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

Chapter 5
Production and Deployment (P&D) Phase

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

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M&Q BoK Chapter 5 Change Record

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

Contents

Figures

Tables

Introduction: How to Use the M&Q BoK

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

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

The BoK chapters 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 six chapters:

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

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

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

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

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

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

- Activity overview description
- **Tasks** that M&Q personnel could be expected to support or lead.
- **Tools** such as checklists, templates, and samples that are available to M&Q personnel are 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.

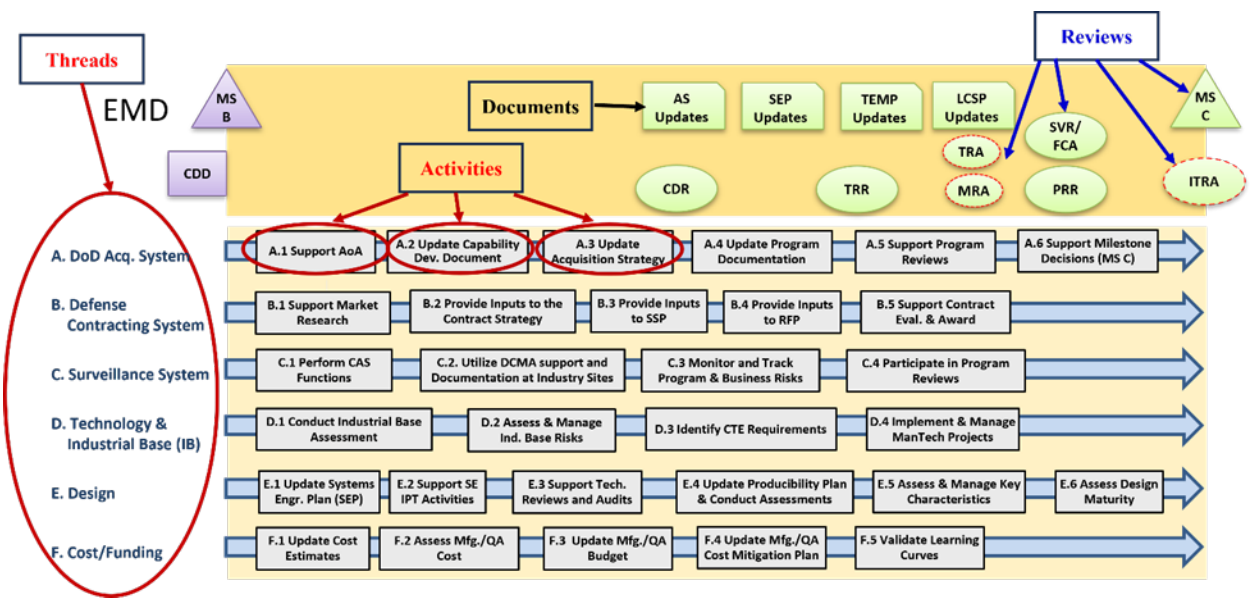
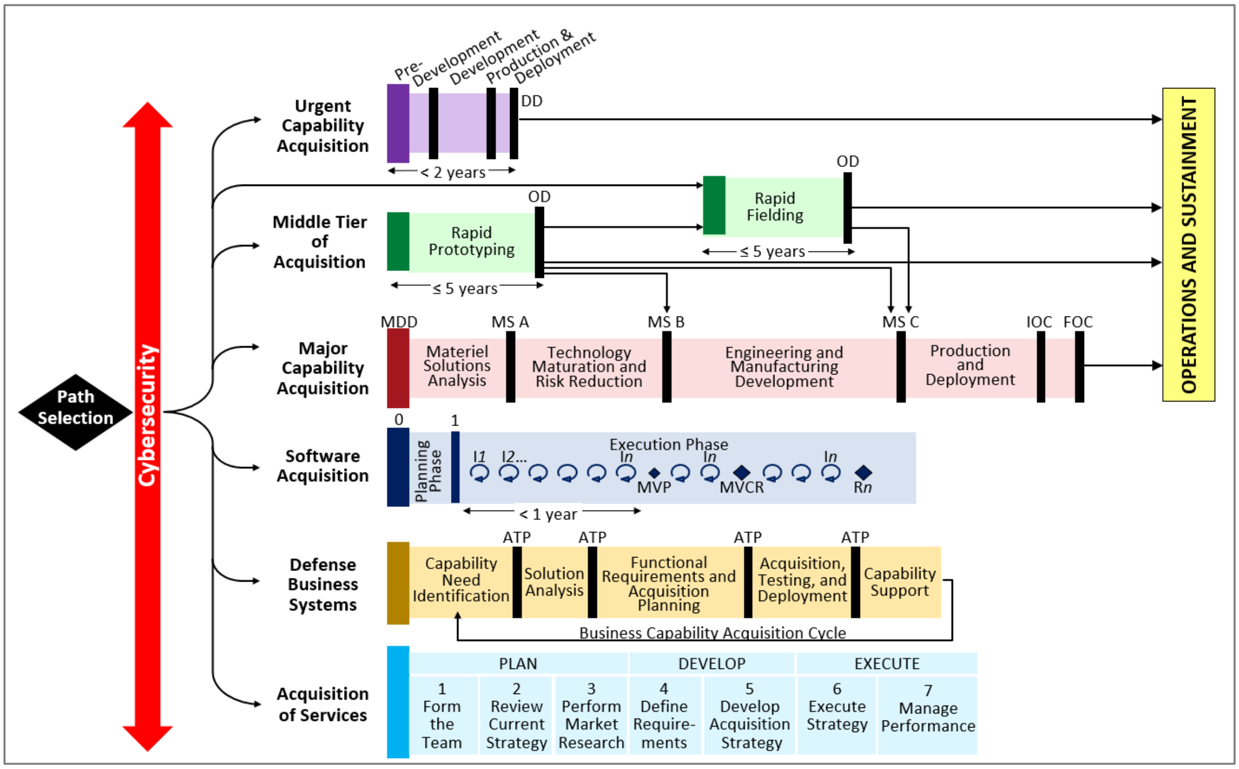


Figure 1. Sample Activity Chart

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.

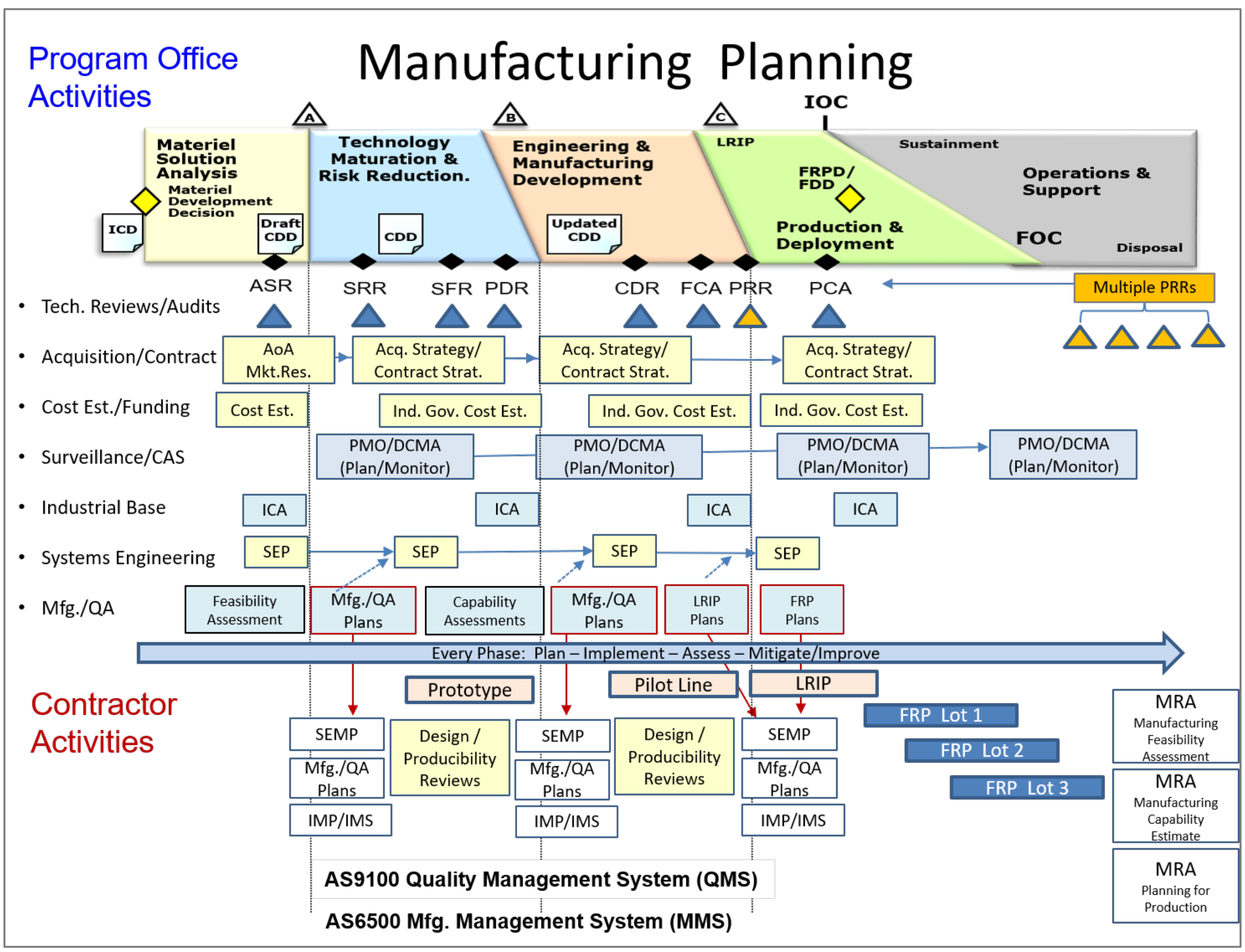


Figure 3. Typical Manufacturing and Quality Planning Activities

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://ac.cto.mil/engineering

Relevant Government Publications (Available via Web/Internet Search)

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

Standards, Specifications, and Standards Organizations

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

Technology Readiness Levels (TRLs)

- Technology Readiness Assessment Deskbook www.acqnotes.com
- Technology Readiness Assessment Calculator www.acqnotes.com
- DoD Technology Readiness Assessment (TRA) Guide https://www.cto.mil/wp-content/uploads/2023/07/TRA-Guide-Jun2023.pdf
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G) www.gao.gov

5. Production and Deployment (P&D) Phase

Introduction

During the Production and Deployment (P&D) phase the following production risks can affect cost, schedule, and performance if the program office is not proactive in managing them.

- Unstable requirements and too many engineering changes
- Unstable production rates and quantities
- Insufficient process proofing
- Insufficient material characterization
- Changes in proven materials, processes, subcontractors, vendors, and components
- Lack of producibility consideration
- Configuration management
- Subcontractor management
- Special tooling and test equipment

These risks can occur early in the program's life, not just during production, and need to be assessed and managed throughout the program's life cycle.

A key Program Manager (PM) role is to reduce manufacturing risk and demonstrate producibility before Full-Rate Production (FRP).

Manufacturing and quality (M&Q) managers have three major roles to perform:

- Influence the design (for producibility)
- Prepare for production (Planning)
- Execute the manufacturing and QA plans (Execution)

The goal is to execute the manufacturing plan with a product that meets the design intent and has repeatable processes, and to focus on continuous product and process improvement.

As members of the Technical Integrated Product Team (IPT) there should be many opportunities to influence the design for producibility to include putting producibility in acquisition plans and contractual documents. In addition, there are numerous technical reviews in which systems engineering technical processes and technical management processes are addressed and assessed. Finally, executing the plan includes typical day-to-day activities that should be managed and assessed, and risks to be identified and mitigated.

At Milestone C, M&Q risks are assessed. Key manufacturing readiness considerations include:

- Industrial base viability
- Design stability
- Process maturity
- Supply chain stability and management

- Quality management throughout the supply chain
- Manufacturing process control
- Facilities/Tooling availability and capability
- Manufacturing skills availability

The Program Management Office (PMO) should update the Acquisition Strategy and identify remaining risks prior to the FRP decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include various technical reviews and audits such as Production Readiness Review (PRR), Industrial Capabilities Assessment (ICA), Manufacturing Readiness Assessment (MRA), Independent Technical Risk Assessment (ITRA), Program Status Review (PSR), etc., pre-award surveys, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or manage remaining risks.

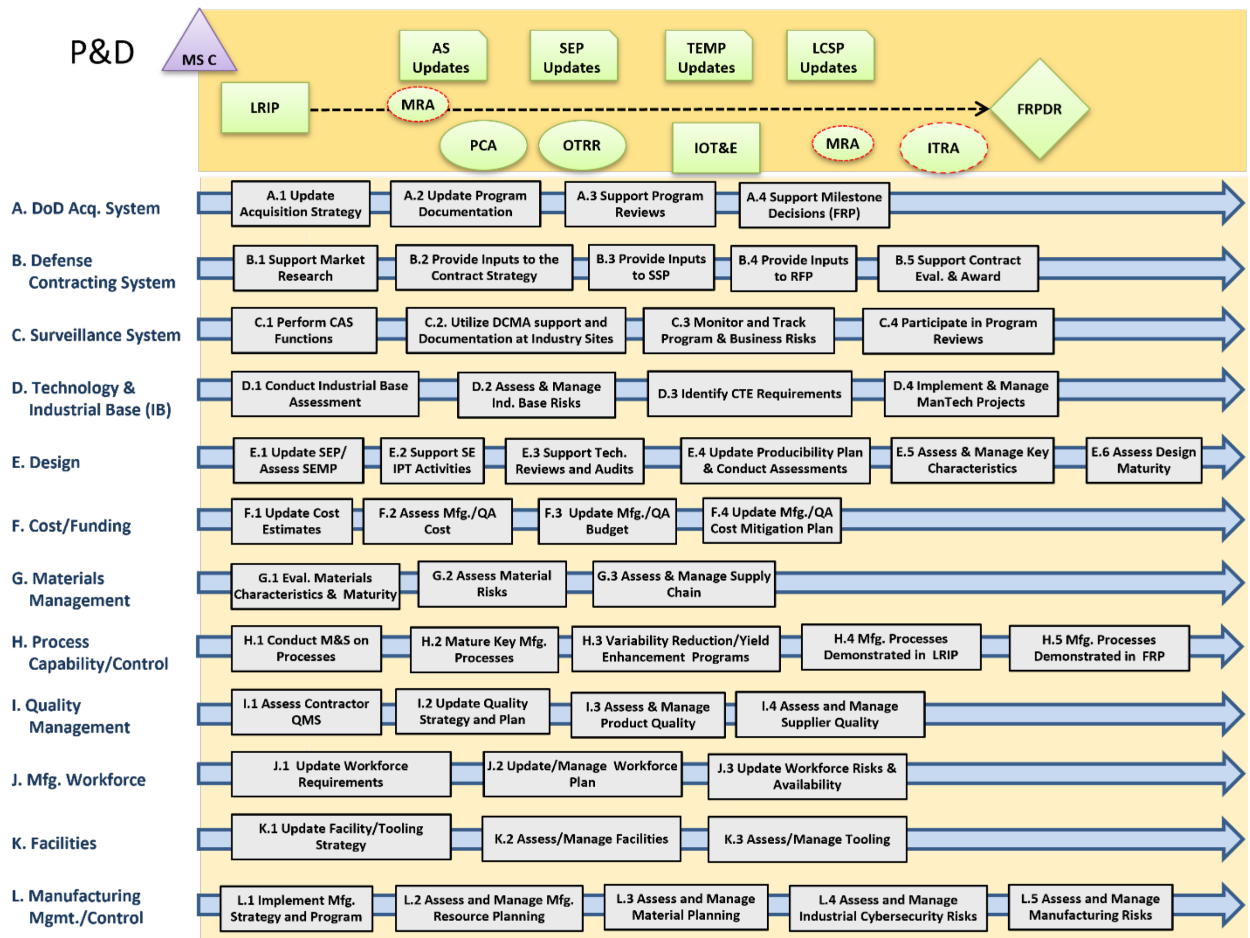


Figure 5-1. P&D Phase Manufacturing and Quality Activities

Manufacturing and Quality Objectives

Specific requirements must be identified for inclusion in the Statement of Work (SOW) for the production phase. The requirements reflect the areas that have been determined to be of importance, given the acquisition strategy of the program. Typical areas to be considered for inclusion are:

- Manufacturing management systems
- Work measurement
- Manufacturing data (including manufacturing plan updates)
- Initial production facilities
- Production and material control systems
- Manufacturing reporting systems (especially line of balance)
- Control of subcontractors and vendor
- Make or Buy programs
- Government Furnished Property
- System audit
- Technical data
- Competition

Incentives may be included to motivate contractors to improve performance and control costs. The benefits attainable through the use of multiyear contracting should also be explored.

The purpose of P&D is to produce items for the warfighter that will achieve operational capability and satisfy mission needs. To achieve those goals, the items being produced must have achieved design stability, had their technologies matured, and their manufacturing processes must be capable, stable and under control. There are two primary related production efforts during the PD phase: Low-Rate Initial Production (LRIP) and FRP. LRIP is often identified as up to 10 percent of the estimated production volume.

LRIP typically demonstrates the production of articles beyond a pilot line environment. Engineering and Manufacturing Development (EMD) items were typically built in a pilot line environment but now need to be able to transition to a low-rate production environment. All systems engineering/design requirements should have been met such that there are minimal system changes. Major system design features are stable and have been proven in test and evaluation. Materials are available to meet planned rate production schedules. Manufacturing process capability in a low-rate production environment is at an appropriate quality level to meet design key characteristics. Production risk monitoring is ongoing. This means that during LRIP the program office should conduct a Manufacturing Readiness Assessment (MRA) at a Manufacturing Readiness Level (MRL) 9 level. LRIP cost targets have been met and learning curves have been analyzed with actual data. The cost model has been developed for the FRP environment and reflects the impact of continuous improvement.

P&D phase objectives include the following:

- Produce authorized quantities, on time and within budget.

- Conduct technical reviews and audits:
    - Integrated Baseline Review (IBR)
    - Operational Test Readiness Review (OTTR)
    - Manufacturing Readiness Assessment (MRA)
    - Independent Technical Risk Assessment (ITRA)
    - Independent Logistics Assessment (ILA)
    - Physical Configuration Audit (PCA)
- Create the following documents:
    - Acquisition Program Baseline (APB)
    - Systems Engineering Plan (SEP)
        - Manufacturing Management Plan
        - Quality Assurance Management Plan
    - Test and Evaluation Master Plan (TEMP)
    - Life Cycle Sustainment Plan (LCSP)
    - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
    - Programmatic Environmental, Safety and Occupational Health Evaluation (PESHE) product support elements
- Achieve Low-Rate Initial Production (LRIP), that is, to demonstrate LRIP
- Support the FRP decision
- Achieve FRP, demonstrate FRP
- Refine logistics support plans to include the Life Cycle Sustainment Plan
- Review the following manufacturing considerations, including:
    - Complete initial production facilities
    - Execute the manufacturing program
        - Integrate spares production
    - Maintain production surveillance
- Provide and support proposal efforts
    - Source Selection Plan (SSP)
    - Request for Proposal (RFP)
- Accomplish value engineering
- Accomplish second sourcing/component breakout
- Complete industrial preparedness planning
- Plan for the system transition/deployment/support
- Provide support to risk assessments
- Provide support to cost estimates and evaluation

A. DEPARTMENT OF DEFENSE (DOD) ACQUISITION SYSTEM

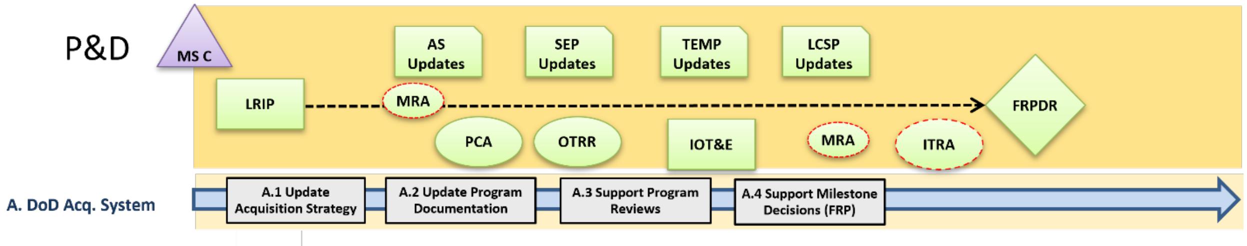


Figure 5-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

The Acquisition Process is an event-based process where a program goes through a series of processes, milestones (five phases), and reviews where it is determined if a program will proceed into the next phase. MDAPs and major systems with production requirements should address industrial and manufacturing readiness in the Acquisition Strategy, during milestone reviews, and in various program documentation.

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

- Acquisition Strategy
- Program Documentation
- Program Reviews
- Milestone Decisions

The Production and Deployment (PD) Phase is where a system that satisfies an operational capability is produced and deployed to an end-user. The phase has two major efforts; (1) Low-Rate Initial Production (LRIP) and (2) Full-Rate Production and Deployment (FRP&D). The phase begins after a successful Milestone C review and Engineering, Manufacturing and Development (EMD) Phase.

The Milestone C Decision will be either an LRIP or Limited Deployment and Operational Test decision followed by an FRP or Full Deployment Decision (FDD). The initial production decision, based primarily on developmental testing results and usually also informed by an operational assessment, commits the resources (i.e., authorizes proceeding to award the contract(s) required to enter production and begin deployment of the product. Evidence from testing that the product design is stable is the critical consideration for this decision. The commitment to enter production is expensive and difficult to reverse, thus moving forward requires a thorough examination of production risks.

Major activities conducted during the P&D phase include:

- Updating Product Baseline
- Updating Test and Evaluation Plan
- Conducting a Risk Assessment
- Updating the Life-Cycle Sustainment Plan

- Ensuring Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE),
- Compliance Schedule for National Environmental Policy Act (NEPA)
- Updating the Systems Engineering Plan (SEP)
- Providing Inputs to Cost and Manpower Estimate
- Updating System Safety Analyses to include finalizing hazard analyses

A.1 Provide Manufacturing Updates to Acquisition Strategy

At the end of the EMD, all the information necessary to plan the detailed manufacturing operations for the system should have been available. This information should be described in a manufacturing plan covering the issues of manufacturing organization, make or buy planning, subcontract management, resources and manufacturing capability, and the detailed fabrication and assembly planning. The plan should also describe the types of government-furnished property (GFP), or government-furnished equipment (GFE) required and the specific need dates for it. The contractor management control systems, including those for configuration management, the control of subcontractors, and manufacturing performance evaluation, should be described in enough detail for the Program Management Office to determine their expected utility.

The plan developed should also include consideration of the potential requirements for industrial preparedness planning, including surge capability during the production phase and the postproduction phase requirements for support to employment of the system in combat situations. The development of this formal manufacturing plan contributes value to the program from two standpoints. The primary benefit accrues from the fact that the contractor must crystallize the manufacturing planning to a point where it can be described in the detail required. The secondary benefit is the usability the plan provides to the Program Management Office personnel. It serves as a basis for a structured review of the contractor approach, the expected cost of the production phase effort, and a fuller assessment of manufacturing risk. Where such a plan is not developed during the EMD phase there is often unnecessarily high cost and schedule turbulence at the front end of and throughout the production phase. Also, if there is no detailed plan in place there can be no effective program office monitoring, assessing, scheduling review, testing, etc. In effect there is no production program.

Manufacturing and Quality Tasks

- Update the Acquisition Strategy to describe the planning to assess and demonstrate that the manufacturing processes/capabilities required for production have been matured to a high enough level of confidence to ensure producing production configuration products in the production phase.
- Ensure the Acquisition Strategy reflects planned efforts that results in completion of manufacturing development and demonstrates:
    - No significant manufacturing risks
    - All manufacturing processes are under control

  - Adequate and efficient manufacturing capability
  - Produces the minimum quantity necessary to provide production or production-representative articles for Initial Operational Test and Evaluation (IOT&E)
  - Establishes an initial production baseline for the system
  - Provides for an orderly increase in the production rate for the system
  - Permits the collection of statistical process control data

- Ensure that the Systems Engineering Plan (SEP) is incorporated into the Acquisition Strategy:
  - Manufacturing Planning should be a part of the SEP
  - Quality Planning should be a part of the SEP
- Ensure the Acquisition Strategy addresses the approach to making production rate and quantity changes in response to contingency needs. Consider these items in developing the strategy:
  - Technology and Industrial Base, including small business
  - Design
  - Cost and Funding
  - Materials
  - Process Capability and Control
  - Quality Management
  - Manufacturing Personnel
  - Facilities
  - Manufacturing Management
- Update other documents with manufacturing and QA input as required:
  - Test and Engineering Master Plan (TEMP)
  - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
  - Life Cycle Sustainment Plan (LCSP)
  - Capabilities Development Document (updated-CDD)
  - Transitioning to Capabilities Production Document (CPD)
- Validate production quantities per year and the total planned production quantity.
- Finalize and validate the Production Plan.
- Ensure manufacturing risk assessments, configuration audits, production schedule reviews and production deliveries and events (including long lead, and multiple suppliers) are on the Program Schedule.
- Ensure manufacturing readiness is assessed throughout the Production and Deployment phase and Manufacturing Readiness Assessments (MRAs) are included in acquisition planning.
- Ensure all industrial base and any manufacturing/production risks and mitigation efforts are scheduled, funded, and actively worked.

- Ensure specific breakout efforts for each major component or subsystem are being worked.
- Ensure the M&Q organization or lead is being effectively utilized.
- Validate all remaining or developing IB constraints, how they are being managed, and the plan and schedule for future assessments.
- Estimate any risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule.
- Validate the Manufacturing Management System (MMS) and the Quality Management System (QMS) being used in production and ensure they are minimizing cost, schedule, and performance risks throughout the product life cycle.
- Validate the make-or-buy approach and maintain access to competitive suppliers.
- Maintain and keep current a list of critical items and their sources.
- Identify and address DMSMS/Obsolescence issues.
- Identify and address cybersecurity issues.
- Identify and address cybersecurity of manufacturing and industrial operations and processes.
- Ensure/verify all manufacturing processes have been effectively demonstrated in a manufacturing environment appropriate to the type of production that this program requires:
    - The manufacturing environment should incorporate all the key elements (manpower, machines, methods, material, measurement, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in rate production
    - To the maximum extent practical, the environment should utilize the same rate manufacturing processes scheduled to be used in production

Tools

- Acquisition Strategy Outline
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Industrial Base Assessment Survey Form Defense Contract management Agency (DCMA) Industrial Analysis Center
- Integrated Master Plan/Integrated Master Schedule: (i.e., Microsoft Project)
- Interactive MRL Users Guide (Checklist)
- ISO 9001, Quality Management System Checklist
- Risk Management Plan Template
- Life Cycle Sustainment Plan Outline
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline
    - Manufacturing Plan
    - Quality Assurance Plan

- Technology Readiness Level (TRL) Assessment Checklist
- Test and Evaluation Master Plan Outline

Resources

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Aerospace
- DoD 5000.60-H, DoD Handbook: Assessing Defense Industrial Capabilities
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE15288, System and Software Engineering
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- ISO 9001, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- Systems Engineering Plan (SEP) Outline
- DoD Technology Readiness Assessment (TRA) Guide
- Test and Evaluation Management Guide
- TRA Deskbook

A.2 Update Program Documentation

M&Q personnel should be actively engaged in the review and update of the following documents:

- **Acquisition Strategy (AS)**
  - Manufacturing Strategy
  - Quality Strategy
- **Systems Engineering Plan (SEP)**
  - Manufacturing Plan
  - Quality Plan
- Test and Engineering Master Plan (TEMP)
- Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
- Life Cycle Sustainment Plan (LCSP)
- Capabilities Development Document (updated-CDD)

- Requests for Proposals (RFP)
- Source Selection Plans (SSP)

In accordance with DoDI 5000.02, programs shall develop a SEP for Milestone Decision Authority (MDA) approval in conjunction with each Milestone review and integrated with the Acquisition Strategy. This plan should describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It should also detail the timing, conduct, and success criteria of technical reviews.

Manufacturing and Quality Tasks

- 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
- Provide inputs and updates to the Acquisition Strategy (AS) based on results, action items, and resolutions pertaining to M&Q requirements, risks, issues, and opportunities from the PDR, CDR, pilot line, and PRR, (i.e., throughout EMD), to address technical progress and management strategy for:
  - Competition and contracting strategies

  - Program manufacturing priorities, allocations, and allotments, and justifications (Defense Priorities and Allocation System (DPAS) code)
  - Managing manufacturing, quality, supply chain, etc.
  - Design feasibility, producibility, KCs, critical characteristics, etc.
  - Implementation of new manufacturing technologies
  - Demonstrations of manufacturing processes in the appropriate environment prior to Milestone C
  - Application of Modular Open Systems Approach (MOSA)
  - Management of IP rights (including deliverables and associated license rights over the entire product life cycle)
  - Management of Materials (characteristics, sourcing, risks, etc.)
  - Manufacturing cyber threat protection measures
  - M&Q inputs Life-Cycle Sustainment Plan
  - M&Q process, rates, and quantities (capabilities, control, risks, etc.)
  - Facilities, Tooling, and Workforce (including government-furnished equipment (GFE)/government-furnished information (GFI), special test equipment (STE)/special inspection equipment (SIE), special requirements, etc.)

- Develop and provide detailed M&Q requirements and metrics in the Manufacturing Strategy and Plan and the Quality Strategy and Plan (for potential inclusion in appropriate program documentation and management reviews) for:

  - Manufacturing maturity and progress against M&Q goals required for each technical review (PDRs, CDRs, and other appropriate reviews)
  - Production quantities per year and the total planned production quantity
  - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
  - Environmental Safety and Health (ESOH) (Human safety and health)
  - HAZMAT management and pollution prevention
  - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security (physical and cyber) for both hardware and software
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
  - Manufacturing supportability and sustainment
  - Management of commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and government-furnished equipment (GFE) (including diminishing manufacturing sources)
  - Management of parts, materials, and processes (PM&P)

- Update the Manufacturing Strategy and Plan and the Quality Strategy and Plan to address the sustainment of industrial base capabilities (including manufacturing technologies and capabilities) and the maturation required during the EMD and subsequent phases:

  - Include M&Q inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystems, item, and component levels
  - Include M&Q inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
  - Domestic alternatives through regeneration of prior capability
  - Creation of new capability for manufacturing products and processes
  - Lifetime buy of items at the subsystems, and component levels
  - Include M&Q inputs on Diminishing Manufacturing Sources and Material Shortages (DMSMS)
  - Maintain a watch-list of critical items, parts, and components and their sources through a Critical Capabilities List (CCL)

- Provide M&Q industrial base (IB) capability analyses update for the AS (per DoDI 5000.02) and the RFP to include inputs on:
  - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical processes, parts, components, etc.)
  - Capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Impacts and interdependencies of the program on the NTIB and the analyses used to make this determination including management and future assessments
  - Government strategy and actions necessary to preserve the IB capabilities (e.g., incentivizing the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)
- Maintain M&Q inputs to Manufacturing Strategy and Plan and the Quality Strategy and Plan on ManTech and/or contractor manufacturing technology project implementation and status for high-risk manufacturing capabilities and processes:
  - Include M&Q risks, issues, and opportunities
  - Include plans for insertion of the new manufacturing capability
- Provide and maintain updated M&Q inputs and plans to the IMP/IMS including:
  - Schedule for any planned use of government-furnished special test equipment, government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.)
  - Schedule impacts from the requirements for special materials and allotments with justification
  - M&Q internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path

  - Inputs on reviews including the sub-tier level (including CDR, PRR, etc.), documentation inputs (e.g., CDD, TEMP, AS, SEP, CDR, PRR, etc.), production events, and deliveries

- Update the government Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan for EMD to include:
  - Updates to M&Q requirements
  - Definition and agreement on requirements for manufacturing environments pilot line, LRIP, and FRP
  - Up to date TDP
  - M&Q resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to M&Q organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
  - Changes to M&Q support organization required to meet program projected needs for P&D and subsequent phases including:
  - Earned Value Management requirements
  - Cost control requirements
  - Data collection, reporting, and management
- Update the M&Q requirements for the P&D contractor's Manufacturing Management System (MMS) and QMS to be included in the Acquisition Strategy and the RFP:
  - Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - If M&Q standards are not specified, develop alternative requirements for program specific manufacturing management plan and quality management plan.
  - Identify M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- Ensure a joint M&Q comprehensive Risk, Issue, and Opportunity Management System that can identify, and track risks and associated mitigation plans is in place:
  - Ensure requirements are up-to-date and maintained for identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program
  - Analyze mitigation plans for adequacy and completeness, and potential impacts on EMD and subsequent phases to include:
  - Industry being unable to provide program design and/or manufacturing capabilities at planned cost and schedule
  - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.

    - Required maturation of critical technologies and manufacturing processes to the appropriate level
    - M&Q cost and schedule impacts
- Ensure other agencies are providing inputs on strategies (e.g., DCMA, DLA, etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.
- Provide, update, and maintain M&Q inputs to the SEP and Test Engineering Master Plan (TEMP) to address technical progress and strategy including the following:
    - M&Q updates on KCs, critical characteristics, and Technical Performance Measures, and the associated impacts on KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
    - Updates on significant activities to the EMD program schedule including:
    - Risk and issue mitigations
    - Manufacturing assessments
    - Critical Design Reviews (including supply chain)
    - Long-lead or advanced procurements
    - Prototype builds and demonstrations
    - Projected lots or phases
    - Production Readiness Reviews
    - Independent reviews and audits
    - Changes or impacts to the workforce (i.e., strikes), supply chain (i.e., disruptions)
    - Environmental impacts (e.g., floods, fires, earthquakes, etc.)
    - Updated outputs and status from the joint Risk, Issue, and Opportunity Management System and mitigations.
    - Updated M&Q inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
    - Compliance with DFARS, PPP, ITAR, etc.
    - Management of Controlled Unclassified Information
    - Technical approaches to cybersecurity and related M&Q security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
    - Application of up-to-date industry best practices for manufacturing to include:
    - Manufacturing Management System
    - Design for Manufacturing
    - Manufacturing Risk Identification (including mitigation)
    - Manufacturing Planning
    - Manufacturing Operations Management
- Up-to-date inputs on the M&Q organization, billets and key assignments including:
    - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics):

  - Up-to-date M&Q planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
  - Up to date M&Q inputs to the configuration managed IMP/IMS including critical path
  - Requirements for manufacturing environments (e.g., pilot line, LRIP, FRP)
  - Requirements for the TDP (including IP)
- Provide M&Q requirements for sustainment (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.) and sustainment processes and activities for the LCSP.

Tools

- Acquisition Strategy Outline
- AS6500 Manufacturing Management System Checklist
- AS9100 Quality Management System Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Integrated Master Plan/Integrated Master Schedule use MS Project
- Interactive MRL Users Guide (Checklist)
- ISO 9001 Quality Management System Checklist
- Life Cycle Sustainment Plan Outline
- Manufacturing Maturation Plan
- Risk Management Plan Template
- SEP Outline
  - Manufacturing Maturation Plan
  - Quality Assurance Plan
- Technology Readiness Level (TRL) Assessment Checklist
- Test and Evaluation Master Plan (TEMP) Outline

Resources

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems
- CDD-CPD Writing Guide
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities
- DoDI 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook

- IEEE 15288, System and Software Engineering
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- ISO 9001:2015, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK Manufacturing Management Program Guide
- Risk, Issue, and Opportunity Management Guide for Defense Programs
- Systems Engineering Plan (SEP) Outline
- DOD Technology Readiness Assessment Guide
- Test and Evaluation Management Guide

A.3 Support Program Management Reviews

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

- Program offices could request an informal review Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)
- Independent Logistics Assessment (ILA)
- Industrial Capabilities Assessments (ICAs)
- Operational Test Readiness Review (OTRR)
- Full-Rate Production (FRP) Decision

Sources of data used to inform industrial and manufacturing readiness include various technical reviews and audits, Production Readiness Reviews (PRRs), Manufacturing Readiness Assessments (MRAs), Industrial Capabilities Assessments (ICAs), Independent Technical Risk Assessments (ITRAs), pre-award surveys, trade-off studies, manufacturing plans, make-or-buy plans, facility plans, tooling plans, and bills of material (BOMs). An important output includes actions to reduce or mitigate any remaining risks.

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

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

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

Manufacturing and Quality Tasks

- Support the following reviews as required:
  - Technical Readiness Assessments (TRAs)
  - Independent Technical Risk Assessments (ITRAs)
  - Independent Logistics Assessment (ILA)
  - Industrial Capabilities Assessments (ICAs)
  - Operational Test Readiness Review (OTRR)
  - Full-Rate Production Decision Review (FRPDR)
  - Manufacturing Readiness Assessments (MRAs)
- Conduct MRL assessment using MRL 9 criteria to assess LRIP maturity.
- Conduct MRL assessment using MRL 10 criteria to assess FRP maturity.
- Identify any actual or potential producibility risks associated with the proposed design and associated manufacturing processes during any review.
- Develop mitigation plans for all quality and manufacturing risks identified during any review.
- Analyze all proposed design documentation submitted in support of reviews by applying design for manufacture and design for assembly principles to identify potential producibility risks associated with the proposed design change.
- Conduct assessment of production schedule.
- Conduct assessments of production capacity and schedule:
  - Aggregate Planning
  - Master Production Scheduling
  - Rough Cut Capacity Planning
  - Capacity Requirements Planning
- Support assessments of Diminishing Manufacturing Sources Materials Sources (DMSMS), Obsolescence, Parts Management Program (PM&P), and counterfeit parts
- During production, assess these key manufacturing readiness considerations:
  - Industrial base viability
  - Design stability
  - Change Control
  - Manufacturing process maturity

  - Supply chain management
  - Quality management
  - Facilities (including performing capacity analyses)
  - Manufacturing skills availability
- Review these sources of industrial and manufacturing readiness data to include:
  - Technical reviews and audits
  - Program Status Reviews
  - Pre-award surveys
  - Manufacturing Readiness Level (MRL) assessments
  - Production Readiness Reviews (PRRs)
  - Industrial Capabilities Assessments (ICAs)
  - Trade-off studies
  - Tooling plans
  - Make-or-buy plans
  - Manufacturing plans
  - Bills of material

Note: An important output includes actions to reduce or address any remaining risks.

Tools

- Army Acquisition Logistician's Assessment Checklist
- Independent Technical Risk Assessments (ITRAs) Execution Guidance
- Industrial Base Capability Assessment
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Operational Test Readiness Review Checklist
- Production Readiness Review (PRR) Checklist (FRP Decision)
- Technology Readiness Assessment (TRA) Checklist
- Technology Readiness Level Calculator
- DCMA Post-award Orientation Checklist

Resources

- ISO 90001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Aerospace
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.7.4 Technical Reviews, and Chapter 12.5 Technical Reviews and Audits

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, IEEE Standard for Technical Reviews and Audits on Defense Programs
- Independent Logistics Assessment Guidebook
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)
- ISO 9001, Quality Management System
- Logistics Assessment Guidebook Tool
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- DoD Technology Readiness Assessment (TRA) Guide
- Test and Evaluation Management Guide
- TRA Deskbook

A.4 Support Program Management Decision Reviews

M&Q personnel should actively support the Full Rate Production (FRP) decision by providing insight into various M&Q considerations. The goal of the FRP decision is to determine if a program has met all its Exit Criteria and can move into Full Rate Production. M&Q managers need to assess risks to ensure that there are no significant manufacturing risks, that industrial production capabilities are available, assess the maturity of critical manufacturing processes to ensure that they are affordable and executable, and ensure the manufacturing and producibility risks are acceptable, supplier qualifications are completed, and applicable manufacturing processes are under statistical process control.

Manufacturing and Quality Tasks

- Support an MRL assessment of the system using MRL 9 criteria as the target for the FRP decision:
  - Capture the results of M&Q processes, demonstrated on the LRIP line, as inputs
  - Verify and validate attainability of KCs (i.e., will be capable and under process control for FRP) including yields and rates
  - Incorporate results of the required Technology Readiness Assessment
  - Incorporate industrial base viability
  - Verify and validate producibility issues, design stability, and configuration management
  - Verify and validate all FRP M&Q requirements (e.g., materials, supply chain, workforce, facilities, tooling, manufacturing planning and management, etc.)

- Assess the contractor FRP lines for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:
  - Manufacturing readiness for manufacture of equipment
  - Materials, components, and tooling availability
  - Adequacy of M&Q workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
  - Capability to meet M&Q requirements for FRP
  - Production processes and risks are well understood and are capable, in control, and affordable
  - Capability and capacity to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule
- Provide M&Q inputs and updates, for the FRP Decision following PRR assessment results (per DoDI 5000.02) to:
  - The Acquisition Strategy
  - Acquisition Approach
  - Benefit Analysis and Determination (required if no Milestone B decision)
  - Business Strategy
  - Contracting Strategy (type and termination liability)
  - Cooperative Opportunities (if necessary)
  - General Equipment Valuation
  - Industrial Base Considerations
  - Intellectual Property (IP) Considerations
  - Modular Open Systems Approach
  - Multiyear Procurement
  - Risk, Issue, and Opportunity Management Approach
  - Small Business Innovation Research/Small Business Technology Transfer
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives (regulatory)
  - Bandwidth Requirements Review
  - Capability Production Document
  - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - Life-Cycle Sustainment Plan (LCSP)
  - Programmatic Environmental Safety and Occupational Health Evaluation (PESHE)and National Environmental Policy Act (NEPA) compliance Schedule
  - Preservation and Storage of Unique Tooling Plan
  - Program Protection Plan (PPP)
  - Request for Proposal (RFP)

  - Should Cost Target
  - Spectrum Supportability Risk Assessment
  - Systems Engineering Plan (SEP)
  - Technology Readiness Assessment (TRA)
  - Test and Evaluation Master Plan (TEMP)
  - Validated On-line Life-cycle Threat (VOLT) Report
- Provide M&Q inputs, updates, and proposed changes for the proposed Production and Deployment (i.e., FRP) contract, based on PRR assessment results.
- Support reviews of any Initial Operational Testa and Evaluations (IOT&E) and subsequent results:
  - KPPs achieved (threshold and objective values)
  - M&Q implications of IOT&E risks
- M&Q personnel provide support for the Program Manager's decision process for acceptability of manufacturing and producibility risks, supplier qualifications, and verification of manufacturing processes under statistical process control.
- M&Q personnel provide support for the Program Manager's modular approach to product design and IP.
- M&Q personnel provide verification and validation of adequacy and completeness of TDP (to include management of IP) for Production and Deployment.
- M&Q personnel provide support to the corrosion prevention and control process to reduce, control, or mitigate corrosion in sustainment.
- M&Q personnel provide input to the Program Managers for assessment of ESOH risks and acceptance decisions.
- M&Q personnel provide updates to M&Q exit criteria metrics for P&D:
  - Update the M&Q personnel support plan for an assessment of manufacturing readiness and the mandated independent assessment
- Provide M&Q personnel updates to the joint Risk, Issue, and Opportunity Management System for the FRP decision.

Tools

- Integrated Master Plan/Schedule
- Interactive MRL Users Guide (Checklist)
- Life Cycle Sustainment Plan
- Manufacturing Maturation Plan
- Market Research using Pugh Template
- MDD ADM Template, Air Force, no date
- Technology Readiness Assessment (Checklist)
- Test and Evaluation Master Plan (TEMP)
- Transition to Production Assessment

Resources

- DoD 4245.7-M, Transition from Development to Production
- DoDI 5000.02, Operation of the Defense Acquisition System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- DOD Technology Readiness Assessment Guide
- DAU Test & Evaluation Management Guide

B. DEFENSE CONTRACTING SYSTEM

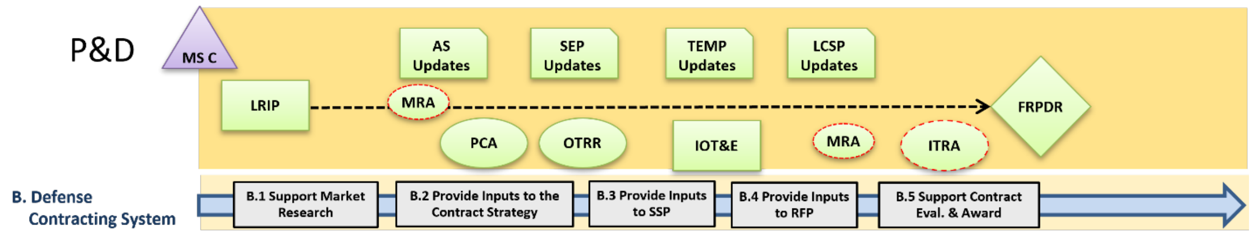


Figure 5-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

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

The contract is the vehicle used to establish 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 are often called upon to support various contracting functions and activities such as the development of the Source Selection Plan, and Request for Proposal to include contract incentives

This thread (Contracting) 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

The purpose of the P&D phase is to produce and deliver requirements-compliant products to receiving military organizations. This requires the development of contracting strategies and other contractual documents that will drive contractor behavior. The Acquisition Strategy discussed earlier is an important document that helps to drive the Contracting Strategy. Other important documents include the Source Selection Plan (SSP), Request for Proposal (RFP), and the Contract.

Prior to RFP development, Market Research is a pre-solicitation activity that involves the identification of the Market or Market of Interest, the sources of market information, the collection of market information, and the evaluation of the market's ability to satisfy the user needs. M&Q personnel need to support market research to identify suppliers and evaluate potential sources and opportunities to assess the risks associated with these opportunities.

Specific requirements must be identified for inclusion in the RFP/SOW for the production phase. The government procuring agency must provide specific and detailed information and guidance in Sections L and M for companies to follow when they prepare and submit their proposals.

- Section –Description/Specification/Statement of Work (SOW)
- Section E – Inspection and Acceptance
- Section L – Instructions, Conditions, and Notices to Offeror's

Section M – Evaluation Factors for Award (unnecessary for sole-source acquisitions). An RFP is a formal negotiated solicitation resulting in a contract that includes the contract form, contract clauses, work statements, specifications, the delivery schedule, and payment terms. The contract's primary function is technical with the administrative function secondary. The RFP must contain clear and sufficient technical guidance, so the contractor has a definite picture of how the system is envisioned to perform once delivered. It is also important that a technical functional description of hardware requirements is included and that those requirements are clearly defined and scoped. Inconsistencies, insufficient detail, and inappropriate requirements in the RFP will result in an inadequate response from industry. From an M&Q perspective, the RFP should include, at a minimum:

- Manufacturing Management System (MMS)
- Quality Management System (QMS)
- Design Development and Demonstration
- Industrial Base assessments
- Manufacturing data (including manufacturing plans and costs)
- Initial production facilities
- Production and material control systems
- Process capability and control
- Production schedule assessment and control
- Manufacturing reporting systems (especially line of balance)
- Work measurement
- Material management and control
- Control of subcontractors and vendor
- Make or Buy programs
- Government Furnished Property
- System audit
- Workforce requirements
- Facility requirements
- Tooling and test equipment requirements
- Manufacturing Readiness Assessments (MRAs)
- Technical data
- Competition

The RFP should specify the requirements for best practices for the contractor's Manufacturing

Management System (MMS) and QMS and what quality level contract requirement should be met per FAR 52.246-11 (e.g., ISO 9000, AS9100, etc.). M&Q should ensure that the RFP includes specific requirements for the integration of producibility into the design process.

SSP should delineate and include metrics and scoring for the above including preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, and quality associated with the proposed system. Additionally, the SSP should include accommodation and support of on-site government Quality personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA).

The proposal evaluation criteria must be clearly identified and defined in the RFP and applied in the SSP. Proposal evaluations must be conducted so the government can select the proposal providing the best value to the government.

Management tools such as award fees and incentive fees can provide increased interaction of program and contractor M&Q management and provide the program with increased visibility into the contractor's best practices for manufacturing, quality, and supply chain processes and procedures. award fees in the contract should be based on contractor performance to industry M&Q best practices and program goals and objectives, rewarding specific accomplishments such as:

- Producibility improvements
- Materials characterization in production relevant environment
- Manufacturing cost reduction efforts
- Manufacturing maturation plan risks burned down
- Variation and variability reduction
- Manufacturing process definition and characterization
- Progress in achieving the targeted MRL
- Progress in maturation and demonstration of KCs (i.e., meeting KPPs/KSAs)
- Progress in achieving specific yield and rate goals
- Progress in meeting the EMD exit criteria

Incentive fees in the contract should be consistent with the Acquisition Strategy (AS) and tied to goals for exceeding contract requirements and program expectations. M&Q incentives in contracts should be designed to obtain specific M&Q objectives by establishing reasonable and attainable criteria that can meet the goals or targets. These criteria must be clearly communicated to the contractor; and include appropriate incentive arrangements that will motivate contractor efforts that might not otherwise be emphasized and discourage contractor inefficiency and waste.

Important M&Q management goals and expectations to be exceeded in contract incentives include:

- Cost (e.g., Cost reductions, Should Costs, Life Cycle Costs)
- Schedule (e.g., expedited development or delivery, early delivery, on-time delivery, etc.)

- Technical (e.g., quality, cycle-time reduction, product improvement, etc.)
- Management commitment
- Producibility processes
- Risk, Issue, and Opportunity Management processes
- Commercial best practices

Contractual incentives assist both government and contractor in understanding program progress and expedite resolution of M&Q issues. Incentives can serve to motivate contractor design personnel to communicate and coordinate decisions with their own manufacturing personnel.

Important M&Q management goals and expectations to be exceeded in contract incentives include:

- Cost (e.g., cost reductions, should costs, life cycle costs)
- Schedule (e.g., expedited development or delivery, early delivery, on-time delivery, etc.)
- Technical (e.g., quality, cycle-time reduction, product improvement, etc.)
- Management commitment
- Producibility processes
- Risk and Opportunity Management processes
- Commercial best practices

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 conducted to determine whether or not small businesses are capable of satisfying the requirements. Methods include researching the Small Business Administration's Dynamic Small Business Search, and/or using format requests such as:

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

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

Manufacturing and Quality Tasks

- Support market research.
- 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.).
- Assess production capability and capacity.
- Assess ability to surge/mobilize.

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

Resources

- 10 USC 2377 Preference for Commercial Products
- FAR Part 7 Acquisition Plans
- FAR Part 10 Market Research
- DFAR 210 Market Research
- DoD Market Research Guide (*See* DAU AcqNotes Market Research website)

- SD-5 Market Research
- HQ AFMC Market Research Process Guide, Sep 2007
- NAVSUP Market Research Link
- Supplier Performance Risk System (SPRS) Market Research Report

B.2 Provide Input to the Contract Strategy

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

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

Contracting Strategy:

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

Contract Type:

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

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

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

- Price Competition, Price Analysis and Cost Analysis
- Type and complexity of requirements
- Urgency of the Requirement
- Period of Performance or length of production run
- Contractor’s technical capability and financial responsibility
- Adequacy of contractor’s accounting system
- Extent and nature of proposed subcontracting

- Acquisition history (past performance)

Contract Risks can include:

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

The Contracting Cone outlines the full spectrum of available FAR and Non-FAR contract strategies. The interactive graphic below is available at the DAU website [Contracting Cone | Adaptive Acquisition Framework (dau.edu)](https://aaf.dau.edu).

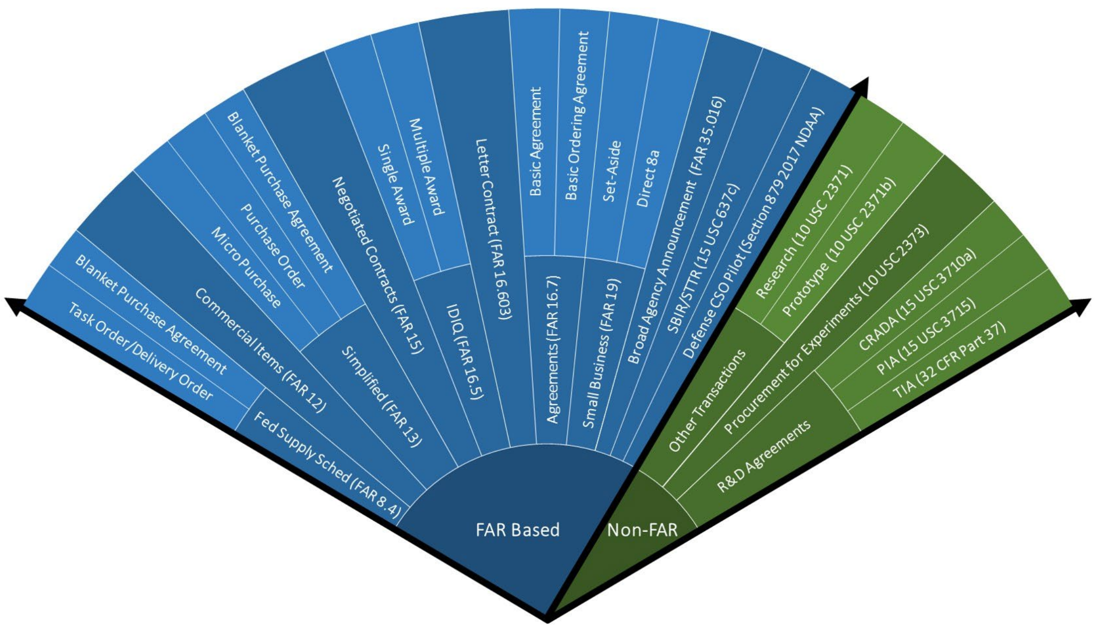


Figure 1-5. Contracting Cone

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

- Support the development of incentive type performance tracking measures that could include the following:

- Organize program to ensure the incorporation of a QMS and incentives for achieving a high-functioning QMS
- Organize program to ensure the incorporation of a Producibility Program and incentives for achieving high producibility scores
- Develop producibility infrastructure (software tools, training, design guides)
- Investments in modern manufacturing methods and equipment (hardware and software)
- Production cost reductions
- Quality Improvement goals to include measuring and managing the cost of quality
- Producibility packages released (#/%)
- Materials characterized in production-representative environment (#/%)
- Manufacturing Cost Reduction Efforts
- Manufacturing Maturation Plan and Risks Burned Down
- Variation/Variability Reduction efforts (initial yield rates/downward trend)
- Manufacturing Processes defined and characterized
- Subcontract metrics/targets (e.g., On-time Deliveries, Material Availability, Complete Kits Delivered to the Floor, etc.) developed and met
- Quality metric/targets (e.g., Cost of Quality, Defects per Million Opportunities, Customer Complaints, Scrap Rate, etc.)
- Schedule performance

- 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)
- 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 ($)
- 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 Input to Source Selection Plan

FAR 15.101, "Best Value" section, states that an agency can obtain best value in negotiated acquisitions by using any one or a combination of source selection approaches. The SSP is a key document which 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. SSP must clearly and succinctly express the Government's minimum needs (evaluation factors) and their relative order of importance. Manufacturing and QA managers, as members of the technical IPT, should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Ensure that M&Q personnel are included in the Source Selection Plan (SSP) writing and review teams.
- Provide significant manufacturing/industrial base/quality inputs into the SSP, which could include the following topics:
    - Manufacturing Readiness
    - Investments in advanced manufacturing technology production equipment, processes, and organization of work systems that build on workers' skill and experience, and work force skill development
    - Tooling, special tooling, special test equipment
    - Material handling, management, availability
    - Production capability and efficiency

- Quality Management
- Supplier Quality History records and reports
- Subcontractor Management

- Specify metrics and scoring that at a minimum address the contractor(s) plans, processes, and procedures based on analyses of EMD M&Q outputs, for:
  - Quality Management System (QMS)
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, process capability, and manufacturability assessments, analyses, and technical and management reviews
  - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
  - Demonstrations and development tests
  - Materials
  - Materials management (i.e., make/buy processes, procedures, and analyses)
  - Costs and budget estimates
  - Market research and analysis
  - Modeling and simulations
  - Process capability and production process verifications
  - ESOH, environmental, HAZMAT, safety, and security (physical, cyber, and industrial)
  - M&Q and associated data (especially CMPs)
  - Workforce (e.g., availability, training, and certification)
  - Work measurement (i.e., learning curve analyses)
  - ManTech project implementation
  - Supply chain assessments and analyses

- Specify in the SSP metrics and scoring for application of best practices for the contractor(s) Manufacturing Management System (MMS) and Plan and QMS and Plan (e.g., AS6500, ISO 9000, AS9100, etc.):
  - SSP should delineate and include metrics and scoring for preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and M&Q risks and issues associated with the proposed system
  - Plans should delineate and include metrics and scoring for accommodation and support of on-site government Quality personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA) including:
    - Source inspections and data monitoring
    - Failures and Corrective Actions and resolutions (i.e., FRACAS)
    - Material Review actions and dispositions (i.e., Material Review Boards)
    - Requests for Variance actions and approvals
    - Engineering Change process and approvals

- Ensure the requirements cited in AS6500 are the basis for specific SSP metrics and scoring of the contractor(s) Manufacturing Management System and Plan even if manufacturing management industry best practice requirements (i.e., AS6500) are not invoked in the contract. The SSP should delineate and specify metrics and scoring for:
  - Documenting how, when, and by whom each requirement of their system is to be accomplished, and define the authority and responsibility for each
  - Conducting producibility analyses
  - Identification and management key and critical characteristics in the TDP
  - Implementation of VR to reduce part to part variation of key and critical characteristics
  - Identification and management of key and critical manufacturing processes
  - Conducting Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
  - Integration of manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
  - Conducting and documenting manufacturing feasibility assessments for a competing design alternative
  - Identification of MRL targets and documenting manufacturing risks through the MRL assessments
  - Establishing and maintaining a manufacturing plan that includes:
    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing M&S
    - Manufacturing costs
    - Manufacturing system verification
    - Manufacturing workforce
    - Tooling, test equipment, and facilities
  - Management of operations including:
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - Production Process Verification
    - First Article Inspections and First Article Tests
    - Supplier Management and Quality

- Ensure that the requirements cited in quality standards (ISO 9001 or AS9100) are the basis for specific SSP metrics and scoring of the contractor(s) QMS and Plan even if these standards are not called out in the contract. The SSP should delineate and specify metrics and scoring for:
    - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
    - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management
    - Quality support with resources, competence, awareness, communication, and documented information
    - Operation including operational planning and control, products and services requirements, and design and development
    - Control of externally provided processes, products, and services
    - Production and service provision
    - Release of products and services
    - Control of non-conforming outputs
    - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
    - Quality improvement including nonconformities and corrective actions, and continual improvement
- Specify metrics and scoring to rank contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment with program goals (corrective actions and/or mitigation plans, if required) for managing M&Q CDRLs, DIDs, etc., including the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.).
- Specify in the SSP metrics and scoring for contractor(s) application of industry best practices for M&Q aspects of Systems Engineering management (e.g., IEEE 15288, -1, -2, etc.):
    - Include metrics and scoring for the contractors proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specify M&Q metrics and scoring for contractor(s) plans for timeliness, completeness, accuracy, and alignment to program goals (with corrective actions and/or mitigation, if required) to include:
    - Meeting each requirement in the Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives
    - M&Q reviews of engineering and software (with frequency of reviews)
    - IP management and government Technical/Manufacturing Data Rights, maintenance, ownership, and access

- Producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
- Utilization of facilities, tooling, test equipment, and workforce
- Supply chain management (e.g., products, locations, capacities, capabilities, monitoring, etc.)
- Parts and materials management (e.g., make/buy, planning, etc.) including:
  - Long-lead
  - Sources and risks (sole, single, foreign, fragile, and critical)
  - Handling and storage
  - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
  - Conservation of critical/strategic materials
  - Counterfeit avoidance
  - Obsolescence
  - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
  - Reduction/elimination of foreign dependency
  - Standardization of components, items, and parts
- Configuration management
- Analyses of failure mode effects and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
- Management (including traceability) of CSIs and/or CAIs to all key and critical M&Q processes (CMP)
- Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Application of statistical process controls and meeting required process capability (C_{pk}) goals
- Collection, storage, analysis, and management of M&Q data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
- Manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- Investments in workforce development including processes, work systems, and skill development
- Joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
- M&Q Variability Reduction program
- Cyber threat protection including:
  - Safeguarding M&Q information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as

physical security and industrial security in accordance with the PPP

        - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
        - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
        - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security

    - Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
    - Utilization of COTS, GOTS, GFE, and NDIs
    - M&Q in the Life-Cycle Sustainment Plan (LCSP)
    - Metrics to be met as exit criteria for LRIP

- Specify metrics and scoring to rank the contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specify M&Q metrics and scoring on timeliness, completeness, accuracy, and alignment with program objectives for contractor planning and processes to support and/or conduct as required M&Q:

    - Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to FRP Decision Review (FRPDR)
    - MRL assessments with trained personnel using the MRL criteria
    - Independent risk assessments as directed
    - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
    - Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities

- Specify M&Q metrics and scoring for the contractor(s) plans to:

    - Support on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
    - Address capital investments
    - Support LRIP and FRP with specific, detailed workforce, facilities, and capacity plans including:

        - Relocations
        - Restarts

        - Changes in materials, manufacturing processes, and/or suppliers
        - Processes, procedures, improvements, etc.
    - Address meeting program schedule and critical path
    - Manage Special Test Equipment (STE), and Special Inspection Equipment (SIE)
    - Support and conduct a Continuous Process Improvement (CPI) program
    - Use, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
    - Support and maintain the IMP/IMS including the critical path
    - Support and maintenance of an up to date TDP
- Specify M&Q metrics and scoring for the contractor(s) plans for manufacturing methods and production flow to include:
    - Advanced or unique manufacturing technologies
    - Planned fabrication and assembly key points
    - Production test and/or inspections
    - Flow of major manufacturing operations
    - Process yields and statistical or other methods for process control

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- Source Selection Plan Template (*see* applicable Service document)

Resources

- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD Source Selection Procedures
- DoD Source Selection Procedures Memo
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288, System and Software Engineering
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Program
- ISO 9001, Quality Management System
- MIL-HDBK-245E, Preparation of Statement of Work
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-882, DoD System Safety

- Source Selection Plan Guide

B.4 Provide Input to Request for Proposal

The Request for Proposal 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. Manufacturing and QA managers typically support the development of the RFP by identifying manufacturing and QA considerations for inclusion in the RFP and subsequent contract. The input to the RFP needs to be short and very succinct. These considerations need to ensure that there is linkage between the manufacturing and QA consideration and the warfighter requirements and evaluation factors and sub-factors. Evaluation factors often include cost or price, and Quality of product or service which includes technical, past performance and others. As a minimum M&Q consideration, 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 inputs.

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
- IG5315.204-5(c), Section M Guide and Template
- ISO 9001, Quality Management System Checklist
- DCMA Pre-award Survey System (PASS)
- DCMA Post-award Orientation Conference

- SF 1403 DCMA Pre-Award Survey General
- SF 1404 DCMA Pre-Award Survey Technical
- SF 1405 DCMA Pre-Award Survey Production
- SF 1406 DCMA Pre-Award Survey Quality Assurance
- SF1407 DCMA Pre-Award Survey Financial Capability

Resources

- Early Manufacturing and Quality Guide
- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- MIL-HDBK-245E, Preparation of Statement of Work
- 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
- ISO9000, Quality Management System
- ACC Systems Engineering RFP Guide
- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288, System and Software Engineering
- IG5315.204-5(b), Section L Guide
- IG5315.204-5(c), Section M Guide
- ISO9000, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- AFMC Inst 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-award Survey Guide
- Pre-Award Survey User's Manual

B.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 development and assessment of Learning Curves:
  - Identify or develop a learning curve model
  - Validate the model
  - Assess performance against the model
  - Identify risks and issues and mitigate
- 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

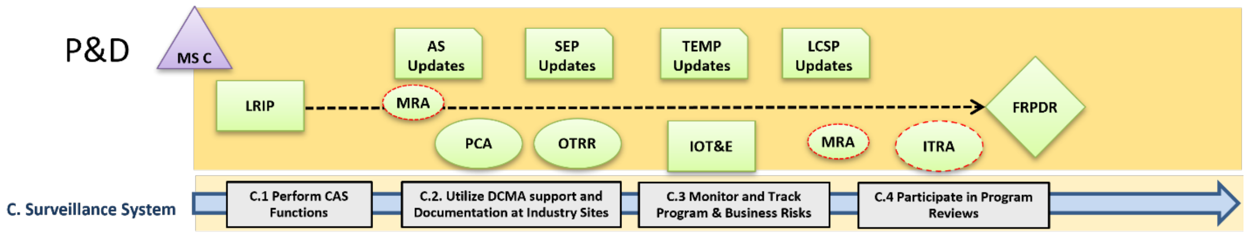


Figure 5-4. Surveillance System Manufacturing and Quality Activities

Introduction

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

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DoD contractor surveillance requirements and activities are required by the FAR/DFAR and by many DoD, Service and Agency regulations, policies, and guidance documents. DFAR Part 242.2 Contract Administration Services and DFAR Part 242.3, Contract Administration Office Functions, and PGI 242.3 Contract Administration Functions outlines the seventy (70) CAS functions that are required and the many that may require M&Q support in order to accomplish. M&Q personnel 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 the Defense Contract Management Agency. In many cases these contractor surveillance activities may be performed by on-site engineering support activity, program office contract administrators, delegated Service contract surveillance offices or a variety of engineering support activities (i.e., supervisor of shipbuilding (SUPSHIP), development command field activities). This thread (Surveillance) will focus on the following:

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

Contractors often depend on their own policies, procedures, processes, plans, controls, and schedules to meet government requirements. Often their plans, procedures and processes mirror government regulations, directives, instructions, and other documentation that may or may not be contractual. Government surveillance is often multifunctional, requiring the support of business and technical personnel. Personnel from the program office as well as from the Defense Contract Management Agency (DCMA) may be required or asked to support surveillance functions at the prime and subcontractor facilities. Manufacturing and QA managers play an integral and vital role in the total scope of contract administration. Most program offices delegate many CAS activities to the Defense Contract Management Agency (DCMA).

The Program Manager should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. This may require the program office to establish a Memorandum of Agreement (MOA) or a Quality Assurance Letter of Delegation (QALI) with DCMA. DCMA may then, based on manpower availability and funding, utilize a systematic approach deploying surveillance through the supply chain to evaluate the supply chain and supplier improvement initiatives. At resident and non-resident facilities DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes. Most contractors will have implemented a higher-level quality management process IAW AS9100 or ISO 9001 as a best practice. Some contractors, but not all, may have implemented a manufacturing management process IAW AS6500. No matter what management processes the contractor has implemented, DCMA personnel should have access to that data and should be reviewing it on a continuous basis.

DCMA audits, support for program reviews, and day-to-day surveillance of contractor and supply chain activities are tools that provide a way to assess progress and maturity of the program as it moves through finalizing the design and demonstration on a pilot line. DCMA and program audits and reviews should be multi-disciplined to ensure that all functional aspects of the program are addressed. This systematic process that assesses risk and issues should facilitate transition from final design development to initial production and beyond by assessing the maturity of the design effort, verifying and validating design requirements, verifying the system configuration, and providing a database of surveillance results and technical decisions with rationale.

Reviews and assessments are important oversight tools that the program can use to review and evaluate the state of the system and the program for CDR, re-directing activity if necessary. DCMA can provide status of the application of M&Q best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.), which includes contractor and supply chain use of Failure Mode, Effects and Criticality Analysis (FMECA), FRACAS, etc., and monitoring and review of TPM status. In addition, DCMA monitoring, tracking, and reporting of contractor and supply chain performance, actions, and compliance with all contractual requirements is a major input to the CDR.

DCMA conducts pre-award surveys required by government buying activities. The process begins with a buying activity's request for a survey and concludes with a Procuring Contracting Officer's (PCO) decision based on a recommendation by a DCMA Contract Management Office (CMO) survey team. A Production and Deployment pre-award survey can focus on every facet of the contractor's business operations technical capability, financial stability, quality assurance, plant safety, etc. M&Q should provide recommendations and inputs to program management for the pre-award survey requirements to be addressed by DCMA. In a sense, the survey process is the contractor's opportunity to provide evidence (i.e., Plan of Performance) that they can successfully fulfill the terms of the contract.

C.1 Perform Contract Administration Service (CAS) Functions

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

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

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

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

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

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

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

Manufacturing and Quality Tasks

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

- Perform engineering surveillance to assess compliance with contractual terms for schedule, cost, and technical performance in the areas of design, development, and production.
- Evaluate for adequacy and perform surveillance of contractor engineering efforts and management systems that relate to design, development, production, engineering changes, subcontractors, tests, management of engineering resources, reliability and maintainability, data control systems, configuration management, and independent research and development.
- Report to the contracting office any inadequacies noted in specifications.
- Perform engineering analyses of contractor cost proposals.
- Review and analyze contractor-proposed engineering and design studies and submit comments and recommendations to the contracting office, as required.
- Review engineering change proposals for proper classification, and when required, for need, technical adequacy of design, producibility, and impact on quality, reliability, schedule, and cost; submit comments to the contracting office.
- Monitor the contractor's value engineering program.
- Monitor the contractor's environmental practices for adverse impact on contract performance or contract cost, and for compliance with environmental requirements specified in the contract:
    - Requesting environmental technical assistance, if needed
    - Monitoring contractor compliance with specifications requiring the delivery or use of environmentally preferable products, energy-efficient products, products containing recovered materials, and biobased products
    - Ensure that the contractor complies with the reporting requirements relating to recovered material content utilized in contract performance.
- Support the review of requests for payments under the progress payments or performance-based payments.
- Support reviews of contractor cost reports and ensure timely notification by the contractor of any anticipated overrun or underrun of the estimated cost.
- Support monitoring the contractor's financial condition.
- Support contract closeout procedures.
- Request the following M&Q support from the appropriate (local) Contract Administration Office (CAO)/Contract Management Office (CMO) in attending, monitoring, and reporting on contractor reviews, performance, and meetings including:
    - Inputs from DMCA monitoring, tracking, and reporting on contractor and supply chain M&Q activities and functions to meet contractual requirements as delineated in C.3
    - Interim Program Reviews (IPRs) including supply chain
    - Performance of Physical Progress Reviews (PPRs) in support of Program Progress Payments
    - Corrective Action Board (CAB) or similar meetings (e.g., quality, manufacturing, supply chain, engineering, and software issues, corrective actions, and dispositions)
- Request M&Q support from the appropriate (local) CAO/CMO in monitoring, tracking, reporting on contractor performance and actions related to and including the following:

  - Estimates to Completion (EACs) as requested
  - Delivery delay notices to the customer
  - Performance Base Payment requests (validation and/or verification)
  - Support to customer priority delivery requests (DX rating)
  - Contractor and supply chain pilot lines
- Ensure M&Q provides inputs for updates to the Memorandum of Agreement (MOA) between the program and the government contract administration for necessary activities.

Tools

- AS9100 Checklist
- ISO 9001 Checklist
- AS6500 Checklist
- DCMA Program Support Plan per DCMA-ANX 205-02
- DCMA Pre-Award Survey System (PASS) review
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- FAR 42.11 Production Surveillance and Reporting
- FAR 42.302 Contract Administration Functions
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DCMA Manual 2302-01 Surveillance
- DCMA-INST-124, Contract Property Management
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-213, Technical Pricing Support
- DCMA-INST- 219, Supply Chain Management Through Standard Contract Surveillance
- DCMA-INST-221, Integrated Surveillance Plan
- DCMA-INST-302, First Article and Production Lot Testing
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-311, Process Review – QA
- DCMA-INST-322, Quality Audit
- DCMA-INST-323, Data Collection and Analysis
- DCMA-INST-324, Product Examination
- DCMA-INST-325, Technical Reviews
- DCMA-INST-401, Industrial Analysis
- DCMA-INST-1102, Product Quality Deficiency Report

- DCMA-INST-1201, Corrective Action Process
- DCMA-INST-2301, Evaluating Contractor Effectiveness
- DCMA-INST-3101, Program Support
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Early Manufacturing and Quality Engineering Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DOD Technology Readiness Assessment Guide
- DD 1423, Contract Data Requirements List
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD-11991A, General Standard for Parts, Materials, and Processes
- SAE EIA 649B, Configuration Management Standard

C.2 DCMA Support at Industry Sites

The EMD phase is where a system is developed and designed before going into production. The goal of this phase is to complete the development of a system, complete system integration, develop affordable and executable manufacturing processes, complete system fabrication, and test and evaluate the system. Many major activities take place at the contractor's design and production facilities and at subcontractor and vendor facilities throughout the supply chain. Program offices often delegate oversight and surveillance responsibilities to DCMA and rely on their expertise to provide the program office with a day-to-day presence. M&Q managers need to create letters of delegation and agreements are in place and communicated with DCMA to ensure that DCMA can and will provide adequate support for EMD activities.

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

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

DCMA personnel can continuously review, assess, and document contractor performance. M&Q personnel need to understand and be able to use DCMA generated data to support the achievement of program objectives. DCMA Instructions provide guidance for a variety of support services with many of these services providing documentation of that support to include:

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

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

A Pre-award Survey may be required per FAR 9.106 and is an evaluation of a prospective contractor's capability to perform under the terms of a proposed contract. It typically requires an on-site visit to the prospective contractor's facility and could be an assessment of their technical, production, quality, and financial capabilities. M&Q managers need to support assessments at the contractors' facilities and should involve support by DCMA personnel stationed at the facility.

A Post-Award Orientation Conference may be performed as prescribed in FAR 42.5. A post-award orientation aids both Government and contractor personnel to (1) achieve a clear and mutual understanding of all contract requirements, and (2) identify and resolve potential problems. However, it is not a substitute for the contractor's full understanding of the work requirements at the time offers are submitted, nor is it to be used to alter the final agreement arrived at in any negotiations leading to contract award. M&Q managers need to support DCMA in this assessment at the contractors' facilities.

Manufacturing and Quality Tasks

- Ensure M&Q provides inputs to the program development of a Letter of Delegation for DCMA support.
- Ensure M&Q participates in the development of a Memorandum of Agreement (MOA) for DCMA support.
- Ensure M&Q provides inputs on contractual requirements for contractor and supply chain activities and functions to be monitored, tracked, and reported by DCMA and/or program personnel in support of EMD.
- Ensure M&Q personnel provide inputs for the request to DCMA to conduct Pre-award Surveys of potential LRIP contractor(s) (including their designated supply chain) for M&Q capabilities in the areas of:
    - Compliance with appropriate industry best practices (e.g., AS6500, AS9100, etc.)
    - Technical Performance including TPMs, Cis, CSIs, KCs, and critical characteristics
    - Design
    - Manufacturing capabilities and capacities
    - Quality assurance including processes and procedures compliance to best practices
    - EVMS processes, procedures, and data
    - Government property management and control (e.g., GFE, GFP, etc.)
    - Transportation, storage, and packaging processes and controls
    - Security (physical, cyber, and industrial)
    - System safety
    - Plant safety, materials handling, hazardous waste disposal, etc.
    - Environmental and Energy compliance with applicable policies and statutes
    - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Configuration management processes and procedures
    - Software surveillance

  - Test planning, test equipment, and test results
- Ensure M&Q personnel provide inputs for the request to DCMA to conduct a Post-Award Orientation Conference. All aspects of the contract are subject to discussion with emphasis in the areas of:
  - Compliance with appropriate industry best practices (e.g., AS6500, AS9100, etc.)
  - Technical Performance including TPMs, Cis, CSIs, KCs, and critical characteristics
  - Design
  - Manufacturing capabilities and capacities
  - Quality assurance including processes and procedures compliance to best practices
  - EVMS processes, procedures, and data
  - Government Property management and control (e.g., GFE, GFP, etc.)
  - Transportation, storage, and packaging processes and controls
  - Security (physical, cyber, and industrial)
  - System Safety
  - Plant safety, materials handling, hazardous waste disposal, etc.
  - Environmental and Energy compliance with applicable policies and statutes
  - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
  - Configuration management processes and procedures
  - Software surveillance
  - Test planning, test equipment, and test results
- Use DCMA surveillance capabilities in monitoring, tracking, and reporting for contractor and supply chain use and application of M&Q best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.):
  - Surveillance of contractor and supply chain use and application of best practices (e.g., AS6500, AS9100, ISO 9000, etc.)
  - Participation in Post Award Orientation Conference
  - Verify closure of PDR actions supply chain (required in the PDR if the PDR was conducted in the TMRR phase)
  - Updates on supply chain CDRs, developmental testing, PCAs, FCAs, other “critical path” events, and notifications to the program office of potential or actual program milestone issues
  - Government surveillance of contractor and supply chain FAIs/FATs and Qualifications (QUAL)
  - Surveillance support of contractor’s Earned Value Management System (EVMS)
  - Conduct cost, schedule, and technical performance variance evaluations
  - Surveillance of Human Rating Certification processes (e.g., Flight Operations, etc.) with unrestricted government access to inspect and/or test processes (i.e., Safety of Flight (SOF) characteristics)

- Government Contract Quality Assurance (GCQA) of engineering development models, engineering models, production prototypes, production representative models/articles, production readiness models/articles, as requested by the program office in the contract
- Authority to accept or reject minor Requests for Variation (RFVs), Material Review Board (MRB) proposals for Use-As-Is (UAI), and post-CDR repair non-conformances (i.e., after the final product (configuration) baseline (PBL) is established)
- Surveillance of the supplier's compliance to DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- Verification of contractor and supply chain compliance with contractual Special Packaging Instructions (SPIs) for end item systems and spares
- Verification of contractor and supply chain compliance with Surveillance Critical Designator (SCD) (FAR 42.11) requirements applied to the contract
- Surveillance of M&Q processes, procedures, and contractor program systems (e.g., Risk, Issue, and Opportunity Management System, Configuration Management System, FRACAS, FMECA processes, test, and evaluation processes, etc.)
- Other CAS functions as outlined in FAR Subpart 42.3 CAS Functions

- Use DCMA surveillance capabilities to monitor M&Q FMECA contract requirements for contractors and supply chain for:
  - Identification of subsystems, items, components, characteristics and/or features, and processes, which if nonconforming, could result in a catastrophic or critical failure of the system:
  - Items and components will be designated as either a critical item (CI) or CSI
  - Product characteristics and/or features will be designated as either KCs or critical characteristics
  - Processes will be designated as critical manufacturing processes (CMPs)
  - Review of the FMECA and/or Critical Items List (CIL) for Cis, CSIs, KCs, and critical characteristics to specify the need for government surveillance of these items
  - Verification of updates of FMEA/FMECA based on FRACAS and developmental testing results
- Use DCMA surveillance capabilities to monitor M&Q aspects of System Safety contract requirements including:
  - Review Safety Assessment Reports (SARs) and/or CIL for Cis, CSIs, KCs, and critical characteristics
- Use DCMA surveillance capabilities to monitor M&Q aspects of Test and Evaluation contract requirements for surveillance of contractor's and supply chain's:
  - Physical Configuration Audits (PCAs) of the required subsystems/components identified in the contract. Perform government surveillance, as required
  - Functional Configuration Audits (FCAs) of the required subsystems/components identified in the contract. Perform government surveillance, as required
  - Developmental Testing for achievement of Critical Technology Elements (CTEs), KPPs,

  and KSAs
  - Software Testing, to include Software Acceptance Test (SAT)/Software Formal Qualification Test (SFQT), if conducted in the EMD phase
  - Environmental testing (e.g., Environmental Stress Screening (ESS), Highly Accelerated Life Testing (HALT), Highly Accelerated Stress Screen (HASS), Thermo-Cycling, Thermo-Shock, Pyrotechnic Shock, Vibration, etc.), if conducted
  - Live Fire Test and Evaluation), if applicable
  - Acceptance Testing
- Support the development of program documentation, planning, and investments using DCMA information and data with respect to:
  - Manufacturing maturity
  - Industrial capability status and readiness
  - Facilities and equipment availability
  - Workforce availability and training
  - Quality system processes and results
  - Manufacturing and/or supply chain risks
- Support the systems engineering process, trade studies, design, analyses, etc., using DCMA M&Q data from DCMA reports on:
  - Manufacturing and Quality System Analyses
  - Manufacturing and Quality Program and Product Analyses
  - Manufacturing and Quality Continuous Improvement and Analysis
  - Supply Chain System Analysis
  - Supply Chain Risk Assessment
- Support program assessments.
- Monitor manufacturing and production operations.
- Perform Quality inspections and monitor the contractors QMS.
- Provide engineering support and analysis.
- Conduct industrial analysis and monitor industrial cyber security programs.
- Support the management of government property.
- Support program cost assessments, and cost/financial reporting.
- Perform or support testing and 1st article inspections/tests.
- Recommend manufacturing investment programs required to mature emerging manufacturing technologies and industrial capabilities based in part on DCMA inputs.
- Request DCMA Contract Management Offices support development of M&Q to ensure agreement on contract oversight needs and perspectives with respect to:
  - Product support analysis
  - Software development
  - Counterfeit parts
  - Cybersecurity

- For manufacturing feasibility assessments of AoA concepts, request information and data input for similar products and manufacturing processes from DCMA in the following areas:
    - Manufacturing maturity
    - Status and readiness of industrial capabilities
    - Current available facilities and equipment
    - Workforce availability and training
    - Quality system processes and results
- Use DCMA M&Q data to analyze the M&Q requirements and feasibility for the AoA.
- Use DCMA M&Q data relevant for emerging technology maturity to develop and provide recommendations/rationale for the AoA preferred concepts.
- Use DCMA data to assist in identifying the manufacturing, quality, and/or supply chain risks for similar products and processes relevant for the AoA.
- Use DCMA surveillance capabilities to enhance M&Q monitoring of KPPs and KSAs progress and periodic review of TPMs.
- Use DCMA surveillance capabilities to monitor contractor's and supply chain's M&Q FRACAS contract requirements including:
    - Government personnel attending FRACAS meetings, or review minutes, and adjusting Government surveillance based on FRACAS results, as required
    - Verifying contractor and supply chain updates of FMEA/FMECA based on FRACAS result, when required
- Use DCMA surveillance capabilities to monitor M&Q contract Parts Management requirements including:
    - Contractor' compliance to Parts Management contract requirements (i.e., MIL-STD-11991A)
    - Verification that contractor and supply chain use parts and/or components in the design that are qualified under a government or Industry specifications or standards
    - Validation of Non-Standard Parts Approval Requests (NSPARs) made to the program office for approval in accordance with specified CDRLs, or DDF1423, that specifies what the supplier must provide as part of the NSPAR
- Use DCMA surveillance capabilities to monitor M&Q contract Configuration Management requirements including contractor's and supply chain compliance to requirements (e.g., SAE/EIA649B, Service specific policies, etc.).
- Use DCMA surveillance capabilities to monitor M&Q contract Software Development, Quality Assurance, Configuration Management and Testing requirements including:
    - Contractor's and supply chain compliance to software development, quality assurance, configuration management and testing requirements
    - Contractor's progress in performance of SAT/SFQT

Tools

- AS9100 Checklist

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

Resources

- FAR Subpart 30.6, CAS Administration
- FAR Subpart 42.3, CAS Functions
- FAR 42.11 Production Surveillance and Reporting
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DCMA Guidebook
- DCMA Manual 2303-01 Surveillance
- DCMA Manual 3101-01 Program Support
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-221 Integrated Surveillance Plan
- DCMA-INST-302 First Article Inspection and Production Lot Testing
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-311 Process Review (QA)
- DCMA-INST-322 QA Audit
- DCMA-INST-323 Data Collection and Analysis
- DCMA-INST-324 Product Examination
- DCMA-INST-325, Technical Reviews
- DCMA-INST-401, Industrial Analysis
- DCMA-INST-1102 Product Quality Deficiency Report
- DCMA-INST-1201 Corrective Action Process
- DCMA-INST-1207 Effective Control of Nonconforming Material
- DCMA-INST-2301 Evaluating Contractor Effectiveness
- DCMA-INST-3101 Program Support
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework

- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- ManTech Strategic Plan
- Manufacturing Readiness Level (MRL) Deskbook
- DOD Technology Readiness Assessment Guide

C.3 Monitor and Track Program and Business Risks

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

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

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

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

Risk Management includes the following five risk areas:

- Risk Planning: Identify the program or contractors risk management process.
- Risk Identification: Identify what could go wrong.
- Risk Analysis: Identify what is the likelihood (probability) and consequence of the risk.
- Risk Mitigation: Identify how the risk is managed (accept, avoid, transfer, or control).

- Risk Monitoring: Identify how the risk will be tracked and how the risk has changed over time.

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

Manufacturing and Quality Tasks

Use DCMA surveillance capabilities to monitor M&Q contract requirements, including risk issues and opportunities.

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

Tools

- AS9100 Checklist
- ISO 9001 Checklist
- AS6500 Checklist
- Systems Engineering Plan (SEP) Outline
- Technical Readiness Assessments (TRAs) Checklist
- Assessment of Manufacturing Risk and Readiness, DI-SESS-81974,
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Manufacturing Maturation Plan
- Quality Status Report, DI-MGMT-82186
- Technical Readiness Assessment (TRA) Checklist

- Defense Technical Risk Assessment Methodology (ITRA criteria)
- Manufacturing Capability Assessment Worksheet
- Manufacturing Maturation Plan
- MDD Development Planning Templates
- System Capabilities Analytic Process (SCAP)
- Hazardous Material Assessment Template
- Interactive MRL Users Guide (Checklist)
- Preliminary Hazard List (PHL) See PHA checklist

Resources

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.6 Risk Assessment
- AS9100, Quality Management Systems
- ISO 14001, Environmental Management
- ISO 9001, Quality Management System
- AS6500 Manufacturing Management System
- Manufacturing Readiness Level (MRL) Deskbook
- ESOH in Acquisition Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DCMA-INST-325, Technical Reviews
- DCMA-INST-3101 Program Support
- DCMA Manual 3101-01 Program Support

C.4 Participate in Program Reviews

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

- Integrated Baseline Review (IBR)
- Operational Test Readiness Review (OTTR)
- Manufacturing Readiness Assessment (MRA)
- Independent Technical Risk Assessment (ITRA)
- Physical Configuration Audit (PCA)

An Integrated Baseline Review (IBR) is a joint assessment conducted by the government Program Manager (PM) and the contractor to establish a mutual understanding of the Performance Measurement Baseline (PMB).

OTRR is a multi-disciplined product and process assessment to ensure that the production configuration system can proceed into Initial Operational Test and Evaluation (IOT&E) with a high probability of success. The Program Manager certifies that all Developmental Test and Evaluation (DT&E) activities are complete and requests approval to proceed into IOT&E.

MRAs are a structured evaluation of a technology, component, manufacturing process, weapon system or subsystem using Manufacturing Readiness Levels (MRLs). It is performed to define the current level of manufacturing maturity, identify maturity shortfalls and associated costs and risks and to provide the basis for manufacturing maturation and risk management.

ITRA will assess technical risks for Major Defense Acquisition Programs as described in this framework and the Department of Defense (DoD) Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs including risks related to critical technologies and manufacturing.

The Physical Configuration Audit (PCA) formally examines the as-built configuration of each configuration item consistent with its item detail specification and technical data package (TDP) of the final product baseline.

Each of these reviews and audits has DoD policy, guidance and direction associated with its accomplishment. Each of these reviews and audits has an associated checklist that should be followed and tailored as appropriate.

Manufacturing and Quality Tasks

- Support any Integrated Baseline Reviews (IBR).
- Support any Operational Test Readiness Reviews (OTTR).

- Support any Manufacturing Readiness Assessments (MRA).
- Support any Technology Readiness Assessment (TRA)
- Support any Independent Technical Risk Assessments (ITRA).
- Support any Physical Configuration Audits (PCA).
- Conduct Production Program Assessments by reviewing the following:
    - Technical Performance
    - Production Performance
    - Quality Management System Assessment
    - Quality Assurance
    - *Finance
    - *Accounting
    - Government Property Control
    - Transportation and Packaging
    - *Security
    - Plant Safety
    - Environmental/Energy Compliance
    - *Flight Operations/Safety

      *Other functional areas should be included in the reviews. It is important to understand how these non-manufacturing areas can and will impact the manufacturing function.
    - Program assessments include:
        - Manufacturing Readiness Level (MRL) Assessment Checklist
        - Manufacturing Maturation Plan
        - Independent Technical Risk Assessment (ITRA)
- Identify, capture, and address any manufacturing concerns identified during the above assessments.

Tools

- Integrated Baseline Review (IBR) Checklist
- Operational Test Readiness Review (OTTR) Checklist
- Manufacturing Readiness Assessment (MRA) Checklist
- Technology Readiness Assessment (TRA) Checklist
- Independent Technical Risk Assessment (ITRA) Checklist
- Physical Configuration Audit (PCA) Checklist
- DCMA Program Assessment Report
- Integrated Master Plan/Schedule (IMP/IMS)
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Interactive MRL Users Guide (Checklist)
- Systems Engineering Plan (SEP)

- Manufacturing Maturation Plan

Resources

- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Standard for Technical Reviews and Audits on Defense Programs
- PGI 209.106-2, Request for Pre-award Surveys
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-323, Data Collection and Analysis
- DCMA-INST-325, Technical Reviews
- DCMA-INST-401, Industrial Analysis
- DFAR subpart 242.3, CAS Functions
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DOD Technology Readiness Assessment Guide
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

D. TECHNOLOGY AND INDUSTRIAL BASE

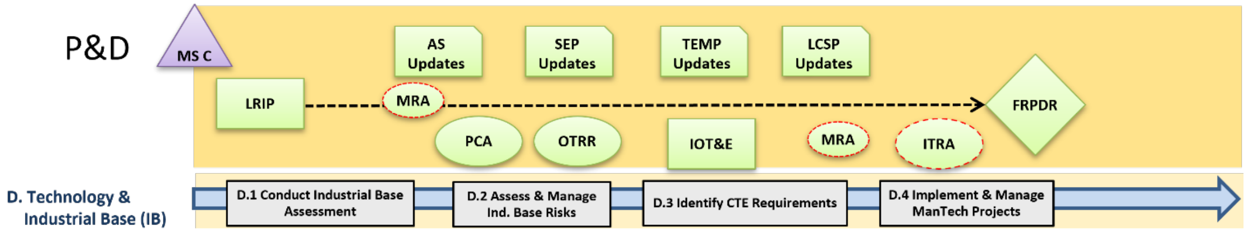


Figure 5-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC – Section 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 in the supply chain (sole source, foreign source, etc.)
- Support for a resilient supply base for critical defense capabilities
- Support for procurement surges and contractions

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

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

During the P&D phase program management is responsible for incorporating industrial base assessments, to include capacity and capability considerations, into acquisition planning and execution. Industrial base (IB) readiness to support program objectives should be assessed to identify risks, issues, and opportunities. The M&Q Strategies, and subsequent inputs to the program Acquisition Strategy (AS), should highlight the strategy for assessing and mitigating any industrial and manufacturing risks as identified in any reports generated from the industrial base assessments. According to DODI 5000.02 Acquisition Strategies must consider industrial base capabilities at Milestones C and provide an update to the Analysis of Alternatives (AoA) conducted in the MSA phase which included an assessment of manufacturing feasibility and required an assessment of the industrial base capabilities.

The update of earlier phase assessments will serve as a baseline as the design evolves. It will document the manufacturing capabilities required for the Acquisition Strategy and facilitate the updates of M&Q inputs to the Systems Engineering Plan (SEP) and Request for Proposal (RFP) documents. The IB topic areas that should be assessed include:

- Industrial base sources relevant to the program, the contractor, and the contractor's supply chain
- M&Q processes and techniques
- Design producibility risks, issues, and opportunities
- Cyber risks and vulnerabilities to M&Q information and data
- Impacts of materials (e.g., critical, long-lead, etc.)
- Supply disruption risks, issues, and program impacts from critical and strategic materials
- Availability and capability of production machinery, equipment, and tooling
- 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

During the Production and Deployment (P&D) phase, industrial base (IB) readiness to support program objectives should be assessed to identify risks, issues, and opportunities associated with the implementation of Low Rate Initial Production (LRIO) and the ramp up to Full Rate Production (FRP).

Industrial Capability Assessments (ICAs) are often conducted using a standardized questionnaire which is sent out to companies of interest, and they complete the survey. After the survey has been completed a small team visits the company to follow-up on the questions and to get a tour of the facilities. Program offices want to ensure that the contractor has the capability to produce "one" and the capacity to produce at "rate" and for the total quantity of the program.

Industrial readiness data sources could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, Manufacturing Readiness Assessments, Manufacturing Readiness Assessment Maturation Plans and Risk Reduction Plans, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. An important output includes actions to reduce or address any remaining risks.

For the FRP Decision Review, the Program should identify remaining risks prior to a production go-ahead decision. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. The ability of the industrial base to ramp up from LRIP to FRP is a major concern.

ManTech programs are used to improve performance while reducing acquisition costs by developing, maturing, and transitioning advanced manufacturing technologies. The risk assessments should identify high risk manufacturing process areas that may require investments in ManTech or other investment programs to further mature a process. These investments must be identified early so that these manufacturing capabilities will be matured in time to support rate production.

If a platform or system depends on specific technologies to meet system operational requirements in development, production, operation, and sustainment, and if the technology or its application is either new or novel, then that technology is considered a critical or enabling technology (CTE).

The ManTech program focuses on advancing state-of-the-art manufacturing technologies and processes from the research and development environment to the production and shop floor environment. Technologies with generic application required for defense systems and having high technical and financia1 risk characterize the projects with the highest priority for ManTech funding.

D.1 Conduct/Update Industrial Base Assessment and Analysis

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

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

Industrial Capabilities Assessments (ICAs) should be conducted at critical sub-tier vendors, as well as at the prime contractor facilities.

- Conduct ICAs.
- Ensure the ICA questionnaire or other assessment tool addresses the following IB considerations:
    - Suppliers name, location, etc.
    - Company Ownership (public or private)
    - Facility Size and other facility information
    - Sales and sales backlog
    - Distribution or Sales Mix (% government vs commercial)
    - DoD Programs Supported
    - Significance of Current Program to overall sales

  - Maturity of product technology
  - Production Status

- Ensure the ICA addresses the following:
  - Industry status (consolidations, rising or falling market, etc.)
  - Unique or critical manufacturing processes
  - Technology issues (DMSMS, obsolescence, etc.)
  - Vendor or supply chain issues
  - Industrial base risks
  - Production rate and quantity
  - All industrial capabilities risks have been identified and all IC risks have associated mitigation efforts.

- Ensure Industrial Base assessment looks at capabilities including the following:
  - New and unique capabilities that must be developed or used to meet program needs.
  - Identifying DoD investments needed to create new or enhance existing industrial capabilities. This includes any new capability (e.g., skills, facilities, equipment, etc.).
  - Identifying new manufacturing processes or tooling required for new technology.
  - Funding profiles must provide for up front development of manufacturing processes/tooling and verification that new components can be produced at production rates and target unit costs.
  - Identifying exceptions to FAR Part 45, which requires contractors to provide all property (equipment, etc.) necessary to perform the contract.
  - Program context in overall prime system and major subsystem level industry sector and market.
  - Strategies to address any suppliers considered to be vulnerable.
  - Risks of industry being unable to provide new program performance capabilities at planned cost and schedule.
  - Alterations in program requirements or acquisition procedures that would allow increased use of non-developmental or commercial capabilities.
  - Strategies to deal with product or component obsolescence, given DoD planned acquisition schedule and product life.
  - Strategies to utilize small business, including small-disadvantaged business, women-owned small business, veteran-owned small business, service-disabled veteran-owned small business and small businesses located in Historically Underutilized Business Zones.
  - Industrial Capability Assessment has been completed and all issues are mitigated.
  - Industrial capability is in place to support LRIP.
  - Industrial capability will be in place to support Production.

- Assess the labor/facility availability by understanding labor contracts and facility leases for the production schedule.

- Industrial capability to support LRIP/Production has been analyzed. Sole/single/foreign sources stability is being assessed/monitored.
- Conduct Logistics analysis:
  - Investigate manufacturing, re-manufacturing, and overhaul opportunities which have high potential impact for reducing life cycle costs and depot operations.
- Assess the impact of programmatic decisions on the national and international technology and industrial base. Overall Industrial Capabilities Assessments (ICAs) should address critical sub-tier, as well as prime contractor capabilities and should include:
  - New and unique capabilities that must be developed or used to meet program needs.
  - Identify DoD investments needed to create new or enhance existing industrial capabilities. This includes any new capability (e.g., skills, facilities, equipment).
  - Identify new manufacturing processes or tooling required for new technology.
  - Funding profiles must provide for up front development of manufacturing processes/tooling and verification that new components can be produced at production rates and target unit costs.
- Assess the overall prime system and major subsystem level industry sector and market strategies to address any suppliers considered to be vulnerable.
- Assess risks of industry being unable to provide new program performance capabilities at planned cost and schedule.
- Assess alterations in program requirements or acquisition procedures that would allow increased use of non-developmental or commercial capabilities.
- Assess strategies to deal with product or component obsolescence, given DoD planned acquisition schedule and product life.

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- DD Form 2737 Industrial Capabilities Questionnaire
- SF 1405 Preaward Survey – Production
- Defense Industrial Base Assessment Survey OMB 0694-0119
- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing Maturation Plan

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
- DoDI 5000.60, Defense Industrial Assessments
- producibility and manufacturabilityDoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DCMA-INST 401, Industrial Analysis
- DCMA Instruction 3401, Defense Industrial Base Mission Assurance
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60, Defense Industrial Base Assessments
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- Defense Manufacturing Management Guide for Program Managers, Chapter 2 Industrial Base
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

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 P&D, 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 risks that should be addressed on a recurring basis to include:

- Lack of Competition
    - Shrinking Industrial Base (Consolidation and companies leaving the market)

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

Manufacturing risk resolution involves assessing risks through formal technical reviews and in demonstrating the manufacturing capability and maturity. ManTech development needs to be accomplished in a phased approach to define and demonstrate capabilities. The P&D 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 Low-Rate and Full Rate 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 mitigation 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.

Manufacturing and Quality Tasks

- Support all risk management activities:
  - Risk Planning
  - Risk Identification
  - Risk Analysis
  - Risk Mitigation
  - Risk Monitoring
- Support the decision to accept, avoid, transfer, or control the risks.
- Support the development of risk mitigation plans to include:
  - Develop potential alternate sources, as necessary.
  - Ensure needed sources are available, multi-sourcing where cost-effective or necessary to mitigate risk.
  - Industrial capability available to support modifications, upgrades, surge, and other potential manufacturing requirements.

Tools

- 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
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- 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

During P&D, management of industrial base and technology considerations to reduce technology, engineering, integration, and life cycle risks must be an integral part of program management and are key to the success of the program through development, production, and sustainment.

Technologies that will be incorporated into the system should be fully matured during P&D for 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 seven hundred research and development projects focused on advanced manufacturing. In addition, the OSD ManTech program supports research in advanced manufacturing technologies and processes in multiple critical technology areas such as advanced materials, Hypersonics, directed energy, etc. M&Q personnel can support the assessment of critical technologies through the identification of CTEs as early as the Analysis of Alternatives by addressing technology maturity, integration risks, manufacturing feasibility, and technology and manufacturing maturation and demonstration.

Additionally, CTEs were identified in the previous phase and assessed for feasibility, affordability, and supportability and for M&Q maturity. Plans to increase maturity were incorporated into the draft CDD, AS, SEP, and the RFP for the MSA phase. For P&D, 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 analysis 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., Operational Test Readiness Review (OTRR), Physical Configuration Audit (PCA), 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 includes an assessment of how new and emerging technology might impact product design requirements, affordability, and manufacturing capabilities.
- Update the assessment of identified high risk manufacturing process areas necessary for the program that require investments in ManTech programs:
  - Estimate cost, schedule, and performance impacts

Tools

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

Resources

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- 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 and must begin early so that 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, 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) 8
- Maturity at end no less than MRL 9, preferably at a 10
- 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. M&Q 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 P&D 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 SE IPT need to implement ManTech projects that have been identified in previous studies and gap analysis. 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 or unique processes or components.

Manufacturing and Quality Tasks

- ManTech projects should be conducted to demonstrate production application of emerging technologies:
  - 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.)
- Ensure primary manufacturing technology efforts are maturing, and improvement efforts are continuing.
- Ensure required ManTech development solutions have been demonstrated in LRIP.
- Validate required manufacturing technology solutions before the FRP decision.
- Manufacturing and QA personnel should conduct “technology gap analysis.”
- Identify new ManTech voids that have surfaced.
- Evaluate ongoing ManTech efforts and determine if they can be applied to the program:
  - Assess if ManTech projects could impact projects from other Services and Agencies.

Tools

- 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
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- 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

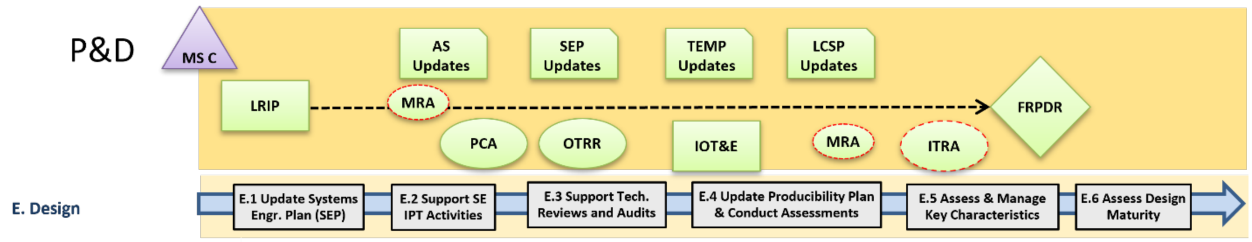


Figure 5-6. Design Manufacturing and Quality Activities

Introduction

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

Table 5-1. 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

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

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

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

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

This thread (Design) requires an analysis of the degree to which the identified, evolving or system design will meet user requirements and the degree to which the design is new and unproven. will focus on the following sub-threads, tasks, activities, tools, and resources:

- 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

E.1 Update to 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

- 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 M&Q impacts and interdependencies of design activities to other functional areas or activities (e.g., engineering, producibility, costs, safety, manpower, schedule, etc.).
- 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
- 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.

- 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 and quality 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
    - Technology Readiness Assessments
    - 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 to be evaluated and matured
  - Integration of manufacturing risks in cost and manpower estimates
- Integration of manufacturing risks in cost and manpower estimates.
- At a minimum M&Q should ensure SEP updates are provided for the following:
  - System architectures and interfaces
  - Required DoD certifications (e.g., Space-worthiness, Airworthiness, Insensitive Munitions, etc.)
  - M&Q risk, issue, and opportunity assessments, including schedule, costs, performance, PRRs, pilot lines, prototypes, demonstrations, milestones, etc.
  - Program M&Q structure and organization including WBS, positions, staffing, etc.
  - M&Q Technical Performance Measures and metrics including yields, rates, process capability indices, etc.
  - Planned M&Q activities for the next phase including Value Engineering, ManTech, and other improvements, learning curves, initiating production, etc.
  - M&Q requirements tracking and change processes including changes from prototypes, demonstrations, development testing, etc.
  - M&Q configuration and Engineering Change Proposal (ECP) management
  - KCs considerations and impacts critical to the achievement of the program's technical requirements

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 and facilities needs
- Resources required for accomplishing the activities.
- Project critical event objectives during any phase of a project's life cycle.
- Work product outputs of the processes and how the processes are integrated.
- Communication standards between project management engineering teams.
- Entry and exit criteria of work products during project phases.
- 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
- Technology Readiness Assessments Checklist
- Manufacturing Maturation Plan
- Manufacturing Plan, DI-MGMT-81889A
- Quality Assurance Plan
- Quality Assurance Program Plan, DI-QCIC-81794
- 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
- Manufacturing Readiness Level (MRL) Deskbook
- DOD Technology Readiness Assessment Guide
- 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 sixteen processes: eight technical management processes and eight technical processes. These sixteen processes provide a structured approach to increasing the technical maturity of a system and increasing the likelihood that the capability being developed balances mission performance with cost, schedule, risk, and design constraints.

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

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)
  - GD&T (Geometric dimensions and tolerances)
  - Surface finish
  - Weld symbols
  - Material specifications
  - Metadata & notes
  - History of engineering change orders
  - Legal/proprietary/export control notices
  - Other definitive digital data

The digital thread allows different acquisition professionals 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.

Manufacturing and Quality Tasks

- Participate in the Systems Engineering process along with other members of the Design Integrated Product Team (IPT).
- Provide inputs into the Acquisition Strategy and SEP.
- 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).
- Assess and monitor adherence to M&Q best practices (e.g., AS6500, AS9100, ISO 9001, etc.) as they impact design processes.
- Identify and assess opportunities to promote advanced manufacturing technologies and techniques
- Provide inputs into the requirements process based on analyses of system requirements and design concepts from TMRR developments and the PDR including:
    - System capabilities and constraints
    - The required M&Q capabilities baseline
    - M&Q cost drivers and impact on schedule and performance
- 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.
- 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

- 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

- Prepare for Production and Deployment and demonstration process, M&Q participants should provide:
  - Inputs that establish, implement, and maintain appropriate processes to manage key and critical subsystems, components, and items including process controls for KCs
  - Criteria and metrics for design and production process verification, test, inspection, product verification and acceptance (including statistical techniques)
  - Monitoring and managing the data from the development process with acceptable frequency, quantity, and metrics
  - Criteria for and monitoring of M&Q development testing for validating design outputs (products)

  - M&Q inputs for design configuration management (including verification, validation, and change control)

- Update the analyses of M&Q design activity impacts and interdependencies to other functional areas or activities (e.g., engineering, producibility, reliability, maintainability, costs, safety, manpower, schedule, etc.).
- Perform assessments of M&Q risks, issues, and opportunities and the associated mitigation activities, based on the changes to and progress of the design, in meeting critical design entrance criteria (e.g., technology, manufacturing, cybersecurity, software development, and sustainment).
- Ensure the product design is stable:
  - The design change process is stable and under control and includes adequate process for identifying and approving Class 1 changes, and the classification of changes is periodically reviewed.
  - Design changes are few and limited to those required for continuous improvement or in reaction to obsolescence.
  - Design change process includes sign-off by contractor manufacturing or production engineer, and quality engineer.
- Ensure the production environment is robust and can be used to validate LRIP manufacturing needs.

Tools

- Acquisition Plan Preparation Guide template
- DCMA Industrial Capability Assessment Survey Form
- Market Research Reporting Template
- 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
- Integrated Master Plan/Integrated Master Schedule template
- Test and Evaluation Master Plan (TEMP) Template
- Life Cycle Sustainment Plan (LCSP) Template
- Interactive MRL Users Guide (Checklist), Design thread

- Manufacturing Maturation Plan
- Technology Readiness Assessment Checklist
- Producibility Assessment Worksheet (PAW)
- Technical Review and Audit Checklist:
  - PCA Checklist
  - TRA Checklist
  - TRR Checklist

Resources

- AS9100, Quality Management Systems – Requirements for Aviation, Space and Defense Organizations
- AS 9103, Variation Management of Key Characteristics
- ISO 9001:2015, Quality Management Program
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896A, Manufacturing Management Program Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- 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
- Digital Engineering Body of Knowledge
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Life Cycle Sustainment Plan (LCSP) memo
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- Defense Manufacturing Management Guide for Program Managers, Chapter 14.6.3.1 Integrated Product and Process Teams (IPPTs)
- DoD Technology Readiness Assessment (TRA) Guide
- Test and Evaluation Management Guide
- Test and Evaluation Master Plan (TEMP) Guide

E.3 Support Technical Reviews and Audits

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

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

A CDR should have been held during EMD, and any items or risk areas that were identified during that review and are still open should be monitored, managed and the risk reduced to an appropriate level and the CDR items closed out as soon as possible. The Post-CDR assessment will include a demonstration that the "maturity of critical manufacturing processes has been accomplished." EMD should end when "manufacturing processes have been effectively demonstrated in a pilot line environment" prior to Milestone C. Most CDR identified risks should have been mitigated by Milestone C, but any risks that are still open and active in the Production and Deployment Phase should be managed using risk reduction techniques.

In addition, an Operational Test Readiness Review (OTRR), Physical Configuration Audit (PCA), and Manufacturing Readiness Assessment (MRA) should be conducted during this phase. M&Q personnel should be actively engaged in these technical reviews and audits as appropriate.

Operational Test Readiness Review (OTRR): The OTRR is a multi-disciplined product and process assessment to ensure that the system can proceed into IOT&E with a high probability of success and that the system is effective and suitable for service introduction. The FRP decision may hinge on this successful determination. The understanding of available system performance in the operational environment to meet the CPD is important to the OTRR. Consequently, it is important that the test addresses and verifies system reliability, maintainability, and supportability performance and determines whether the hazards and ESOH residual risks are manageable within the planned testing operations. The OTRR is complete when the SAE evaluates and determines materiel system readiness for IOT&E. The OTRR risk assessment checklist is designed as a technical review preparation tool and should be used as the primary guide for assessing risk during the review.

DT may be necessary after the FRP decision is made. This testing is normally tailored to verify correction of identified design problems and demonstrate the system modifications readiness for production. This testing is conducted under controlled conditions and provides quantitative and qualitative data. It is conducted on production items delivered from either the pilot or initial production runs. To ensure that the items are produced according to contract specification, limited quantity production sampling processes are used. This testing determines whether the system has successfully transitioned from engineering development prototype to production, and whether it meets design specifications.

Qualification testing is a form of DT that verifies the design and manufacturing process. PQTs are formal contractual tests that confirm the integrity of the system design over the operational and environmental range in the specification. These tests usually use production hardware fabricated to the proposed production design specifications and drawings. Such tests typically include contractual reliability and maintainability (R&M) demonstration tests required before production release. PQT must be completed before FRP.

DCMA typically conducts PQT at the direction of the program office. PQTs may be conducted on LRIP items to ensure the maturity of the manufacturing process, equipment, and procedures. These tests are conducted on each item, or a sample lot taken at random from the first production lot and are repeated if the process or design is changed significantly or a second or alternative source is brought online. These tests are also conducted against contractual design and performance requirements.

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 the CDR, and concerns include:
    - That the system product baseline has been established and documented to enable hardware fabrication to proceed with proper configuration management.
    - Adequate processes and metrics are in place for the program to succeed.
    - All the known risks are understood and manageable for testing in support of developmental and operational evaluation objectives.
    - The program schedule is executable (technical/cost risks).
    - The program is executable with the existing budget and the approved product baseline.
    - The detailed design is producible within the production budget.
    - The updated Cost Analysis Requirements Description (CARD) is consistent with the approved product baseline.

  - The updated cost estimate fits within the existing budget.
  - Key product characteristics that have the most impact on system performance, assembly, cost, and sustainment or safety are identified.
  - The critical manufacturing processes that affect the key characteristics have been identified and their capability to meet design tolerances determined.
  - Process control plans have been developed for critical manufacturing processes.
  - Manufacturing processes have been demonstrated in a production representative environment.
  - Detailed trade studies and system producibility assessments are complete.
  - Materials and tooling are available to meet LRIP/FRP schedule.
  - System production cost models have been updated, allocated to subsystem level, and tracked against targets.
  - Long-lead procurement plans are in place and the supply chain has been validated.
  - All product data essential for component manufacturing has been released.
  - Design change traffic does not impact LRIP.
  - Ensure that major product design features and configuration are stable.

- M&Q personnel should support the development of Operational Test Plans (OTP) and the conduct of Operational Test Readiness, and the following production related activities and concerns:
  - Quality in Design:
    - Leads to a producible and testable product
    - Design efforts lead to effective and efficient manufacturing processes and process controls
    - System design facilitates timely and affordable manufacture, assembly, and delivery of a quality product throughout the supply chain
  - Production Management:
    - Effective use of resources to produce, on schedule, the required number of end items that meet quality, performance, and cost objectives
  - Production Readiness Review:
    - Determine the status of the factory floor prior to executing a production (LRIP) decision
  - Production Qualification Testing:
    - Verify the design and manufacturing processes at the unit, subsystem, and system level are ready for production
  - First Article Testing:
    - Ensure the effectiveness of manufacturing processes, machines, equipment, and processes thru formal testing
  - Transition to Production:
    - Ensure manufacturing processes and controls during the transition period from EMC to LRIP

        - Review field failures to assess the impact to design, quality, producibility, and supportability that may require additional design, development, and testing
- M&Q personnel should support the conduct of the PCA, and the following concerns:
    - Verify all test deficiencies have been resolved
    - Verify that the product baseline is stable and all changes after the PCA have been approved and incorporated
    - Verify that all production-related activities can produce accurately to the design
    - Verify that the software and hardware have an established product baseline
    - Verify that all manufacturing, quality, test & evaluation, training processes are in place
    - Verify that the product baseline information appropriately represents all hardware and software CI
    - Verify that manufacturing procedures, the quality assurance system, the testing and measuring tools, and the training are all properly designed, monitored, and regulated
- 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

- Critical Design Review Checklist and Assessment
- Operational Test Readiness Review (OTRR)
- Physical Configuration Audit (PCA)
- Independent Technical Risk Assessment (ITRA)
- 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.

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

- 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 Assessment

Support the following producibility planning and assessment processes:

- Conduct regular Producibility reviews as the design evolves.
- Ensure that the contractor's detailed producibility trade studies used knowledge of key design characteristics and related manufacturing process capability.
- Ensure that producibility improvements get implemented into system design and specifications.
- Resolve all known producibility issues and ensure that they pose minimum risk for LRIP and no risk for FRP.
- Ensure that contractor producibility enhancement efforts (e.g., DFX) are completed for optimized integrated system.
- Evaluate the contractor's design producibility activities for such factors as:
    - Liberal tolerances (dimensions, mechanical, electrical).
    - Use of materials that provide optimum machinability, formability, and weldability.
    - Shapes and forms designed for castings, stampings, extrusions, etc., provide maximum economy.
    - Inspection and test requirements are the minimum needed to assure desired quality and maximum usage of available and standard inspection equipment.

- Assembly by efficient, economical methods and procedures.
- Minimized requirements for complex or expensive manufacturing tooling or special skills.

- 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 analysis
  - Requirements validation analyses
  - Trade studies on alternative product and process designs
  - Product complexity analysis
  - Safety analyses
  - Manufacturing process analyses
  - Quality and quality process analyses
  - Measurement System Analysis
  - Costs, cost drivers, and controls analysis
  - Materials characterization and availability
  - Prototyping of components, items, subsystems, etc.
  - Learning curve goals and projections
  - Product and process measurements utilizing Statistical Process Control (SPC)
  - Data and database management
  - Testing
- Ongoing Producibility Assessments conducted on current efforts including additional efforts if necessary:
  - At the enterprise level (including infrastructure – software tools, design guides, training, and policies).

- On a product-by-product level (including trade studies, and design principles – reduce part count, use of common parts, ease of assembly, and simplicity of fabrication).
- Producibility issues/risks discovered in LRIP have been mitigated and pose no significant risk for FRP.

Tools

- 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)
- Design of Experiments (DOE)
- Preliminary Hazards List
- Pugh Matrix
- Technology Readiness Assessment Checklist
- Six Sigma and Lean Techniques

Resources

- 10 USC 144B, Sec 2366 and 2448
- DoD Producibility/Manufacturability Guide (Draft)
- NAVSO P-3687 Producibility Systems Guidelines
- NAVSO P-6071, Best Practices for Transitioning from Development to Production
- Producibility Engineering Standard Practice Manual, U.S. Army Belvoir R&D Center
- DoD Manual 4245.7-M, Transition from Development to Production
- MIL-HDBK-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, Chapter 6.2.2 Key Characteristics
- 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
- AS9102 First Article Inspection Requirements
- ISO 9001:2015, Quality Management Program
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- AIAG Measurement Systems Analysis (MSA) Manual
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1629A Failure Modes Effect and Critical Analysis
- SAE J1739, 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 where 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.
- The design is stable:
  - Number of design changes
  - Design released to production
- Assess the organizations approach to systems engineering and the use of best practices to manage design and manufacturing considerations.
- Ensure all product level M&Q design requirements are defined and validated to be consistent with the specifications.
- Ensure all M&Q inputs to the product design support meeting the program requirements:
  - Verify M&Q requirements meet program cost, schedule, and performance requirements
  - Verify M&Q requirements are met at the subsystem, item, and component levels
- 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 Level 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 and Manage 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)

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

The Work Breakdown Structure (WBS) is a government approved framework that includes all program elements for which the contractor is responsible and for which they must report. The WBS is defined, developed, and maintained throughout the system life cycle based on a disciplined application of the systems engineering process. The goal is to develop a WBS that defines the logical relationship among all program elements to a specific level (typically Level 3 or 4) of indenture that does not constrain the contractor's ability to define or manage the program and resources.

Product design should have been stable by the time the CDR was conducted; however, detailed design often continues well into the P&D phase. The Physical Configuration Audit (PCA) is a formal examination of the "as-built" configuration of the system or a configuration item against its technical documentation to establish or verify its product baseline. A successful PCA provides the Milestone Decision Authority with evidence that the design is stable. At the conclusion of the PCA, the final product baseline is established, and all subsequent changes are processed by a formal engineering change action and under the control of configuration management practices.

The Milestone C review should provide the status of manufacturing process assessments and highlight the steps needed to progress from an EMD manufacturing environment to an LRIP environment. Then after the Milestone C decision to go into Low-Rate Initial Production, the program office needs to assess the LRIP process to demonstrate that manufacturing and QA processes are effective.

LRIP quantities are produced to provide production representative test articles for operational test and evaluation (OT&E) and to establish an initial production base for the system and provide efficient ramp up to FRP, and to maintain continuity in production pending completion of operational testing. The LRIP environment builds on M&Q experience gained on the pilot line prior to the Milestone C decision. The LRIP build provides M&Q managers the opportunity to prove or demonstrate the production capability and assess manufacturing readiness at the LRIP production rate and to plan for the progression to FRP.

LRIP describes the initial production effort needed to reduce the government's exposure in transitioning to FRP. It usually begins at the end of the EMD phase and often transitions from a pilot line to an LRIP then FRP production capability.

The FRP environment builds on M&Q experience gained during LRIP and provides M&Q managers the opportunity to prove or demonstrate the production capability and manufacturing readiness at the FRP production rate and to plan for eventual shutdown and Demil/Disposal. Manufacturing assessments could include a follow-on Production Readiness Review, a Manufacturing Readiness Assessment, or other manufacturing/ quality assessment as deemed appropriate for the program and risks. FRP is the highest level of production readiness.

For the FRP Decision Review update, the program should identify remaining risks prior to a production go-ahead decision. Then after the FRP decision, the program office needs to assess production processes to demonstrate that manufacturing and QA processes are effective in achieving FRP. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, PRRs, MRAs, ICAs, trade-off studies, tooling plans, make-or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or manage remaining risks.

Manufacturing and Quality Tasks

- Continue design maturity assessments. Ensure that all:
    - Product data required for pilot-line component manufacturing completed
    - Pilot-line product requirements and features have been defined
    - Product data essential for subsystem/system pilot line has been released
    - All enabling/critical components have been demonstrated on the pilot line
    - Design maturity metrics have been applied to the planned Production Line
- Support the development of the Program and Contract WBS to ensure planning, execution and control of the production phase activities are compatible with the existing manufacturing and performance measurement systems:
    - Ensure that the Program WBS is accurate down to at least three levels and includes manufacturing and quality considerations.
    - Ensure the contractor identifies the Contract WBS down to at least three levels and that production phase costs and schedule can be related to the development WBS, tracked and managed.
- Support the development of the detailed product design.
- Ensure detailed design drawings, bills of material and product and process specifications are completed by release of design to manufacturing.
- Participate in design reviews to ensure that the contractor is complying with the design requirements and meeting the cost/design goals.
- Ensure the final design definition is the result of the performance requirements, the outcomes of the testing accomplished, producibility studies and other design influences.
- Ensure that the design is specified to a low level of detail so that the required production phase processes and resources can be identified and obtained.
- Demonstrate design producibility improvements in LRIP and in FRP.
- Assess the contractors' use of best practices to manage design and manufacturing considerations.
- Assess the contractors' manufacturing capability and capacity to produce an item and ensure that the assessment covers:
    - All required manufacturing processes and techniques
    - All design producibility risks
    - Manufacturing capability and capacity has a high probability of meeting delivery dates including spares and in-line repair work
    - Manufacturing capability and capacity provides for minimal impact of critical and long-lead time material

- Manufacturing capability and capacity ensures all production equipment will be available
- Manufacturing capability and capacity provides accurate production unit cost goals
- Capability and capacity include cost and production schedule estimates updated with actuals to support management reviews
- All alternatives have adequate manufacturing feasibility and cost and schedule impact analyses that support trade-offs
- Capability and capacity include recommendations for anticipated production testing and demonstration efforts
- Prior producibility improvements analyzed for effectiveness during LRIP

- Product design and features should be assessed during the CDR to support a production decision:
    - Verify that design change traffic should be minimal
    - Verify that 80% of the drawing packages have been released to production
- Verify the detailed design of all product features and interfaces is completed:
    - All product data essential for product manufacturing has been released
- Evaluate the final material selection for completeness and for producibility.
- Evaluate the product specifications/build-to packages to ensure that they are matured to the same level as the design.
- Verify that the LRIP Build-to Packages are complete.
- Verify that the FRP Build-to Packages are complete.
- Verify that the system design has been validated through operational testing of LRIP items.
- Verify that the design change traffic is now limited to Class II ECPs.
- Verify that the design efforts achieved effective and efficient manufacturing processes with the necessary process controls to satisfy requirements and minimize manufacturing costs.
- Verify that the design of the system facilitates the timely and affordable manufacture, assembly, and delivery of a quality product to the customer.
- Assess LRIP to ensure that:
    - New technologies are mature and ready to transition into production units
    - The detailed system design is complete with few engineering changes, and none that impact form, fit or function
    - All manufacturing processes are capable and under statistical control, and there are no producibility risks
    - A complete definition of the fabrication and assembly tasks and they are transferred to the general factory workforce
    - Detailed work instructions exist and a controlled system for changes to the documents used in the factory, such as drawings and process specifications
    - Required production planning documentation are based on a stable design, quantity requirements and delivery schedule

  - Engineering changes are controlled to minimize disruption to production documentation and planned manufacturing schedules
  - QMS is operating effectively to produce quality systems
  - Participate in the PCA and examine the actual configuration of an item being produced and confirm that the manufacturing processes, QMS, measurement and test equipment, and training are adequately planned, tracked, and controlled and that the related design documentation matches the item as specified in the contract

- Ensure affordable and executable manufacturing process have been developed and demonstrated/proven.
- Demonstrate that the maturity of critical manufacturing processes has been accomplished.
- Support the conduct of Technology Readiness Assessments, as necessary.
- Ensure all manufacturing processes have been effectively demonstrated during LRIP.
- Manufacturing personnel must ensure that:
  - Engineering/design changes are few and limited to quality and cost improvements
  - System, components, or items are in FRP and meet all engineering, performance, and quality requirements
  - Manufacturing process capability is at the appropriate quality level
  - All materials, tooling, inspection and test equipment, facilities and manpower are in place and have met FRP requirements
  - Rate production unit costs meet goals, and funding is enough for production at required rates
  - Lean practices are well established, and continuous process improvements are ongoing
  - There are no significant manufacturing risks
  - Manufacturing processes should be under statistical control if quantities warrant
- Identify remaining risks prior to FRP production go-ahead decision. Key considerations should include:
  - Industrial base viability
  - Design stability
  - Process maturity
  - Supply chain management
  - Quality management
  - Facilities and manufacturing skills availability
  - Mitigation plans from the FRP MRA
- Review and assess the following sources of data to include:
  - Technical reviews and audits
  - Program Status Reviews
  - Pre-award surveys
  - Production Readiness Reviews
  - Industrial Capabilities Assessments

  - Trade-off studies
  - Tooling plans
  - Make-or-buy plans
  - Manufacturing plans
  - Bills of material

- Assess if a follow-on, tailored, PRR may be appropriate in the Production and Deployment phase for the prime contractor and major subcontractors if:
  - Changes from the EMD phase and during the production stage of the design, in either materials or manufacturing processes, occur
  - Production start-up or re-start occurs after a significant shutdown period
  - Production start-up with a new contractor, or
  - Relocation of a manufacturing site

Tools

- Integrated Master Plan/Integrated Master Schedule assessment
- 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 for Manufacturing and Assembly (DFMA) Assessment
- AIAG Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP) Checklist
- Failure Mode and Effects Analysis (FMEA)
- Design Failure Modes and Effects Analysis (DFMEA) Assessment
- Process Failure Modes and Effects Analysis (PFMEA) Assessment
- Design for Six Sigma Assessment
- Design of Experiments Assessment
- Work Breakdown Standard review
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Critical to Quality Tree
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- Technology Readiness Assessment Checklist
- Fault Tree Analysis (FTA)

- Production Readiness Review (PRR) checklist
- Production Verification Test
- Tolerance Design

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook, Sample Format 4.5 Technical Maturity
- DoD Systems Engineering Plan Preparation Guide
- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- AIAG Production Part Approval Process (PPAP) Manual
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- ISO 9001, Quality Management System
- 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
- DoD MIL-STD 882E, System Safety
- Capability Maturity Model Integration (CMMI)
- Manufacturing Readiness Level (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 System Guidelines, Dept. of the Navy
- 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/FUNDING

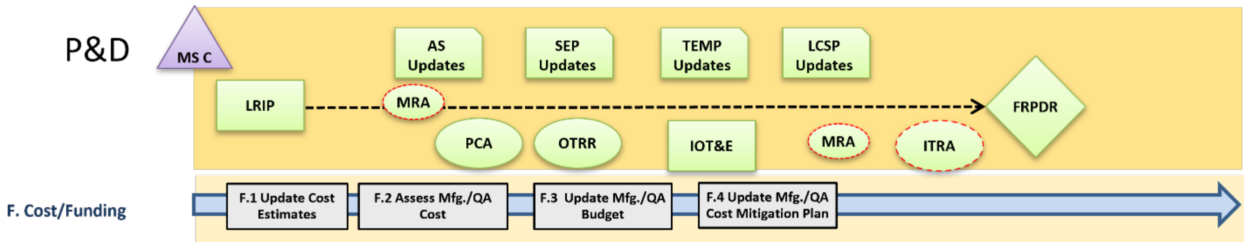


Figure 5-7. Cost and Funding Manufacturing and Quality Activities

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 Estimates

The Department of Defense (DoD) must spend the DoD budget on the right things, in the right amounts, at the right time. DoD cost analysts play a critical role in this by producing cost estimates that support the planning, programming, budgeting, acquisition, and requirements generation processes. There are numerous laws and regulations that direct the development of cost estimates that support the acquisition process. The Director of CAPE (DCAPE) has prescribed policies and procedures for the conduct of cost estimation and cost analysis, to include Independent Cost Estimates (ICEs), Analysis of Alternatives (AoA), multiyear procurements (MYP), data collection, etc.

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

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

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

- **Independent Cost Estimate (ICE):** A life-cycle cost estimate is statutorily required for all MDAPs during acquisition and sustainment decision reviews and other significant out-of-cycle reviews such as Critical Nunn-McCurdy breaches. This cost estimate is conducted independently of the Program Office or defense agency by an outside organization.
    - 10 USC 2334 Independent Cost Estimation and Cost Analysis
    - DoDI 5000.73 Cost Analysis Guidance Procedures
- **DoD Component Cost Estimate (CCE):** A life-cycle cost estimate developed by one of the Components typically developed by the Component Cost Agency but may be delegated to the Program Office. Required at MS A, B, C, and the FRP decision.
    - CAPE Operating and Support Cost Estimate
    - DoDI 5000.73 Cost Analysis Guidance Procedures
- **Program Office Estimate (POE):** A life-cycle cost estimate developed by the program office and used as a baseline for all subsequent tracking and auditing purposes throughout the life of the program. A program updates its POE as required to capture actual incurred costs to date and refined estimating methods. The program manager uses the POE to support high-level decisions (DoD Component Cost Estimate).
    - DoDI 5000.02 Operation of the Defense Acquisition System (requires a POE in support of program initiation).
    - DoD Operating and Support Cost Estimating Guide
    - DoDI 5000.73 Cost Analysis Guidance Procedures
- **DoD Component Cost Position (CCP):** The CCP is the outcome of the reconciliation between the CCE and the POE (above), except for the DON. It serves as the program official cost position from that Component. For the DON, the POE serves as its official cost position, in the absence of a CCP. The DoD is expected to fully fund a program to its cost position under DoD's Full Funding Policy.
- **Cost Capability Analysis (CCA):** An estimate typically developed by the program office to support the program manager in the delivery of cost-effective solutions through deliberate trade-off analysis between operational capability and affordability based on requirements. The CCA uses Multi-Objective Decision Analysis (MODA) to study the trade space between cost and warfighter capability.
    - AFLCMC Standard Process for Cost Capability Analysis
- **Independent Government Cost Estimate (IGCE):** Pertains mostly to services acquisitions, specifically contracts, as mentioned in DoDI 5000.74. It provides a government developed cost

estimate for an individual contract. The analyst conducts an IGCE to check the reasonableness of a contractor's cost proposal and to make sure that the offered prices are within the budget range for a particular program.
  - AFARS 5107.90 Independent Cost Estimates
  - DoD Independent Government Cost Estimate (IGCE) Handbook for Services Acquisition
- **Should Cost Estimate (SCE):** The objective is to proactively target cost reduction through process and productivity improvements. The FAR definition of "should cost" relates to developing a negotiating position for production contracts. The focus is on identifying inefficiencies in contractor production processes and overhead to find areas that could be streamlined or changed to save costs.
  - DFARS 215.407-4 Should-cost review

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.

The underlying objective of Design to Cost (DTC) is to identify cost drivers early in the system life cycle so trade-off decisions can be considered and ways to mitigate those costs identified. The program accomplishes this by making cost a design constraint with design options fixed to a cost limit.

Cost as an Independent Variable (CAIV) refocused DTC to consider cost objectives for the total life cycle of the program and to view CAIV with the understanding it may be necessary to trade-off performance to stay within cost objectives and constraints.

Manufacturing and quality personnel are still concerned in the Production and Deployment Phase with controlling cost, and as the design matures the ability to manage those costs matures. A new design can also be introduced because of Pre-Planned Product Improvements (P3I) and Value Engineering Change Proposals (VECPs).

Manufacturing cost estimates for the production phase are normally based on the assumption that the design is complete, that the manufacturing processes are stable and well known, and manufacturing operations will be accomplished as planned. Any deviation from these assumptions could cause a growth in cost. As such, time and conformance measures can give some indication of potential or real cost aberrations since there is normally a direct correlation between late delivery or conformance problems and cost. Historically the major cost drivers for manufacturing were direct labor and direct materials. But in today's modern industrial environment overhead to include manufacturing overhead has become the bigger cost driver. These changes make assessing manufacturing costs much more complex. In addition, the following measures may also indicate the existence of cost problems:

- Machine set-up and tear-down
- Machine maintenance
- Production attainment
- Manufacturing cycle time
- Percentage of out-of-station work
- Scrap and rework rates
- Yield rates on manufacturing operations
- Supplier quality problems
- Engineering change volume

The cost to manufacture a weapon system or equipment results from a combination of the design, the physical facility, and the five Ms (manpower, materials, methods, measurements, and machines) used to build the design and the management efficiency of the operation. As such, the manufacturing cost for a product should be viewed within the context of the factory in which the product will be built. Three significant cost factors that need to be identified to support the estimating activity, and these are rate, quantity, and efficiency.

Production cost and production cost estimates change over time. In the early acquisition phases, cost estimating is based on analogy. At this point, the estimate is not perfectly accurate as the basis of the estimate may only resemble the final product, and much may change as the new system is developed thus driving changes in the cost model. Then as the program matures and moves through the acquisition life cycle, more is learned about the final product to the point estimating may move from analogy to parametric cost estimating. Again, as the program matures and more is known about the system as it transitions from development toward production, the cost estimating methodology moves toward engineering estimates. The final and most accurate cost estimating technique is the use of actuals. The actual cost estimating method uses the actual cost of the previous production lot adjusted for inflation, labor saving, material cost, technology changes and other factors.

The problems with all cost models are that they are not perfectly accurate, and often we find programs overrunning costs for various reasons. An actual cost is calculated based on costs actually incurred and recorded in accomplishing the work performed within a given time period, as distinguished from forecasted or estimated costs, and when costs are overrun, the program may need to develop cost mitigation and maturation plans.

Manufacturing and Quality Tasks

- Support the development of various cost models and estimates:
    - 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
- 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.
- Update the initial manufacturing cost estimate to reflect the final definition of the system design and the completed manufacturing approach.
- Update material cost drivers based on:
    - Design requirements
    - Material specifications and tolerances
    - Material specification is stable
    - Bill of Materials
    - Make/Buy decisions
    - Projected rates/quantities (lot buys)
    - Price stability
    - Supply Chain stability
    - Material maturities demonstrated on pilot-line build and LRIP
    - Materials proven and validated during EMD as adequate to support LRIP/FRP
- Support fact finding and negotiations by collecting and analyzing cost and efficiency data from LRIP and earlier Production lots, development and application of learning curves, and development and defense of negotiation positions.
- Base manufacturing cost estimates on the application of detailed manufacturing standards to the operations to be performed and adjusted, as necessary, by realization factors and/or learning curves to develop the time phased manufacturing cost.
- Consider including a contract requirement for Work Measurement in the LRIP/FRP phase contract if the contractor does not have a system for development and application of labor standards.

- Update the FRP cost model based on the results of the LRIP build.
- Provide significant inputs into the development and management of an appropriate learning curve for the program.
- Establish the learning curve based on appropriate factors such as:
    - Worker learning
    - Supervisor learning
    - Reductions in crowded workstations
    - Tooling improvements
    - Design producibility improvements
    - Improved work methods
    - Improved planning and scheduling
    - Increased lot sizes
    - Reduced engineering change activity
    - Reduction in scrap and rework
    - Better operation sequencing and synchronizations
- Ensure that the cost estimate includes the following:
    - Cost estimate includes all life cycle costs
    - The technical baseline description completely defines the program, reflects the current schedule, and is technically reasonable
    - The cost estimate WBS is product-oriented, traceable to the statement of work, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double counted
    - The estimate documents all cost-influencing ground rules and assumptions and was used as inputs to any sensitivity analysis
    - Cost documentation shows the source data used, the reliability of the data, and the estimating methodology used to derive each element's cost
    - Cost documentation describes how the estimate was developed so that a cost analyst unfamiliar with the program could understand what was done and replicate it
    - Cost documentation discusses the technical baseline description and the data in the technical baseline are consistent with the cost estimate
    - The cost model was developed by estimating each WBS element using the best methodology from the data collected. Note: Each WBS could have a different estimating methodology
    - Variances between planned and actual costs are monitored, documented, explained, and reviewed on a regular basis
    - Cost risk and uncertainty analysis was conducted that quantifies risks and identifies the effects of changing key cost driver assumptions and factors.

- M&Q personnel should support the analysis of design changes, and program progress, analyze and update M&Q cost drivers derived from manufacturing, quality, materials, and/or unique requirements, and associated risks, issues, and opportunities for the CDR to include:
  - Identified subsystems, parts, items, and components
  - Sourcing risks from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
  - Should-cost and will-cost analyses
  - Required trade studies and engineering change requests
  - Updates to predicted life cycle estimates and their associated models
  - Interdependencies
  - Uncertainties from quantification of cost drivers
- Analyze and update M&Q materials cost drivers for the CDR based on manufacturing, quality, and unique and/or specialized requirements, specifications, and tolerances, and associated risks and issues to include:
  - Contractor plans for materials, materials processes, rates, and quantities (including lot buys),
  - Risk mitigation processes (ongoing, identification, reduction, etc.)
  - Supplier Chain (e.g., capability, capacity, quality, etc.)
  - Special handling and training
  - Environmental compliance and training,
  - Materials security (physical, cyber, industrial, etc.)
  - Planned subsystems, parts, items, and components (supply chain commodities) to include alternative sources
  - Planned rates and quantities for pilot line and LRIP
  - Updated "should-cost" analyses and actuals
  - Updated materials cost driver uncertainties (based on actuals)
  - Cost drivers' updates impacted by conservation critical and strategic materials
  - Cost drivers for mitigation of supply disruptions
  - Updated estimates for the cost of quality
  - Updated estimates for the cost of materials testing
- Establish the expected cost of the first items using previous cost models and actuals.
- Establish how much cost reduction is possible using expected schedule, production amounts, and process time using the learning curve formula.
- Apply the curve against the program schedule and determine the expected cost reductions.
- Manage cost reductions from the learning curve.

Tools

- Interactive MRL Users Guide (Checklist), the Cost thread
- Cost Analysis Requirements Description (CARD) template (*See* CAPE website)

- 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
- Earned Value Management (EVM)
- Cost/Schedule Control System Criteria (see EVM)
- Funds Management Platinum Card
- Analogy and Parametric Estimating Techniques
- Manufacturing Cost Estimating Spreadsheet
- *See* CAPE website for tools http://www.cape.osd.mil/

Resources

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

- DoDI 5000.97, Digital Engineering
- DODD 5105.84 Director of Cost Assessment and Program Evaluation (CAPE)
- 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 Manufacturing Cost Estimating
- Cost/Schedule Control Systems Criteria Reference Guide
- Guidelines for the Preparation and Maintenance of CARD Tables
- MIL-HDBK-896, Manufacturing Management Program
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-766 Design to Cost
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Should-Cost and Affordability Memo

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 5-2. 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.

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

During the Production and Deployment phase, most manufacturing costs should be based on actual cost data provided by the contractor. Cost drivers could be high-cost items, or items that have high manufacturing costs due to several factors (long processing times, low yield rates, etc.). These cost drivers need to be updated.

Manufacturing and Quality Tasks

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 that 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
- Manufacturing cost drivers should be identified and updated on a regular basis based on actual cost performance.
- Manufacturing costs should be rolled up to system/subsystem level and tracked against targets.
- Detailed trade studies and engineering change requests should be supported by cost estimates.
- 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.
- Cost reduction and avoidance strategies should be developed and implemented.
- LRIP costs estimates should be analyzed using pilot-line actuals and updated into manufacturing cost estimates to ensure target costs are achievable.
- Manufacturing cost analysis should be conducted when there are proposed changes to requirements or configuration.
- All cost models should be updated based on the results of pilot line build.
- All cost models should be updated based on the results of LRIP build.
- LRIP cost should be monitored to ensure they meet program goals, and the learning curve should be analyzed based on actual data.

Tools

- Cost Analysis Requirements Description (CARD) template
- DoD Program Office Estimate Template
- Acquisition Requirements Roadmap Tool (ARRT) Cost Estimating Worksheet
- Cost Analysis Requirements Description (CARD) Template
- Earned Value Management System (EVM) Cost Report
- Cost/Schedule Control System Criteria

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

Resources

- 10 USC Section 2334 Independent Cost Estimation and Cost Analysis
- 10 USC 2337a Assessment, Management, and Control of Operating and Support Cost for Major Weapon Systems
- 10 USC 2336a, b and c MDAP Submissions to Congress for Milestone A, B and C
- 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
- 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
- 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
- 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 requests and obtain resources to execute the mission. The budget process involves budget formulation and budget execution.

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

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

Budget estimates should be developed to take the program from EMD (pilot line) to low-rate production, and this budget needs to be updated to take the program through LRIP to FRP and beyond.

Manufacturing and Quality Tasks

- Support the development and management of M&Q Budgets.
- Support the development of a Program budget/estimate:
  - Manufacturing budget (direct materials and labor, indirect materials and labor)
  - Quality budget
  - Investments/Special projects budget (ManTech)
- Estimate investments required for materiel solution approach:
  - Capital equipment (tooling, machines, structures, etc.)
  - Tooling and test equipment (specialized, environmental, etc.)
  - Inspection equipment and capabilities
  - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
  - Government-furnished equipment (GFE)
- Identify the cost estimating methodology (Analogy, Parametric, Engineering, Actual, Activity-based, etc. used for budget estimates.
- Identify cost drivers:
  - Materials (new, long lead, critical, hazardous, shelf-life, utilization, etc.)
  - Processes or methods (new or untested, expensive, limited, secondary processing, etc.)
  - Manpower (labor skills, training, certifications, availability, utilization, etc.)
  - Machines (utilization, down time, cycle times, set-up times, overall equipment effectiveness rate, etc.)
  - Transportation, inventory, motion, waiting
- 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 are enough to support production at the required rates and schedule.

Tools

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

Resources

- DoD Cost Estimating Guide
  - Department of the Army Cost Analysis Manual
  - AFI 65-508 Cost Analysis Guidance and Procedures
  - DON Cost Estimating Guide
    Missile Defense Agency Cost Estimating and Analysis Handbook
- 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
- DoD Cost Estimating Guide
- O&S Cost Management Guide
- 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
- DoD Technology Readiness Assessment Guide
- 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 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 mitigation 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.

It is often difficult to distinguish initiatives that are "over and above" the historical learning curves that were already used to estimate the program costs. Historical learning curves usually include some amount of cost reduction initiatives, so the challenge in documenting and estimating the impacts of new cost reduction initiatives is to determine if they are truly over and above what has been done in the past. Initiatives that reduce the scope of work can be considered over and above, but ones that improve the efficiency of the work must be more carefully evaluated.

Manufacturing and Quality Tasks

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 original cost estimate and compare that 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
- Develop and update Manufacturing cost models regularly to include:
  - The collection of actual cost data during fact finding.
  - Analysis of contractor cost and pricing data.
  - The ability to develop and defend cost estimates for future production lots.
  - The ability to be used in design trades to assess the cost impacts of specific design changes, alternative production processes or process improvements.
  - The ability to incorporate the current, actual manufacturing costs into the production cost estimate.
  - The ability to support Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs.)

- Develop Manufacturing Maturation Plans for any areas assessed that do not comply with the appropriate manufacturing readiness criteria.
- Analyze touch labor efficiency to ensure the contractor can meet production rates and elements of inefficiency identified with plans for reduction.

Tools

- Cost Analysis Requirements Description (CARD) (*See* CAPE website)
- 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), Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan (no template available)
- Technology Readiness Level (TRL) Assessment Checklist
- Parametric, Engineering and Actual estimating

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
- 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 5000.80 Operation of the Middle Tier of Acquisition (MTA)
- DoDI 5000.81 Urgent Capability Acquisition
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- 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
- Public Law 114-328, §807, Cost, Schedule, and performance of major defense acquisition programs

G. MATERIALS MANAGEMENT

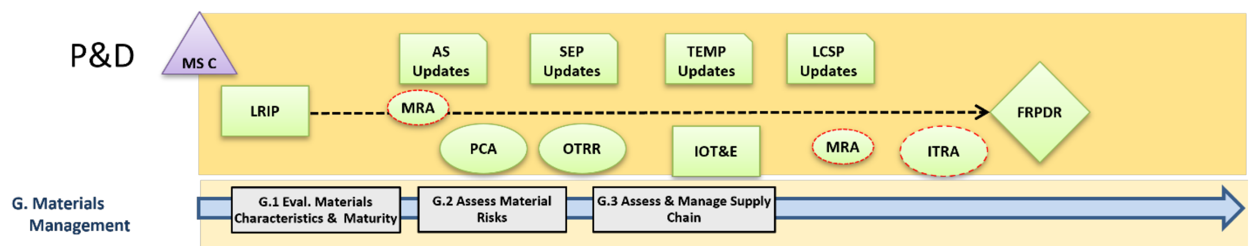


Figure 5-8. Materials Management Manufacturing and Quality Activities

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.

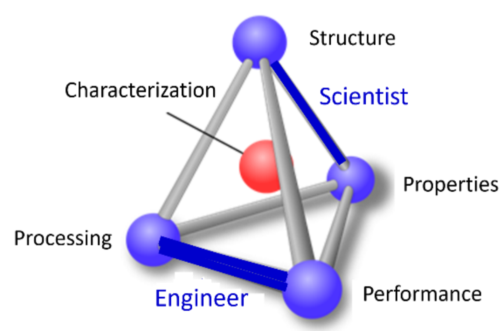
Material Management begins with customer requirements (demand signal), and this information flows throughout the supply chain, from the prime contractor, down many tiers, from raw materials, to fabrication, assembly, test, quality control, distribution and to the customer. The assessment of material 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 experiments for validation and assessment for basic manufacturability.

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

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

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

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)
- 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 have been known to be risks and issues that can slow or delay a program, add additional costs to a program, or create field failures because of poor material reliability. Material risks could include:

- 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.

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

- No action (assume the risk)
- Finding foreign sources of supply
- Finding alternative or substitute parts
- Making a Lifetime buy to meet all planned future needs
- Maintaining a current capability
- Developing a new technology
- Smart shutdown

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

- Vat photopolymerization

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

As programs ramp up production from the pilot line to low-rate, and then FRP M&Q managers are forced to deal with issues and concerns relating to scaling up. Often companies can prove that they have the capability to build one, but can they scale up to 100 a year, a month, a week, or an hour? The entire factory floor including the 5Ms (manpower, machines, materials, methods, and measurement) must be capable of responding adequately to the requirements imposed by scaling up.

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

Manufacturing and Quality Tasks

- Assess materials maturity and availability M&Q risks that are:
    - New or emerging 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

- Identify material availability risks and minimize through mitigations.
- Assess material availability risks to meet LRIP.
- Assess material availability risks to meet FRP.
- Identify, manage, and mitigate lead procurement risk.
- Assess and initiate long-lead procurement LRIP/FRP.
- Develop and put into place an effective supply chain management process.
- Assessment of critical first tier supply chain must be completed.
- Assessment of critical second and lower tier supply chain must be conducted.
- Assess the supply chain to ensure it is adequate to support LRIP/FRP.
- Identify and manage sole source/single source items.
- Assess make/buy decisions.
- Analyze make/buy decisions for all key or critical components.
- Analyze make/buy decisions for capability of selected manufacturers, whether in factory or at vendor facility, to meet quality requirements, schedule, and cost targets.
- Develop an obsolescent plan.
- Ensure DMSMS and parts obsolescence risks are managed and mitigated.
- Ensure that counterfeit material is not finding its way into the product.
- Manage all part shortage issues to minimize impact on production line.
- 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

- Develop special handling procedures and incorporate them into the production line instructions:
  - Verify that special handling procedures have been integrated into the work instructions.
  - Verify special handling procedures have been demonstrated in the LRIP and FRP environments.
- Verify that special handling poses no significant risk for LRIP/FRP. Characterize all new materials in a factory environment.
- Account for and manage all GFE, GFP, government-furnished facilities (GFF), and government-furnished materials (GFM).
- Prove and validate materials as adequate to support FRP.
- Identify any manufacturing processes and techniques that are not currently available.
- Identify any design producibility risks.
- Identify probability of meeting delivery dates.
- Identify the potential impact of critical and long-lead time material.
- Identify any production equipment availability issues.
- Verify that all production unit cost goals are realistic.
- Verify that all cost and production schedule estimates support management reviews.
- Verify that all manufacturing feasibility and cost and schedule impact analyses that support trade-offs among alternatives.
- Verify all recommendations for anticipated production testing and demonstration efforts.
- Validate all methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials.
- Verify that all manufacturing processes and techniques are currently available and used on pilot line.
- Verify that there are no design producibility risks.
- Verify that there are no production manpower constraints.
- Verify that there are no capacity constraints.
- Verify that there is a high probability of meeting delivery dates.
- Verify that the potential impact of critical and long-lead time material is minimal.
- Verify that there are no production equipment availability issues.
- Verify production unit cost goal realism on the pilot line.
- Verify that cost and production schedule estimates support management estimates.
- Conduct manufacturing feasibility studies and analyze cost and schedule impact to support all trade-offs among alternatives.
- Verify that the supply chain is stable and adequate to support FRP.
- Verify that recommendations for anticipated production testing and demonstration efforts have been implemented.

Tools

- DCMA Material Management and Accounting System Audit
- Bill of Materials
- Make/Buy Decision Tools
- Lead Time Estimator
- DMSMS Product Life Cycle Assessment (Consult Defense Logistics Agency (DLA))
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), Materials thread
- ISO 14001 Gap Analysis Toolkit
- Manufacturing Maturation Plan
- Market Research Reporting Template
- PESHE Assessment/Template
- Producibility Assessment Worksheet
- Supply Chain Management Risk Assessment Checklist
- TRL Assessment Questionnaire

Resources

- AS5553, Counterfeit Electronics Parts
- AS6500, Manufacturing Management Systems
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- AS9103, Variation Management of Key Characteristics
- AS9133, Qualification Procedure for Aerospace Standard Parts
- DFARS 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 SD-5
- ESOH in Acquisition Guide
- DoD 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD 4140.01-R, Supply Chain Materiel Management
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- ISO 14001 Environmental Management Systems
- SD-19, Parts Management Guide
- SD-22, DMSMS Guidebook
- Supply Chain Operations Reference (SCOR) Model
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687
- DoD Technology Readiness Assessment Guidance

G.3. Assess and Manage Supply Chain

The complexity of the DoD supply chain for a weapon system is staggering with a supply chain that often encompasses hundreds of vendors and subcontractors. Adding to the complexity is the fact that on many large weapon system programs the prime contractor is often the integrator, with (60-80%) of the program's components and subsystems coming from subcontractor, government, and other vendors or suppliers. This makes Supply Chain Management (SCM) a pivotal task.

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

- SCM Management
  - Strategy, Vision, and Objectives
  - Performance Metrics
    - Perfect Order Fulfillment, SCM Cost, Supplier Quality, on-time delivery, etc.
  - Forecasting and Demand Management
  - Supply Chain Development
  - Continuous Improvement
- Supplier Selection and Make/Buy criteria and decisions
  - Lead Times

  - Critical sources of supply
  - Alternate sources
  - Visibility (especially below the 1st tier) and communication
  - Velocity (customer wait time, cycle times

Supply Chain 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.

The GAO has consistently rated Supply Chain Management (SCM) as a “high-risk” area for DoD acquisition programs. Therefore, M&Q personnel need to be active in helping to identify and manage supply chain risks. SCM risks can include the following:

- Material Cost and Cost Drivers
- Scale up (Pilot Line, to LRIP, to FRP)
- Supply Chain Management (SCM)
- Lead Times (especially long lead items)
- Sourcing Issues:
  - Sole Source/Single Source
  - Foreign Source
  - Critical Sources
  - Alternate Sources

The contractor may go out to their suppliers and ask for lead times or delivery dates, but how accurate are those dates? What happens when there is a disruption in the supply chain caused by weather, political unrest, change in suppliers, etc.? Forecasting and lead time assessment gets harder to do the further out the delivery date is. Furthermore, there is always a balance between the cost of holding an item and the cost of ordering. If too much is ordered or it comes in early, it could cause additional cost and risks. The same holds true if too little is ordered, or it comes in late.

Meeting program schedules is often dependent on lead times within the supply chain. Long lead items require long lead buys. These long lead buys could include special tooling, special test equipment and special inspection equipment. The program office should maintain continuing visibility of the status of their supply chain and the forecast changes in lead times.

The impact of lead time variations on a program can be minimized but requires management attention. Tools like JIT, Supplier Partnerships, Lean, Six Sigma and Theory of Constraints can be used to minimize the cycle time.

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 may be four sources of supply and the next day one or none. Diminishing Manufacturing Sources and Obsolescence is a real problem on DoD programs, including programs that are pushing the state of the art but have components that are aging. One way to mitigate those risks and to increase competition (reduce cost) is to identify and develop alternative sources of supply. This is not a quick or a cheap fix as the new supplier will need to go through a qualification program and prove that it has the capability to produce one, the capacity to produce all that are needed and the financial stability to be able to perform for the entire contract period of performance.

Manufacturing and Quality Tasks

- Support a review of the contractors Supply Chain Management (SCM) program for:
    - Strategic partnerships with vendors and suppliers
    - Stronger collaboration of information (especially forecasting data)
    - Reducing lead times on the critical path
    - Reducing variability

  - Supply Chain Planning
  - Demand Planning
  - Vendor Managed Inventory
  - Supplier Management
  - Procurement
  - Strategic Sourcing
  - Warehouse Management
  - Transportation Management
  - Order Fulfillment
  - Contract Management

- Review contractor's procurement system to ensure procurement packages are complete and accurate.
- Review contractor's parts management program including:
  - Management of distinct part numbers
  - Reduction in the number of distinct part numbers
- Review contractor's supplier qualification process to make sure it adequately ensures supplier's processes are capable on critical parts.
- Review contractor's supplier audit process to make sure it adequately ensures quality on critical parts.
- Participate in supplier audits and encourage other relevant organizations to participate (DCMA, etc.) to determine effectiveness of supplier qualification and auditing of supplier quality.
- Identify potential long-lead items or issues.
- Analyze lead time fluctuations for schedule impacts.
- Ensure government funding is aligned with contractor long-lead requirements.
- Verify long-lead procurement has been initiated for LRIP.
- Verify long-lead procurement initiated for FRP.
- Verify procurement packages are complete and accurate.
- Perform material availability risk assessment.
- Develop long-lead material agreements, processes, and/or contracts.
- Verify that long-term agreements are in place where practical
- Review contractor's Bill of Materials to identify risks and potential requirements for alternative sources of supply.
- Review contractor's Parts Management Program to assess risks of not having parts when needed for production.
- 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
- Identify supply chain supplier risks.
- Develop mitigation strategies for quality and manufacturing-related supply chain counterfeit and anti-tamper and related exportability risks.
- Update Critical Suppliers List.
- Identify single/sole/foreign sources of supply.
- Identify DMSMS and Obsolescence risks and plans for mitigation.
- Review contractor's use of the Government and Industry Data Exchange Program (GIDEP) database for configuration items that are susceptible to DMSMS issues.
- Identify potential alternative sources of supply.
- Identify and develop Qualification Plans for alternative sources of supply.
- Review contractor's DMSMS recommendations for the program risk management plan.
- Assess the supply chain management process for effectiveness:
  - Assessment of critical first tier supply chain completed.
- Ensure the supply chain is adequate to support LRIP:
  - Assessment of critical second and lower tier supply chain completed.
- Assess the supply chain to verify that it is proven and supports FRP requirements.

Tools

- 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
- DCMA Material Management and Accounting System Audit
- Contractor Purchasing System Review

- DMSMS Program Self-Assessment Guide
- FRACAS Reporting System
- Make or Buy Plans
- Gannt Charts
- Milestone Charts
- PERT/Network Charts
- Critical to Customer Assessment
- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronics Parts
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- AS6500, Manufacturing Management Systems
- AS9100, Quality Management Systems
- AS9103, Variation Management of Key Characteristics
- AS9133, Qualification Procedure for Aerospace Standard Parts
- DFAR 15.407-2, Make or Buy Programs
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, System and Software Engineering
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Contractor Purchasing System Review (CPSR) Guidebook
- SD-19, Parts Management Guide
- SD-22, DMSMS Guidebook
- MIL-STD-3018, Parts Management
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide

- ISO 9001, Quality Management Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security

H. PROCESS CAPABILITY/CONTROL

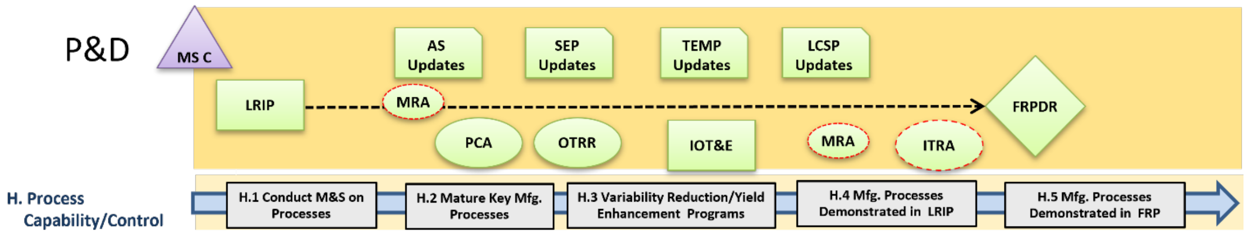


Figure 5-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with "uniform, defect free product that has consistent performance and is affordable. 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 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. Process capability clarifies the inherent process variability of a given process or characteristic. A capability study is used to assess the ability of a process to meet a 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

H.1. Conduct Modeling and Simulation of Manufacturing Processes

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

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.

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.
- Digital engineering should be used to support process capability studies and follow-on process control activities.
- 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
- 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.
- Verify and demonstrate models/simulation (M&S) of process capabilities developed earlier using the LRIP.
- Use M&S analysis to assist in the management of LRIP, and to determine that FRP requirements can be met.
- Develop manufacturing process documentation concurrently with the product specification to ensure the design is producible, supportable, and affordable.
- Conduct manufacturing assessments to determine system constraints and identify improvement opportunities.
- Conduct process capability studies to baseline the as-is process and further the development of improvement plans.

- Demonstrate manufacturing processes capability using production data:
  - Statistical analysis of current capability (Cp and Cpk, Pp and Ppk, or other appropriate metrics)
  - Results used to improve process and determine that LRIP/FRP requirements can be met
  - Continue collecting or estimating process capability data and using to improve
- Assess manufacturing processes and verified for LRIP/FRP:
  - Process Capability data from LRIP should be assessed against LRIP build target values
  - Process Capability data from FRP should be assessed against FRP Build target values
- Update and refine process capability requirements as the production environment moves from LRIP to FRP.
- Ensure continuous improvement of both LRIP and FRP are ongoing and generating positive results based on process capability models.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Critical to Quality Tree
- AIAG Advanced Product Quality Planning (APQP
- 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 Maturity Plan
- Independent Technical Risk Assessment Checklist
- Plant Modeling and Simulation tools (e.g., FlexSim, SimFactory)
- Process Modeling Tools (e.g., Siemens PLM, Delmia)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins)
- 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
- Manufacturing Readiness Level (MRL) Deskbook
- 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
- 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.

The purpose of the P&D phase is to produce items for the warfighter that achieve operational capability and satisfy mission needs. Once a program passes Milestone C and goes into LRIP, there is an expectation that manufacturing processes are mature, well characterized, and controlled. The production output should be uniform and defect free.

Manufacturing process capability analysis determines the available manufacturing capacity and its capability to produce the desired end item without special controls. It is a critical activity in producibility analysis. This normally includes analysis of the degree of process variability, the causes of variability, and the definition of methods to reduce it.

Manufacturing and Quality Tasks

- Identify and assess key and critical processes.
- Conduct FMEAs (DFMEA and PFMEA).
- Verify that manufacturing processes are stable, adequately controlled, capable, and have achieved program LRIP objectives.
- Evaluate manufacturing yields and rates actuals against production targets (LRIP and FRP) and use the results to feed improvement plans.
- Validate that production process capability actuals support achieving production targets.
- Verify and refine yields and rates on processes required for LRIP.
- Updated ongoing improvement plans.
- Ensure key processes are identified, and their status briefed at program meetings and reviews.

Tools

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

Resources

- AS9100, Quality Management System – Aerospace
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9138, Statistical Process Acceptance
    - AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)

- AS6500 Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9145, Advanced Product Quality Plan (APQP)/Production Part Approval Process (PPAP)
- AIAG Production Part Approval Process (PPAP) Manual
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Defense Management Guide for Program Managers, Chapter 7.6.2 Determine Process Capability
- Defense Manufacturing Guide for Program Managers, Chapter 5.5.4 Seven Quality Control Tools
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- NAVSO P-3687, Producibility Systems Guidelines
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.3 Conduct Yield Enhancements and Variability Reduction Efforts

One of the major goals of manufacturing is to provide the customer with uniform, defect-free products that have consistent performance and is affordable. Product quality comes from robust product and process designs and process control activities to include continuous process improvement to identify and remove sources of variation. Yield is one measure of uniformity and is the percentage of products that are defect free and is usually described by the ratio of non-defective parts vs. total parts produced. An ideal process is one without any defects, no scrap, rework or repair activities. Organizations often measure yield using one of the following measures:

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

Manufacturing risk assessments should identify any gaps in M&Q processes. These gaps should include 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
- Conduct variability experiments to foster variability reduction and continuous improvement and to support FRP.
- Demonstrate LRIP has been achieved using production articles.

- Verify that industrial capabilities are in place and the production items have achieved their requirements as validated through testing.
- Verify that LRIP yield, and rate targets have been achieved.
- Assess yields and rates required to begin FRP using LRIP results. Verify that yield improvements are ongoing.
- Demonstrate FRP has been achieved using production articles.
- Verify that FRP yield, and rate targets have been achieved.
- Verify that yield improvements are ongoing.
- Ensure that process capability risk reduction efforts include the effects of changes in:
    - workers
    - materials
    - fabrication methods
    - tooling and equipment
    - set-up, and other process conditions

Tools

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

Resources

- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- 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
- Engineering of Defense Systems Guidebook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook

H.4 Demonstrate Critical Manufacturing Processes in LRIP

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 Production and Deployment phase when most production takes place and as the program ramps up production to LRIP and FRP. As a program moves forward, process maturity takes on greater importance. According to DoDI 5000.02, the FRP decision requires that manufacturing risk be understood and that the manufacturing processes for the system be capable, in statistical control, and affordable. If these processes are not capable, in control, and affordable, the program office needs to continue to mature those processes. 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.)
- Assess risks, issues, and impacts of the manufacturing environment on M&Q processes and develop recommended mitigation plans for both the contractor and the supply chain.
- Verify that manufacturing processes are stable, adequately controlled, and have the capability to achieve program LRIP objectives.
- Conduct manufacturing process demonstrations (LRIP) which include the development of affordable and executable manufacturing processes, the completion of system fabrication, production of test articles so that system integration, interoperability, supportability, safety, and utility can be demonstrated.
- Ensure processes demonstrations include such items as cleaning, heat treatment, clean room controls, controlled testing, and special handling (i.e., personal grounding requirements for electronic components).
- Ensure processes are identified in the design and manufacturing documentation.

- Proof manufacturing processes that could contribute manufacturing risk to the program for LRIP:
  - Ensure that process can repeatedly produce conforming hardware within the cost and time constraints of the production phase.
  - Evaluate expected process yields for each critical process and indicate the statistical or other method used to maintain control of process performance.
  - Ensure proofing is accomplished in LRIP and FRP environments.
  - Assess and verify that factory floor conditions include the physical facilities, personnel, and manufacturing documentation.
  - Ensure that the contractor establishes training and certification programs for the shop personnel to ensure that process capabilities can be attained on a recurring basis for LRIP and FRP.
  - Ensure environmental and safety regulations and standards are a part of the production planning and are compliant with federal, state, and industry standards and laws.
  - Ensure that the impacts of environmental and safety regulations and standards on the cost of production operations are known.
- 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

- ISO9001 Checklist
- AS6500 Checklist
- Feasibility Study Checklist
- Cause and Effect Diagram
- Cost of Quality Estimates
- First Pass Yield Estimates Worksheet
- Pareto Analysis
- Histograms
- FMEA Templates (DFMEA and PFMEA)
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan
- Process Capability Assessment

Resources

- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- 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
    - AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- ISO 17025, Testing and Calibration Labs
- AS6500 Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- 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
- Manufacturing Readiness Level (MRL) Deskbook

H.5 Demonstrate Critical Manufacturing Processes FRP

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 Production and Deployment phase when most production takes place and as the program ramps up production to LRIP and FRP. As a program moves forward, process maturity takes on greater importance. According to DoDI 5000.02, the FRP decision requires that manufacturing risk be understood and that the manufacturing processes for the system be capable, in statistical control, and affordable. If these processes are not capable, in control, and affordable, the program office needs to continue to mature those processes. 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.)
- Verify that manufacturing processes are stable, adequately controlled, and have the capability to achieve program FRP objectives.
- Conduct manufacturing process demonstrations (FRP) which includes the development of affordable and executable manufacturing processes, the completion of system fabrication, production of test articles so that system integration, interoperability, supportability, safety, and utility can be demonstrated.
- Ensure processes demonstrations include such items as cleaning, heat treatment, clean room controls, controlled testing, and special handling (i.e., personal grounding requirements for electronic components).
- Ensure processes are identified in the design and manufacturing documentation.
- Proof manufacturing processes that could contribute manufacturing risk to the program for FRP:
  - Ensure that process can repeatedly produce conforming hardware within the cost and time constraints of the production phase
  - Evaluate expected process yields for each critical process and indicate the statistical or other method used to maintain control of process performance
  - Ensure proofing is accomplished in LRIP and FRP environments
  - Assess and verify that factory floor conditions include the physical facilities, personnel, and manufacturing documentation
  - Ensure that the contractor establishes training and certification programs for the shop personnel to ensure that process capabilities can be attained on a recurring basis for LRIP and FRP

  - Ensure environmental and safety regulations and standards are a part of the production planning and are compliant with federal, state, and industry standards and laws
  - Ensure that the impacts of environmental and safety regulations and standards on the cost of production operations is known

- 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
- ISO9001 Checklist
- AS6500 Checklist
- I Feasibility Study Checklist
- Cause and Effect Diagram
- Cost of Quality Estimates
- First Pass Yield Estimates Worksheet
- Pareto Analysis
- Histograms
- FMEA Templates (DFMEA and PFMEA)
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan
- Process Capability Assessment (Cp and Cpk assessment)

- Statistical Process Control Charts
- Producibility Assessment Worksheet (PAW)
- Six Sigma Worksheet

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9138, Statistical Process Acceptance
  - AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- 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
- 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
- Manufacturing Readiness Level (MRL) Deskbook

I. QUALITY MANAGEMENT

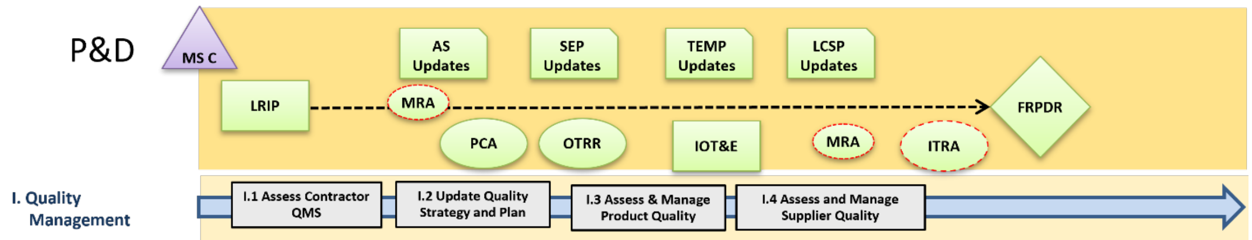


Figure 5-10. Quality Management Manufacturing and Quality Activities

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, which 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 Management) will focus on the following sub-threads as required in each phase:

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

I.1 Assess the Contractor's 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 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.

M&Q personnel need to identify the potential requirements for a Quality Management System (QMS) of an identified material based on FAR 46.202 Types of Contract Quality Requirements, and FAR 52.246.11 Higher-Level Contract Quality Requirements. Best practices should 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.

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.
- Identify and manage product quality requirements:
  - Mature new quality technologies and process state of the art into product quality requirements
  - Identify and manage product quality requirements (i.e., specific product characteristics)
  - Identify product acceptance methods and determine sampling plan as appropriate
  - Conduct First Article Inspection if required

- Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks:
  - 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.
- 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 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 Quality Strategy and 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

Ramping up production to LRIP and then to FRP requires that the Program Management Office identify remaining risks prior to production and then manage those risks during production. Key considerations should include industrial base viability, design stability, process maturity, supply chain management, quality strategy/management, and facilities and manufacturing skills availability. Sources of data could include technical reviews and audits, Program Status Reviews, pre-award surveys, Production Readiness Reviews, Industrial Capabilities Assessments, trade-off studies, tooling plans, make- or-buy plans, manufacturing plans, and bills of material. Important outputs include actions to reduce or manage remaining risks.

Many of the program plans and risk assessments will focus on the prime contractor, but of equal importance is the health and vitality of the supply chain. Good execution of program plans requires execution throughout the supply chain. As soon as the Make/Buy decision is made and the decision is to buy, then the Supplier QA program needs to be actively engaged to ensure that the appropriate requirements are contractually flow down thru the supply chain, that the suppliers are actively managed and have appropriate oversight, and that product delivery supports LRIP and FRP with conforming product, at the right time and place and at the right costs. Quality requirements may reach all the way down to the component level or even the raw material level.

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

Manufacturing and Quality Tasks

- Ensure the following documents have been updated to support both LRIP and FRP:
  - Acquisition Strategy
  - Systems Engineering Plan (SEP)
  - Manufacturing Strategy/Plan
  - Quality Assurance Strategy/Plan
- Review and update the program's Quality Strategy (Government and Contractor):
  - The Quality Strategy should be developed to link corporate goals and objectives with operations, customer requirements, regulatory requirements, growth and innovation
  - Quality strategies should outline the following based on AS9100 or other industry best practice:
    - Vision and Leadership Commitment
    - Goals and Objectives
    - Management Responsibilities
    - Resource Management (Allocation and Use)
    - Product realization requirements (e.g., risk management, design, and development, purchasing, etc.)
    - Risks, issues, and opportunities
    - Measurement, analysis, and improvement requirements
    - Supply Chain Requirements
    - Strategic Tradeoffs
  - The Quality Strategy should identify contract quality requirements per FAR 52.246 Contract Quality Requirements
  - The Quality Strategy should establish quality performance metrics that are tied to Key Performance Parameters, Key System Attributes, Measures of Performance, and Technical Performance Measures
  - The Quality Strategy should identify and implement and internal audit program
  - The Quality Strategy should identify and establish appropriate agreements, delegations, and contracts with other agencies, e.g., DCMA, throughout the supply chain
- Identify best practice business quality strategies that address the following areas:
  - Customer Focus

  - Benchmarking
  - Continuous Improvement
  - Process Approach
  - Engaged Workforce
  - Evidence-based Decision Making
  - Periodic Audits

- Ensure quality plan addresses the following areas:
  - Contract Review
  - Resource Identification and Allocation
  - Product Realization
  - Product Acceptance Plan and Procedures
  - Quality Checklists
  - Process Controls
  - Process Improvement Plan
  - Quality Performance Objectives and Metrics
  - Baseline Metrics and Goals
  - Servicing
  - Request for DCMA Support

- Review and update the program's Quality Plan:
  - The Quality Plan should establish quality performance metrics that are tied to Key Performance Parameters, Key System Attributes, Measures of Performance, and Technical Performance Measures
  - The Quality Plan should identify and implement and internal audit program

- The Quality Plan may also be involved in the following:
  - Process and analyze mission data
  - Manage Preplanned Product Improvements
  - Develop and implement technology refresh schedules
  - Conduct technology insertion efforts as needed to maintain or improve system performance
  - Update system safety assessments
  - Perform engineering analysis to investigate the impact of DMSMS issues
  - Work with vendors and the general technical community to determine opportunities for technology incursion to increase reliability and affordability

- Ensure Quality Strategy and Plan, including initial product baseline documentation for quality, is sufficient, complete, and adequate to enable inspections and testing of components, hardware, and embedded software in support of the CDR:

  - Ensure all KCs, CSIs, and CAIs have completed drawings and specifications with tolerances and test points under configuration control
  - Ensure all product data essential for component quality has been released

- Ensure quality inputs to the schedule (IMP/IMS) are up-to-date and are executable with acceptable risks.
- Ensure quality plans, activities, and processes are executable within the existing quality budget to support the approved initial product baseline and critical path.
- Analyze contractor quality plans for materials, facilities, equipment, test facilities and equipment, and tooling to support the pilot line requirements.
- Ensure all key and critical manufacturing processes process control plans, have been analyzed, updated, and approved for the capability to meet design tolerances.
- Analyze the contractor FRACAS for adequacy to meet needs based on the Quality Plan.

Tools

- Acquisition Strategy Outline
- Acquisition Strategy Template
- AS9100 Audit Checklist
- ISO 9001 QMS Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread

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
- AFMC Instruction 63-501, AFMC Quality Assurance
- AFLCMC Manufacturing and Quality Assurance Acquisition Process Deskbook, Chapter 4.7 Document the Quality Strategy in a Program Quality Plan
- DoD Systems Engineering Guidebook

- Early Manufacturing and Quality Engineering Guide
- 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 Assess and Manage Product Quality (LRIP or FRP Lines)

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

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

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

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

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.

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.

M&Q personnel need to assess product quality first for Low Rate Initial Production (LRIP) and then for Full Rate Production (FRP).

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
    - Conduct First Article Inspection if required
    - Incorporate and mature quality technologies and process into product quality requirements
    - Identify and manage product quality requirements on pilot line items (i.e., specific product characteristics)
    - Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks

- Assess contractor and supply chain pilot lines and demonstrations for quality verification and validation efforts including:
    - Quality processes and procedures including continuous improvement efforts
    - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)
    - Quality and process controls in place (e.g., plans, audits, process capabilities (C_{pk}s), SPC, FRACAS, etc.)
    - Adequacy and completeness of acceptance and qualification testing for LRIP
    - All quality instructions, sequencing, in-process tests, and test procedures (including those in work instructions)
    - Quality scheduling and control
    - Quality model and simulations
    - Quality workforce capabilities
    - Implementations of quality technologies
    - Tooling, work holding fixtures, jigs, etc. for inspection and test
    - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
    - Conduct Measurement System Analysis (MSA) to identify the amount of variation that exists within a measurement system
    - 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
    - Quality of ESOH processes and procedures
    - Quality of security processes, procedures, capabilities, and compliance
    - Impacts from direct and indirect infrastructure
    - Mitigation results of quality and adequacy of risks and issues resolutions
    - Quality costs (and impacts to schedule and performance)
    - Quality of materials' sources and selections
    - Quality of embedded software (integration)
- Ensure contractor quality management systems for M&Q metrics and data collection and tracking to the component level are in place and functional.
- Ensure adequacy and completeness of mitigation activities for mitigation of quality risks, issues, and opportunities in the joint Government/ contractor Risk, Issue, and Opportunity Management System, including quality risks to:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields

    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and HAZMAT management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment
- Analyze quality processes performed during the pilot lines operations (including simulations) to include:
    - Rate of quality processes (actual time to complete) vs. planned
    - Quality data actuals vs. estimated
    - Quality process yields actuals vs. planned
    - Changes in processes (actual vs. planned)
    - Cost of quality actuals vs. desired
- Assess process control plans, including all plans for process control of key and critical processes, for adequacy and completeness on the pilot line.
- Assess all work instructions for required quality outputs (e.g., data, in-process inspections and tests, process capability indices, etc.) based on build-to documentation and information gathered during the pilot line:
    - Verify updated work instructions, processes, drawings, etc.
    - Include KCs and their control plans
- Assess quality outputs from the pilot line and demonstrations for adequacy and completeness and validate:
    - All Production Process Verifications (PPVs) performed
    - Implementation of manufacturing technology solutions (including ManTech)
    - Attainability of KCs (will be capable and under process control for LRIP)
    - Data collected for the Variability Reduction program
        - Data should demonstrate progress to metrics
        - Include updates based on process improvements
    - All FAIs and FATs against specifications, drawings, models, etc.
    - Continuous improvement plans.
        - Include assessment of quality targets (gaps)
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements.

- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards.
- Provide quality input for a Letter of Delegation or Memorandum of Agreement to DCMA for support to, witness of, and assessment of demonstrations, pilot line operations, FAIs and/or FATs, etc.
- 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

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
- 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 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 9001:2015, Quality Management System
- ISO 17025, Testing and Calibration Labs
- Defense Manufacturing Management Guide for Program Managers, Chapter 5.3.5.1 ISO 9001/AS9100
- AS6500, Manufacturing Management Program
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896 Manufacturing Management Program Guide
- DoD Risk, Issue, and Opportunity Management 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 Guide
- 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
- 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
- ASME Y14.5 Dimensioning and Tolerancing
- MIL-STD-1916, DoD Test Method Standard
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (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 twenty-one elements of an ISO 9001:
    - Meets ESOH and Safety statutory and best practice requirement
- Specify and Flow-down Quality Requirements.
- Evaluate Subcontractor and Vendor QMS.
- Evaluate Subcontractor and Vendor Product Quality.
- Establish and Assess SCM Metrics:
    - 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

- 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).

- Provide quality input on program, contractor, and supply chain implementation status of industry best practices (e.g., ISO 9000, AS9100, and other standards on quality management and quality management systems) in support of the CDR.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality management, ESOH, etc.) for quality risks, issues, and opportunities and appropriate mitigation plans.
- Ensure all subsystem, item, and component CDRs are complete and the results impacting quality available for the system CDR:
    - Analyze the results of design maturity assessments including all appropriate reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.) for closure or approval of quality related risks, issues, and opportunities
- Identify, assess, and manage supplier QA concerns such as DMSMS, Obsolescence, Counterfeit Parts, etc.
- Ensure acceptance testing and inspection of supplier products is adequate to begin LRIP.
- Develop acceptance criteria for supplier products based on need (e.g., AQL).
- Ensure supplier products have completed qualification testing and first article inspection.
- Ensure acceptance testing and inspection of supplier products is adequate to begin FRP.
- Ensure Key Characteristics are being managed.
- Ensure continuous quality improvement is ongoing.
- Identify, assess, and manage supplier QA concerns such as DMSMS, Obsolescence, Counterfeit Parts, etc.

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 Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- ISO 9001, Quality Management System
- ASTM 2782, Standard Guide for Measurement Systems Analysis (MSA)
- AIAG Measurement Systems Analysis (MSA) Manual
- AS5553, 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
- 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
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200, Contractor Material Management and Accounting
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- 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

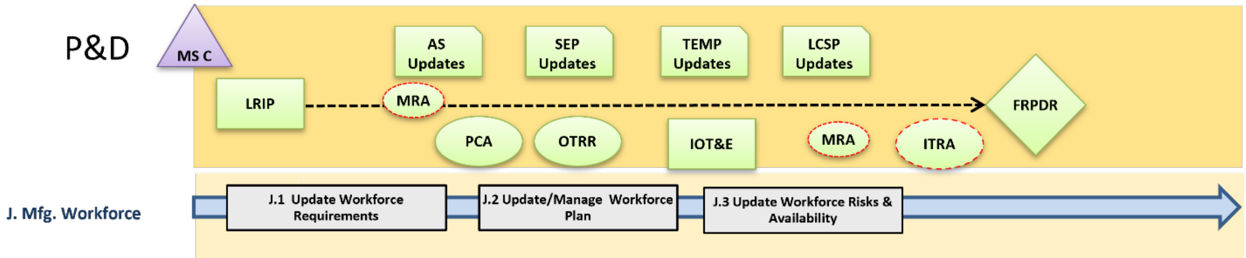


Figure 5-11. Manufacturing Workforce Manufacturing and Quality Activities

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.

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 for LRIP/FRP

Workforce requirements planning provides quantitative inputs to program planning. Workforce planning should identify and align the skills and workforce numbers required to the scope of the technical effort required. 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).

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

Manufacturing and Quality Tasks

- Conduct an analysis on the supply of workforce:
  - Identify industry and sector M&Q workforce competencies:
    - Technical competencies
    - Academic competencies
    - Competencies for advanced manufacturing
    - Competencies for additive manufacturing
    - Lean/Six Sigma and CPI
  - Identify workforce requirements by job/skills category
  - Identify new M&Q skills and training/workforce development requirements for materiel solution approaches to include the need for a Training and Certification Program.
  - How well does the current workforce supply align/support the plan for production?
  - How many employees are required at each skill category and level?
  - 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.
  - Have M&Q skills been identified to address digital engineering skills?
  - 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 for LRIP/FRP

M&Q Workforce management covers a wide range of business processes that are used to ensure that the organizations workforce is strategically allocated, the right people, in the right place, at the right times, and doing the right things in order to maximize business performance, increase organizational competency, and satisfy the customer. Workforce 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 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. Manpower skills availability and capability should have been assessed prior to the Milestone C decision, and now that the program is ramping up production for LRIP, then manpower needs to be assessed to ensure that there is enough capability to meet the demands of LRIP.

Manufacturing and Quality Tasks

- 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 relocations, and changes (e.g., location, improvements and expansion, lay-out changes, etc.)
- Tooling improvements and changes (e.g., operation and maintenance, safety, security, cleanliness, acoustics, HVAC, and environmental controls, etc.)
- Quality requirements changes and additions (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- New materials and technologies impact on workforce ability to address processing, testing, and acceptance
- Environmental, safety, and health requirements changes impact on workforce
- Impacts of regulatory requirements (e.g., special handling, security, HAZMAT, environmental needs, storage requirements, etc.) on the workforce
- Planning for digital engineering requirements and activities
- Incorporation of appropriate workforce lessons learned for processes, tools, and techniques for manufacturing workforce strategy
- Development of M&Q metrics to measure performance

* Assess contractor M&Q workforce management and plans for this phase to include:
    - Synchronization with the SEP, the IMP/IMS, and the Subcontractor Management Plan
    - Consistency with the contractor's Manufacturing Plan
    - Staffing rate requirements for production environment
    - Workforce skills availability (i.e., number of trained capable workers)
    - Workforce stability (e.g., labor force age, turnover rate, labor force sustainability, etc.)
    - Special skills certification and training requirements
* Identify LRIP/FRP manufacturing workforce resource requirements.
* Ensure required workforce availability forecast by monthly requirement against the LRIP/FRP schedule.
* Ensure workforce training requirements forecast against the LRIP/FRP schedule.
* Review any union agreements to ensure workforce/schedule compatibility.
* Update plans to achieve LRIP workforce requirements.
* Update plans to achieve FRP workforce requirements.
* Train and certify workforce to meet LRIP and FRP requirements.

Tools

* Workforce Planning Tools (SAP/Oracle/MRPII)
* Manufacturing Resource Planning (MRPII)
* Interactive MRL Users Guide (Checklist), Workforce thread
* Manufacturing Maturation Plan
* DCMA Production Planning and Control (PPC) Checklist
* AS6500 Manufacturing Management Assessment
* Industrial Base Assessment Survey Form DCMA Industrial Analysis Center

- Forecasting and Regression Analysis
- 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 Template
- Learning Curve Calculator (Estimator)
- Work Measurement Analysis
- Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis

Resources

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

J.3 Update and Manage Workforce Risks and Availability for LRIP/FRP

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

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

Manufacturing USA estimates that by 2028 manufacturers will need to fill 4.6 million jobs, which indicates a mismatch between 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.

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.

Manpower skills availability and capability should have been assessed during LRIP and an assessment made on the needs for ramping up production to FRP. Now that the program is in FRP, manpower needs to be assessed to ensure that there is enough capability to meet the demands of FRP.

Manufacturing and Quality Tasks

- Identify manufacturing workforce resource requirements for LRIP/FRP:
  - Required workforce availability has been forecasted by monthly requirement against the production schedule
  - Required workforce is available, by labor skill category, to meet planned production requirements

  - Required workforce skills, training, and certifications have been forecasted by monthly requirement against the production schedule
  - Required workforce training and certification have been planned for by monthly requirement against the production schedule
  - Have any new or emerging skills been identified that need to be assessed for availability and training
  - Union agreements have been reviewed to ensure workforce/schedule availability

- Develop workforce plans to maintain LRIP and achieve FRP requirements.
- Update workforce plans to maintain LRIP and achieve FRP workforce requirements.
- Ensure FRP personnel are trained on LRIP line and able to execute on the FRP line.
- Ensure LRIP and FRP personnel requirements are met.
- Implement a plan to maintain LRIP and achieve FRP workforce requirements.
- Assess potential disruptive activities that could impact workforce availability (natural disasters, pandemics, changes in technologies, strikes, plant closures, etc.)

Tools

- Workforce Planning Tools (SAP/Oracle/MRPII)
- Manufacturing Resource Planning (MRPII)
- Independent Technical Risk Assessments (ITRAs)
- Technology Readiness Assessment
- Interactive MRL Users Guide (Checklist), Workforce thread
- Manufacturing Maturation Plan
- DCMA Production Planning and Control (PPC) Checklist
- AS6500 Manufacturing Management Assessment
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Forecasting and Regression Analysis
- Make/Buy Decisions
- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Milestone Chart
- Gantt Chart
- Route Sheet Analysis
- Critical Path Template
- Critical Chain Project Management
- Capacity Planning Worksheet
- Line of Balance Template
- Line of Balance Assessment
- Learning Curve Calculator (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
- AS6500, Manufacturing Management Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Plan, DI-MGMT-81889A
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9100, Quality Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Technology Readiness Assessment (TRA) Guide
- Independent Technical Risk Assessment Framework for Risk Categorization
- DoDI 5000.88, Engineering of Defense Systems
- AFI 63-145, Manufacturing and Quality Management
- DoDI 5000.60H, Defense Industrial Capabilities Assessment
- DCMA Instruction 204 Manufacturing and Production
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.7.12 Personnel Planning
- Defense Manufacturing Management Guide for Program Managers, Chapter 14.5.5 The Future of Manpower

K. FACILITIES

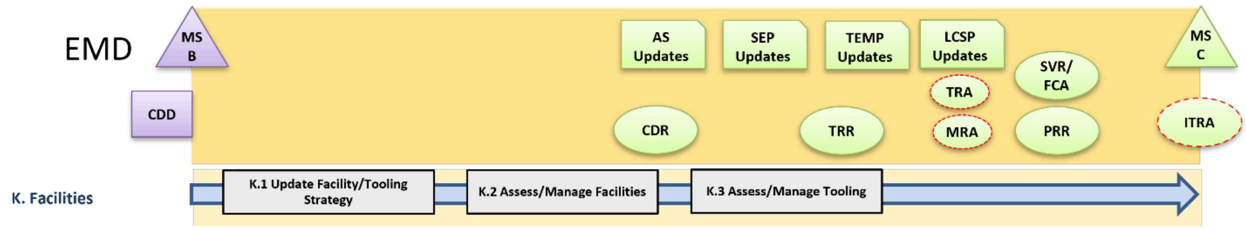


Figure 5-12. Facilities Manufacturing and Quality Activities

Introduction

Facilities management 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 semipermanent real property required to support a system throughout the systems 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.

Special tooling and test equipment required for a program can be expensive and take a long time to develop and procure. The general guidelines for planning for tooling and test equipment need to be established and established early. The issues include contractor investment, the level of rate tooling and test equipment to be used, the transition from limited life to rate tools and the degree of similarity between production test equipment and depot test equipment to be required. Also, guidelines for calibrating and maintaining tools and test equipment need to be set forth.

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

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 $1B in tooling, and the lead times for facility and tooling development was over a year. Because of this programs and organizations need a Facility/Tooling Strategy to help guide their decisions, investments, and other actions aimed at achieving long term goals and business strategies. One strategy is to begin development of facilities and long-lead tooling well in advance of the contract for the next phase. Contractor M&Q managers need to develop a strategy for implementing a facility and tooling plan and for reducing risk in the implementation of a facility and tooling program with program office M&Q personnel monitoring these activities and risks. Facility and Tooling Strategies should focus on the following:

- **Facility design** includes addressing the product/process structure intersection to identify the type of facility required (job shop, batch processing, assembly line, continuous flow line, etc.)
- Facility design includes a floor layout that supports material handling and flow:
  - Static material flow analysis using 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 facilities assessment includes an analysis of the capabilities, capacity, and availability of the key production facilities to include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities to determine if these facilities can meet the requirements of the contract. Anywhere where production may occur. This assessment is looking at the capabilities and capacity for LRIP and preparations for ramping up production during FRP.

Manufacturing and Quality Tasks

- Identify facility requirements for LRIP and FRP.
- 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.

Tools

- Acquisition Strategy Template

- Systems Engineering Plan (SEP) Outline
  - Manufacturing Plan
  - Quality Assurance Plan
- Interactive MRL Users Guide Checklist, for the 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

- Defense Manufacturing Management Guide for Program Managers, Chapter 4.5, Elements of a Manufacturing Strategy
- 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 Program
- MIL-HDBK-896A, Manufacturing Management Program Guide
- AS9100, Quality Systems – Aerospace
- ISO 9001, Quality Management System
- Systems Engineering Plan Preparation Guide
- IEEE15288, Best Practices for Using System Engineering Standards
- IEEE15288.2, Standard for Technical Reviews and Audits on Defense Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.97, Digital Engineering
- DoD Systems Engineering Guidebook
- Early Manufacturing and Quality Engineering Guide
- Digital Engineering Body of Knowledge
- Risk, Issue, and Opportunity Management Guide
- Defense Technical Risk Assessment Methodology (DTRAM)

K.2 Assess and Manage Facilities

Contractor manufacturing facilities planning and assessment includes an analysis of the capabilities, capacity, and availability of the key production facilities to support Low-Rate Initial Production (LRIP) and Full Rate Production (FRP). Facilities assessments should include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities to determine if these facilities can meet the requirements of the contract 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
- Identify facility requirements for LRIP and FRP.
- Identify floor plan, layout, and workflow for the following:
  - Receiving and Inspection
  - Kitting
  - Fabrication and Assembly
  - In-process inspection and Test
  - Final Inspection and Shipping
- Assess machine/process availability.
- Assess machine/process floor space requirements including feeding, storage, WIP, and maintenance requirements.
- Assess surge capability/requirements.
- Assess pilot line to LRIP production ramp-up requirements.
- Assess LRIP to FRP production ramp-up requirements.
- Assess tooling/special tooling/special test equipment requirements.
- Assess soft/limited and hard/durable tooling needs.
- Assess the following against the schedule to ensure they will meet the program's needs:
  - Facilities and capability demonstrated to fulfill LRIP/FRP requirements
  - Manufacturing facilities identified and plans developed to produce LRIP build
    - Receiving and Inspection
    - Kitting
    - Fabrication and Assembly
    - In-process Inspection and Test
    - Final Inspection and Shipping
  - Manufacturing facilities adequate to begin LRIP
  - All tooling, test and inspection equipment proven in LRIP, and requirements identified for FRP
  - Manufacturing equipment maintenance schedule demonstrated
  - Plans in place to support transition to FRP
  - Production facilities in place and capacity demonstrated to meet FRP requirements
  - Facilities are flexible enough to accommodate growth or surge
  - Facilities investments have factored in the impact of government changes in inventory objectives (e.g., lower rates)
  - Contingency planning is considered in the manufacturing facility planning effort
  - Production facilities physical layout has been assessed and validated including the flow of material, components, and product

Tools

- 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 Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- AS9100, Quality Systems – Aerospace
- ISO 9001, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- IEEE15288, Best Practices for Using System Engineering Standards
- IEEE15288.2, Standard for Technical Reviews and Audits on Defense Programs
- DoDI 5000.97, Digital Engineering
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge
- Defense Manufacturing Management Guide for Program Managers, Chapter 6.7.13 Facility Planning
- DCMA-INST-204, Manufacturing and Production
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook

- Early Manufacturing and Quality Engineering Guide

K.3 Assess and Manage Tooling, 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.
- Evaluate all documentation used to manage and account for Tooling, Special Tooling (ST), and Special Test Equipment (STE), which may include the following items:
  - Limited/Soft Tooling
  - Durable/Hard Tooling
  - ST/STE needed for development and manufacture only
  - ST/STE having mission support utility
  - Already available government assets

- Ensure processes for qualification of special tooling is adequate and operating effectively.
- Demonstrate and prove all tooling, test, and inspection equipment can support LRIP.
- Ensure that all tooling, test, and inspection equipment is in place to support maximum FRP.
- Ensure that adequate production test infrastructure, resources, and facilities are available.
- Assess and manage planned equipment maintenance to ensure maximum overall equipment effectiveness (OEE).
- Ensure that design and development of production tooling and STE/special inspection equipment (SIE) must be underway and can support LRIP/FRP.
- Develop, demonstrate, and manage a manufacturing equipment maintenance strategy to support both LRIP and FRP.

Tools

- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Risk Assessment Report DI-SESS-81974
- DCMA Production Planning and Control Risk Assessment Checklist
- SF 1432 Special Tooling and Special Test Equipment Inventory Worksheet
- Factory Simulation and Layout Software Tools (various)
    - Production System Planning tools
    - Ergonomic tools
    - Process Planning & Workflow tools
    - Virtual Factory tool
- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- Capacity Planning Spreadsheet

Resources

- FAR Part 45 – Government Property
- DFARS 252.245-1 Government Property
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- AS6500, Manufacturing Management System
- MIL-HDBK-539, Digital Engineering and Modeling Practices
- MIL-HDBK-896, Manufacturing Management Program Guide
- 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 4.5.7 Tooling and Test Equipment, and Chapter 9.4.7 Other Costs (Tooling and Test Equipment)
- DCMA-INST-204 Manufacturing and Production
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 4275.5, Acquisition and Management of Industrial Resources
- DoD Systems Engineering Guidebook

L. MANUFACTURING MANAGEMENT/CONTROL

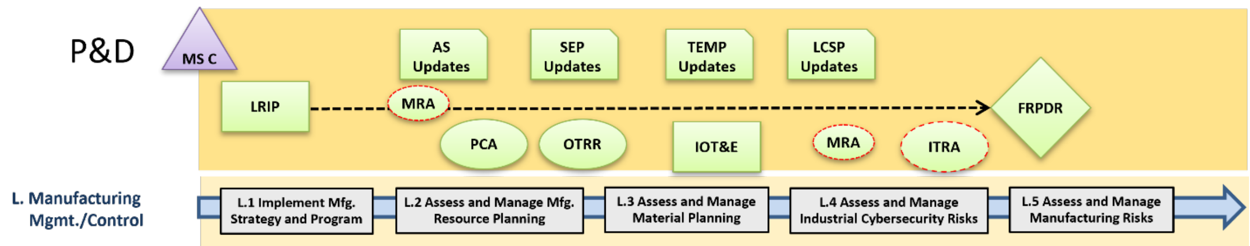


Figure 5-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

Manufacturing is concerned with transforming raw material and/or components into products or finished goods. This transformation 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 Planning
- Manufacturing Resource (Management) Planning
- Material Requirements (Management) Planning
- Assess and Manage Industrial Cybersecurity
- Assess and Manage Manufacturing Risks

L.1 Implement Manufacturing Strategy for LRIP/FRP

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

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

M&Q managers need to develop and execute a manufacturing plan. This requires constant management attention as production and deployment could last for many years, and along the way change will happen. There may be a change in the design due to upgrade opportunities, there will be a change in the 5Ms as manpower changes due to retirement and personnel changes, there may be a change to material as subcontractors and vendors change. Risks and opportunities are constantly evolving, and M&Q managers need to be on top of these changes.

Manufacturing and Quality Tasks

- Support the development of the Acquisition Strategy (AS).
- Support the development of the Systems Engineering Plan (SEP).
- Develop and implement a Manufacturing Strategy, 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 materiel solution approach to include, as a minimum:
  - Description of the M&Q organization
  - Describe the make or buy plan
  - Description and initial identification of resources and M&Q capabilities
  - Identification of M&Q data requirements for facilities, processing, and scheduling
- Evaluate the overall manufacturing feasibility analysis for inputs to planning and scheduling. The analysis should have included:
  - Producibility
  - Design and materials reproducible
  - Critical and key M&Q processes
  - Processes stable and in control
  - Tolerances achievable
  - Special tooling requirements
  - Special skills requirements (training, certification, etc.)
  - Test and demonstration requirements for new materials and processes
  - Supply chain capable and in place
  - Alternate design approaches
  - Schedule achievable (cycle times, lead times, critical path, etc.;)
  - Anticipated M&Q risks and potential cost impacts and identify the needed actions to be incorporated into the initial M&Q plan
- Develop Manufacturing Plans to support LRIP Manufacturing Strategy and risk reduction efforts.
- Develop Manufacturing Plans to support FRP Manufacturing Strategy and risk reduction efforts.
- 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

- Update the LRIP Manufacturing Plans needs to incorporate actual production results.
- Update the FRP Manufacturing Plans needs to incorporate LRIP actual results.
- Ensure that manufacturing planning is included in the Initial Manufacturing Planning Strategy.
- Identify and assess manufacturing risks and develop approved mitigation plans in place.
- Integrate manufacturing risks into risk mitigation plans.
- Track and mitigate manufacturing risks for LRIP.
- Track and mitigate manufacturing risks for FRP.
- Ensure that production control systems are in place to support LRIP.
- Ensure that production control systems are in place to support FRP.
- Ensure material planning systems are in place and proven to support LRIP build.
- Ensure material planning systems are in place and proven to support FRP build.
- Complete Make/Buy decisions and develop a BOM to support LRIP.
- Complete Make/Buy decisions and develop a BOM to support FRP.
- Finalize production work instructions:
  - Labor standards should be developed and are considered a key aspect of production planning and important in workforce projection. These standards are also considered when planning facilities and equipment to ensure efficient utilization rates and overall productivity of the workforce.
- Develop LRIP work instructions and validate with actual experience.
- Develop FRP work instructions and validate with actual experience.
- Ensure that the Manufacturing Strategy addresses production and rate issues such as process capabilities and proofing, factory layout, availability of tooling, lead-times, etc.
- 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.

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, Manufacturing Management Program Assessment
- Interactive MRL Users Guide (Checklist), Management, 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 Program
- 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
- Manufacturing Readiness Level (MRL) Deskbook
- DoD Systems Engineering Guidebook
- Digital Engineering Body of Knowledge
- DoDI 5000.97, Digital Engineering
- NIST Guide to Industrial Control Systems (ICS) Security
- EEE 15288 Technical Reviews and Audits

L.2 Assess and Manage Manufacturing Resource Plans

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 over time

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 includes 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 the planning for LRIP and the transition from LRIP to FRP, and then FRP demonstration.

The purpose of manufacturing planning is the identification of these resources and their integration into a structure that provides the capability to achieve production objectives. This is especially true as the program ramps up production from the pilot line, to LRIP and then to FRP.

Manufacturing and Quality Tasks

- Identify manufacturing resource planning requirements.
- Manufacturing resource needs assessed, analyzed, and validated.
- Manufacturing resource requirements for potential systems or concepts identified.
- Identify long-term manufacturing resource planning requirements:
    - 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.
- Identify mid-term manufacturing resource planning requirements:
    - Conduct a capacity requirements plan to analyze available resources
    - Identify and quantify key resources (5Ms)
    - Identify the Bill of Materials (BOM)
    - Extend the BOM against the Master Production Schedule
    - Identify manufacturing resource gaps (under and over capacity workstations)
    - Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.
- Identify short-term manufacturing resource planning requirements (production execution):
    - Conduct shop floor execution of production against available resources
    - Schedule the activities (routings or workflow)
    - Dispatch the work, release the production order to the floor

  - Monitor the workflow and take corrective action on potential or real problems
  - Identify and quantify key resources (5Ms)
  - Identify the Bill of Materials (BOM)
  - Extend the BOM against the Master Production Schedule
  - Calculate utilization rates
  - Calculate or identify lead times
  - Calculate Overall Equipment Effectiveness rates
  - Identify constraints or bottlenecks
  - Identify manufacturing resource gaps (under and over capacity workstations)
  - Assess the impact of technology and process state of the art on the concepts being considered and the impacts on manufacturing management.

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

- Update manufacturing planning for LRIP and FRP and ensure the planning covers the following items:
  - Ensure that all the information necessary to plan the detailed manufacturing operations for the system should be available to the contractor
  - Ensure that this information described in a contractor's manufacturing plan covers:
    - Manufacturing organization including who is responsible, organization charts, points of contact.
    - Manufacturing Management System including how materials and parts are ordered, structure order for parts and components, and track a project to produce the end item.
    - How all manufacturing risks are being tracked and mitigated.
  - Ensure that the Manufacturing Management Program describing manufacturing strategy includes:
    - Program manufacturing time-phased schedule,
    - Manpower Plan,
    - Industrial facilities capacity assessment,
    - Surge and Mobilization capacity assessment,
    - Manufacturing risk assessment,
    - Capital investment commitment,
  - Ensure that the Manufacturing Program Planning including:
    - Producibility Program Plan,
    - Make-or-Buy Criteria including considerations used in making decisions

- Ensure the conservation of critical/strategic materials
- Ensure the reduction of critical components and parts (reducing foreign dependency)
- Ensure that there is the capacity to support normal production needs, surge, mobilization
- Ensure risk reduction efforts are ongoing
- Ensure that there is a second sourcing of critical components including critical safety items as appropriate
- Ensure the standardization of components and parts
- Ensure that there is a trade-off analysis that documents and provides an optimized solution that is the basis for the production planning effort
  - The analyses are based on established modeling tools and factors in the current capabilities and experience of the contractor
  - Cost optimization is a significant factor
  - The production plan provides for scheduled and unscheduled maintenance with little disruption to the production schedule
- Ensure subcontractor/Supplier Management includes:
  - List of proposed major/critical subs and suppliers including products
  - Locations
  - Make/Buy decisions and BOM complete to support FRP
- Ensure that the Make/Buy decisions are consistent with contractor policy and reflect a rationale that meets the planned schedule and offers the best value to the government.
  - Data used to determine supplier capacity and capability to meet program needs
  - Data used to support second sourcing decisions and to define supplier risk
  - Supplier management methodology/process/tracking
- Ensure that Manufacturing Methods and Production Flow includes:
  - Advanced or unique manufacturing technology required to produce components or end items including tools and processes requiring proofing or demonstration to minimize high risk or critical operations
  - Effective production control system in place to support FRP
  - Production flow utilizing a "goes-into" chart, tree chart, to portray the planned process of fabrication and assembly in terms of key operational points; this includes lead times from procurement of raw material to delivery of product
  - The acquisition of production tooling and equipment is based on a schedule that represents reasonable acquisition lead times, installation and setup, training, etc., that is coordinated with the overall schedule and presents contingency plans that address any schedule risks
  - Identify production, test, or inspection stations which have bottleneck potential and identify corrective action

    - Plant flow of major in-plant manufacturing operations including operation, equipment, and location
    - Identify expected process yields for each process and indicate statistical or other method used to maintain control
    - During LRIP or Production obtain and evaluate processes using process control system
    - A detailed allocation of production space and equipment is described, along with the factors used in developing the plan
    - The status of design and acquisition of production equipment is tracked in the schedule; equipment cost, efficiency, and availability are reflected in the planning process
- Ensure that the Tooling, ST, and STE program verifies procedures for ensuring functional compliance and calibration of all tooling and test equipment
- Ensure that a Productivity Improvement program is reducing manufacturing risks, and the risks are being mitigated
- Ensure that Industrial Materials Management includes:
    - Critical forms and parts
    - Strategic and critical materials
    - Diminishing Manufacturing Sources and Materials Shortages
    - Material planning systems proven in LRIP and enough for FRP.
    - Requests for Special Priorities Assistance
    - Scrap management and reclamation
    - Material planning systems validated on FRP build
- Ensure that Manufacturing Management Data includes:
    - Cost of work scheduled, cost of work performed, and the actual cost of work performed in hours
    - Cause, corrective action, and means of follow-up to attain planned performance
- Ensure that manufacturing audits including checklists and other criteria used by the prime to conduct audits of the contractor and supplier operations
    - Include audit summaries and corrective actions
- Ensure a review and assessment of Labor Relations includes:
    - Location of facilities performing program work
    - Each union representing workers at the facility locations, type, and number of workers
    - Expiration date of union's labor management agreement.
    - History of last three negotiations
- Ensure that the Facility plan describes:

    - All GFP required and specific need dates.
    - Components supplied by each facility location
    - Contingency plan listing possible alternate suppliers
  - Ensure the contractor has procedures for management of company and GFI assets that support the needs of the program
  - Ensure that contractor management control systems, including those for configuration management and the control of subcontractors and manufacturing performance evaluation are evaluated for risks
  - Ensure that contractor assets and government-owned resources are identified and are supported by the confirmed availability of the resources. Resource sharing between programs is on a non-competing basis
    - The plan should also include industrial preparedness planning, including surge capability during the production phase and the postproduction phase requirements for support to employment of the system in combat situations

Tools

- AS6500, Assessment
- Interactive MRL Users Guide (Checklist), Management/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
- Operations Process Chart
- Route Sheet
- Line of Balance Assessment
- Input/Output Analysis
- Make/Buy Decisions
- Work Breakdown Structure

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
- Manufacturing Maturation Plan
- Bill of Materials
- Parts List
- Process Plans and Route Sheets
- Assembly Charts and Operations Process Chart
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- AIAG Production Part Approval Process (PPAP) Manual
- Defense Manufacturing Management Guide for Program Managers, Chapter6 Manufacturing Planning
- Defense Manufacturing Management Guide for Program Managers, Chapter 13 Manufacturing Controls
- DoDI 5000.97, Digital Engineering
- NIST Guide to Industrial Control Systems (ICS) Security
- Digital Engineering Body of Knowledge
- AFI 63-145, Manufacturing and Quality Management
- Manufacturing Resource Planning (MRP II) software

L.3 Assess and Manage Material Requirements Plan

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

Material planning begins with material managers determining the amount of material required in order to meet planned production operations. The amount of material is dependent on 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 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 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 the Bill of Materials.
- Identify the inventory status of all items on the BOM required for production.
- Identify material requirements by assessing the Bill of Materials (BOM) against the Master Production Schedule, and current inventory on hand.
- Identify what to Make vs. what to Buy items in the BOM.
- Develop and implement a supplier sourcing process with evaluation criteria for Buy items:
    - Past performance
    - Ability to meet capacity and schedule requirements
    - Financial stability of vendor
    - Ability to provide technical support
    - Adequacy of vendor quality management system
    - Total part cost including warranty costs
- Create and issue purchase orders to support planned production.

- Develop inventory control and management processes
- Assess availability and quality of materials to be used for each production requirement:
  - Assess the maturity (technical and characterization) of material sources, essential raw materials, special alloys, composite materials, etc.
  - Assess material risks such as counterfeit parts, DMSMS and Obsolescence, corrosion, etc.
  - Understand alternatives to preferred materials for each materiel solution or production requirement
- Assess all aspects of tasks in materiel availability:
  - Assess the quality, processing, aging, handling, and transit times, etc., as an impact to lead times to include alternative materials
  - Evaluate military vulnerability from source considerations such as quality, fragility, sole source, domestic vs. foreign, etc., for the AoA Study Guidance and MDD processes that could result from the lack of alternatives
- Identify Material Requirements key performance measures:
  - Perfect Order Fulfillment
  - Delivery On-time Performance
  - Inventory days of supply
  - Inventory turnover
- Support the use of DCAA material management audit program.
- MSRA Production Planning and Control (PPC), Material Requirement Planning Checklist can be used to assess Material Requirements Planning.

Tools

- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control Thread
- Manufacturing Maturation Plan
- AS6500 Assessment
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- 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
- Manufacturing Readiness Level (MRL) Deskbook
- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- Material Management and Accounting System – Audit Program
- DFAR 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
- Early Manufacturing and Quality Engineering Guide

L.4 Assess and Manage Industrial Cybersecurity Risk

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

Operational technologies and Industrial Control Systems can include:

- Enterprise resource planning (ERP) system supports functional management resources within an enterprise, and control process performance.
- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution 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 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 personnel 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. OT cybersecurity incidents are identified and assessed. OT cyber incidents throughout the supply chain are identified and assessed. Workforce trained as appropriate in up-to-date cybersecurity procedures for production. Planning and documentation for FRP facilities and equipment OT systems including cybersecurity and physical/digital controls and access requirements complete. OT cybersecurity improvement efforts initiated for FRP. OT cybersecurity procedures implemented in LRIP and support FRP.

Manufacturing and Quality Tasks

During the Production and Deployment phase, OT cybersecurity incidents are identified and assessed. OT cyber incidents throughout the supply chain are identified and assessed. Workforce trained as appropriate in up-to-date cybersecurity procedures for production. Planning and documentation for FRP facilities and equipment OT systems including cybersecurity and physical/digital controls and access requirements complete. OT cybersecurity improvement efforts initiated for FRP. OT cybersecurity procedures implemented in LRIP and support FRP.

- 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, assessed and reported.
- OT cybersecurity incidents throughout the supply chain are identified and assessed.
- Workforce trained in the latest cybersecurity procedures.
- Cybersecurity planning for OT systems to be used in FRP is complete and documented.
- Cybersecurity procedures have been assessed and validated on the LRIP line.
- Information analysis conducted.
- Update Critical Program Information (CPI) analysis.
- Update Trusted System Networks (TSN) analysis.
- Update SSE/SE tradeoffs.

- 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, assess and report 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 for LRIP/FRP

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

Manufacturing and Quality Tasks

Assessments should be made for each production environment, 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)
- Interactive MRL Users Guide (Checklist), Manufacturing Management and Control Thread
- Manufacturing Maturation Plan
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- AS6500 Manufacturing Management Assessment
- MIL-HDBK-896, Manufacturing Management Program Guide
- DCMA Production Planning and Control (PPC) Checklist
- Production Surveillance Plan Flowchart
- Production Surveillance Flowchart
- Development Surveillance Flowchart
- Over and Above Surveillance Flowchart
- Time and Material Surveillance Flowchart
- Physical Progress Reviews Flowchart
- Performance Based Payment Support Flowchart
- Continuous Improvement Opportunities Flowchart
- Industrial Labor Relations Flowchart
- Line of Balance Assessment
- Make/Buy Decisions

- Materials Requirements Planning (MRP) Assessment
- Manufacturing Resource Planning (MRPII) Assessment
- Master Production Schedule
- Production Plan
- Technology Readiness Assessment
- Supplier/Supply Chain Assessment

Resources

- AS6500, Manufacturing Management Program
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Manufacturing Readiness Level (MRL) Deskbook
- DoDI 5000.60H, Defense Industrial Capabilities Assessment
- DCMA Instruction 204 Manufacturing and Production
- DCMA Instruction 326, Risk Assessment
- DCMA Manual 2303-01, Surveillance – Assess Risk
- AFI 63-145, Manufacturing and Quality Management
- 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^{3}I	Preplanned Product Improvement
PAOC	Post-Award Orientation Conference
PAW	Producibility Assessment Worksheet
PBL	Performance-Based Logistics
PCA	Physical Configuration Audit
PCO	Procurement Contracting Officer
PDR	Preliminary Design Review
PEP	Producibility Engineering and Planning
PESHE	Programmatic Environmental, Safety, and Occupational Health Evaluation
PFMEA	Process Failure Modes and Effects Analysis
PHL	Preliminary Hazard List
PHST	Packing, Handling, Storage, and Transportation
PLM	Product Lifecycle Management
PM	Program Manager
PMO	Program Management Office
PMP	Parts, Materials, and Processes

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

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

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

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

Appendix B: References

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

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

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

10 USC 2305, Contracts: Planning, Solicitation, Evaluation and Award Procedures
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FAR Subpart 16.4 Incentive Contracts
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FAR Subpart 30.6 Contract Administration Service (CAS) Administration
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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

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Appendix C: Manufacturing and Quality Tools

Tools identified in the M&Q BoK are listed below alphabetically and many contain a link to the referenced tools that are published by a U.S. Government entity and available in the public domain. If the tool is commercially available either for free or for a charge, the entry will direct the reader to *Internet Search*. Individual publishers may provide a short video on how to use the tool.

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

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Benchmarking
Internet Search

Bill of Material Assessment
Internet Search

Bill of Material Data Item Description - DI-PSSS-81656B
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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

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Cost Estimating Technique – Parametric
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Cost of Quality (CoQ) Estimates
Internet Search

Critical Chain Project Management
Internet Search

Critical Design Review (CDR) Checklist
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Critical Path Template
Internet Search

Critical to Customer Template
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Critical to Quality Tree Template
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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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