5000.04 Cost and Software Data Reporting
- DoDI 5000.73 Cost Analysis Guidance and Procedures
- DoDI 5000.80 Operation of the Middle Tier of Acquisition (MTA)
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.97, Digital Engineering
- DoDD 5000.04, DoD Cost Analysis Improvement Group (CAIG)
- 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
- 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-502A, Product Support Analysis
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Should-Cost and Affordability Memo
- GAO Cost Estimating and Assessment Guide
- Life-Cycle Sustainment Plan Outline

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 over $100M and includes the following deliverables:

Table 6-2. 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. 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 contractors 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.

Sustainment is a major focus during the Operations and Support (O&S) Phase. Organizations need to identify root causes for field failures and provide resolutions for safety and critical readiness issues that degrade military readiness. These efforts include participating in Trade Studies and decision-making relative to changes to the product support package, process improvements, system, sub-system or component modifications, upgrades, and future increments of the system. All these changes need to consider the operational needs and the remaining expected service life, Interoperability or technology improvements, parts or manufacturing obsolescence, aging aircraft (or system) issues, premature failures, changes in fuel or lubricants, and Joint or service commonality. Cost drivers could be high-cost items, or items that have high manufacturing costs due to several factors (long processing times, low yield rates, etc.). These cost drivers need to be updated.

Manufacturing and Quality Tasks

Support the assessment of M&Q cost:

- Support the assessment of M&Q Cost based upon the Program Office Estimate (POE), sometimes referred to as Life-Cycle Cost Estimate, as well as other cost estimates and actual costs:
    - Identify how cost estimates were developed (Analogy, Parametric, etc.)
    - Identify M&Q expertise with cost estimating experience
    - Identify M&Q cost drivers
- Assess Program plan and schedule against the Integrated Program Management Report or other contractor scheduling reports.
- Assess the Manufacturing Plan and Schedule.
- Utilize Earned Value Management (EVM) or other cost, schedule, and performance reporting to assess Budgeted Cost of Work Scheduled against Budgeted Cost of Work Performed.
- Utilize Earned Value Management (EVM) or other cost, schedule, and performance reporting to assess Actual Cost of Work Performed:

  - Identify and assess Schedule Variance
  - Identify and assess Cost Variance
- Review and assess Direct Cost:
  - Direct Material
  - Direct Labor
- Review and assess Indirect Cost:
  - Indirect Material
  - Indirect Labor
- Identify and assess Overhead Cost.
- Identify and assess M&Q cost related measures and metrics:
  - Learning curves
  - Work measurement
  - Throughput
  - Capacity utilization
  - Overall equipment effectiveness
- Identify original cost estimate and compare it to actual cost.
- Support the review and assessment of the following cost documents:
  - Cost and Software Data Report Plan, DD Form 2794
  - Contractor Cost Data Summary Report DD Form 1921, should be viewed to at least the third level of the WBS
  - Functional Cost-Hour Report, DD Form 1921-1
  - Progress Curve Report, DD Form 1921-2
  - Sustainment Functional Cost-Hour Report
  - Contractor Business Data Report, DD Form 1921-3
  - Cost and Hour Report (FlexFile),
  - Technical Data Report

- Identify manufacturing cost and cost drivers, and then continuously control and reduce costs.
- Use the actuals generated to update Sustainment costs to determine new cost drivers and to validate funding estimates.
- Assess risks and the costs associated with those risks.
- 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.
- Employ should-cost management and analysis approach to identify and implement system and enterprise sustainment cost reduction initiatives:
  - Employ other cost reduction initiatives (Lean/Six Sigma, etc.)

- Periodically establish and review cost targets based on analysis of acquisition sustainment costs and O&S cost element drivers.
- Support the PM to capture product support metrics and cost data and track performance against should-cost targets.
- Conduct cost analysis and cost reduction programs for subcontractors and vendors.

Tools

- Cost Analysis Requirements Description (CARD) template
- DoD Program Office Estimate Template
- Acquisition Requirements Roadmap Tool (ARRT) Cost Estimating Worksheet
- Cost Analysis Requirements Description (CARD) Template
- Earned Value Management (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
- 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
- Cash Flow Tool for Evaluating Alternative Finance Arrangement
- DFAR Subpart 232.10, Performance-Based Payments
- DoD Progress-Based Payments Tool
- Interactive MRL Users Guide (Checklist), Cost 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 Manual 5000.04 Cost and Software Data Reporting
- DoD 5000.04-M-1 Cost and Software Data Reporting Manual
- 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 (CAPE)
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Earned Value Management Implementation Guide
- Cost/Schedule Control System Criteria Reference Guide
- Guidelines for the Preparation and Maintenance of CARD Tables
- Cash Flow Tool for Evaluating Alternative Finance Arrangement
- DFAR Subpart 232.10, Performance-Based Payments
- DoD Progress-Based Payments Tool
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- 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
- Manufacturing Readiness Level (MRL) Deskbook

F.3 Prepare/Update 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 request and obtain resources to execute the mission. The budget process involves budget formulation and budget execution.

Budget estimates are developed to justify future production expenditures, and these estimates are often based on the rate and quantity of production units. Rate being how many a day, week, or month the contractor is planning to produce, and quantity is the grand total of units to be produced. Rate and quantity drive the process layout of a factory and impact the costs per unit. Identifying these factors will help to identify where manufacturing investments may be needed. There could be investments in facilities, capital equipment, training and certification of personnel, or money to improve current production processes and performance.

When preparing budgets for the O&S budgets, services and agencies focus on sustainment activities and finally on disposal and demilitarization. M&Q personnel need to focus on budgets that support various manufacturing and quality activities and investments that support sustainment, disposal and demil. Budgets should include an investment strategy that includes long lead funding for capital equipment, facilities, new processes, new materials, workforce development, sustainable manufacturing, supply chains, ManTech, continuous process improvements, and digital engineering efforts such as Industry 4.0 capabilities, etc.).

Manufacturing and Quality Tasks

Support the development and management of M&Q Budgets:

- Program budget/estimate:

  - Manufacturing (direct materials/labor, indirect materials/labor, overhead, etc.)
  - Quality (personnel, operating expenses, training, inspection and testing, equipment, facilities, etc.)
  - Special projects (ManTech)
- Investments required for the system/subsystem/component:
  - 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
- Support the development of a program budget estimate for achieving FRP:
  - Program estimate should support cost for achieving MRL 9 by the FRP decision point
- Identify manufacturing costs and cost drivers associated with design alternatives considered in trade-off process.
- Evaluate the ongoing manufacturing technology investments (ManTech programs) for sufficiency to meet program objectives (e.g., EMD, P&D, and O&S):
  - 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.
  - Include sponsored initiatives in the program budget and from other sources
- Update manufacturing cost drivers for "Should-Cost" and other models.
- Support “Should-cost” activities.
- Develop manufacturing mitigation plans for outstanding MRL 9 risk areas that impact budget estimates and actual costs.
- Ensure that all program budget estimates include investment for LRIP and FRP.
- Assess the affordability and executability of the manufacturing processes.

- Determine the risks to affordably to develop, manage and execute required manufacturing processes for each identified prototype.
- Analyze the identified risks.
- Integrate the individual risks identified for each prototype into a cumulative assessment of the ability to affordably install and execute the proposed manufacturing processes.
- Document and provide the cumulative assessment of the ability/risk to affordably install and execute the proposed manufacturing processes.
- Analyze the adequacy, reasonableness and necessity of contractor-proposed manufacturing labor hours and material costs.
- Recommend quality and manufacturing cost reduction initiatives.
- Provide accurate cost performance versus target analysis and assessment of identified trends.
- Analyze the quality, manufacturing, and production cost data against cost targets, and identify trends.
- Identify and provide quality, and manufacturing cost/funding estimates and recommendations on emerging requirements.
- Identify manufacturing investment opportunities and develop investment roadmaps for achieving the manufacturing development efforts.
- Develop funding and budgeting request for quality and manufacturing initiatives.
    - Identify emerging quality and manufacturing initiatives.
    - Develop program estimates for applicable quality and manufacturing initiatives.
- Develop and manage industrial base investment programs that create, expand, or preserve assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense.
- Assess cost models and validate them based against actual FRP cost.
- FRP cost goals should be assessed.
- Production budgets should be developed that support production at the required rates and schedule.

Tools

- Manufacturing Cost Estimating Worksheet
- Interactive MRL Users Guide (Checklist), Cost thread
- Technology Readiness Level Assessment Checklist
- 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

- DoD Operating and Support Cost Management Guidebook
- 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
- 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
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- *See* CAPE website for guidance http://www.cape.osd.mil/

F.4 Develop Manufacturing and Quality Cost Mitigation/Maturation Plan

Numerous GAO reports highlight cost growth on DoD weapon system programs. The growth in cost was often matched by a slip in schedule and higher development risk. Cost growth is often linked to the lack of technical maturity, lack of design maturity, and lack of production maturity.

- Technologies often did not have the time, funding, and other resources to match customer needs, with critical technologies demonstrated late
- Designs often were unstable, with too many design changes for the point in time CDR), and production set to begin
- Critical manufacturing processes were not demonstrated in a timely manner, and when in production were not under statistical process control

The purpose of an assessment of M&Q cost risk is to analyze current conditions and to identify significant cost risks in order to assist the program/project manager in creating a plan or options to reduce or remove those risks. Identifying cost risk is a key part of developing mitigation efforts; it is a key enabler of program success. Risk management includes risk planning, risk assessment, risk mitigation strategies, and risk monitoring approaches.

A key product resulting from an assessment of M&Q cost risk is the development of cost mitigation plans, which address the identified cost risk and provides a mitigation plan for each risk area throughout the duration of the program/project, including supplier and sub-tier supplier risk management shortfalls. M&Q cost mitigation plans should be a part of Manufacturing Maturation Plans as identified in the Manufacturing Readiness Level (MRL) Deskbook.

Cost mitigation plans should identify each cost element that is at risk and where in the WBS the cost appears, what work package. M&Q personnel should support the assessment of cost mitigation plans and monitor progress towards meeting cost goals.

M&Q personnel need to support the development of cost mitigation plans which could occur in all phases. These plans will be dependent upon the size of the contract, current cost problems, and future contract actions.

Affordability is always a concern for the DoD. Manufacturing and quality managers need to support the development and implementation of cost mitigation plans. These plans often focus on manufacturing cost drivers and continuous improvement opportunities.

Cost reduction initiatives should be formally documented, and the documentation must include the baseline (“before” implementation) costs and projected (“after” implementation) costs, as well as the nonrecurring costs to implement the initiative.

Manufacturing and Quality Tasks

Analyze costs:

- Utilize Earned Value Management (EVM) or other cost, schedule, and performance reporting to assess Budgeted Cost of Work Scheduled against Budgeted Cost of Work Performed.
- Utilize Earned Value Management (EVM) or other cost, schedule, and performance reporting to assess Actual Cost of Work Performed:
    - Identify and assess Schedule Variance
    - Identify and assess Cost Variance
- Review and assess Direct Cost:
    - Direct Material
    - Direct Labor
    - Review and assess Indirect Cost:
    - Indirect Material
    - Indirect Labor
- Identify and assess Overhead Cost.
- Identify and assess M&Q cost related measures and metrics:

  - Learning curves
  - Work measurement
  - Throughput
  - Capacity utilization
  - Overall equipment effectiveness

- Identify the original cost estimate and compare it to actual cost.
- Support the review and assessment of the following cost documents:
  - Cost and Software Data Report Plan, DD Form 2794
  - Contractor Cost Data Summary Report DD Form 1921, should be viewed to at least the third level of the WBS
  - Functional Cost-Hour Report, DD Form 1921-1
  - Progress Curve Report, DD Form 1921-2
  - Sustainment Functional Cost-Hour Report
  - Contractor Business Data Report, DD Form 1921-3
  - Cost and Hour Report (FlexFile),
  - Technical Data Report
- Support the implementation and assessment of costs using EVM or other appropriate cost monitoring tool:
  - Review the Work Breakdown Structure (Program and Contract)
  - Identify the program structure (contractor and government) for monitoring and managing costs
  - Review the IMP/IMS to include critical path
  - Identify M&Q cost concerns by WBS elements (activities and costs)
  - Review MRP/ERP system performance outputs
  - Identify and track performance measures
  - Identify and manage work packages and planning packages
- Support the development and management of Cost Mitigation Plans:
  - Develop and assess Cost Mitigation Plans
  - Identify cost drivers and root causes
  - Identify and assign specific mitigation actions
  - Create a business case for investments to reduce costs
  - Develop budgets for investments
  - Execute and manage the investment/mitigation projects or activities
- Manufacturing and QA personnel should be engaged in the development of a Cost Mitigation/ Maturation Plan:
    - Prime Contractor
    - Key and critical subcontractors and vendors.

- Support the development of the Cost Mitigation/Maturation Plan (refer to the Independent Logistics Assessment).
- Track cost and cost trends using Earned Value Management (EVM) or Cost, Schedule Control Systems Criteria (C/SCSC).
- Assess if DoD investments will be needed to create or enhance certain critical industrial capabilities.
- Monitor product support performance and correct trends that could negatively impact availability and cost.
- Develop Manufacturing Cost Risk Mitigation/Maturation Plans:
    - Prime Contractor
    - Key and critical subcontractors and vendors.
- Use field data and failure reports to update cost models and help ensure that Sustainability targets are being met.
- Identify and account for demil. and disposal cost.
- Review reliability and maintainability data from operational testing and fielding in developing the Cost Mitigation/Maturation Plan.

Tools

- Cost Analysis Requirements Description (CARD) (See CAPE website for tools)
- Earned Value Management (EVM)
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Manufacturing Cost Estimating Worksheet
- Functional Cost Hour Report, DD Form 1423-1
- Progress Curve Report, DD Form 1423-2
- Sustainment Functional Cost Hour Report, DD Form 1921-5
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Maturation Plan
- Technology Readiness Level (TRL) Assessment Checklist

Resources

- 10 USC § 139a - Director of Cost Assessment and Program Evaluation
- 10 USC § 2433 Unit Cost Reports
- 10 USC § 2433a. Critical Cost Growth in MDAPs
- 10 USC 2334, Independent Cost Estimation and Cost Analysis
- Public Law 110-181, Sec. 330 as amended by FY2013 NDAA (Public Law 112-329), Sec. 332, Product Improvement
- Public Law 114-328, §807, Cost, Schedule, and performance of major defense acquisition programs

- Cost Analysis Requirements Description (CARD) Template (*see* CAPE website for guidance)
- DoD Cost Estimating Guide
- O&S Cost Management Guide
- Cost/Schedule Control Systems Criteria Reference Guide
- 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 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.81 Urgent Capability Acquisition
- DoDI 5000.85, Major Capability Acquisition
- DoDD 5105.84 Director of Cost Assessment and Program Evaluation (CAPE)
- DoD Earned Value Management System Implementation Guide
- DCMA-INST-123 Cost Monitoring
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- AS6500, Manufacturing Management Program
- Manufacturing Readiness Level (MRL) Deskbook

G. MATERIALS MANAGEMENT

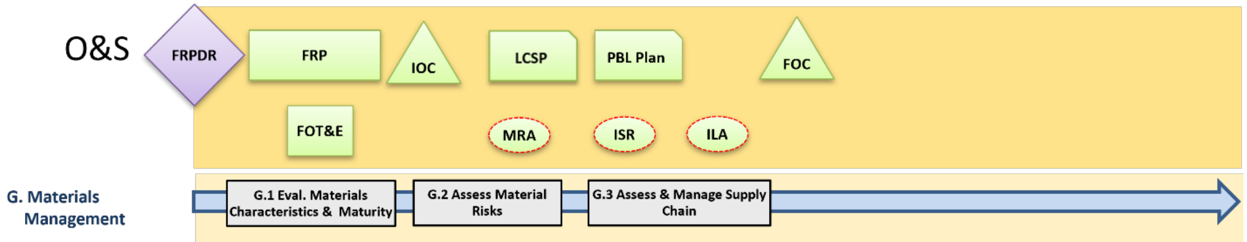


Figure 6-8. Materials Management Manufacturing and Quality Activities

Introduction

Material Management is a core function of supply chain management including the process for planning and controlling material requirements and material flow for industrial and other organizations. 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, etc. requirements.

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 to mature materials and identify the properties, characteristics, and quality deemed necessary to support the concepts being considered. Material properties, characteristics, and quality will require an assessment manufacturability.

One of the key elements in a successful program is aggressive materials management and planning. Materials management ranges from basic considerations of materials and process properties, material maturity and availability, to understanding management of the supply chain and to details of GFP, shelf life, security, safety, HAZMAT, storage environment, etc. All program materials risks, issues, and opportunities should be assessed based on contractor data and plans to meet program requirements.

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

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

During the O&S Phase, there is an increased focus on logistics and sustainment and on the difference between Material Management and Materiel Management. **Material management** in acquisition is concerned with the management of materials or supplies used in manufacturing or production. **Materiel management** in logistics or sustainment community is concerned with the management of supplies, equipment and weapon systems used to support the military. Material management is driven by several specifications and standards to include:

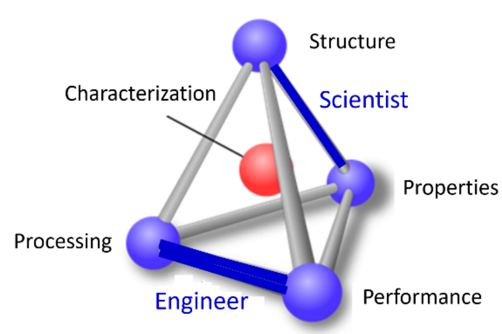
- DoDM 4140.01, DoD Supply Chain Materiel Management Procedures
- DoDM 4140.01, Volumes 1-11, DoD SCM Management Procedures
- Supply Chain Operations Reference (SCOR) Model
- MIL-STD-3018 Parts Management
- SD-19, Parts Management Guide
- SD-22, Diminishing Manufacturing Sources and Material Shortages
- DoDM 4160.21, Defense Materiel Disposition: Disposal Guidance and Procedures

The objective of the O&S phase is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. During this phase programs face unique challenges as they attempt to manage their both production support to the warfighter (material management) and military supply chains, especially during wartime. When the system reaches the end of its useful life, the appropriate military department should dispose or demil that weapon system.

At the strategic level, military and private organizations must address the logistics issues of acquisition, distribution, sustainment, and disposition and disposal. As the program matures and moves from production to spares production, and ongoing maintenance and sustainment activities, the nature of the business arrangement often changes as DoD contractors get out of the business and DoD MRO activities take on increasingly more responsibilities.

DoD Supply Chain Material Management Regulation directs DoD Components to use the supply chain operational reference processes of Plan, Source, Make/Maintain, Deliver, and Return as a framework for developing, improving, and conducting material management activities. Most of the DoD supply chain focus is on operations and logistics.

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 stress, they may need to conduct electricity, allow heat to transfer, transmit or block light, etc. Physical properties are important 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 often 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.

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 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.

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 be selecting materials based on availability, suitability (properties), manufacturing readiness, and cost. Engineers need to be able to make design choices that provide the system with the best performance at the lowest costs.

Manufacturing and Quality Tasks

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.

Tools

- Axiomatic Design Techniques
- Design for Six Sigma

- Design of Experiments Analysis
- Taguchi Loss Function Analysis (Robust Design)
- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- P-Diagram (Parameter Design Techniques)
- 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
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide Checklist, Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Supply Chain Management Risk Assessment Checklist
- TRL Assessment Questionnaire
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Lead Time Estimator
- Rough Cut Capacity Planning
- TRL Assessment Questionnaire
- Checklist, Section Preservation (Handling, Storage, Packaging and Delivery)

Resources

- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- AIAG Production Part Approval Process (PPAP) Manual
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- 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
- SD-19, Parts Management Guide
- SD-22, DMSMS Guidebook
- DoD 4140.1-R, Supply Chain Management Regulation
- DoD 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.84, Analysis of Alternatives
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems 4140.01, DoD Supply Chain Materiel Management Regulation
- IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- DoD Systems Engineering Guidebook
- 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 (TRA) Guide

G.2 Manage Materials Risk

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Material risks may slow or delay a program, add additional costs to a program, or create field failures because of poor material reliability. Material risks could include:

- 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 assessments 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 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 and Demil

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

During sustainment, M&Q managers should support in-service reviews to identify material risks including identifying root causes of risks, corrective action, and continuous improvement. Sustainment activities include participating in trade studies and decision making that may impact the product support package, manufacturing process improvements, modifications, upgrades, and future increments of the system while considering the operational needs and expected service life.

DMSMS, the loss of sources of items or material, surfaces when a source announces the actual or impending discontinuation of a product, or when procurements fail because of product unavailability. DMSMS may endanger the life cycle support and viability of the weapon system or equipment.

Counterfeiting of parts and materials, especially in the electronic business segment, is growing at an alarming rate. In addition, there are unique conditions that make aerospace and defense products susceptible to counterfeiting, including a long-life cycle and DMSMS issues. Therefore, supporting aerospace and defense products throughout their life cycle sometimes requires the use of parts that may no longer be available from the Original Equipment Manufacturer, authorized aftermarket manufacturer or through franchised or authorized distributors or resellers.

Many DoD systems require maintenance long beyond the useful life initially anticipated. Extending the service life of military systems increases the costs of ownership. One way to reduce O&S costs is to take advantage of the commercial sector's technological innovations by inserting commercial technology into fielded weapon systems.

One of the major challenges facing DoD is modernizing legacy systems using state-of-the-art technology. Therefore, from the start of an acquisition program, DoD must consider not only how to field a useful military capability quickly, but also how it can upgrade a system later. Considerations include the latest technology, increasing mission performance, reducing O&S costs, and enhancing supportability. Modernizing legacy systems requires the identification of potential replacement parts, components, and even subsystems requiring the validation and acceptance of alternative materials.

Where and how the contractor gets sources of material can be a vital concern for PMs. Having just one sole source, single source or foreign source in supply chain could be a showstopper, especially if that item is a critical item that significantly impacts the capability of the system to perform its mission.

- A sole source is one in which there is only one source for that item. There are no other alternatives.
- A single source is one in which there is only one "qualified" source. Qualification can be an expensive and time-consuming process.

- A foreign source is one that is outside of the U.S. industrial base

If the contractor is in a sole source, single source, or a foreign source situation, it may want to consider an investment strategy to qualify a second source. Now the contractor has competition in addition to a second source.

Foreign sources carry with them many problems. The transfer of some intellectual information to companies outside of the United States can be restricted by International Traffic in Arms Regulations (ITAR). In addition, some countries restrict the types of items their companies can sell to the United States. For example, items that go into nuclear programs are often restricted by countries with strong nuclear concerns. Sometimes politics can play a role and an item that is available this week may not be available next week due to political pressures. If the contractor has a foreign sources item that is critical to the program, they might want to consider funding a second source, a U.S. source.

Manufacturing and Quality Tasks

- Assess materials maturity and availability M&Q risks that are:
  - New or critical materials in development
    - Developed in a lab environment, but are not immediately available
    - Readily available within 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 the contractors Material Management and Accounting System for:
  - Time-phased material planning to fulfill the production plan to include reasonable quantities for scrap, shrinkage, yield rates, etc.
  - Bill of Materials has a 98% accuracy rate
  - Master Production Schedule has a 95% accuracy rate
  - Material costing meets 48 CFR 9904.411-50(b). Cost Accounting Standards
  - Adequate inventory controls
- 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.

- Help identify material availability risks to include:
  - DMSMS/obsolete parts and develop plans for suitable replacements
  - Sole Source, Single Source or Foreign Sourced items
  - Counterfeit parts
- 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 hazardous and special handling/storage/environmental compliance procedures, risks, and issues to include:
    - Potential regulatory requirements
    - HAZMAT and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Help identify material maturity risks or materials that have not been fully characterized.
    - Help identify supply chain risks at the prime, subcontractors, and vendors.
    - Periodically assess product support performance and take corrective action to prevent degraded materiel readiness or O&S cost growth.

Tools

- AIAG Advanced Product Quality Planning (APQP and Production Part Approval Process (PPAP) Checklist
- DCAA Material Management and Accounting System Audit Checklist
- Bill of Materials
- Make/Buy Decision Tools
- Lead Time Estimator
- DCMA Industrial Capability Assessment Survey Form
- Supply Chain Management Risk Assessment Checklist
- PESHE Assessment/Template

- Diminishing Manufacturing Sources and Material Sources (DMSMS) Product Life Cycle Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan
- Market Research Reporting Template
- Supply Chain Management Risk Assessment Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Audit Checklist
- AS9103, Variation Management of Key Characteristics
- AS9134, Supply Chain Risk Management Guidelines
- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- AIAG Production Part Approval Process (PPAP) Manual
- AS5553, Counterfeit Electronics Parts
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.242-7004, Material Management and Accounting System
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- SD-19, Parts Management Guide
- SD-22, DMSMS Guidebook
- DoD Market Research Guide
- ESOH in Acquisition Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- DoD Product Support Managers Handbook
- DoDM 4140.01, Volumes 1-11, DoD SCM Management Procedures
- DoDM 4160.21, Volumes 1-4, Defense Materiel Disposition: Disposal Guidance and Procedures
- MIL-STD-3018, Parts Management
- Manufacturing Readiness Level (MRL) Deskbook
- SD-22 Diminishing Manufacturing Sources and Material Shortages
- Supply Chain Operations Reference (SCOR) Model
- DoD Technology Readiness Assessment Guidance

G.3 Assess and Manage Supply Chains

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 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 accuracy, 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 and allow managers to identify problems early in order to take corrective action. 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.

Supply chain material assessments are especially needed for those items that may be considered critical sources of supply. These critical items (Pareto the vital few vs the trivial many) are often long-lead or are sole/single sources of supply. Lead times for defense materials and components can be long and volatile. There are various reasons for this situation, such as:

- Imbalances between capacity and demand
- Imperfect forecasting of needs
- Competition from commercial suppliers
- Poor quality and lack of process improvement
- Production bottlenecks
- Long testing cycles
- Raw materials not available
- Long contracting process
- Lack of funding
- Transportation

- Labor issues

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole source, single source, and foreign sources of supply come with a lot of risks. In addition, suppliers come and go in the marketplace. One day there might be four sources of supply and the next day one or none. DMSMS and obsolescence are two very real problems on DoD programs, especially older programs that are well into the operations and support activities.

When programs are terminated or at the end of their useful life, the program must develop procedures for a smart shutdown, or orderly production line ramp-down and closeout, to include demil and disposal. And then also plan what to do if there needs to be a restart of a cold line.

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
    - 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
  - Identify hazardous and special handling/storage/environmental compliance procedures, risks, and issues to include:
    - Potential regulatory requirements

    - HAZMAT and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal

- Periodically assess product support performance and assist PMs, users, resource sponsors, and materiel enterprise stakeholders to take corrective action to prevent degraded materiel readiness or O&S cost growth.
- Help identify and assess materials risks, especially critical materials, and sources of supply that should include the assessment of:
    - Material Availability: Concerned primarily about sole source and foreign source but could also include limited sourcing and long lead sourcing. In the O&S phase there will be growing concerns about DMSMS and obsolescence. Along with that there will be concerns about counterfeit parts.
    - Material Maturity: Concerned about the introduction of new parts, especially electronic parts that are replacing parts that are old and no longer being produced. This is usually concerned with having complete material knowledge at the time of production.
    - Material Supply Chain Management (SCM): Concerned about SCM since 60-80 percent of the fabricated and assembled items come from subcontractors and vendors and this is often where we have problems. Often the design occurs at the supplier level. The supply chain for the O&S phase often shifts from the prime and subcontractors to Maintenance Activities, Inventory Control Points, depots, MRO facilities, and installation support activities.
    - Material Special Handling: Concerned about the movement of material to and within the plant and any ESOH concerns.
- Review critical sources of supply, including contractor's technical capabilities in engineering, configuration management, and quality.
- Analyze and encourage sources to continually improve their processes and products. Encourage internal improvements at depots and within the support facilities.
- Review and analyze a contractor's parts program for the identification and elimination of counterfeit parts and materials.
- Ensure the prime contractor has delegated all technical requirements to include quality requirements.
- Ensure that DCMA at the prime contractor is reviewing the flow-down of requirements and oversight to their counterparts at subcontractor and vendor organizations.

Tools

- 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
- Failure Modes, Effects & Criticality Analysis (FMECA) Template
- Design Failure Mode & Effects Analysis (DFMEA) Template
- Process Failure Modes & Effects Analysis (PFMEA) Template
- FRACAS Reporting System
- Supply Chain Management Risk Assessment Checklist
- Lead Time Estimator
- DCMA Material Management and Accounting System Audit
- DMSMS Product Life Cycle Assessment
- Market Research
- Interactive MRL Users Guide (Checklist), 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
- AS5553, Counterfeit Electronics Parts
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- 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
- Defense Manufacturing Management Guide for Program Managers, Chapter 15 Supply Chain Management
- IAQG Supply Chain Management Handbook (SCMH)

- DoD Product Support Managers Handbook
- DoDM 4140.01, DoD Supply Chain Materiel Management Procedures
- Supply Chain Operations Reference (SCOR) Model
- MIL-STD-3018, Parts Management
- SD-19, Parts Management Guide
- SD-22, DMSMS Guidebook
- DLA DMSMS Acquisition Guidelines
- DoD Market Research Guide
- MRL Deskbook
- SCM: A Recommended Performance Measurement Scorecard
- DoDM 4160.21, Volumes 1-4, Defense Materiel Disposition: Disposal Guidance and Procedures
- DoDM 4140.01, Volumes 1-11

H. PROCESS CABABILITY AND CONTROL

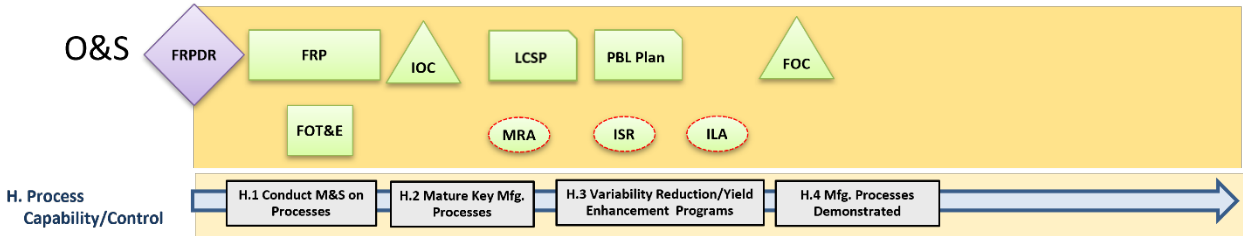


Figure 6-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with "uniform, defect free product that has consistent performance and is affordable. 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 that will demonstrate process capabilities. A capability study is 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:

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

During the O&S phase, organizations will have to supply compliant sustainment products, parts, and limited life supplies to maintain the systems they have produced. In order to do so programs should employ effective performance-based logistics (PBL) planning, development, implementation, and management in developing a system's product support arrangements. PBL is performance-based product support, where outcomes are acquired through performance-based arrangements that deliver warfighter requirements and incentivize product support providers to reduce costs through innovation.

develop and refine their product support strategy based on projected and actual performance. One of the major O&S performance objectives is the Sustainment KPP (Availability) which is as critical to a program's success as cost, schedule, and performance. Acquisition Category I and II PMs will use availability and sustainment cost metrics as triggers to conduct further investigation and analysis into drivers of those metrics. Manufacturing and quality managers need to assess and improve specific process capabilities that can have a negative impact on reliability, availability, and maintainability to help reduce cost. The materiel availability portion of the KPP will be based on the entire system inventory and supported by the following sustainment metrics.

H.1 Conduct Modeling and Simulation

A model is a simplified representation of a system and is used to promote understanding of a real system. Modeling and Simulations (M&S) helps 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 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.

During the O&S Phase, the program office and sustainment organizations are continuing to plan for and sustain aging weapon systems. Often this means the planning for program service life extensions through preplanned product improvement, block upgrades, and other programs. These programs may require the use of M&S to understand and characterize new and emerging manufacturing processes and products.

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
    - Tolerance/Parameter Design
  - Manufacturing and Quality
    - Plant Design
    - Factory Flow Analysis
    - Process Planning
    - Manufacturing Simulation
    - Ergonomic Analysis
    - Tool Design
    - Dimensional Management
  - Operations and Sustainment
  - Affordability and Cost Models/Drivers
- Digital engineering should be used to support process capability studies and follow-on process control activities.
- Identify and implement M&S contract language and provisions.

- Assess contractors experience and expertise in program related M&S activities as a part of the source selection process.
- Assess contractor M&S system prior to product and/or process implementation for the capability to model (product and processes) and assess the system for CDR and pilot line to include:
  - Integration with supply chain M&S Systems
  - Integration with CAD, MRP, scheduling, time standards, work instructions, planning, etc.
  - Yield and rate modeling to predict first pass yields including key design and process attributes
  - Manufacturing ergonomics M&S to ensure human factors considerations are applied in manufacturing
  - Production process M&S addressing material flow, surges, processing times, scrap, rework, and repair levels, etc.
  - Supply chain M&S includes impacts of disruptions, supplier capabilities and yields, learning curve effects, obsolescence issues, etc.
  - Other tools such as:
    - Value stream mapping displays all types of information, material, parts, physical processing times, physical movements, wait times, etc.
    - Factory simulations for system production including facility, production lines, transportation, storage, handling, security, etc.
    - Lean Manufacturing, Six-Sigma, etc.
  - Capability to evaluate the design and manufacturing processes to meet program M&Q objectives including quantification of risk and issue mitigation including:
    - Factory floor, process flows, assembly lines, yields/ throughput/variability, cycle times, etc. with estimated quantities of tooling, personnel, and inventory
    - Throughput concurrent with other ongoing production
  - Capability to provide estimated yields, rates, cycle times, schedule, and cost performance to meet program M&Q goals
    - Use data from production of subsystems, items, and components to validate M&S System
    - Use data from production of subsystems, items, and components to identify of M&Q bottlenecks or constraints
    - Validate M&Q cycle times achievability
- Assess the results and data from M&Q demonstrations, tests, production of items and components, etc. by the contractor and supply chain in production representative environment to validate M&S of subsystems, components, and items for CDR, including:
  - A mix of mature hardware, prototypes, models and simulations

  - Interfaces, integration, and interdependencies
  - Ergonomics
  - Identification of constraints
  - Performance
  - Throughput
  - Sufficient complexity to match the complexity of the system

Tools

- AS19100 Checklist
- AS6500 Checklist
- Advanced Product Quality Planning (APQP) Checklist
- 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
- Plant M&S tools (FlexSim, SimFactory, etc.)
- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- 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
- System Capabilities Analytic Process (SCAP)
- 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
- DoD 5000.59-P, Modeling and Simulation Master Plan
- DoDI 5000.97, Digital Engineering
- 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 – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9138, Statistical Process Acceptance
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- 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
- 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
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- 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
- Modeling and Simulation Guidance for the Acquisition Workforce
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.2 Mature Key Manufacturing Processes

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

- Capability studies
- Yields and rates
- Process demonstrations

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.

An 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.

During the sustainment phase, Process Capability and Control should be well understood, based on knowledge and experience during the P&D phase. However, production operations may shift from the prime contractor to government owned and operated facilities such as depots, MROs, and other industrial operations. Moving from one facility to another, with a different workforce, machines and other factory floor considerations may cause the process capability and control to slip below levels required to satisfy the warfighter.

Manufacturing and Quality Tasks

- Support the identification and management of key/critical characteristics.
- Identify opportunities for government surveillance of key/critical characteristics:
    - At prime contractor, subcontractor, or government facility.
- Review process control plans for management and control of key/critical characteristics and identify government surveillance.
- Review key/critical process capability performance measures (Cp and Cpk, Pp and Ppk, or other appropriate measure) to identify government surveillance and flow-down requirements, and to determine process stability and capability.

- Review process yields and Process Failure Modes and Effects Analysis (PFMEA) conducted on key/critical manufacturing processes to identify government surveillance and continuous improvement opportunities.
- Manage sustainment performance by using sustainment metrics mapped to the Sustainment KPP and KSAs.
- Conduct a PRR or MRA to assess the risk in standing up a new spare parts line or conducting work at a repair facility.

Tools

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

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Risk Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook

- Capability-Based Assessment (CBA) Handbook
- DCMA-INST 323, Data Collection and Analysis
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program
- MRL Deskbook

H.2. Mature Critical Manufacturing Processes

Immature processes are a major source of risks on acquisition programs, especially during the P&D phase when most production takes place. As a program moves forward, process maturity takes on greater importance. According to DoDI 5000.85, Major Capability Acquisition, the FRP decision requires the control of manufacturing processes. If these processes are not capable, in control, and affordable, then the program office needs to continue to mature those processes.

Manufacturing and Quality Tasks

- Support the maturation of critical manufacturing processes.
- Promote standard and stable manufacturing/factory floor processes that could be used in a depot as well as production activities:
  - Utilize SPC or other appropriate controls
- Support performance-based logistics (PBL) planning, development, implementation, and management at contractor and government facilities to mature critical manufacturing processes.
- Identify outcomes for critical manufacturing processes and incentivize product support providers to reduce costs through innovation.
- Support the assessment and refinement of the product support strategy based on projected and actual factory floor performance.
- Assess key/critical manufacturing processes to ensure that they are stable and in control.

Tools

- AS9100 Checklist
- AS6500 Checklist
- AS6500, Manufacturing Management Program
- Interactive MRL Users Guide (Checklist) for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Study (Cp and Cpk assessments)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Program

  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS913,3, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Risk Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- DCMA-INST 323, Data Collection and Analysis
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program
- MRL Deskbook
- PBL Guidebook

H.3 Conduct a Variability Reduction and Yield Enhancement Program

One of the major goals of manufacturing is to provide the customer with uniform, defect-free products that have consistent performance and are 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 gap in capabilities as a risk and an impact to yields, with time and resources planned to mature these critical capabilities. Manufacturing yields and rates can play a major role in manufacturing 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 (FMEA) 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 being considered, a determination of the manufacturing processes capability will be completed. This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Critical and key manufacturing processes can also be identified during the assessment and analysis either through M&S or experimentation.

Manufacturing and Quality Tasks

- Collect up-to-date data from system and subsystem pilot line demonstrations of M&Q processes, and production line M&Q data for components and items as the basis for yield and rate analyses to validate “as is” status:
    - Rate of quality processes (actual time to complete) vs. planned
    - Quality data actuals vs. estimated
    - Quality process 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 pilot line and lower level production against pilot line and LRIP targets, goals, and projections:
  - Validate achievement of targets (e.g., pilot line, LRIP, etc.)
  - Refine yields and rates required for LRIP
  - Based on results of analyses develop and implement improvement plans as required
- 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
- Review manufacturing risks at contractor and DoD facilities to ensure compliant products are produced and delivered to the warfighter.
- Assess manufacturing risks and develop a manufacturing maturity program.
- Track cost, schedule, and performance using the sustainment KPP (Availability) as a critical metric.
- Identify, track, and manage sustainment metrics (availability and sustainment cost), and act when metrics exceed goals or targets.
  - KPPSs, KSAs, MOEs, TPMs, etc.
- Develop Should Cost targets, and develop strategies for improving reliability, availability, and maintainability (R&M) while reducing cost.
- Ensure that the materiel availability portion of the KPP is based on the entire system inventory.

Tools

- AS9100 Checklist
- AS 9103 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 Management Program
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Risk Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- 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
- DoD Systems Engineering Guidebook
- DCMA-INST 323 Data Collection and Analysis
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MRL Deskbook

H.4 Demonstrate Manufacturing Maturity

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

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

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

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

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

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

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
- Assess the status of risks from previous demonstrations of M&Q processes considering the maturity of the design throughout the supply chain including:
  - Equipment (e.g., capability, capacity accuracy, calibration, age and condition, suitability, etc.)

  - Workforce (i.e., training, skills, and certifications)
  - Work instructions and processes (e.g., cleaning, heat treating, ESD protection, clean rooms, etc.)
  - Human factors (i.e., noise, vibrations, ergonomics)
  - Materials and components
  - Environmental Safety and Occupational Health (HAZMAT, Safety, security, etc.)
  - Environmental conditions (i.e., temperature, humidity, air quality)
  - Tooling and test equipment
  - Capability to meet the cost, schedule, and performance requirements
  - Estimates of manufacturing costs
  - Manufacturing key performance indicators (OEE, cycle times, takt time, yields, rates, etc.)

- Collect data from production operations of M&Q processes and production line M&Q processes for components and items to support verification, validation, and authentication of system-level M&S for new and emerging manufacturing processes and components.
- Verify that the contractor conducts process capability studies that meet program targets (C_{pk}s) to include:
  - All manufacturing processes for KCs and critical characteristics
  - Process capability studies conducted throughout the supply chain
- Based on process capability targets and production results, update the comprehensive M&Q Plans for O&S to:
  - Maintain currency of M&Q
  - Maintain all M&Q risks, issues, and mitigations status
  - Update PFMEAs for all M&Q processes from pilot line changes
  - Update plans for achieving process capability targets during O&S
- Ensure key M&Q processes are sufficiently mature by conducting an MRL assessment to support program requirements:
  - System-level target should utilize appropriate MRL criteria and metrics
  - Subsystem, item, and components targets should utilize MRL 9 criteria and metrics
- Ensure Government surveillance of contractor and supply chain key and/or critical manufacturing processes for compliance to best practices or AS6500 (depending on contract).
- Ensure all policies, procedures, processes, work instructions, data, plans, metrics, tooling, equipment, and documentation are under program configuration management and control.
- Update status of the comprehensive M&Q Plans based on demonstrations of M&Q processes for the appropriate manufacturing environment:
  - Include all M&Q risks and issues
  - Use Process Failure Modes and Effects Analyses (PFMEAs) on all M&Q processes
  - Update plans for achieving pilot line process capability targets

- Ensure key M&Q processes are sufficiently mature by conducting MRL assessments as required in support of program office decisions:
  - System-level target should utilize MRL criteria and metrics at the appropriate level for that phase
  - Subsystem, item, and components targets should utilize MRL criteria and metrics for that phase
- 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
- Cause and Effect Diagram
- Cost of Quality Estimates
- First Pass Yield Estimates Worksheet
- Pareto Analysis
- Histograms
- FMEA Templates (DFMEA and PFMEA)
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Assessment (Cp and Cpk assessment)
- Statistical Process Control Charts
- Producibility Assessment Worksheet (PAW)
- Six Sigma Worksheet

Resources

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- AS9100, Quality Management System
- AS9103, Variation Management of Key Characteristics
- AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- ISO 9001:2015, 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
- 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
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Systems
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook

I. QUALITY MANAGEMENT

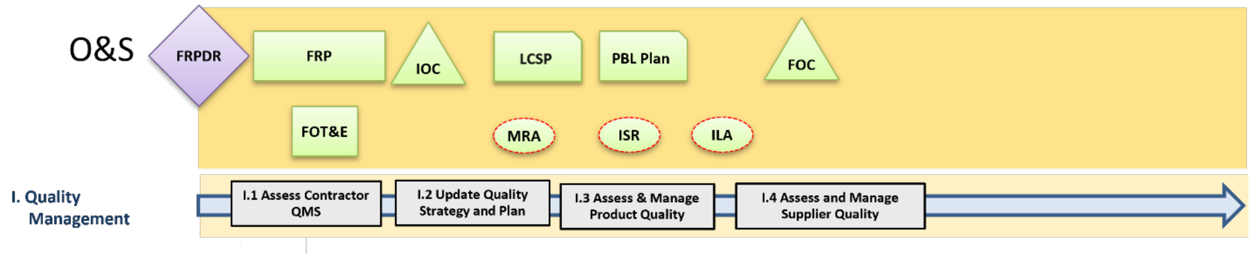


Figure 6-10. Quality Management Manufacturing and Quality Activities

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 the set of coordinated activities to direct and control an organization, including the supply chain, regarding quality policy, quality objectives, quality planning, quality assurance, and quality improvement. These activities are performed as part of a 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 that are required 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 its internal processes, procedures, and standards.

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

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

- Quality Risk

An effective QMS is required to produce operationally safe, suitable, and effective weapon systems. A QMS should be compliant with industry standards such as ISO 9001 or AS9100 and is foundational to producing products that meet contractual requirements. The QMS ensures the as-delivered configuration is the same as the as-designed and as-tested configuration. The QMS serves as the management and control function, requiring controls over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. It also requires monitoring and measuring of processes and products to ensure they conform to requirements.

Quality Assurance focuses on having a:

- Quality Management System (QMS)
- Product Quality Focus
- Supplier Quality Program

A program should ensure that the Acquisition Strategy incorporated a Quality Strategy that supports and aligns with the program strategy, objectives, goals, and the contract. This will involve the use of process audits as to whether the contractor's and supply chain activities, resources, and behaviors are being managed efficiently and effectively including participation of DCMA, Key Characteristic control and management, use of acceptance testing, application of Statistical Process Controls (SPC), etc. Similarly, these audits should be conducted on the supply chain, as necessary.

The initial quality strategy should have been developed during the MSA phase and updated in every phase in support of the Systems Engineering Plan (SEP) to include the O&S phase.

During the sustainment phase, a contractor, or a government owned or operated remanufacturing facility (depot/MRO, etc.) should have implemented an effective QMS in accordance with FAR 46.202-4 Higher-level Contract Quality Requirements.

The Contractor Quality Control Plan (QCP) is the contractor's management plan for executing the contract. The Contractor QCP describes the way in which the contractor will produce the deliverables, and the step-by-step approach that will be taken to ensure the quality of the engineering and design services and the products derived from those services. The contractor is required to submit a Contractor QCP as the first item of work in each delivery order or may submit a Contractor QCP as the first item of work in his contract and, at a minimum, a quality control supplement for each delivery order for an indefinite delivery contract. Subcontractors make up 60-80 percent of the material content on many programs, thus prime control of subcontractors' Quality Management System and Plan are essential to the success of any program.

The intent of verifying supplier quality programs is to draw attention to troubled suppliers or critical processes needing corrective action by on-site visits/reviews. The contractor will usually respond by sending his own representative to the site when the program office outlines their reasoning. Consider inviting the program chief engineer or even the program director if the situation warrants their attention. The contractor will usually respond with equal high-level attention.

Primes and suppliers conduct training in counterfeit parts avoidance for inspectors, operators, auditors, and lower tier suppliers to include awareness of AS5553. Training should discuss how to inspect parts and identify counterfeits (e.g., non-conforming part markings).

As MDAPs become more complex and supply chains become longer, more obscure, and prone to unforeseen quality breakdowns, program risk associated with supplier processes has increased exponentially. Since the issues surrounding the supply chain typically impact program quality, cost, and schedule, the M&Q personnel at DCMA can be key contributors in addressing this type of risk and providing visibility into potential future suppliers' problems/ issues.

The Quality Surveillance Plan (QSP) is a government document that establishes the methodology that the government will use to monitor and evaluate contractor performance and to ensure that the contract objectives are being met. A properly developed QSP provides guidance to all government contract oversight personnel on their contract surveillance roles and responsibilities.

A QMS is a formal system that documents policies, processes, and procedures that may be required to achieve specific quality goals and objectives. The intent is to use the QMS to meet or exceed customer expectations and improve overall efficiency and effectiveness. The two dominant QMS programs currently available are ISO 9001 and AS9100. A QMS should be in place at all contractor facilities with a higher-level quality requirement per FAR/DFAR or at any government owned and operated facility doing production type work.

I.1 Assess Contractor Quality Management System

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 product is 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 product quality requirements of an identified material based on FAR 46.202, Types of Contract Quality Requirements, and FAR 52.246.1, Contractor Inspection Requirements. Best practices has contractors operating to either ISO 9001 Quality Management System or AS9100 Quality Management System. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

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 contractors control of subcontractors.

Manufacturing and Quality Tasks

- Identify and put on contract an appropriate QMS for the identified product.
- Verify that an approved QMS is in place, operating, and is achieving desired outcomes.
- Evaluate the QMSs in use for each of the following areas:
    - Understand 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)

- Assess the QMS against an industry standard and the contract requirement:
  - ISO 9001
  - AS9100
  - Appropriate contractor QMS

- Assess the contractor's corporate strategic vision, objectives, policies, plans, processes, and procedures for alignment to the contracted program needs and industry best practices (e.g., AS9100, ISO 9000, etc.) for quality both in-house and in suppliers' facilities to include:
  - Established quality policy, at the highest level in the company, based on industry best practices, which commits to continuously improving processes and exceeding customer expectations
  - Organizational direction and values regarding quality are communicated throughout the supply chain
  - Management provides structures and resources supporting full implementation of the QMS
  - Management solicits quantitative and qualitative feedback on the effectiveness and efficiency of QMS and takes actions based on that feedback
  - Procedures for internal reviewing of the QMS periodically with goals and objectives throughout the organization for customer satisfaction, and continuous improvement
  - Procedures independent reporting channels for quality functions and audits
  - Management accountability with emphasis on quality results and customer satisfaction

- Conduct a process audit of the contractor's QMS including assessment of Quality processes and supply chain quality including:
  - Identification, control, and auditing of critical manufacturing processes
  - Role and participation of DCMA (contractor and supply chain)
  - KCs control and management
  - Acceptance testing including software
  - In-process and final inspection functionality
  - Statistical process controls, rates, and yields (and management of same)
  - Execution of and adherence to quality plans including control plans and quality improvement plans
  - Certification processes (e.g., flight safety, man-ratings, etc.)
  - Continuous process improvement results
  - Software quality assurance results
  - Data storage, management, and security (physical and cyber)
  - Management of safety, environmental, transportation, storage, etc.
  - Use of COTS items, GOTS items, and NDIs

- GFE/GFP management (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
- Internal and supply chain audits and verification results

- Establish quality targets.
- Verify quality targets on LRIP line:
  - Processes for management, control, and monitoring of KPPs, KSAs, and KCs, CSIs, and CAIs, and their integration into the QMS.
  - FRACAS processes for sufficiency and adequacy including results of dispositions (i.e., material review boards and processes)
  - QMS impacts on tasks, costs, schedules, and outcomes
  - QMS compliance with standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
  - Planning, integration, and execution of the Risk, Issue, and Opportunity Management System processes
- Request DCMA support and assistance to assess adequacy and completeness of contractor and supply chain QMSs application to system, subsystems, items, and components.
- Identify and manage product quality requirements:
  - Mature new quality technologies and process state of the art into product quality requirements
  - Identify and manage product quality requirements (i.e., specific product characteristics)
  - Identify product acceptance methods and determine sampling plan as appropriate
  - Conduct First Article Inspection if required
  - Contractors Measurement System by conducting Measurement System Analysis (MSA) evaluates measurement instruments, inspection equipment, and test methods to understand the integrity of the inspection and quality data and the uncertainty and error resulting from the measurement system
- Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks.
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements.
- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards.
- Collect and analyze quality data from production and use results to feed improvement plans.
- Ensure that continuous quality improvement activities are ongoing.
- Verify quality targets on FRP line.
- Assess planned non-developmental items (NDI) or COTS items to determine that they meet program system performance and sustainment requirements through a defined acceptance process.

Tools

- AS9100 Audit Checklist
- ISO 9001 QMS Audit Checklist
- Manufacturing Maturation Plan
- Quality Management Plan
- Interactive MRL Users Guide (Checklist), Quality thread
- Manufacturing Maturation Plan
- 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
- Lot Acceptance Testing Calculator

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
  - AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- ISO 9001, Quality Management System
- ISO 17025, Testing and Calibration Labs
- 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
- AFMC Instruction 63-145, Manufacturing and Quality
- AFMC Instruction 63-501, AFMC Quality Assurance
- AFLCMC Manufacturing and Quality Assurance Acquisition Process Deskbook

- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- 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
- DoD Risk, Issue, and Opportunity Management Guide
- Manufacturing Readiness Level (MRL) Deskbook

I.2 Update and Manage Quality Strategy/Plans

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 managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and 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**. The SEP describes the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. The SEP details 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.

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.

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

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.

During the O&S phase much of the production activities occur at DoD organic facilities to include depots, arsenals, air logistics centers, fleet readiness centers, shipyards, fleet logistics centers, and other organizations that are involved in the sustainment, restoration, and modernization activities. In addition, acquisition programs continue to support on-going production that may involve spares production and upgrading or modernization activities. All of these organizations need to update the Quality Strategies and plans.

Manufacturing and Quality Tasks

- Review and update the program's Quality Strategy:
  - The Quality Strategy should be updated based on performance results, sustainment metrics mapped to the Sustainment Key Performance Parameter and Key System Attributes, to manage sustainment performance.
  - 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
- Continually monitor product support performance using field data and correct trends that could negatively impact availability and cost.

- Review factory floor department status (schedule, work measurement, Scrap, Rework, and Repair, yields, etc.).
- Review and improve M&Q processes to reinforce the need for process improvement efforts.
- Review and assess problem/failure reports (Failure Reporting, Analysis and Corrective Action System) as appropriate.
- Determine the root cause of problems, identify corrective actions, and manage continuous improvement activities to completion.
- Ensure quality 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
- Ensure quality plans address the following areas:
    - Process and analyze mission data
    - Manage Preplanned Product Improvements
    - Develop and implement technology refresh schedules
    - Conduct technology insertion efforts as needed to maintain or improve system performance
    - Update system safety assessments
    - Perform engineering analysis to investigate the impact of DMSMS issues
    - Work with vendors and the general technical community to determine opportunities for technology incursion to increase reliability and affordability
    - Support demilitarizing and disposing of the system; in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment

Tools

- Acquisition Strategy Outline
- Acquisition Strategy Template
- Acquisition Strategy Outline
- Acquisition Strategy Building Blocks on Major Acquisitions – DAU
- Systems Engineering Plan (SEP) Outline
    - Manufacturing Plan
    - Quality Assurance Plan
- AS9100, Audit Checklist
- ISO 9001, QMS Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974
- Manufacturing and Quality Assurance Status Report DI-QCIC-82323
- Quality Status Report DI-MGMT-82186
- Quality Program Plan (QPP) DI-QCIC-81722
- Quality Management System (QMS) DI-MGMT-82184
- Quality Engineering Inspection Requirements and Equipment List DI-QCIC-80756A
- Quality Assurance Program Plan DI-QCIC-81794
- Quality Assurance Provisions (QAP) DI-SESS-80789A
- Critical to Customer Assessment
- Critical to Quality Tree

Resources

- 10 USC 2431a. Acquisition Strategy
- FAR Part 7.105 Contents of Written Acquisition Plans
- Acquisition Strategy Guide (DSMC)
- Acquisition Strategy Guide (NAVSEA)
- DSMC Acquisition Strategy Guide
- AS9100, Quality Management System – Aerospace
- ISO 9001, Quality Management System
- 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
- DoDI 5000.97, Digital Engineering
- AFMC Instruction 63-145, Manufacturing and Quality

- 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
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- 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)
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- SD-19, Parts Management Guide
- SD-22, DMSMS Guidebook
- 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 Evaluate and Manage Product Quality at Contractor and Organic Facility

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 specifications are the most obvious form of QC. The inspection and test methods used depends on the technical nature of the product being developed. These methods could include product and process inspection, First Article Inspection, First Article Testing, Production Lot Testing, Qualification Testing, and Production Qualification Testing.

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

Planning for product quality may require the support of DCMA to provide day-to-day in-plant product inspection and acceptance. The Program Manager should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. This may require the program office to establish an MOA or a Quality Assurance Letter of Delegation (QALI) with DCMA. DCMA may then, based on manpower availability and funding, utilize a systematic approach deploying surveillance through the supply chain to evaluate the supply chain and supplier improvement initiatives. At resident and non-resident facilities DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes. Most contractors will have implemented a higher-level quality management process in accordance with AS9100 or ISO 9001 as a best practice. Some contractors, but not all, may have implemented a manufacturing management process in accordance with AS6500. Regardless of what management processes the contractor has implemented, DCMA personnel should have access to that data and should be reviewing it on a continuous basis.

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.

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

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

- Personal and product safety
- Producibility and Inspectability

- 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.

The following applies to either contractor or organic (i.e., depot, arsenal, shipyard) manufacturing operations. M&Q personnel need to identify the potential product quality requirements of an identified material based on FAR 46.202, Types of Contract Quality Requirements, and FAR 52.246.1, Contractor Inspection Requirements. Organizations need to identify the process of measuring, examining, testing, or otherwise comparing the product to the requirements for acceptance. FAR 46.291 Production Lot Testing identifies the purpose of production lot testing is to validate quality conformance of products prior to lot acceptance, which usually occurs after acceptance testing. Best practices have contractors operating to either ISO 9001 Quality Management System or AS9100 Quality Management System. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

Manufacturing and Quality Tasks

- 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 and evaluate product quality requirements:

  - Identify product acceptance methods and determine sampling plan as appropriate
  - Statistical process controls, rates, and yields (and management of same)
  - Process control plans for variability reduction
  - Statistical control of process capabilities (i.e., C_p, C_{pk}, P_p, and P_{pk})
  - Production process verification
- 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)
  - Conduct Gage R&R studies to quantify the amount of variation in the measurement system in order to assess repeatability and reproducibility
  - 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 to schedule and performance)
  - Quality of materials' sources and selections
- Identify and manage Quality in Design:
  - Establish, implement, and maintain a design and development processes

    - Identify key and critical characteristics
    - Conduct design reviews and associated verification and validation activities
    - Support the requirements process to include the allocated and functional designs

- 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
- 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
- Ensure the prime contractor or organic has implemented a Quality Management System Based on Best Practices (AS9100 or ISO 9001 as appropriate).
- Ensure the requirement for a QMS flows down throughout the supply chain as appropriate.
- Ensure the depots and MRO activities have implemented a Quality Management System Based on Best Practices (AS9100 or ISO 9001 as appropriate).
- Ensure that quality audits of the QMS and product take place at regular intervals and at the Prime, subcontractor, depot, and MRO activities.
- Ensure product quality requirements have been identified and are being managed:
    - Identify product acceptance methods and determine sampling plans as appropriate
    - Mature new quality technologies and process state of the art into product quality requirements
    - Identify and manage product quality requirements (i.e., specific product characteristics)
    - Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks
    - Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements
    - Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards
- Ensure the following:

  - Primes and suppliers have implemented a strong incoming quality review on all parts and visually inspect for defects.
  - Organizations implement root cause corrective action for all defects.
  - Prime contractors require certificates of conformance, testing certification, and procedures for managing any counterfeit parts that might slip through the system.
  - First Article Inspection (FAI) and First Article Testing (FAT) are conducted, as necessary.
  - They determine the need for delegated government surveillance on critical products, configuration items, critical product characteristics and critical manufacturing processes that are produced at a sub tier supplier, especially those that have been designated high or moderate risk and those that impact KSA/KPP compliance.
  - Review the implementation of a reliability improvement program based on Failure Modes and Effects Criticality Analysis (FMECA).
  - Continually assess and refine the product support strategy based on projected and actual performance.
  - Conduct benchmarking to survey outside organizations that perform similar processes.
  - Support shutdown activities at all levels (Prime contractor, depot, MRO, etc.).

Tools

- AS9100, Audit Checklist
  - 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, QMS Audit Checklist
- ISO 17025, Testing and Calibration Labs
- Critical to Customer Assessment
- Quality Management Plan Template
- Critical to Quality Tree
- QA Surveillance Template
- Lot Acceptance Testing Calculator
- Control Charts (Attributes and Variables)
- First Article Inspection Checklist
- AIAG Advanced Product Quality Planning (APQP)
- Production Part Approval Process (PPAP) Checklist

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- Manufacturing Maturation Plan
- Lot Acceptance Testing Calculator

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Risk Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- ISO 9001, Quality Management System
- Defense Manufacturing Management Guide for Program Managers, Chapter 5.3.5.1 ISO 9001/AS9100
- AS6500, Manufacturing Management Program
- MIL-HDBK-896 Manufacturing Management Program Guide
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook
- Digital Engineering Body of Knowledge
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- AIAG Measurement Systems Analysis (MSA) Manual
- ASTM E2782-17 Standard Guide for Measurement Systems Analysis
- SAE J1739 Potential Failure Mode and Effects Analysis (Design FMEA, Process FMEA)
- AIAG APQP Manual
- IAQG Aerospace APQP Manual
- ANSI Z1.4 Sampling Procedures and Tables for Inspection by Attributes
- ANSI Z1.9 Sampling Procedure and Tables for Inspection by Variables for Percent Nonconforming
- DCMA-INST 302, First Article and Production Lot Testing
- MIL-STD-1916, DoD Test Method Standard
- Defense Technical Risk Assessment Methodology (DTRAM)

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- MRL Deskbook
- Manufacturing and Quality Assurance Status Report DI-QCIC-82323
- Manufacturing Nonconformance Material Report DI-MGMT-891137
- 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

I.4 Evaluate and Manage Supplier Quality

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 source, single source and foreign sources of supply come with risks. In addition, suppliers come and go in 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 to 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 21 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.
- Review and verify the Subcontractor Quality Management Plan.
- Ensure that the appropriate quality clauses flow down into the supply chain.
- Ensure that subcontractor quality requirements to include quality management plans are reviewed and managed at depots and MRO activities.
- Establish supply chain quality management metrics for each of the concepts being considered for incoming quality inspection to include the identification of acceptable quality levels (AQLs):
  - 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
  - Customer Support and Satisfaction (Past Performance)
  - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks

  - Determine 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
  - 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 to schedule and performance)
  - Quality of materials' sources and selections

- Ensure that the assessment of potential supplier's quality management (in the lower supply chain) for each concept being considered includes DCMA input.
- Ensure quality and manufacturing requirements are included in contracts of proposed suppliers and in appropriate agreements with other agencies (e.g., DCMA).
- Identify, assess, and manage supplier QA concerns such as DMSMS, Obsolescence, Counterfeit Parts, etc.

- Assess how efficiently the subcontractor or vendor is producing products, primarily through on-site quality assessments and the evaluation of work measurement data.
- Analyze the causes of variances, their root causes, and championing and motivating contractor improvements.
- Verify the supplier is conducting a Corrective Action Board (CAB) and/or Material Review Board (MRB), or similar meetings, to discuss quality, manufacturing/production, supply chain, engineering and software deficiencies/issues and proposed/status corrective actions, at a minimum.
- Draw management attention to troubled suppliers or critical processes needing corrective action by on-site visits/reviews.
- Perform government surveillance of supplier's compliance to software quality assurance, configuration management, and testing contract requirements.
- Review how primes and suppliers conduct training in counterfeit parts avoidance for inspectors, operators, auditors, and lower tier suppliers.
- Ensure that training discusses how to inspect parts and identify counterfeits (e.g., non-conforming part markings).

Tools

- AS9100, Audit Checklist
  - AS9133, Supplier Audit Checklist
  - AS9134 Supply Chain Risk Management Guidelines Checklist
  - AS5553 Supply Chain Assessment Checklist
- ISO 9001, QMS Audit Checklist
- DCMA Material Management and Accounting System Audit
- Corporate Supplier Quality Questionnaire
- Critical to Customer Assessment
- Critical to Quality Tree
- Supply Chain Management Risk Assessment Checklist
- Lead Time Estimator
- Interactive MRL Users Guide (Checklist), Quality thread
- Manufacturing Maturation Plan
- Quality Management Plan Template
- 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 Risk Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- ISO 9001, Quality Management System
- AS6500, Manufacturing Management Program
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- AIAG Measurement Systems Analysis (MSA) Manual
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6081, Fraudulent/Counterfeit Electronic Parts: Avoidance Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- 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
- DoDI 5000.88, Engineering of Defense Systems
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- SD-19, Parts Management Guide
- SD-22, DMSMS Guidebook
- 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

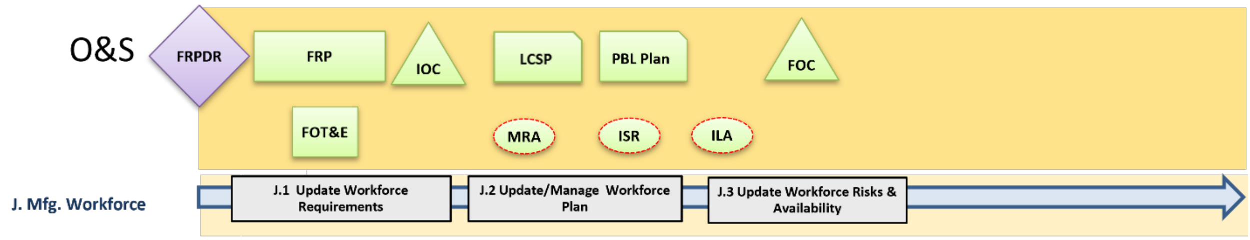


Figure 6-11. Manufacturing Workforce Manufacturing and Quality Activities

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.

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.

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.

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

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

J.1. Update Workforce Requirements

Workforce requirements planning provides quantitative inputs to program planning. Contractor 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 (looks at the existing market to see how many workers are available)
- Gap Analysis: Identify skills gaps between demand and supply
- Solution Identification and Management: Identify ways to close the gaps between Demand and Supply
    - Recruitment and retention
    - Develop training and development programs
- Monitor and Manage Workforce Requirements

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

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

M&Q Workforce requirements, planning and analysis cover a wide range of knowledge, skills, and abilities from a competency perspective. In addition is the concern over workforce availability as many companies face serious shortfalls in personnel. In addition to specific labor skills (welding, machining, fabrication, assembly, inspection, testing, etc.) associated with production processes, there is a need for M&Q personnel to understand the requirements for fabrication and assembly of countless numbers of types of materials. Leading the M&Q effort at many industrial organizations are the M&Q

professionals with degrees in Industrial Engineering, Manufacturing Engineering and Quality Engineering.

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

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 on the supply of workforce:
    - Have industry and sector M&Q workforce competencies been identified?
        - Technical competencies
        - Academic competencies
        - Competencies for advanced manufacturing
        - Competencies for additive manufacturing
        - Lean/Six Sigma and CPI
    - Has workforce requirements analysis been conducted 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?
    - How will be turnover of key personnel affect the organization's ability to deliver products?
    - What are the critical positions to fill?
    - What positions are difficult to fill positions with quality applicants?
    - Are there local recruitment sources that can provide top talent?
    - What new ways of working or skill mix would aid in recruitment?
    - Can the workforce be arranged differently to better facilitate workload coverage?
    - What is the current distribution of employee years by years of service?
- Conduct an analysis on workforce demand:
    - Identify planned personnel loadings to ensure that adequate numbers of people with the required skills are made available for each candidate materiel solution approach
        - Define a profile of the required workforce

        - Identify workforce requirements, special skills, and training requirements.
        - Identify sources of personnel and their potential availability
        - Plan for the acquisition and training of new personnel
    - What drivers affect organizational workload?
    - How is workload measured?
    - How many employees are needed to deliver product by skill category?
    - What percentage of an FTE's time is required to deliver the product?
    - Are there anticipated changes in technology, policies, regulations, or supplier base that would affect workload demand?
    - Assess new materials and technologies as they evolve and how the M&Q workforce will address processing, testing, and acceptance of these materials.
    - Identify potential regulatory requirements and special handling (e.g., hazardous materials, environmental needs, storage requirements, etc.) impacts to the manufacturing workforce by the materiel solution approaches.
    - How would the workload on each product line be impacted by those changes? (as one line expands, what is the impact and as one line decreases, what is the impact)?
    - How would changes in FTEs affect workload?
    - What opportunities are there to leverage resources with other programs or products?
- Conduct an analysis on the workforce gap (Demand – Supply):
    - What workforce competency/skill gaps exist?
    - How are those competencies/skills being updated to reflect the changing business environment?
    - Identify and assess gaps in manufacturing workforce knowledge of the digital engineering and industrial cybersecurity concerns
    - Identify potential workforce shortfalls based on an aging workforce and needs for early recruitment of new employees
    - Are there certain occupations or geographic areas with hard to fill positions?
    - Are there certain occupations that require hard-to-find skills?
    - Identify, plan for, and mitigate potential workforce disruption (Covid, natural disasters, etc.)
    - How will retirement affect the overall spread of employees?
- Develop a plan to address the workforce gaps:
    - Are short-term and long-term organization plans/ strategies being used to inform workforce goals? How is workforce planning aligned with organizational strategy and direction? Where are the organization's greatest workforce planning needs?
    - Train or acquire personnel appropriately to address the digital engineering knowledge gaps and expertise needed.
    - Identify traditional and non-traditional training and education opportunities for workforce development to meet goals.

  - What metrics/ratios will best help to monitor/identify workforce challenges/risks? What metrics/ratios should be used to diagnose workforce challenges?
  - What workforce data source best supports workforce gap analysis, planning, and management?

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

Tools

- Workforce Planning Tools (SAP/Oracle/MRP II)
- Manufacturing Resource Planning (MRPII)
- Interactive MRL Users Guide (Checklist), Manufacturing 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 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

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

J.2 Update and Manage Workforce Plan

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. Two major focus areas are:

- Workforce Skills availability
- Workforce Skills capability

Manpower skills availability and capability should have been assessed prior to the Milestone C decision, and now that the program in in LRIP, then manpower needs to be assessed to ensure that there is enough capability to meet the demands of LRIP and the ramp up in production.

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) is 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

A comprehensive assessment of contractor manufacturing plans for system development is necessary to understand the requirements for workforce skills, capabilities, training, and certifications with program office personnel monitoring these activities. In support of LRIP/FRP workforce requirements, contractor plans should be assessed for human resource policies, processes, and procedures, forecasts for the number of workers, skills, and capabilities, etc. Additionally, the current training, certifications, and education, sourcing availability and stability, demographics of the contractor and supply chain should be evaluated for adequacy, as well as their capability and capacity to expand the workforce, through hiring, training, and certification, for all production requirements.

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 long lead workforce needs (training, certification, recruitment, etc.)
    - 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's re-locations, and changes (e.g., location, improvements and expansion, lay-out changes, etc.)
    - Tooling improvements and changes (e.g., operation and maintenance, safety, security, cleanliness, acoustics, HVAC, and environmental controls, etc.)
    - Quality requirements changes and additions (e.g., inspections, equipment operation, maintenance, calibration, etc.)
    - New materials and technologies impact on workforce ability to address processing, testing, and acceptance
    - Planning for digital engineering requirements and activities
    - 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
    - Development of M&Q metrics to measure performance
- Assess the factory floor environment (union contract status, earthquakes, power outages, etc.) to determine potential impacts to program performance and sustainability goals.
- Assess factory efficiency and utilization. This activity involves the assessment of how efficiently the contractor is producing products, primarily through the evaluation of work measurement data. It also includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.
- Review and assess the contractor's manufacturing plans to identify workforce requirements for skills, capabilities, training, and certification requirements:

    - Contractor's make/buy processes for factors that determine the outsourcing of workforce skills
    - Scale-up or scale down materials, subsystems, items, and components
    - Contractor's labor market (availability, stability, capabilities, training, etc.)
    - Potential ManTech changes, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
    - Potential facilities changes (e.g., location, improvements and expansion, layout changes, etc.)
    - Materials handling (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
    - Environment, safety, and occupational health
    - Manufacturing machinery and equipment (e.g., programming and operation, maintenance, calibration, and repair, etc.)
    - Facilities and tooling (e.g., operation and maintenance, safety, security, cleanliness, acoustics, Heating, Ventilation, Air Conditioning (HVAC) and environmental controls, etc.)
    - Quality (e.g., inspections, equipment operation, maintenance, calibration, etc.)

- Assess the factory floor environment (union contract status, earthquakes, power outages, etc.) to determine potential impacts to program performance and sustainability goals.
- Assess factory efficiency and utilization. This activity involves the assessment of how efficiently the contractor is producing products, primarily through the evaluation of work measurement data. It also includes the analysis of causes of variances, their root causes, and championing and motivating contractor improvements.

Tools

- 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 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-896, Manufacturing Management Program Guide
- AS9100, Quality Management System
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- Manufacturing Resource Planning (MRP II) software
- 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 Assess 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?)

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 outputs 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.

Manufacturing USA estimates that by 2028 manufacturers will need to fill 4.6 million jobs, which indicates a mismatch between supply of workers and the demand for them. This gap in 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.

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

- Identify manufacturing workforce resource requirements for FRP and sustainment activities:
  - Required workforce availability has been forecasted by monthly requirement against the production schedule (FRP and Sustainment)
  - Required workforce is available, by labor skill category, to meet planned production requirements (FRP and Sustainment)
  - Required workforce skills, training, and certifications have been forecasted by monthly requirement against the production schedule (FRP and Sustainment)
  - Required workforce training and certification have been planned for by monthly requirement against the production schedule (FRP and Sustainment)
  - Have any new or emerging skills been identified that need to be assessed for availability and training (FRP and Sustainment)
  - Assess potential disruptive activities that could impact workforce availability (natural disasters, pandemics, changes in technologies, strikes, plant closures, etc.)
- Develop workforce plans to achieve FRP and Sustainment requirements.
- Update workforce plans to achieve FRP and Sustainment workforce requirements.
- Ensure FRP and Sustainment personnel requirements are met.
- Implement a plan to achieve FRP and Sustainment workforce requirements.
- Ensure production workforce skill sets been maintained based on attrition of workforce.

Tools

- Workforce Planning Tools (SAP/Oracle/MRP II)
- Manufacturing Resource Planning (MRPII)
- Independent Technical Risk Assessments (ITRAs)
- Technology Readiness Assessment
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control 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
- Capacity Planning Worksheet
- Critical Chain Project Management
- 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, Workforce thread
- 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)

- Independent Technical Risk Assessment Framework for Risk Categorization DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.88, Engineering of Defense Systems
- DoD Technology Readiness Assessment (TRA) Guide
- 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

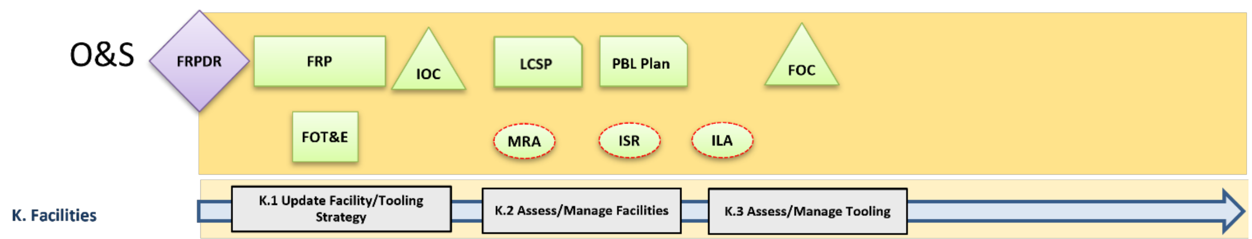


Figure 6-12. Facilities Manufacturing and Quality Activities

Introduction

Facilities management thread is a contractor activity 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 (job shop, batch processing, continuous flow, etc.), 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. Program office personnel monitor these requirements.

The facility 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. 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. 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 sustainment phase, M&Q personnel should update the facility and tooling strategies and plans developed and used during production and operations. In addition, they should conduct assessments of proposed production facilities and update and finalize the tooling plan for the O&S phases and then plan for smart shutdown.

During the sustainment phase, a contractor, or a government owned or operated remanufacturing facility (depot/MRO, etc.) should have implemented an effective facilities management plan along with a tooling plan.

Manufacturing tooling, to include special tooling (ST), special test equipment (STE), and special inspection equipment (SIE) should be assessed for its ability to support sustainment production and operations. Current special tooling strategies favor condition-based maintenance or total productive maintenance (also known as total preventive maintenance). Often special tools, test, and inspection equipment have been in use in the production environment for a long time and may face the need for refurbishment or purchasing of new tools and test equipment. But as production rates and quantities go down, the budget for special tools and test equipment may also go down. In addition, the manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as depots, MROs, etc.

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 Update 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 influencer on product quality outcomes. The B1 program for example had over $1 billion in tooling, and the lead times for facility and tooling development can be years. 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 risk reduction strategy is to begin development of facilities and long-lead tooling well in advance of the contract for the next phase. During the O&S phase 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 such tools 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/Update the 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.
- Initiate planning for construction, fabrication, test, and demonstration of required new or modified facilities or tools.
- Update the planning for Special Test Equipment (STE) and Special Inspection Equipment (SIE) based on prototyping results (e.g., acquisition of specialized fixtures, construction of test chambers, upgrading laboratories and clean rooms, upgrading waste storage and disposal equipment, etc.).
- Update new M&Q capital equipment, tooling, and Special Test or Inspection Equipment (STE/SIE) requirements for new technology and materials for preferred concepts.
- Update the M&Q assessments of:
    - Tooling requirements for capability to produce at planned production rates and target unit costs
    - Needs for soft tooling versus hard tooling
    - Supplier and sub-tier capabilities, requirements, and investment incentives
    - STE/SIE requirements and capabilities
- Assess M&Q requirements for unique or special transportation, handling, and storage equipment to be manufactured for preferred concepts.
- Identify funding estimates required for facilities, capital equipment, tooling, and test equipment for preferred concepts.
- Ensure that updated Tooling Strategy and Plans include:
    - Identify special tooling, special test, and special inspection equipment
    - Update the manufacturing plan (tooling section)
    - Identify smart shutdown conditions and operations with respect to special tooling, test, and inspection equipment
    - Implement preservation and storage of unique tooling plan once shutdown is accomplished
    - Identify ST, STE, and SIE risk areas
    - Identify ST, STE, and SIE requirements to maintain equipment for the life of the program
- Review the use of existing government owned inventory prior to use of product support arrangements.
    - The government accountable property system that documents all government owned property whether it is held and managed by the government, contractor, or third party
    - The government accountable property system that documents all government-owned property whether it is held and managed by the government, contractor, or third party, in accordance with 40 USC 524

Tools

- Acquisition Strategy Template
- Systems Engineering Plan (SEP) Outline
    - Manufacturing Plan
    - Quality Assurance Plan
- Interactive MRL Users Guide (Checklist), Facilities thread
- AS6500 Manufacturing Management System Checklist
- 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
- Defense Manufacturing Management Guide for Program Managers, Chapter 6, Manufacturing Planning
- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5, Elements of a Manufacturing Strategy
- Manufacturing Readiness Level (MRL) Deskbook
- AS6500, Manufacturing Management System
- MIL-HDBK-896A, Manufacturing Management Program Guide
- AS9100, Quality Management Program
- 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
- Digital Engineering Body of Knowledge
- DoD Risk, Issue, and Opportunity Management Guide for 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.

K.2 Assess and Manage Facilities

Contractor manufacturing facilities assessment includes an analysis of the capabilities and capacity of the production facilities to continue production through the O&S phase and prepare for a smart shut-down. Facilities assessments should include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities anywhere with program office personnel monitoring these activities and risks. 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
- 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 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 being considered.
    - Identify the availability, design, rate, and capacity capabilities of the facilities under consideration (existing, new, or redeveloped)
    - Identify the types of processes required and the resulting impacts on facilities by each of the concepts being considered (e.g., specialized fixtures, test chambers, laboratories, clean rooms, waste storage and disposal, etc.)
    - Identify the unique or special facility requirements for transportation, handling, and storage equipment being manufactured for each materiel solution

- Assess the contractor's manufacturing management plans for facilities including plans, utilization, and any relocation/consolidation, program schedules, and manufacturing maturity requirements for adequacy, compliance, and impact to the contract to include:
    - Identify new to the contractor materials, technologies, manufacturing methods that require new M&Q processes requiring additional facilities, equipment, and tools
    - Review of the technical data package to identify specific material specifications that require unique production facilities
    - Assess current utilization for proposed manufacturing facilities
        - Assess adequacy of contractor identified facility, manufacturing equipment, test, and quality assurance equipment
        - Review contractor capabilities required for special handling, material storage, ultra-clean work environments, material, and part handling, storage, and transportation, etc.
    - Identify any planned relocation and/or consolidation of production facilities, tooling, and production lines impacts to schedule and costs

  - Identify impacts to schedule and costs from planned changes to increase manufacturing maturity (i.e., manufacturing technology)
  - Identify any 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

- Conduct production facilities assessments to ensure that:
  - Facilities had the capability and capacity to produce items needed during the O&S phase
  - Facilities assessments consider the impact of a program winding down production and producing only to support spares.
  - Facilities should plan for a smart shut down at the end of the program.
  - The contractor's manufacturing plan has been updated to include facilities management.
  - That the current usage and utilization rates are cost effective and affordable.
  - Product support integrators and product support providers identify future production or remanufacturing as organic, commercial, or a combination.

- Prepare an assessment of facility capacity to include:
  - General knowledge of factory and environment (union contract status, earthquakes, power outages, etc.)
  - Identify schedule, key milestones, decision points, risks, and long lead items
  - Delineate between shutdown tasks to be charged directly to the shutdown effort, tasks covered by existing contracts including postproduction planning, and tasks to be otherwise allocated to overhead/indirect expenses
  - Assess any impact on the last production contract due to Ramp-Down. There may be a loss of efficiency due in part to employee morale unless the workforce moves to another program immediately
  - Process to include government personnel in the preliminary planning phases to identify items to be retained, disposed, and/or stored for sustainment or production restart
  - Union termination agreements
  - Shutdown of subcontractor activities and contract close-out
  - Cessation of production, disposal, and other related activities unless initially negotiated for the government to pay certain costs

Tools

- 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 System
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9100, Quality Management Program
- 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 6.7.13 Facility Planning
- DCMA-INST-204, Manufacturing and Production
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook

K.3. Assess and Manage Special Tooling, Test, and Inspection Equipment

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. 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.

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
  - Requirements for safeguarding from adjustments, damage, or deterioration
- Develop and implement a Tooling Plan (developed in MSA) for specialized tooling whose use is limited to the development or production of supplies or parts or to the performance of functions for the program including jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items including foundations and similar improvements necessary:
  - 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
- Update the Tooling Plan for single or multipurpose integrated specialized test equipment (STE/SIE) that is engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items or assemblies of equipment including inter-connected or interdependent, and foundations and similar improvements necessary.
- Assess contractor demonstrations and validation of prototype, soft, hard, and other tooling and STE/SIE in the appropriate production environment for functionality and sufficiency.
- Identify new capital equipment and tooling required for new or emerging technologies and materials, and M&Q processes:
  - Assess new tooling requirements for capability to produce at planned production rates and target unit costs
  - Assess needs for soft tooling vs. hard tooling for facility and funding impacts
  - Assess supplier and sub-tier capabilities and investment incentives
  - Assess the funding requirements and develop appropriate funding profiles
- Evaluate each concept or production approach being considered to include alternative designs for ST/STE/SIE:

  - Assess the requirements for ST/STE/SIE
  - Assess the capabilities of ST/STE/SIE to meet needs
  - Demonstrate and validate the capabilities of the ST/STE/SIE
  - Ensure the ST/STE/SIE is maintained and capable of meeting production requirements

- Identify specific ST/STE/SIE for government-furnished equipment (GFE):

  - Assess the requirements for GFE
  - Assess the capabilities of GFE to meet needs
  - Assess requirements for managing GFE until proper disposal

- Identify requirements for unique or special transportation, handling, and storage equipment to be designed, produced, and validated.
- Identify the funding required for capital equipment, M&Q processes, tooling, and test equipment.
- Perform a M&Q assessment of the contractor's and supply chain tooling, test, and inspection equipment resources provided for:

  - Suitability for the specific type of monitoring and measurement activities required
  - Maintenance and accountability to required standards with appropriate documentation

- Assess contractor and supply chain demonstrations of tooling and STE/SIE for subsystems, items, and components in the appropriate production environment (e.g., representative, pilot line, production line) for functionality, sufficiency, and capacity.
- Identify unique tooling associated with the production of hardware to facilitate its protection and storage through the end of the program's service life.
- Review the contractor's or government's tooling plan and inventory.
- Review movement of special tooling and special test equipment.
- Review the use of existing government owned inventory prior to use of product support arrangements.
- Minimize the need for unique automatic test equipment (ATE) by using designated DoD automatic test system families for all ATE hardware in DoD field and depot operations.
- Review the Preservation and Storage of Unique Tooling Plan and ensure that it includes the review cycle for assessing tool retention across the life of the system.
- Review and assess all STE whether single or multipurpose integrated test units engineered, designed, fabricated, or modified to accomplish special purpose testing in performing a contract.

Tools

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

- 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
- Rough Cut Capacity Planning Spreadsheet

Resources

- FAR 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
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- 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 Instruction 124, Contract Property Administration
- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5, Elements of a Manufacturing Strategy
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 4275.5, Acquisition and Management of Industrial Resources
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook
- Guidebook for Contract Property Administration
- USD(AT&L) Memo, Preservation, and Storage of Tooling for MDAPs

L. MANUFACTURING MANAGEMENT AND CONTROL

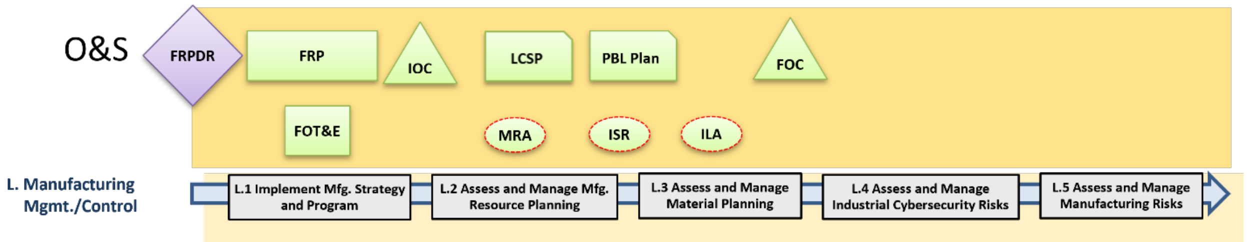


Figure 6-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

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

The purpose of manufacturing planning is the identification of resources and integration into a structure that provides the capability to achieve 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 Implement the Manufacturing Strategy and Program

A Manufacturing Strategy should be developed as part of the Systems Engineering Plan and Acquisition strategy. These plans and strategies will be used to support the development and production of an affordable program and include 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 industry best practice for manufacturing management is AS6500 Manufacturing Management Program. Even if not called out on contract, the requirements of AS6500 are worth reviewing while assessing a contractors manufacturing management program. 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.

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

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 cutting edge materials and emerging capabilities enabled by the physical and biological sciences. Advanced manufacturing includes additive manufacturing, artificial intelligence, robotics, and advanced composite materials. M&Q personnel

Manufacturing and Quality Tasks

- Support the development of the Acquisition Strategy (AS).
- Support the development of the Systems Engineering Plan (SEP).
- Develop the initial Manufacturing Strategy, if appropriate, and ensure the Manufacturing Strategy addresses M&Q considerations for:
    - IB Risk Mitigation
    - Enabling/critical technologies and constraints
    - ManTech projects
    - Design and producibility
    - 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 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
    - 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
    - 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 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.

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

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

- Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- Identify and understand potential sources that could address manufacturing management needs:
    - Identify and understand M&Q management lessons learned and best practices among programs and across centers
    - Assess and evaluate manufacturing technologies that could assist on materiel solution programs.
- Initiate planning for each system, subsystem, or component 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 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
- 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.

- Establish manufacturing management metrics:
  - 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.
- Support the development of a Manufacturing Strategy to include the following items:
  - Should be included in the Systems Engineering Plan (SEP) and/or the Life Cycle Sustainment Plan (LCSP)
  - Should include Make/Buy decisions and the decision to have either organic or contractor sustainment support.
  - Should support the PMs in developing and maintaining an LCSP consistent with the product support strategy.
  - Should describe sustainment influences on system design and the technical, business, and management activities to develop, implement, and deliver a product support package that maintains affordable system operational effectiveness over the system life cycle and seeks to reduce costs without sacrificing necessary levels of program support.
  - Should specify Manufacturing Management System requirements (e.g., AS6500), if applicable to be met by the prime contractor and flowed down to suppliers, as appropriate.
- Review the following sources of industrial and manufacturing readiness data to develop the Manufacturing Strategy:
  - Program Status Reviews
  - Pre-Award Surveys
  - Production Readiness Reviews
  - Industrial Base Assessments
  - Trade-off studies, tooling plans
  - Make-or-buy plans
  - Manufacturing plans
  - Bills of material

Tools

- Acquisition Strategy Outline
- Systems Engineering Management Plan, DI-SESS-81785A
- Systems Engineering Plan (SEP) Outline
  - Manufacturing Plan, DI-MGMT-81889A
  - Quality Assurance Program Plan, DI-QCIC-81794

- AS6500 Assessment
- Interactive MRL Users Guide (Checklist), 2018 for the Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- Work Breakdown Structure

Resources

- 10 USC 2431a. Acquisition Strategy
- FAR Part 7.105 Contents of Written Acquisition Plans
- Acquisition Strategy Guide (DSMC)
- Acquisition Strategy Guide (NAVSEA)
- Systems Engineering Plan Preparation Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.6.6.1 Develop Acquisition Strategy
- Defense Manufacturing Management Guide for Program Managers, Chapter 4 Manufacturing Strategy
- AS6500, Manufacturing Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition ProgramsAS6500, Manufacturing Management System
- ASD(LM&R) Life-Cycle Sustainment Plan memo
- MRL Deskbook
- 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 Assess and Manage Manufacturing Resource Planning Requirements

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 control is 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**: 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 units costs over time
- Maintenance Costs: Evaluate your equipment costs in the long run

Planning is conducted to ensure that activities and resources are coordinated over time to achieve production goals. Planning must be done so the progress of the plan can be monitored at regular intervals and control over operations can be maintained. Planning in the manufacturing environment involves many elements: scheduling, labor planning, equipment planning, process planning, materials planning, quality planning, and cost planning.

- Scheduling involves specifying the start, duration, and sequencing of operations.
- Labor planning involves the training and allocation of qualified personnel, distribution of responsibilities and resources.
- Equipment planning involves identification, purchasing, installation, and proofing.
- Process planning involves the identification, maturing, and continuous improvement of processes, especially key and critical processes, so that cost and performance are managed.
- Materials planning involves identifying and coordinating the supply chain and at a minimum should include key and critical suppliers and vendors.
- Quality planning involves the identification of methods to manage product quality (measurement) and the purchasing and proofing of inspection equipment.

Detailed Manufacturing Plans are often reflected in the use of an MRP II system and include the ability to create:

- Rough Cut Capacity Plan
- Capacity Requirements Plan
- Production Schedule
- Labor Reports
- Quality Reports
- Cost Reports

Work instructions are a basic manufacturing tool, developed to assist a worker in accomplishing a task. A work instruction details the sequence of steps that an employee must follow every time they perform a task. The work instruction organizes the work into logical steps so that an employee can easily follow it independently. Planning for this phase includes planning for long term sustainment, and then eventual disposal or de-mil activities.

During the system Sustainment, the PM will deploy the product support package and monitor its performance according to the Life Cycle Sustainment Plan (LCSP). PMs are responsible for developing and maintaining an LCSP consistent with the product support strategy. The LCSP describes how sustainment influences the technical, business, and management activities that help to implement a product support package that maintains affordable system operational effectiveness over the system life cycle. The Acquisition Strategy should also include an overview of the product support strategy and sustainment-related contracts as well as address significant manufacturing concerns such as DMSMS, Advanced Manufacturing, and Additive Manufacturing.

DMSMS, obsolescence, and counterfeiting of parts and materials, especially in the electronic segment, are growing at an alarming rate. A large network of suppliers in an increasingly global supply chain creates limited visibility into these sources, leading to a greater risk of procuring counterfeit parts. In addition, there are unique conditions that make aerospace and defense products susceptible to counterfeiting, including a long-life cycle and DMSMS issues. Therefore, supporting aerospace and defense programs require increased vigilance and oversight.

During the O&S phase, M&Q personnel will be involved in the following:

- Conduct Environment, Safety and Occupational Health risk assessments and maintain oversight of critical safety item supply chain management.
- Conduct analysis to identify and mitigate potential obsolescence impacts (i.e., DMSMS).
- Support implementation of follow-on development efforts in response to formal decisions to extend the weapon system's service life extension program (SLEP), or to initiate a major modification (may be treated as a stand-alone acquisition program).

Manufacturing and Quality Tasks

- Identify manufacturing resource planning requirements.
- Manufacturing resource needs assessed, analyzed, and validated.
- Manufacturing resource requirements for potential systems or concepts identified.
- Support the evaluation of Manufacturing Planning and Control systems (MRP II) to include:
    - Long-Term Planning
    - Medium-term planning
    - Short-term planning
- 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

  - Develop a production schedule
  - Establish performance measures
  - Monitor, assess, and take corrective action based on various production reports (cost, quality, labor, etc.)
  - 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.
- Support the following Long-term Planning requirements:
  - Demand Management (Customer requirements, how many and when)
  - Sales and Operations Planning
  - Resource/Production Planning (Rough Cut Capacity Planning)
  - Master Production Scheduling
  - Medium-term planning is the "engine" of an MRP II system and includes:
  - Detailed Material Planning
  - Demand Capacity Planning (Capacity Requirements Planning)
  - Material and Capacity Plans
- Identify mid-term manufacturing resource planning requirements:
  - Conduct a capacity requirements plan to analyze available resources
  - Identify and quantify key resources (5Ms)
  - Identify the Bill of Materials (BOM)
  - Extend the BOM against the Master Production Schedule
  - Identify manufacturing resource gaps (under and over capacity workstations)
  - Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- Identify short-term manufacturing resource planning requirements (production execution):
  - Conduct shop floor execution of production against available resources
  - Schedule the activities (routings or workflow)
  - Dispatch the work, release the production order to the floor
  - Monitor the workflow and take corrective action on potential or real problems
  - Identify and quantify key resources (5Ms)
  - Identify the Bill of Materials (BOM)
  - Extend the BOM against the Master Production Schedule
  - Calculate utilization rates
  - Calculate or identify lead times
  - Calculate Overall Equipment Effectiveness rates

  - Identify constraints or bottlenecks
  - Identify manufacturing resource gaps (under and over capacity workstations)
  - Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- Support planning and implementation activities associated with the "back-end" of an MRP II system and includes:
  - Supplier Systems (Purchase Order Release)
  - Shop-Floor Systems (Work Order Release)
  - Shop Floor Activities
- Periodically assess manufacturing plans along with the LCSP to identify risks and develop risk mitigation measures.
- Review the Manufacturing Plan to ensure it will provide the resources needed for sustainment operations as outlined in the LCSP.
- Assess the Manufacturing Plan for impact to the "5Ms" (Manpower, Material, Methods, Measurement and Machinery).
- Assess the Manufacturing Plan for Risks, Issues, and Opportunities.
- Identify any assumptions made in developing the shutdown plan.
- Ensure the contractor is conducting First Article Inspections on the hardware being produced from the new facility.
- The DCMA MSRA Production Planning and Control, Material Requirement Planning Checklist can be used to assess:
  - Resource Requirements Planning
  - Aggregate Planning
  - Master Production Schedule
  - Rough Cut Capacity Planning
  - Capacity Requirements Planning
  - Shop Floor Controls
- Support development of Manufacturing Plans in support of the O&S phase and sustainment operations.
- Review the Manufacturing Plan to ensure it will provide the resources needed for sustainment operations as outlined in the LCSP.
- Assess the Manufacturing Plan for impact to the '5Ms' (Manpower, Material, Methods, Measurement and Machinery).
- Assess the Manufacturing Plan for Risks, Issues and Opportunities.
- Ensure that Defense acquisition programs minimize the need for new defense-unique industrial capabilities.
- Support the development of a Smart Shutdown plan.

- Ensure the contractor is conducting First Article Inspections on the hardware being produced from any new facility:
  - The manufacturing environment may have moved from a prime contractor facility to government owned and operated facilities, such as depots, MROs, etc.
- Ensure manufacturing planning addresses transition considerations that may be impacted by:
  - Funding constraints and phasing of money
  - Design considerations, goals, and risks
  - Test and evaluation methods and approaches along with success criteria
  - Production processes, methods, workforce, facilities, equipment, and capabilities
  - Life cycle logistics and sustainment criteria, approach, and goals
  - Management approach to transition risks
- Establish manufacturing management metrics for each of the concepts being considered:
  - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Contact DCMA for input on manufacturing management system evaluation of potential contractors and suppliers for each concept being considered.

Tools

- AS6500 Assessment
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline
- Systems Engineering Management Plan, DI-SESS-81785A
  - Manufacturing Plan, DI-MGMT-81889A
  - Quality Assurance Program Plan, DI-QCIC-81794
- AIAG 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 (L-2, Manufacturing Resource Planning):
    - Production Planning and Scheduling
    - Work Order Management
    - Inventory Management
    - Equipment and Asset Management
    - Quality Management and Statistical Process Control
    - Process Management
    - Resource Allocation
    - Product Tracking
    - Data Collection and Analysis (Manufacturing KPIs)
- Bill of Material Assessment
- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Operations Process Chart
- Route Sheet Analysis
- Line of Balance Assessment
- Input/Output Analysis
- Make/Buy Decisions
- Work Breakdown Structure

Resources

- AS6500, Manufacturing Management Program
- DFARS 252.72 Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge
- ISO/IEC/IEEE 15288, Systems and Software Engineering–System Life Cycle Processes
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- Systems Engineering Plan (SEP) Outline

L.3 Assess and Manage Materials 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.

Contractor M&Q managers should be actively involved in the evaluation of a contractor's material management and control systems and with Material Resource Planning activities with program office M&Q managers assessing contractor performance and risks in this area. 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 are the basic building blocks for the company. Often this is in the form of raw materials and components.
- Work-in-Progress (WIP): WIP is made up of materials, components, subassemblies, and assemblies that are in the process of being produced. That is, they have been released from material stores and have not yet been through final inspection and acceptance.
- Finished Goods: Finished goods have been inspected and accepted and are awaiting delivery to the customer.

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 the demand signal (what, how much, and when) that needs to be available to meet the production schedule and plans for the replenishment of these stocks. Material planning creates inventory levels for each type of item (raw material, work in progress or finished goods), and communicates information and 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 is about understanding what inventories it takes to produce the items required by the contract, on time and within budget. Material planning directly affects profits as the lower the inventories, the lower the cost of production and the more profit. Reducing material cost has caused some industries to consider 'Just in Time (JIT)' strategies that require very small levels of inventory. However, this still requires careful planning to maintain without impacting production schedules and there are other material or inventory strategies to consider and should only be considered when there is a clear demand signal and short lead times.

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

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

Manufacturing and Quality Tasks

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

- Create a Master Production Schedule based on actual and forecasted orders.
- Identify all of the items in 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
- Manufacturing Readiness Level Assessment, Manufacturing Management thread
- 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
- Systems Engineering Management Plan, DI-SESS-81785A
  - Manufacturing Plan Inputs
  - Manufacturing Plan, DI-MGMT-81889A
  - Quality Plan Inputs
  - Quality Assurance Program Plan, DI-QCIC-81794
- Systems Engineering Plan (SEP) Outline
- 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 System
- MIL-HDBK-896, Manufacturing Management Program Guide
- Material Management and Accounting System – Audit Program
- MRL Deskbook
- DFAR Subpart 242.72 – Contractor Material Management and Accounting System
- Bill of Materials
- Inventory Records
- Master Production Schedule
- AS5553, Counterfeit Electronic Parts
- AS6174, Counterfeit Material
- SD-19, Parts Management Guide
- SD-22, DMSMS Guidebook
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.10.2 Material Requirements Planning
- DoDI 5000.88, Engineering of Defense Systems

L.4 Assess and Manage Industrial Cybersecurity Risks

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

Operational technologies and Industrial Control Systems can include:

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

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

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

Industrial cybersecurity is concerned with the ability of organizations to securely create, manage, control, and share information digitally. While the management and exchange of information is critical, it is equally important to do so in a safe and secure environment. Industrial cybersecurity is concerned with the transfer of digital data via Operational Technologies (OT) inside a facility and through the cloud to other organizations and facilities. Current digital environments are complex and made up of many systems with digital threads that connect government program offices to industry, prime contractors to subcontractors, laboratories to program offices, within an organization, etc. This digital thread includes design data in the form of model based designs, model based systems engineering, shop floor machines that use the design data to manufacture products, and the cloud to share data with suppliers, retailers, and other service organizations.

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

> "*Programmable systems or devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems/devices detect or cause a direct change through the monitoring and/or control of devices, processes, and events. Examples include industrial control systems, building management systems, fire control systems, and physical access control mechanisms.*"

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

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

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

M&Q personnel need to identify and manage industrial cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the acquisition framework in what is called the Industrial Internet of Things (IIoT).

Contractor M&Q personnel need to develop and execute industrial cybersecurity planning for system concepts identified and execute the management of those plans with program office M&Q managers assessing contractor performance and risks in this area 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

- 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
- Utilize digital engineering to support the development, implementation, and management of industrial cybersecurity programs and procedures.
- OT cybersecurity incidents are identified and assessed and are minimal.
- OT cybersecurity capabilities and solutions tested to support modifications and other sustainment activities.
- Workforce trained in the latest cybersecurity procedures.
- Cybersecurity is continuously assessed and improved.
- Perform SCRM assessments and reviews.
- Implement SCRM oversight and monitoring.
- Monitor and Manage Security Controls.
- Assess supply chain OT cybersecurity and vulnerability risks and develop risk management plans.
- Implement supply chain OT cybersecurity and vulnerability risk mitigation plans.
- Demonstrate OT cybersecurity solutions in an LRIP environment.
- Demonstrate OT cybersecurity solutions in an FRP environment.

- Assess the design of OT systems for facilities and equipment (i.e., in-house factory systems, production equipment, STE/SIE, and tooling) to ensure they include cybersecurity and physical/digital controls and access requirements.
- Plan for and document that LRIP facilities and equipment OT systems include cybersecurity and physical/digital controls, and access requirements.
- Identify and assess OT cyber incidents throughout the supply chain.
- Ensure that OT cybersecurity Incident Reporting procedures are in-place, including reporting, tracking, and corrective actions.
- Train the workforce in current cybersecurity procedures for production environment.

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (CALIT), DAU
- Cybersecurity Strategy ADDM Template
- CISA Industrial Cybersecurity Checklist, Appendix F
- NIST Security Plan 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
- Digital Engineering Body of Knowledge
- ASME Y14.41, Digital Product Definition Data Practices
- MIL-STD-31000B, Technical Data Package
- Trusted Systems and Networks (TSN) Analysis Guide
- DoDI 8500.01 Cybersecurity

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.83 Technology and Program Protection to Maintain Technological Advantage
- DoDI 5000.90 Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoDI 5200.39, Critical Program Information Identification and Protection within RDT&E
- DoDI 5200.44, Protection of Mission Critical Functions to Achieve Trusted System and Networks (TSN)
- DoD 5220.22-M National Industrial Security Program
- DoDI 8510.01, Risk Management Framework for DoD Systems
- 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 an 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 for more information.

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 programs 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 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. Assessing manufacturing risk is a constant activity focused on production risk areas but often focused on specific production problems in the various O&S environments.

Manufacturing and Quality Tasks

Assessments should be made for each O&S production environment to include MROs, and then manage these risks:

- Identify required production processes and manufacturing techniques that are not currently available and the risks associated with development of manufacturing technologies, the probability of meeting the need dates and possible contingency actions.
- Identify potential impact of critical and long lead time material and production equipment, the probability of meeting the need dates and possible contingency actions.
- Provide production feasibility, design performance, cost, and schedule impact analyses to support trade-offs among alternatives.
- Provide cost and production schedule estimates to support management reviews.
- Conduct manufacturing schedule assessments.
- 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, DI-MGMT-81889A
  - Quality Assurance Program Plan, DI-QCIC-81794
- Independent Technical Risk Assessments (ITRAs)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control thread
- Manufacturing Maturation Plan
- AS6500, Assessment
- DCMA Production Planning and Control 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 System
- 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
- AFLCMC/EZSM Acquisition Manufacturing and Quality Assurance Process Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Acquisition Program Support (DAPS) Methodology
- Independent Technical Risk Assessment Framework for Risk Categorization
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.6 Risk Assessment
- Defense Manufacturing Management Guide for Program Managers, Chapter 17.4 Assessment of Manufacturing Readiness
- Defense Manufacturing Management Guide for Program Managers, Chapter 17.8 The MRL Assessment
- Defense Manufacturing Management Guide for Program Managers, Chapter 17.9 The Manufacturing Management Maturation Plan
- DoD Technology Readiness Assessment (TRA) Guide
- SD-19, Parts Management Guide
- SD-22 DMSMS Guidebook
- DoD Corrosion Prevention and Control Guidebook
- DoDI 5000.67 Prevention and Mitigation of Corrosion on DoD Military Equipment and Infrastructure
- Overarching DoD Counterfeit Prevention Guidance
- Counterfeit Materiel Process Guidebook, Department of Navy
- ITAR Law: Arms Export Control Act of 1976
- USC 22 Subchapter M International Traffic in Arms Regulation
- MIL-HDBK-61 Configuration Management Handbook

Appendix A: Abbreviations and Acronyms

AAF	Adaptive Acquisition Framework
AAFDIT	Adaptive Acquisition Framework Document Identification Tool
ADM	Acquisition Decision Memorandum
AdM	Advanced Manufacturing
AFRL	Air Force Research Laboratory
AIAG	Automotive Industry Action Group
A_m	Materiel Availability
AM	Additive Manufacturing
ANSI	American National Standards Institute
A_o	Operational Availability
AoA	Analysis of Alternatives
APA	Additional Performance Attributes
APB	Acquisition Program Baseline
APQP	Advanced Product Quality Planning
AQL	Acceptable Quality Level
ARL	Army Research Laboratory
ARRT	Acquisition Requirements Roadmap Tool Suite
AS	Acquisition Strategy
ASME	American Society of Mechanical Engineers
ASR	Alternative Systems Review
ASTM	American Society for Testing and Materials
AT	Anti-Tamper
ATE	Automatic Test Equipment
AUPC	Average Unit Procurement Cost
BCA	Business Case Analysis
BER	Beyond Economical Repair
BES	Budget Estimate Submission
BoK	Body of Knowledge
BOM	Bill of Materials
C/SCSC	Cost/Schedule Control Systems Criteria

C/SCSC	Cost and Schedule Control Systems Criteria
C4I	Command, Control, Communications, Computers, and Intelligence
CAB	Corrective Action Board
CAD	Computer-Aided Design
CAE	Component Acquisition Executive
CAI	Critical Application Item
CAIG	Cost Analysis Improvement Group
CAIV	Cost as an Independent Variable
CAM	Computer-Aided Manufacturing
CAPE	Cost Assessment and Program Evaluation
CAPP	Computer-Aided Process Planning
CARD	Cost Analysis Requirements Description
CAS	Contract Administration Services
CBA	Capabilities-Based Assessment
CC	Critical Characteristic
CCA	Cost Capability Analysis
CCB	Configuration Control Board
CCE	Component Cost Estimate
CDD	Capability Development Document
CDRL	Contract Data Requirements List
CI	Configuration Item
CI	Critical Item
CJCS	Chairman of the Joint Chiefs of Staff
CLIN	Contract Line Item Number
CM	Configuration Management
CMO	Contract Management Office
CMP	Configuration Management Plan
CMP	Critical Manufacturing Process
CO	Contracting Officer
COE	Center of Excellence
COMSEC	Communications Security
CONOPS	Concept of Operations
COSSI	Commercial Operations and Support Savings Initiative
COTS	Commercial Off-the-Shelf

CP	Critical Part
Cp/Cpk	Process Capability/Process Capability Index
CPAR	Contractor Performance Assessment Report
CPC	Corrosion Prevention and Control
CPFF	Cost Plus Fixed Fee
CPI	Continuous Process Improvement
CRI	Cost Reduction Initiative
CSDR	Cost and Software Data Reporting
CSI	Critical Safety Item
CTC	Critical to Customer
CTE	Critical Technology Element
CTQ	Critical to Quality
CUI	Controlled Unclassified Information
DAE	Defense Acquisition Executive
DAG	Defense Acquisition Guidebook
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University
DCAPE	Director of Cost Assessment and Program Evaluation
DCMA	Defense Contract Management Agency
DFA	Design for Assembly
DFARS	Defense Federal Acquisition Regulation Supplement
DFM	Design for Manufacturability
DFMA	Design for Manufacture and Assembly
DFMEA	Design Failure Modes and Effects Analysis
DFSS	Design for Six Sigma
DIB	Defense Industrial Base
DID	Data Item Description
DLA	Defense Logistics Agency
DMMG	Defense Manufacturing Management Guide
DMS	Diminishing Manufacturing Sources
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoD	Department of Defense
DoDD	DoD Directive

DoDI	DoD Instruction
DoDM	DoD Manual
DOE	Design of Experiments
DPAS	Defense Priorities and Allocation System
DPM	Defective Parts Per Million
DSS	Design for Six Sigma
DT&E	Developmental Test and Evaluation
DTC	Design to Cost
DTRAM	Defense Technical Risk Assessment Methodology
EAC	Estimate at Completion
ECP	Engineering Change Proposal
ED, SE&A	Executive Director, Systems Engineering and Architecture
EMC	Electromagnetic Compatibility
EMD	Engineering and Manufacturing Development
EMI	Electromagnetic Interference
EOQ	Economic Order Quantity
ERP	Enterprise Resource Plan
ESA	Engineering Support Activity
ESOH	Environment, Safety, and Occupational Health
ESS	Environmental Stress Screening
EVMS	Earned Value Management System
5Ms	Manpower, Machines, Materials, Methods, Measurement
FA	First Article
FAI	First Article Inspection
FAR	Federal Acquisition Regulation
FAT	First Article Test
FCA	Functional Configuration Audit
FDD	Full Deployment Decision
FFP	Firm Fixed Price
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOD	Foreign Object Damage

FOT&E	Follow-on Test and Evaluation
FPAF	Fixed Price Award Fee
FPIF	Fixed Price Incentive Fee
FRACAS	Failure Reporting, Analysis, and Corrective Action System
FRP	Full-Rate Production
FRPDR	Full-Rate Production Decision Review
FTA	Fault Tree Analysis
FYDP	Future Years Defense Program
GAO	Government Accountability Office
GCQA	Government Contract Quality Assurance
GFE	Government-Furnished Equipment
GFM	Government-Furnished Material
GFP	Government-Furnished Property
GIDEP	Government and Industry Data Exchange Program
GOTS	Government Off-the-Shelf
HAZMAT	Hazardous Material
HSI	Human Systems Integration
HVAC	Heating, Ventilation, and Air Conditioning
HWCIs	Hardware Configuration Items
IB	Industrial Base
ICA	Industrial Capabilities Assessments
ICD	Initial Capabilities Document
ICE	Independent Cost Estimate
ICS	Industrial Control Systems
IEEE	Institute of Electrical and Electronics Engineers
IG	Inspector General
IGCE	Independent Government Cost Estimate
ILA	Independent Logistics Assessment
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOC	Initial Operational Capability

IP	Intellectual Property
IPMDAR	Integrated Program Management Data Analysis Report
IPS	Integrated Product Support
IPT	Integrated Product Team
IPT	Integrated Product Team
IRAD	Independent Research and Development
ISO	International Organization for Standardization
ISR	In-Service Review
ITAR	International Trafficking in Arms Regulation
ITRA	Independent Technical Risk Assessment
JCIDS	Joint Capabilities Integration and Development System
JROC	Joint Requirements Oversight Council
KC	Key Characteristics
KLP	Key Leadership Position
KMP	Key Manufacturing Process
KPP	Key Performance Parameter
KSA	Key System Attribute
LCC	Life Cycle Cost
LCSP	Life Cycle Sustainment Plan
LFT&E	Live-Fire Test and Evaluation
LOB	Line of Balance
LOD	Letter of Delegation
LRIP	Low-Rate Initial Production
M&Q	Manufacturing and Quality
M&S	Modeling and Simulation
ManTech	Manufacturing Technology
MATE	Multi-Attribute Trade Space Exploration
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDD	Milestone Development Decision

MEP	Manufacturing Extension Program
MES	Manufacturing Execution System
MIL-STD	Military Standard
MMAS	Material Management and Accounting System
MMP	Manufacturing Maturation Plan
MMS	Manufacturing Management System
MOA	Memorandum of Agreement
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOSA	Modular Open Systems Approach
MP	Mission Profile
MRA	Manufacturing Readiness Assessment
MRB	Material Review Board
MRL	Manufacturing Readiness Level
MRO	Maintenance, Repair, and Overhaul
MRP	Material Requirements Planning
MRP II	Manufacturing Resource Planning
MS A	Milestone A
MS B	Milestone B
MS C	Milestone C
MSA	Measurement System Analysis
MSA	Materiel Solution Analysis
MSRA	Manufacturing Systems Risk Assessment
MTA	Middle Tier Acquisition
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
MTTR	Mean Time to Repair
NAVSO-P	Navy Standard Operating Procedure
NDAA	National Defense Authorization Act
NDI	Non-Developmental Item
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NRL	Naval Research Laboratory

NSPAR	Non-Standard Parts Approval Request
NTIB	National Technology Industrial Base
O&A	Over and Above
O&M	Operations and Maintenance
O&S	Operations and Support
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
OIPT	Overarching Integrated Product Team
OMB	Office of Management and Budget
OMS/MP	Operational Mode Summary/Mission Profile
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
OT	Operational Technology
OTRR	Operational Test Readiness Review
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
P&D	Production and Deployment
P3I/P^3I	Preplanned Product Improvement
PAOC	Post-Award Orientation Conference
PAW	Producibility Assessment Worksheet
PBL	Performance-Based Logistics
PCA	Physical Configuration Audit
PCO	Procurement Contracting Officer
PDR	Preliminary Design Review
PEP	Producibility Engineering and Planning
PESHE	Programmatic Environmental, Safety, and Occupational Health Evaluation
PFMEA	Process Failure Modes and Effects Analysis
PHL	Preliminary Hazard List
PHST	Packing, Handling, Storage, and Transportation
PLM	Product Lifecycle Management
PM	Program Manager
PMO	Program Management Office
PMP	Parts, Materials, and Processes

PMR	Program Management Review
POE	Program Office Estimate
POM	Program Objective Memorandum
Pp / Ppk	Process Performance/Process Performance Index
PPAP	Production Part Approval Process
PPBE	Program, Planning, Budget, and Execution
PPC	Production Planning and Control
PPIRS	Past Performance Information Retrieval System
PPP	Program Protection Plan
PPV	Production Part Verification
PQM	Production, Quality, and Manufacturing
Pre-MDD	Pre-Materiel Development Decision
PRR	Production Readiness Review
PSA	Program Support Assessment
PSC	Preferred System Concept
PSM	Product Support Manager
PSS	Product Support Strategy
PTAC	Procurement Technical Assistance Center
PWBS	Program Work Breakdown Structure
QA	Quality Assurance
QALI	Quality Assurance Letter of Instruction
QDR	Quality Deficiency Report
QFD	Quality Function Deployment
QMS	Quality Management System
QSP	Quality Surveillance Plan
R&D	Research and Development
R&M	Reliability and Maintainability
RAM	Reliability, Availability, Maintainability
RCM	Requirements Correlation Matrix
RCT	Requirements Correlation Table
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RFI	Request for Information

RFP	Request for Proposal
RFP DP	Request for Proposal Release Decision Point
RFV	Request for Variation
RIO	Risk, Issues and Opportunities
RMBoK	Reliability and Maintainability Body of Knowledge
S&T	Science and Technology
SAE	Society of Automotive Engineers
SAR	Safety Assessment Report
SAT	Software Acceptance Test
SCAP	System Capability Analytic Process
SCE	Should Cost Estimate
SCM	Supply Chain Management
SCMP	Software Configuration Management Plan
SCOR	Supply Chain Operations Reference
SCRM	Supply Chain Risk Management
SDP	Software Development Plan
SE	Systems Engineering
SE&A	Systems Engineering and Architecture
SEMP	Systems Engineering Management Plan
SEP	Systems Engineering Plan
SF	Standard Form
SFMEA	System Failure Modes and Effects Analysis
SFQT	Software Formal Qualification Testing
SFR	System Functional Review
SIE	Special Inspection Equipment
SLEP	Service Life Extension Program
SME	Society of Manufacturing Engineers
SOO	Statement of Objectives
SOW	Statement of Work
SPC	Statistical Process Control
SPI	Special Packaging Instructions
SQAP	Software Quality Assurance Plan
SRR	System Requirements Review

SSA	System Safety Assessment
SSE	System Security Engineering
SSN	Sources Sought Notice
SSP	Source Selection Plan
ST	Special Tooling
STE	Special Test Equipment
STEM	Science, Technology, Engineering, and Math
SUPSHIP	Supervisor of Shipbuilding
SVR	System Verification Review
SWOT	Strengths, Weaknesses, Opportunities, and Threats
T&E	Test and Evaluation
TAPP	Technology Area Protection Plan
TBD	To Be Determined
TDP	Technical Data Package
TEMP	Test and Evaluation Master Plan
TMRR	Technology Maturation and Risk Reduction
TO	Technical Order
TOC	Total Ownership Cost
TOC	Theory of Constraints
TPM	Technical Performance Measure
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
TRR	Test Readiness Review
USC	United States Code
USD(R&E)	Under Secretary of Defense for Research and Engineering
V&V	Verification and Validation
VCRM	Verification Cross-Reference Matrix
VOLT	Validated Online Lifecycle Threat
VR	Variability Reduction
VSM	Value Stream Mapping

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

Appendix B: References

Resources identified in the M&Q BoK are listed below alphabetically and contain links to the referenced document or website. As many of these resources are revised frequently, readers are advised the documents may change or be updated, replaced, or cancelled between editions of this BoK. Readers may need to conduct an Internet search to find the most recent version.

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
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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
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Acquisition Logistician's Assessment Checklist (Army)
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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

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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

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https://apps.dtic.mil/dtic/tr/fulltext/u2/a258445.pdf

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

Cost of Quality (CoQ) Estimates
Internet Search

Critical Chain Project Management
Internet Search

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

Critical Path Template
Internet Search

Critical to Customer Template
Internet Search

Critical to Quality Tree Template
Internet Search

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Design Failure Modes and Effects Analysis (DFMEA)
Internet Search

Design for Affordability
Internet Search

Design for Manufacture and Assembly (DFMA)
Internet Search

Design for Performance
Internet Search

Design for Producibility
Internet Search

Design for Six Sigma (DFSS)
Internet Search

Design of Experiments (DoE)
Internet Search

Design of Experiments (DoE) Analysis
Internet Search

DFAR Subpart 232.10 Performance-Based Payments
https://www.acq.osd.mil/dpap/dars/dfars/html/current/232_10.htm

DMSMS Cost of Alternative Solutions Worksheet (see SD-22)
https://www.dau.edu/tools/t/SD-22-Diminishing-Manufacturing-Sources-and-Material-Shortages-(DMSMS)-Guidebook

DMSMS Implementation Plan - DI-MGMT-81949
https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=280073

DMSMS Health Assessment Report
https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=283247

Earned Value Management
https://www.dau.edu/tools/t/EVM-General-Reference-(Gold-Card)

Failure Mode and Effects Analysis (FMEA)
Internet Search

Failure Modes, Effects, and Criticality Analysis (FMECA)
Internet Search

First Pass Yield Estimates Worksheet
Internet Search

First Article Inspection (FAI) Checklist, AFMC Form 260, First Article Requirements
https://www.e-publishing.af.mil/Product-Index/#/?view=form&orgID=4&catID=9&low=200&high=299&modID=449&tabID=131

First Article Test (FAT) Checklist
https://www.dcma.mil/Portals/31/Documents/Policy/DCMA-INST-302.pdf

Functional Configuration Audit (FCA) Checklist (Air Force)
Templates – USAF Acquisition Process Model (afacpo.com)

Gantt Charts
Internet Search

Government Property Compliance Checklist (Navy)
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiyivT-sbnsAhVHuVkKHaU5Di0QFjAAegQIAhAC&url=http%3A%2F%2Fwww.secnav.navy.mil%2Frda%2FDocuments%2FCompliance%2520Checklist.xlsx&usg=AOvVaw0Jec3r4-gNaxYYoLYbcDLM

Histograms
Internet Search

IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
Internet Search

IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
Internet Search

IG5315.204-5(b) Section L Guide and Template
https://far.affinitext.com/public/book?id=18966&toc_id=5280626#PG_5280626_60386996

IG5315.204-5(c) Section M Guide and Template
https://far.affinitext.com/public/book?id=18966&toc_id=5280779#PG_5280779_60387780

Incentive Fee Template
https://www.dau.edu/tools/t/FPIF-CPIF

Independent Logistics Assessment Checklist (MCSC)
https://www.dau.edu/cop/log/_layouts/15/WopiFrame.aspx?sourcedoc=/cop/log/DAU%20Sponsored%20Documents/MCSC%20ILA%20Checklist%20v3%206AUG09.xls&action=default

Independent Technical Risk Assessments (ITRAs) Execution Guidance
https:ac.cto.mil/wp-content/uploads/2020/12/DoD-ITRA-ExecGuide-2020s.pdf

Industrial Base Assessment Survey Form (DCMA Industrial Analysis Group)
Internet Search

Industrial Base Sector Plans (no specific tool)
Internet Search

Initial Capabilities Document (ICD) Template (on page 2 of ICD Writers Guide
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiz0K6U09XtAhUNWq0KHYuuAMEQFjABegQIARAC&url=http%3A%2F%2Fwww.acqnotes.com%2FAttachments%2FCapability%2520Development%2520Document%2520Template%252030%2520Oct%252012.doc&usg=AOvVaw167Ffrt1uVVB8BdH4AjRAj

In-Service Review (Checklist)
In-Service Review - AcqNotes

Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
Internet Search MS Project

Interactive MRL Users Guide (Checklist), all threads
http://www.dodmrl.com/

Initial Capabilities Document (ICD) Template
http://acqnotes.com/acqnote/acquisitions/initial-capabilities-document-icd

ISO 9001, Quality Management Systems, Quality Audit Checklist
Internet Search

ISO 14001 Environmental Management System (EMS) Gap Analysis Checklist
Internet Search

ITAR Compliance Checklist
Internet Search

Lead Time Estimator
Internet Search

Learning Curve Calculator (Estimator)
https://www.dau.edu/tools/t/Learning-Curve-QuickCalc

Learning Curve Estimation (M&S Software)
Internet Search

Learning Curve Worksheet (in Excel)
Internet Search

Life Cycle Sustainment Plan outline
https://www.dau.mil/tools/t/Life-Cycle-Sustainment-Plan-(LCSP)-Outline

Life Cycle Sustainment Plan template (AFLCMC)
https://www.dau.mil/tools/Lists/DAUTools/Attachments/56/Life%20Cycle%20Sustainment%20Plan%20(LCSP)%20%20Outline%20AFLCMC%20ADDM%20Template%20v2.docx

Line of Balance Template
Internet Search

Logistics Assessment Guidebook (DAU), Appendix A: Integrated Product Support Element
https://www.dau.edu/tools/t/Logistics-Assessment-Guidebook

Long Lead Times Material Report, DI-PSSS-82201
https://standards.globalspec.com/std/10291122/di-psss-82201

Make/Buy Plans/Decision
Internet Search

ManTech Roadmap
Internet Search

ManTech Strategic Plan
Internet Search

Manufacturing Capability Assessment Worksheet
Internet Search

Manufacturing Cost Estimating Worksheet (commercial)
Internet Search

Manufacturing Maturation Plan (see MRL Deskbook)
http://www.dodmrl.com/

Manufacturing Plan, DI-MGMT-81889A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-MGMT/DI-MGMT-81889A_55798/

Manufacturing Resource Planning (MRP II)
Internet Search

Manufacturing Resource Planning (MRPII) Assessment
Internet Search

Manufacturing Technology (ManTech) Report, DI-MISC-81176A
    http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-MISC/DI-MISC-81176A_13522/

Manufacturing Strategy (no template available)
    Internet Search

Market Research (DAU)
    https://www.dau.edu/tools/t/Market-Research-Methods

Market Research Report Template
    https://www.dau.edu/tools/t/Market-Research-Report-Template-v1-1
    Material Forecasting Models
    Qualitative Forecasting
        Executive Opinion
        Sales Forecast Composite
        Consumer Market Survey
        Delphi
        Group Discussion
    Quantitative Forecasting
        Time Series
        Regression Modeling
    Internet Search

Material Management and Accounting System (MMAS) Audit
    https://www.dcaa.mil/Portals/88/Documents/Guidance/Directory%20of%20Audit%20Programs/12500%20Material%20Management%20and%20Accounting%20System%20(MMAS)%20AP.pdf?ver=2020-07-01-133628-443

Material Requirements Planning (MRP I)
    Internet Search

Materials Requirements Planning (MRP) Assessment
    Internet Search

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

Materiel Development Decision (MDD) ADM Template (Air Force)
    https://www.afacpo.com/apm/core-documents/templates/

Materiel Development Decision (MDD) Development Planning Templates
    https://www.afacpo.com/apm/core-documents/templates/

Milestone Charts (Program)
    Internet Search

Multi-Attribute Tradespace Exploration (MATE) (see MIT Thesis)
    Internet Search

Operational Test Readiness Review (OTRR) Checklist
http://acqnotes.com/acqnote/acquisitions/operational-test-readiness-review

Operations Process Chart
Internet Search

Pareto Analysis
Internet Search

Parts List
Internet Search

Performance-Based Payments Guide
https://www.acq.osd.mil/dpap/cpic/cp/docs/Performance_Based_Payment_(PBP)_Guide.pdf

PERT/Network Charts
Internet Search

Pilot Line Demonstration and Assessment
Internet Search

Plant Design and Facility Layout Software Evaluation Tools
Internet Search

Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)
Internet Search

Pre-award Survey – Technical (SF 1404)
http://www.acqnotes.com/Attachments/SF%201404%20Preaward%20Survey%20of%20Prospective%20Contractor%20-%20Technical.pdf

Pre-award Survey – Production (sf 1405)
http://www.acqnotes.com/Attachments/SF%201405%20Preaward%20Survey%20of%20Prospective%20Contractor%20-%20Production.pdf

Pre-award Survey – Quality Assurance (SF 1406)
http://www.acqnotes.com/Attachments/SF%201406%20Preaward%20Survey%20of%20Prospective%20Contractor%20-%20Quality%20Assurance.pdf

Pre-award Survey – Financial Capability (SF 1407)
http://www.acqnotes.com/Attachments/SF%201407%20Preaward%20Survey%20of%20Prospective%20Contractor%20-%20Financial%20Capability.pdf

Preliminary Hazard List (PHL) (*See* MIL-STD-882E, Task 201)
https://www.dau.edu/cop/armyesoh/DAU%20Sponsored%20Documents/MIL-STD-882E.pdf

Preliminary Hazards Analysis (PHA) (*See* MIL-STD-882E, Task 202)
https://www.dau.edu/cop/armyesoh/DAU%20Sponsored%20Documents/MIL-STD-882E.pdf

Preservation, Handling, Storage, Packaging and Delivery (PHSPD) Checklist
Internet Search

Process Capability Studies (Cp and Cpk assessment)
Internet Search

Process Capability Study Worksheet (Cp and Cpk Assessment)
Internet Search

Process Control Document (PCD)
Internet Search

Process Control Plan Worksheet
Internet Search

Process Failure Modes and Effects Analysis (PFMEA)
Internet Search

Process Modeling Tools (Siemens PLM, Delmia)
Internet Search

Producibility Assessment Worksheet (PAW) (see NAVSO P-3687, page F-20)
https://www.dau.edu/cop/pqm/DAU%20Sponsored%20Documents/NAVSO%20P%203687.PDF

Producibility Engineering and Planning (PEP) Data Item Description – DI- MGMT-80797A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-MGMT/DI-MGMT-80797_4277/

Production Part Approval Process (PPAP), see AS9137 Advanced Quality Assurance Procedure (AQAP)
Internet Search

Production Part Approval Process (PPAP) Checklist
Internet Search

Production Plan (schedule)
Internet Search

Production Readiness Review (PRR) Checklist
Internet Search

Production Verification Test
Internet Search

Product Support Business Case Analysis Guidebook Appendix A BCA Checklist
https://www.dau.edu/tools/t/Product-Support-Business-Case-Analysis-(BCA)-Guidebook

Product Support Strategy Development Tool, Defense Acquisition University (DAU)
https://www.dau.edu/guidebooks/Shared%20Documents/Product%20Support%20Strategy%20Development%20Tool.pdf

Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) Template
https://www.dau.mil/cop/pm/DAU%20Sponsored%20Documents/PESHE%20AFLCMC%20ADDM%20Template%20v2.1.docx

Progress-Based Payments Tool (recommend changing to Performance Based Payments Analysis Tool (DAU)
https://www.dau.edu/tools/t/Performance-Based-Payments-Analysis-Tool

Pugh Matrix Template
Internet Search

Quality Assurance Program Plan, DI-QCIC-81794
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-QCIC/DI-QCIC-81794_20418/

Quality Assurance Provisions, DI-SESS-80789A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-QCIC/DI-QCIC-81794_20418/

Quality Function Deployment (QFD) or House of Quality Matrix
Internet Search

Quality Function Deployment (QFD) Excel Spreadsheet
Internet Search

Quality Management Plan (Sample)
Internet Search

Quality Management System (QMS), DI-MGMT-82184
https://quicksearch.dla.mil/qaDocDetails.aspx?ident_number=282795

Quality Program Plan, DI-QCIC-81722
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-QCIC/DI-QCIC-81722_43871/

Quality Status Report, DI-MGMT-82186
https://quicksearch.dla.mil/qaDocDetails.aspx?ident_number=282783

Requirements Roadmap Worksheet, DAU
https://www.dau.edu/tools/Documents/SAM/resources/Requirements_Roadmap.html

Requirements Traceability Matrix Template, DAU
https://www.dau.edu/tools/Documents/SAM/resources/RTM_Risk_Register.html

Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs (DoD)
http://acqnotes.com/wp-content/uploads/2017/07/DoD-Risk-Issue-and-Opportunity-Management-Guide-Jan-2017.pdf

Risk, Issue, and Opportunity (RIO) assessment
Internet Search

Risk Management Plan Template – DAU
https://www.dau.edu/tools/t/Risk-Management-Plan-Template-2017

Robust Design (Taguchi)
Internet Search

Rough Cut Capacity Planning Spreadsheet
Internet Search

Route Sheet
Internet Search

Route Sheet Analysis
Internet Search

Safety and Industrial Hygiene Hazard Assessment Checklist
https://www.dla.mil/Portals/104/Documents/Strategic%20Materials/IATK/Copy%20of%20Safety%20and%20health%20checklist%20Strategic%20Materials.pdf?ver=2015-09-23-114310-987

Shop Floor Manufacturing Plan Analysis
Internet Search

Six Sigma Worksheet
Internet Search

Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins)
Internet Search

Source Selection Plan Template (USMC)
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiOiba-i8bsAhUCR6wKHfTRAGsQFjAAegQIBRAC&url=https%3A%2F%2Fwww.quantico.marines.mil%2FPortals%2F147%2FDocs%2FRCO%2FSource%2520Selection%2520Plan%2520Template.doc&usg=AOvVaw0v19l6mRlO1PqWG6r6zOWY

Supplier Quality Questionnaire
Internet Search

Supply Chain Management Risk Assessment Checklist
Internet Search

Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis
Internet Search

System Capabilities Analytic Process (SCAP)
https://apps.dtic.mil/dtic/tr/fulltext/u2/a539905.pdf

Systems Engineering Management Plan, DI-SESS-81785A
http://everyspec.com/DATA-ITEM-DESC-DIDs/DI-SESS/DI-SESS-81785A_53778/

Systems Engineering Plan (SEP) Outline
http://acqnotes.com/acqnote/acquisitions/systems-engineering-plan

Systems and Software Engineering–System Life Cycle Processes, ISO/IEC/IEEE 15288
Internet Search

System Verification Review (SVR) Checklist
http://acqnotes.com/acqnote/acquisitions/system-verification-review-svr#:~:text=The%20System%20Verification%20Review%20(SVR,and%20Development%20(EMD)%20Phase.

Taguchi Loss Function Analysis
Internet Search

Technology Readiness Assessment Calculator
https://www.dau.edu/cop/stm/Lists/Tools/AllItems.aspx

Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
https://www.gao.gov/products/GAO-20-48G

Technology Readiness Level (TRL) Assessment Checklist
Internet Search

Test and Evaluation Master Plan (TEMP) Guidebook
http://www.acqnotes.com/Attachments/DOT&E%20and%20TEMP%20Guidebook%20-%2028%20Mar%2013.pdf

Test and Evaluation Master Plan (TEMP) template
https://www.dau.edu/tools/t/Test-and-Evaluation-Master-Plan-(TEMP)-Template--v3-0

Test Readiness Review (TRR) Checklist
http://acqnotes.com/acqnote/careerfields/test-readiness-review-te

Theory of Inventive Problem Solving (TRIZ) Matrix
Internet Search

Tolerance Design
Internet Search

Transition from Development to Production, DoD 4245.7-M
https://apps.dtic.mil/dtic/tr/fulltext/u2/a303209.pdf

TRIZ Matrix Template
Internet Search

Work Breakdown Structure (Template)
Internet Search

Work Measurement Analysis
Internet Search

Work Measurement Time Study Worksheet (DD Form 2042-1)
https://www.esd.whs.mil/Portals/54/Documents/DD/forms/dd/dd2042-1.pdf

Workforce Planning Tools (SAP/Oracle/MRP II)
Internet Search

Yield Rate Assessment
Internet Search

Appendix D: Sample Manufacturing and Quality Assurance Request for Proposal Input

Sample Manufacturing and Quality Assurance Request for Proposal Input

Office of the Under Secretary of Defense for Research and Engineering

2021

Developed in coordination with Air Force Life Cycle Management Center and industry representatives following the 2017 Defense Manufacturing Conference Manufacturing and Quality Roundtable, which identified the need for more consistent manufacturing and quality contracting approaches across the Department of Defense.

Contents

Introduction

This document provides examples for Manufacturing and Quality Request for Proposal (RFP) inputs, including the Statement of Work (SOW), Sections L and M for competitive acquisitions, and Federal Acquisition Regulation (FAR)/Defense Federal Acquisition Regulation (DFAR) requirements.

The Core SOW requirements should be used on all Acquisition Category (ACAT) I programs. They may be used on other programs but should be tailored as needed to match the scope and needs of each program. For all of the requirements and other inputs in this guide, program team with input from manufacturing and quality specialist should conduct specific tailoring to ensure requirements are appropriate to meeting the unique needs and circumstances of each program.

If possible, developing contractual requirements should be a collaborative process between the government program office and the prime contractor.

Data Item Descriptions (DIDs):

- Prior to using a DID, ensure the most current version is being referenced.
- Use caution when calling out DIDs: Some requirements in the SOW do not have DIDs that directly correspond to them. In those cases, the closest, related DID is suggested. In other cases, some DIDs may be significantly outdated. They were provided to serve as a potential starting point and may need to be tailored. These will be discussed in each section, if applicable.

Manufacturing and Quality RFP Guide Summary Applicability Matrix

The following table is provided for general guidance only. Specific determinations of program and contract applicability should be made on a case-by-case basis.

All requirements are applicable to land, sea, air, and space-based systems. The only exception is for Aviation Critical Safety Items, which are applicable only to air and space systems.

Where checkmarks are shown, that requirement should be considered for inclusion in a SOW. Requirements may still be tailored to meet program needs.

Manufacturing and Quality Input to RFP

Manufacturing/Quality RFP Inputs	MSA	TMRR	EMD	P&D	O&S	Design Change	NDI/COTS
Core SOW Inputs							
Manufacturing Management Program		✓	✓	✓	✓	✓	
Quality Management System Requirements		✓	✓	✓	✓	✓	✓
Manufacturing Readiness Levels and Assessments (MRLs)	✓	✓	✓	✓	✓	✓	✓
Quality and Manufacturing Metrics		✓	✓	✓	✓	✓	✓
Counterfeit Parts Prevention		✓	✓	✓	✓	✓	✓
First Article Inspections/First Article Tests			✓	✓	✓	✓	✓
GIDEP Participation			✓	✓	✓	✓	
Production Readiness Review			✓	✓		✓	✓
Other SOW requirements to consider							
Aviation Critical Safety Items		✓	✓	✓	✓	✓	
Manufacturing Modeling and Simulation		✓	✓	✓	✓	✓	
Calibration			✓	✓	✓	✓	
Configuration Management		✓	✓	✓	✓	✓	
Risk Management		✓	✓	✓	✓	✓	
Parts, Materials, and Processes Control Program		✓	✓	✓	✓	✓	
Environmental Stress Screening		✓	✓	✓	✓	✓	
Key Characteristics and Variation Reduction		✓	✓	✓	✓	✓	
Advanced Product Quality Planning (APQP) & Production Part Approval Process (PPAP)			✓	✓	✓	✓	

1. Core SOW Inputs

1.1. Manufacturing Management Program

The contractor shall establish and maintain a Manufacturing Management Program that meets the requirements of SAE AS6500A and flow this requirement down to major/critical suppliers. The contractor shall document this program as part of their Manufacturing Plan. The contractor shall include its plans for Production Readiness Reviews (PRRs) and Manufacturing Readiness Level (MRL) Assessments in the Manufacturing Plan.

Suggested Data Item Description (DID):

- DI-MGMT-81889B, Manufacturing Plan

Guidance:

1. Major and critical suppliers are defined in AS6500A:

Critical Supplier: A contractor whose performance could seriously jeopardize the successful achievement of a program's cost, schedule, technical, or supportability requirements if not satisfactorily managed (e.g., a sole source supplier or supplier of critical parts, strategic and critical materials, or unique or special processes.)

Major Supplier: A supplier, distributor, vendor, or firm that furnishes supplies or services to or for the prime contractor whose total costs are a significant portion of the total purchased value for the program.

2. While the requirement for a manufacturing management system is applicable during the TMRR phase, it may be too early to require a deliverable manufacturing plan.

3. The DID for a Manufacturing Plan, DI-MGMT-81889B, was updated to be consistent with AS6500A.

1.2. Quality Management System Requirements

The contractor shall establish and maintain a Quality Management System (QMS) that meets the requirements of AS9100. The quality system shall ensure delivery of product that complies with all technical requirements. The Contractor shall document how the QMS is implemented with any unique requirements within the Quality Assurance Program Plan. Major/critical suppliers and suppliers with design authority shall be required to establish and maintain a Quality Management System (QMS) in accordance with requirements of AS9100. Suppliers without design authority shall be compliant to SAE AS9003, Inspection and Test Quality System, as a minimum.

Suggested DID:

- DI-QCIC-81794A, Quality Assurance Program Plan, contractor format acceptable

Guidance:

1. AS9100 is the preferred requirement for a Quality Management System for ACAT I programs in Aviation, Space, and Defense Organizations. The Federal Acquisition Regulation, Part 46, also recognizes overarching quality management system standards such as ISO 9001, ASQ/ANSI E4; ASME NQA-1, SAE AS9003, and ISO/TS 16949. If applying any of these other standards, ensure they are appropriate to the complexity and criticality of the product.

2. The most recent version of AS9100 (or equivalent standard) shall be specified.

3. While the requirement for a quality management system is applicable during the TMRR phase, it may be too early to require a deliverable quality plan.

1.3. Manufacturing Readiness Levels and Assessments (MRLs)

The contractor shall conduct assessments of manufacturing readiness in accordance with AS6500A and use the definitions, criteria, and processes defined in the Manufacturing Readiness Level Deskbook as a guide. Assessments will be conducted at the locations and frequencies specified in Appendix TBD. They will be led by the government program office at the prime contractor's facilities. The prime contractor shall lead the assessments at suppliers and include government participants. The selection of supplier assessments should be determined by the government and prime contractor using the MRL Deskbook, Section 4.3 as a guide. The contractor shall develop and implement Manufacturing Maturation Plans or their equivalent for criteria in which the MRL is lower than the target MRL. The contractor shall monitor and provide status at all program reviews for in-house and supplier MRLs and shall re-assess MRLs in areas for which design, process, source of supply, or facility location changes have occurred that could impact the MRL.

Suggested DIDs:

- DI-SESS-81974, Assessment of Manufacturing Risk and Readiness
- DI-ADMIN-81249B, Conference Agendas
- DI-ADMIN-81250B, Conference Minutes
- DI-MISC-80508B, Technical Report – Study/Services

Guidance:

1. Ensure DIDs are current and appropriate.

1.4. Quality and Manufacturing Metrics

In accordance with AS6500A, the contractor shall maintain a manufacturing surveillance process. The contractor shall submit quality and manufacturing metrics at the agreed upon frequency that report the contractor's and major/critical suppliers' performance and progress. Metrics shall include cost, schedule, and quality metrics to monitor the effectiveness of the contractor's manufacturing, quality, and supplier management programs. Metrics shall be presented at design, technical, and program management reviews. The contractor shall provide on-line access of these metrics to the government.

Suggested DIDs:

- DI-QCIC-82323, Manufacturing and Quality Assurance Status Report

Guidance:

1. Tailor the list of metrics in the DID to meet your specific program needs.

2. On-line access to contractor metrics may be desired, but not feasible. Discuss this with the prime contractor before including this as a requirement.

1.5. Counterfeit Parts Prevention

The contractor shall develop and implement a Counterfeit Parts Prevention (CPP) program in compliance with SAE AS5553 and AS6174 to prevent the inclusion of counterfeit parts or parts embedded with malicious logic into products intended for sale to the Government. These requirements shall be flowed to suppliers to ensure requirements are met. As part of CPP, the contractor shall make available to the government Certificates of Conformance (CoC) as well as supply chain traceability for all electronic part purchases.

Suggested DID:

- DI-MISC-81832, Counterfeit Prevention Plan

Guidance:

1. The RFP could request the elements of DI-MISC-81832 be included in the contractor's Program Protection Implementation Plan (PPIP), DI-ADMN-81306. Another good reference source is SAE-AS6081; Parts, Electronic, Fraudulent/Counterfeit: Avoidance, Detection, Mitigation, and Disposition.

2. The DID may be significantly out of date. Review for appropriateness prior to use.

1.6. First Article Inspections (FAI)/First Article Tests (FAT)

The contractor shall establish an FAI/FAT process and perform FAIs/FATs on new and modified product in accordance with AS9102, "Aerospace First Article Inspection Requirement." First article inspections shall be conducted on new products representative of the first production run and when changes occur that invalidate the original results (e.g., engineering changes, manufacturing process changes, tooling changes). The contractor shall notify the Government program office, and designated representative(s) of first article inspection events to allow for participation. An FAI/FAT report shall be generated for each product as evidence that the engineering requirements have been met.

Suggested DIDs:

- DI-NDTI-81307A, First Article Qualification Test Plan and Procedures
- DI-NDTI-80809, Test/Inspection Report

Guidance:

1. The DIDs may be out of date or not related exactly to the SOW requirement. Review for appropriateness prior to use.

2. Applicability to O&S phase is based on new designs, suppliers, or other changes.

1.7. Government Industry Data Exchange Program (GIDEP) Participation

The contractor shall implement procedures and processes for their participation in GIDEP, including the submission of alerts/advisories to GIDEP when warranted. The processes and procedures shall describe how the contractor (a) receives alerts and advisories from GIDEP and other sources, (b) determines any impact to their product design and already manufactured hardware, (c) implements corrective action procedures when design and/or produced hardware are affected, and (d) includes supplier participation.

Suggested DID:

- DI-QCIC-80125B, Government Industry Data Exchange Program (GIDEP) Alert/Safe-Alert Report
- DI-QCIC-80126B, Government Industry Data Exchange Program (GIDEP) Alert Response

1.8. Production Readiness Review (PRR)

The contractor shall perform PRRs in support of the Milestone C/FRP Decision in accordance with IEEE 15288.2. These requirements shall be flowed to the contractor's major and critical suppliers.

Suggested DIDs:

- DI-ADMIN-81249B, Conference Agendas
- DI-ADMIN-81250B, Conference Minutes
- DI-MISC-80508B, Technical Report – Study/Services

Guidance:

1. The requirement for a PRR is a Core requirement for contracts that will result in a Milestone C or FRP Decision

2. Ensure deliverable plans, minutes, etc., are not already required in another section of the SOW for technical reviews and audits. Ensure DIDs are compatible with IEEE 15288.2 requirements, if imposed.

2. Other SOW Requirements to Consider

2.1. Aviation Critical Safety Items (CSIs)

The contractor shall identify, establish and manage aviation CSIs using the Joint Aeronautical Logistics Commanders (JALC) Critical Safety Item Management Handbook and SAE AS9017, "Control of Aviation Critical Safety Items," as guides. The contractor shall develop a list of Critical Safety Items, their Key or Critical Characteristics (KCs/CCs), and associated Critical Manufacturing Processes. The contractor shall identify, measure and reduce variability of KCs/CCs and provide a formal method to manage and monitor all critical processes associated with CSIs. The contractor shall flow requirements to the lowest level of the supply chain.

Suggested DIDs:

- DI-SAFT-81932, Critical Safety Item (CSI) / Critical Application Item (CAI) List
- DI-SAFT-80970A, Critical Safety Item, Characteristic and Critical Defect Report

Guidance:

1. Requirements for CSI management should be balanced against the costs.

2. The DIDs may be out of date. Review for appropriateness prior to use.

2.2. Manufacturing Modeling and Simulation

The contractor shall analyze manufacturing processes using Modeling & Simulation (M&S) techniques to identify potential bottlenecks or constraints and confirm the achievability of planned cycle times, etc., and provide the government access to the model and data. The model should use commercially available simulation software used to evaluate scenarios and impacts of process variabilities, plant optimizations, production rate changes, capacity planning, and estimate required quantities of tooling, personnel, and inventory. The contractor shall update the production simulation model for facility modifications and other significant changes.

Suggested DID:

DI-MISC-80508B, Technical Report – Study/Services

Guidance:

1. While AS6500A requires the use of Modeling & Simulation, this additional requirement should be imposed if the government program office needs to obtain the contractor's manufacturing model(s) as a deliverable item. This would enable the program office to conduct independent capacity and schedule assessments and to better identify risks independently from the contractor.

2. The DID may be out of date. Review for appropriateness prior to use.

2.3. Calibration

The contractor shall maintain a calibration system in accordance with ANSI/NCSL Z540.3. The calibration system shall control the accuracy of measuring and test equipment, and measurement standards, used to ensure that products delivered to the Government comply with all contract technical specifications. The calibration system shall prevent inaccuracy by ready detection of deficiencies and timely positive action for their correction. Contractors who operate and maintain calibration laboratories or subcontract to outside calibration laboratories shall ensure compliance with requirements of ISO/IEC 17025:2017, General Requirements for the Competence of Testing and Calibration Laboratories.

2.4. Configuration Management

The contractor shall establish, document, and maintain a Configuration Management (CM) system for control of all configuration documentation, physical media, and physical parts representing or comprising the product, which includes all hardware, software, and firmware. The contractor's configuration management system shall consist of these elements:

a. Configuration management and planning.
b. Configuration identification.
c. Configuration change management.
d. Configuration status accounting.
e. Configuration audit.
f. Configuration management of digital data.

The contractor may use MIL-HDBK-61A as additional guidance for CM.

Guidance:

1. Applicability during TMRR should be determined on a case-by-case basis. Consult Configuration Management Subject Matter Experts for guidance.

2.5. Risk Management

The contractor shall establish and maintain a risk management program to continuously identify, analyze, mitigate, monitor, and report systems engineering process, product, technology, cost, schedule, and other program risks. Risk management process results shall be used for continual improvement and risk reduction. Program risks must be assessed and managed at the appropriate level. The contractor shall establish and maintain risk management programs consistent with the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs.

2.6. Parts, Materials, and Processes Control Program

The contractor shall establish, document, and maintain a Parts, Materials, and Processes Control Program (PMPCP) to ensure selection and use of parts, devices, and materials, including commercial and non-developmental items, meet specified performance, quality, reliability, safety, supportability, and configuration management requirements throughout the life cycle of the system. The program shall include provisions for mitigating the impact of counterfeit parts and parts obsolescence on product integrity. The contractor shall flow down applicable PMPCP requirements to applicable lower-tier suppliers.

The contractor may use SD-22, MDA-QS-003-PMAP, MIL-STD-3018, or SMC Standard SMC-S-009 as additional guidance for control of Parts, Materials, and Processes.

Suggested DID:

- DI-MGMT-81949, DMSMS Implementation Plan

2.7. Environmental Stress Screening

The contractor shall implement an Environmental Stress Screening (ESS) program to surface defects by stressing the item without degrading its inherent reliability. Environmental stresses (i.e., thermal cycling and random vibration) may be applied in sequence or in combination, with the intent of stimulating hardware defects. The ESS program should not be used to simulate an operational environment. Results of ESS shall be used to continually improve manufacturing processes. The contractor may use MIL-HDBK-344 as additional guidance for planning, controlling, and measuring the effectiveness of the ESS program.

Guidance:

1. Imposing ESS requirements should be a joint determination by engineering, manufacturing, Quality, and Reliability functional experts. Consider using ESS on major and critical suppliers of electrical, electronic, electro-optical, electromechanical or electrochemical components in demonstration & validation, engineering & manufacturing development and production phases.

2.8. Key Characteristics and Variation Reduction

The contractor shall identify Key Characteristics and implement a Variation Reduction program in accordance with AS9103.

2.9. Advanced Product Quality Planning (APQP) & Production Part Approval Process (PPAP)

The contractor shall implement APQP and PPAP programs in accordance with AS9145.

2.10. Value Management

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

3. Suggested Section L and M inputs

3.1. Instructions to Offerors Guidance (Section L):

1. Manufacturing Readiness Level Demonstration. The offeror's proposal shall identify those elements (systems, subsystems, suppliers, and/or processes) being assessed for manufacturing risk and their current Manufacturing Readiness Levels using the criteria and process identified in the Manufacturing Readiness Level Deskbook (Link http://www.dodmrl.com). The contractor shall describe the approach used to assess the MRLs. For any element that is assessed to be below the target MRL of 'X', the offeror shall identify the current MRL and the plan to achieve the target MRL.

(Note: DFARS Subpart 215.304 requires that the manufacturing readiness of offerors be considered during source selection for ACAT I programs.)

2. Manufacturing Plan. The offeror shall describe:

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

3. Quality Systems. The offeror shall describe how their quality system assures product quality; achieves stable, capable processes; prevents defects; and employs effective methods for conducting root cause analyses and implementation of corrective actions.

4. Supplier Management. The offeror shall describe their:

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

3.2. Evaluation Criteria Guidance (Section M):

1. Manufacturing Readiness Level Demonstration. The offeror's proposal will be evaluated on the maturity of their proposed manufacturing capability, the adequacy of their supporting documentation to justify this capability, and the adequacy of the offeror's process and plans to achieve the target MRL as described in the Manufacturing Readiness Level Deskbook.

This sub-factor is met when the offeror's proposal identifies the elements being assessed for manufacturing readiness and their current MRLs. As described in the proposal, the offeror's

MRL assessment process is consistent with the MRL Deskbook. For elements that are below the target MRL, the proposal describes an achievable plan to meet the target MRL.

2. Manufacturing Plan. This sub-factor evaluates the proposed methods, schedules, and resources for producing the required products. This sub-factor is met when the offeror's proposal:

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

3. Quality Systems. This sub-factor evaluates the offeror's planned quality assurance system. This sub-factor is met when the offeror's proposal describes policies and practices that will:

a. Assure product quality.
b. Achieve stable, capable processes.
c. Prevent defects.
d. Result in effective root cause analyses and corrective actions.

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

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

4. FAR/DFARS Clauses

Although the Contracting Officer is ultimately responsible for applying the appropriate FAR and DFARS clauses to the contract, the following sections address topics relevant to the Manufacturing and Quality function. Manufacturing and Quality Subject Matter Experts should be familiar with the requirements of these sections and offer their support and recommendations to the Contracting Officer.

4.1. Higher Level Quality Requirements

FAR Part 46, “Quality Assurance,” prescribes the use of various FAR clauses that address quality and inspection requirements, depending upon the nature of the contract. For critical or complex items, clause 52.246-11 must be included in the contract. This clause requires the identification of a specific higher-level contract quality standard. Section 46.202-4 lists examples, such as ISO 9001 and AS9100. The Manufacturing/Quality Subject Matter Expert should work with the Contracting Officer to ensure the appropriate clause is included in the contract and the appropriate higher-level quality requirement is included in 52.246-11.

4.2. Counterfeit Parts Prevention

DFARS 246.870-3 prescribes the use of clauses 252.246-7007, “Contractor Counterfeit Electronic Part Detection and Avoidance System,” and 252.246-7008, “Sources of Electronic Parts” when procuring electronic parts or end items that contain electronic parts.

4.3. First Article Approvals

FAR Subpart 9.3 governs First Article Testing and Approval and describes when this testing is required. When it is required, Subpart 9.3 requires either FAR clause 52.209-3 for contractor testing or 52.209-4 for government testing.

4.4. Contract Administration Functions

FAR Subpart 42.302, “Contract Administration functions,” lists the activities performed by the Contract Administration Office (typically DCMA.) Manufacturing & Quality-related functions include activities such as performing production surveillance and status reporting, conducting pre-award surveys, monitoring industrial labor relations, ensuring contractor compliance with contractual quality assurance requirements, and reviewing waivers and deviations.

4.5. Value Engineering Change Proposals

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

Regarding FAR VE guidance:

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

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

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

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

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

4.6. Labor Relationships

FAR Part 22 describes the government's policies and practices regarding labor relations at contractor facilities. Subpart 22.103-5 prescribes the use of Clause 52.222-1 to require the contractor to notify the government of labor disputes.

4.7. Government Property

FAR Part 45 governs the use of government property. Subpart 45.107 prescribes the use of Clause 52.245-1 when government property is being used.

4.8. Records Retention

FAR Subpart 4.7 governs records retention. Many Manufacturing and Quality-related items, such as receiving and inspection reports, purchase orders, and quality control and inspection records must be retained for four years.

4.9. Contractor Debarment, Suspension, and Ineligibility

FAR Subpart 9.4 discusses reasons that contractors may not be allowed to obtain government contracts. This includes limitations on subcontracting (Subpart 9.405-2). Most contracts must include Clause 52.209-6 that protects the government's interests when subcontracting with debarred (or soon to be debarred) or suspended suppliers.

Acronyms

3D	Three-Dimensional
A_o	Operational Availability
AAF	Adaptive Acquisition Framework
AFRL	Air Force Research Laboratory
AM	Additive Manufacturing
AoA	Analysis of Alternatives
ASR	Alternative Systems Review
CARD	Cost Analysis Requirements Description
CBA	Capabilities-Based Assessment
CCTD	Concept Characterization and Technical Description
CDD	Capability Development Document
CoI	Community of Interest
CONOPS	Concept of Operations
COTS	Commercial Off-the-Shelf
Cpk	Process Capability
CSI	Critical Safety Item
CTE	Critical Technology Element
DARPA	Defense Advanced Research Projects Agency
DID	Data Item Description
DCMA	Defense Contact Management Agency
DTIC	Defense Technical Information Center
DE	Digital Engineering
DFARS	Defense Federal Acquisition Regulation Supplement
DFMA	Design for Manufacturing and Assembly
DFMEA	Design Failure Modes and Effects Analysis
DIU	Defense Innovation Unit
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoD	Department of Defense
DoDD	DoD Directive
DoDI	DoD Instruction
DP	Development Planning
DTRAM	Defense Technical Risk Assessment Methodology
EMD	Engineering and Manufacturing Development
ESOH	Environment, Safety, and Occupational Health
FFRDC	Federally Funded Research and Development Center
FMEA	Failure Modes and Effects Analysis
FOC	Full Operational Capability
FRP	Full-Rate Production
GAO	Government Accountability Office

GFE	Government Furnished Equipment
GOTS	Government off-the-shelf
IB	Industrial Base
IBA	Industrial Base Assessment or Industrial Base Analysis
ICA	Industrial Capability Assessment
ICD	Initial Capabilities Document
IMP/IMS	Integrated Master Plan/Integrated Master Schedule
IoT	Internet of Things
IIOT	Industrial Internet of Things
IOC	Initial Operational Capability
IPT	Integrated Product Team
ISO	International Organization for Standardization
IT	Information Technology
ITRA	Independent Technical Risk Assessment
JCIDS	Joint Capabilities Integration and Development System
KC	Key Characteristic
KPP	Key Performance Parameter
KSA	Key System Attribute
LCSP	Life Cycle Sustainment Plan
LRIP	Low-Rate Initial Production
M&S	Modeling and Simulation
M&Q	Manufacturing and Quality
ManTech	Manufacturing Technology
MBE	Model-Based Engineering
MBSE	Model-Based Systems Engineering
MCA	Major Capability Acquisition
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDD	Materiel Development Decision
ME	Mission Engineering
MFA	Manufacturing Feasibility Assessment
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOS	Measure of Suitability
MOSA	Modular Open Systems Approach
MTBF	Mean Time Between Repair
MTTR	Mean Time To Repair
MMP	Manufacturing Maturation Plan
MRA	Manufacturing Readiness Assessment
MRL	Manufacturing Readiness Level

MS A	Milestone A
MS B	Milestone B
MS C	Milestone C
MSA	Materiel Solution Analysis
MS&T	Manufacturing Science and Technology
MTA	Middle Tier of Acquisition
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NRL	Naval Research Laboratory
NTIB	National Technology and Industrial Base
O&S	Operations and Support
OT	Operational Technology
OT&E	Operational Test and Evaluation
PDR	Preliminary Design Review
PESHE	Programmatic Environmental, Safety, and Occupational Health Evaluation
PFMEA	Process Failure Modes and Effects Analysis
PM	Program Manager or Program Management
Ppk	Process Performance
PPP	Program Protection Plan
Pre-MDD	Pre-Materiel Development Decision
P&D	Production and Deployment
PRR	Production Readiness Review
QA	Quality Assurance
QMS	Quality Management System
R&D	Research and Development
RAM	Reliability, Availability and Maintainability
RCO	Rapid Capability Office
RCT	Requirements Correlation Table
RFP	Request for Proposal
RIO	Risk, Issue, and Opportunity
ROI	Return on Investment
SBIR	Small Business Innovation Research
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SEP	Systems Engineering Plan
SETR	Systems Engineering Technical Review
SFR	System Functional Review
SME	Subject Matter Expert
SRD	System Requirements Document

SRR	System Requirements Review
STTR	Small Business Technology Transfer
S&T	Science and Technology
TAPP	Technology Area Protection Plan
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TMRR	Technology Maturation and Risk Reduction
TPM	Technical Performance Measure
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
UCA	Urgent Capability Acquisition
WBS	Work Breakdown Structure

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