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

Chapter 4
Engineering and Manufacturing Development (EMD) Phase (Milestone B)

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

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Introduction: How to Use the M&Q BoK

The Department of Defense (DoD) Manufacturing and Quality (M&Q) Body of Knowledge (BoK) is a compilation of best practices and lessons learned for completing M&Q activities across the DoD system acquisition life cycle. The office of the Deputy Director for Engineering (DD, ENG) 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 Production, Quality, and Manufacturing (PQM) managers may refer to the BoK to find information relevant to the phase of the program they are working on. Within a specific phase, the user may focus on the section and tasks that apply (with appropriate tailoring) for the M&Q activities the program is conducting.

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

The BoK includes 6 chapters:

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

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

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

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

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

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

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

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

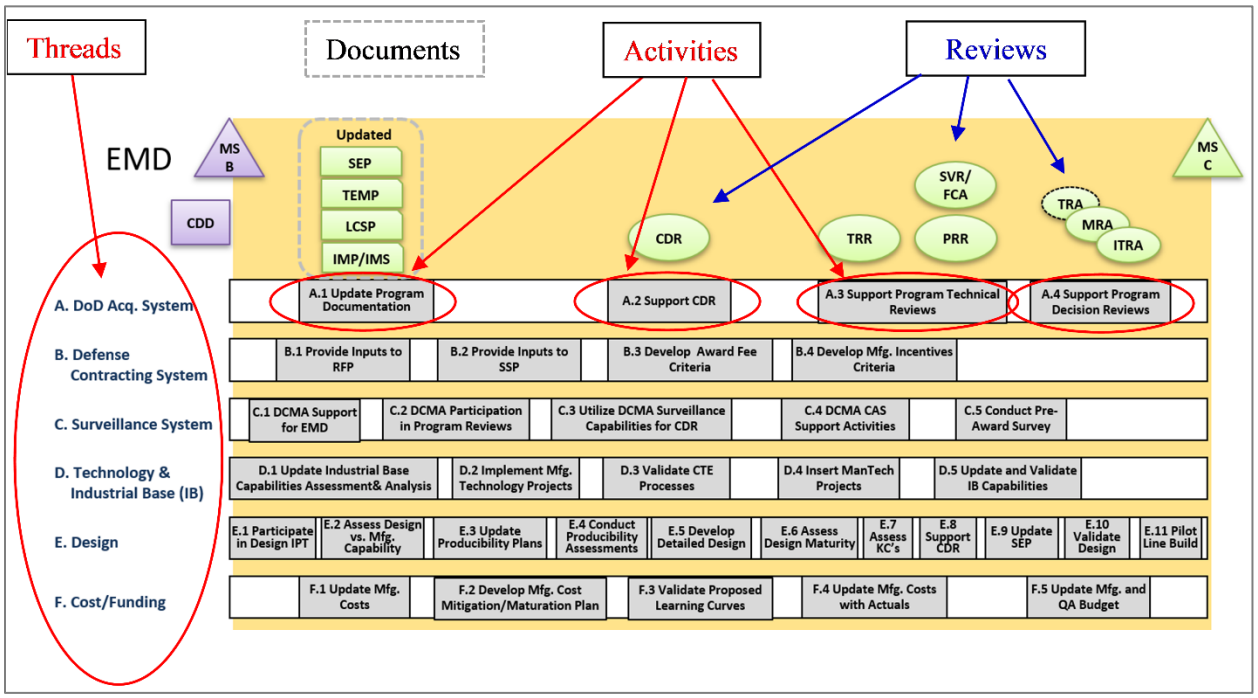
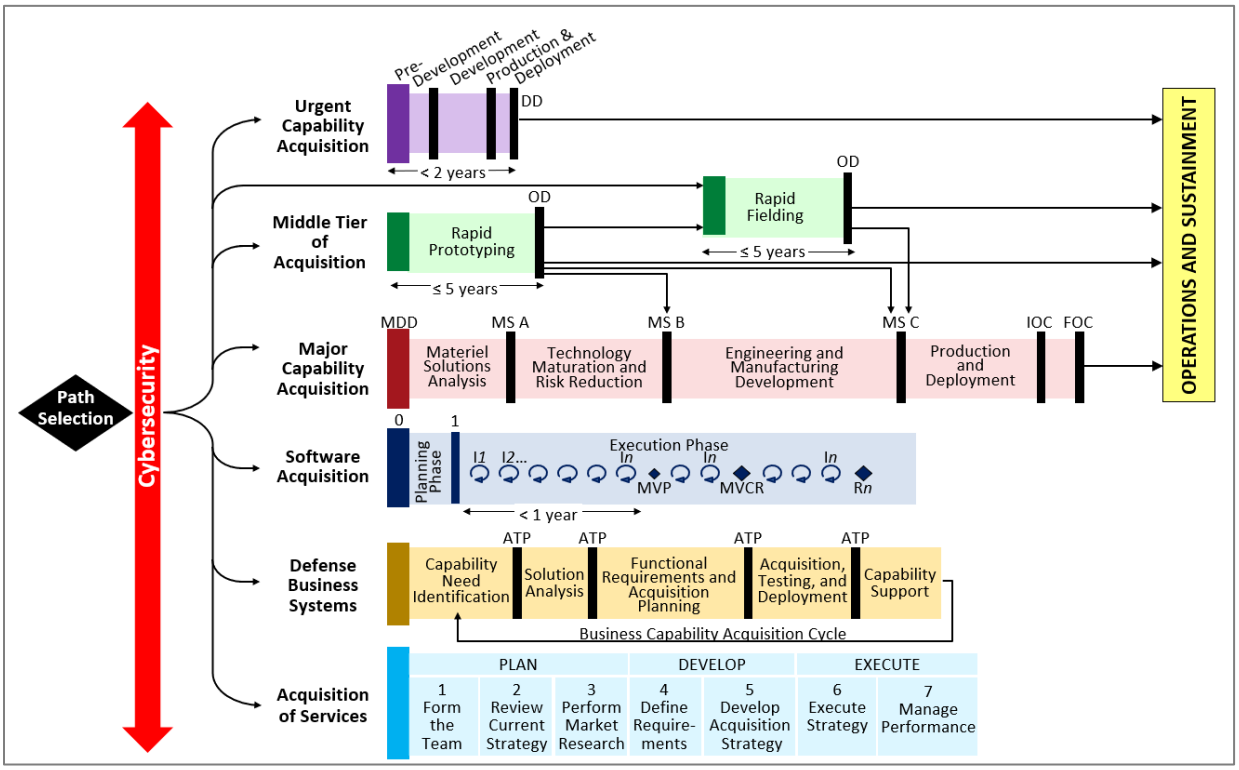


Figure 1. Sample Activity Chart

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

This BoK follows DoDI 5000.02, Operation of the Adaptive Acquisition Framework (AAF), and for the most part will describe M&Q activities for the path labeled "Major Capability Acquisition." 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 acquisition paths as well. AAF paths 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 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 Major Capability Acquisition process in Figure 2 and use those BoK chapters to identify and accomplish required tasks and activities.

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

- DoD Instruction 5000.74, Defense Acquisition of Services
- DoD Instruction 5000.75, Business Systems Requirements and Acquisition
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- 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

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

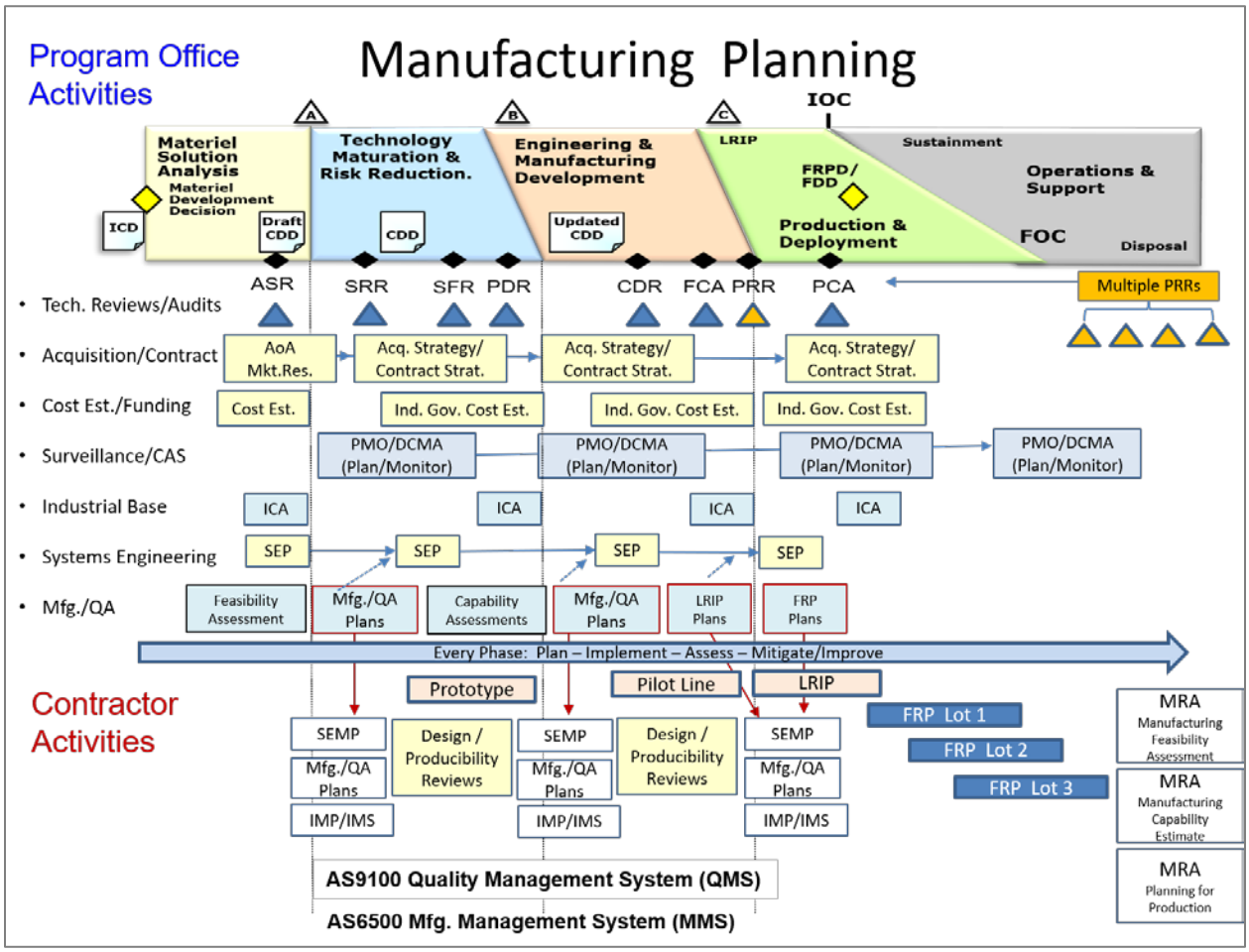


Figure 3. Typical Manufacturing and Quality Planning Activities

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

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occurs. 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), 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-HNBK-896A, "Manufacturing Management Program Guide;" SAE Standard AS6500, "Manufacturing Management Program;" and Quality Management Systems standards ISO 9100 and/or AS9100. As a best practice, DoD PQM managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

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

Sections labeled "Tools and Resources" are provided throughout the document chapters. In addition, following is a summary of key references and links by publisher or topic:

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 Agile 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 5000.60, 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

- Acquisition Notes (AcqNotes) www.acqnotes.com
- Defense Acquisition Guidebook (DAG) https://www.dau.edu/tools/dag
- 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 www.acqnote/acquisitions/acquisition-strategy
- System Engineering Plan (SEP) Outline and Preparation Guidance www.acqnotes.com/acqnote/acquisitions/systems-engineering-plan
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

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

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

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

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

- DFARS Subpart 242.7200, Contractor Material Management and Accounting

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

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

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-896A, 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

Office of the Secretary of Defense (OSD) Cost Assessment and Program Evaluation (CAPE) www.cape.osd.mil

Relevant Government Publications (Available via Web/Internet Search)

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

Standards, Specifications, and Standards Organizations

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

Technology Readiness Levels (TRLs)

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

4. Engineering and Manufacturing Development (EMD) Phase (Milestone B)

Introduction

The purpose of the Engineering and Manufacturing Development (EMD) phase is to develop, build, and test a product to verify that all operational and derived requirements have been met, and to support production or deployment decisions. To accomplish this, the EMD phase involves completing all hardware and software detailed designs, mitigation and closure of open risks and issues, and building and testing of prototypes and/or first articles and verifying compliance with requirements. EMD also includes the Critical Design Review (CDR), which establishes the initial product baseline and transfers configuration control to the program. In preparation for transition to Low-Rate Initial Production (LRIP), the final stage of EMD is producing products that look and operate like final production units. These units are built on a pilot line.

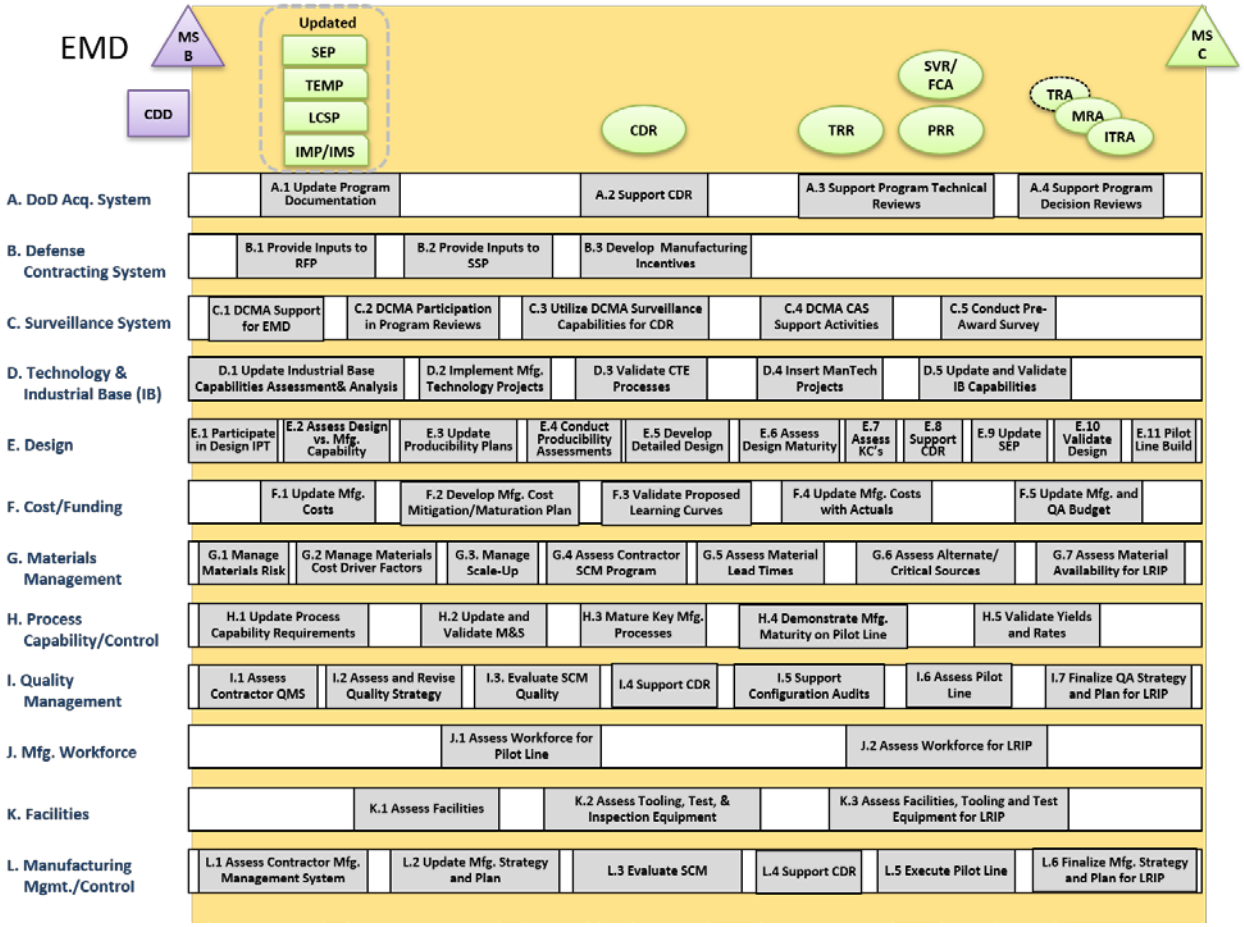


Figure 4-1. EMD Phase Manufacturing and Quality Activities

During EMD, the program will assess the maturity of critical manufacturing processes to ensure they are affordable and executable. Early in the EMD phase, the program's initial manufacturing and quality (M&Q) requirements are identified and allocated. They are refined during EMD based on the results of assessments and analyses to include the design, the contractor, the supply chain, the industrial base, materials, processes, procedures, etc., and are finalized at CDR. Later in EMD, programs will demonstrate M&Q process maturity by production of initial systems on a pilot line. This enables the program to ensure M&Q producibility risks are acceptable, qualifications are complete throughout the supply chain, and manufacturing processes for Key Characteristics (KCs) and critical characteristics will be under statistical process control for LRIP, prior to the production decision at Milestone C.

M&Q managers have three major roles to perform:

- Influence the Design (for producibility)
- Prepare for Production (planning)
- Execute the M&Q Plans (execution)

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

The Technical IPT should have many opportunities to influence the design for producibility to include putting producibility in acquisition plans and contractual documents. In addition, there are numerous technical reviews in which systems engineering technical processes and technical management processes are addressed and assessed. Finally, executing the plan includes all those day-to-day activities that should be managed, assessed and risks identified and mitigated.

M&Q personnel should be key contributors and participants in all technical reviews and program documentation, providing inputs and recommendations based on results from assessments, analyses, and demonstrations. Key program documentation and reviews during EMD include:

- Acquisition Strategy (AS)
    - Manufacturing Strategy
    - Quality Strategy
- Systems Engineering Plan (SEP)
    - Manufacturing Plan
    - Quality Plan
- Test and Engineering Master Plan (TEMP)
- Capabilities Development Document (CDD)
    - Transitioning to Capabilities Production Document (CPD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)
- Critical Design Review(s) (CDR)

- Test Readiness Review (TRR)
- Pilot Line Demonstration(s)
- System Verification Review (SVR)/Functional Configuration Audit (FCA)
- Production Readiness Review(s) (PRR)
- Manufacturing Readiness Assessment (MRA)
- Independent Technical Risk Assessment (ITRA)
- Technology Readiness Assessment (TRA)
- Milestone C Decision

Manufacturing and Quality Objectives

M&Q risks, issues, and opportunities are important factors in making the decision to proceed within all phases of development and production. The producibility of the design and risks were reviewed prior to entry into the EMD phase; however, there may be a new contractor(s), a changed industrial base and/or technology base, etc., requiring new or additional assessments.

To meet the EMD phase objective, the program must demonstrate on a pilot line a product capable of meeting system performance requirements within cost and schedule constraints. This requires thorough planning and documentation of hardware and software designs, mitigation and closure of open risks and issues, and compliance with requirements. M&Q's contributions to the EMD phase objective are documented in updates to the Manufacturing Strategy and Plan and the Quality Strategy and Plan which are incorporated into the Acquisition Strategy, the SEP, and the Test and Evaluation Master Plan (TEMP). Risk assessments often occur during one of the many technical reviews and audits that can occur during this phase to include the Independent Technical Risk Assessment (ITRA).

The Office of the Under Secretary of Defense for Research and Engineering (USD(R&E)) established policy for the conduct of ITRAs in accordance with Title 10, United States Code (U.S.C.) section 2448b. These independent assessments should be conducted in accordance with the Defense Technical Risk Assessment Methodology (DTRAM). DTRAM focus areas include:

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

To meet the Production and Deployment (P&D) phase objective of producing "products in Low-Rate Initial Production (LRIP) and deliver to receiving military organizations," M&Q personnel should have a key role during the EMD phase in development of the Request for Proposal (RFP) and the Source

Selection Plan (SSP), including providing M&Q award fee and incentives criteria for the P&D phase. A cohesive effort between the Contracts and M&Q personnel is essential to ensuring that M&Q processes are sufficiently mature for entry into the P&D phase and LRIP.

Day-to-day surveillance of contractor and supply chain activities is key to monitoring progress and maturity of the program as it moves through finalizing the design and demonstration on a pilot line. Reviews and assessments are important oversight tools that the program can use to review and evaluate the state of the system and the program, re-directing activity if necessary. The Defense Contract Management Agency (DCMA) is key to providing monitoring, tracking, and reporting of contractor and supply chain performance, actions, and compliance with all contractual requirements. DCMA and program audits and reviews should be multi-disciplined to ensure that all functional aspects of the program are addressed. This systematic process assesses risk and issues and verifies the application of M&Q best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.) at the contractor and in the supply chain.

DoD policy requires an analysis of the capabilities of the National Technology and Industrial Base (NTIB) to support the design, development, production, operation, uninterrupted maintenance support, and eventual disposal of the system. Without a supporting industrial base, the program may find that accomplishing objectives within the defined cost and schedule will be difficult because of incompatibilities between the requirements and the NTIB available to support program requirements. A key M&Q focus should be on risk mitigation measures needed to sustain a reliable, technologically superior, affordable, and resilient defense industrial base.

The necessity to reduce program risk and the desire to improve program performance while reducing costs can benefit from development, maturation, and implementation of advanced manufacturing technologies. As manufacturing technology project are matured, these ManTech projects should be completed, integrated, and demonstrated on a pilot line at the appropriate contractor and/or supply chain facilities. In addition, DoD Instruction (DoDI) 5000.02, Operation of the Adaptive Acquisition Framework, requires a systematic process that assesses the maturity of Critical Technology Elements (CTEs) for all acquisition programs. In completing the development of a system or incremental capability, one of the key tasks is to mature Critical Manufacturing Processes (CMPs) associated with KCs, and therefore with CTEs.

At CDR, all the design information necessary to plan the detailed manufacturing operations for the system should be available. M&Q participation early in the design process through active participation in the Design IPT is the key to creating a producible design. M&Q planning in EMD should address all areas of M&Q impacting cost, schedule, and performance requirements such as KCs, selection of specific materials, specific M&Q processes, changes in requirements, changes in workforce, facilities, tooling, equipment, etc.

Producibility assessments of the design should be conducted throughout the supply chain using industry best practice tools, techniques, and procedures. Prior to a system-level CDR, the detailed

design must be developed from the component level up to the system level with CDRs conducted to assure meeting design requirements at all levels of the supply chain. Prior to release of drawings to manufacturing, the detailed design drawings, bills-of-material, and product and process specifications must be completed.

Risks associated with M&Q will have a major impact on the maturity of the design. Many system-level risks occur from immature designs and the failure to consider design risks. M&Q must assess maturity based on manufacturing feasibility, capability, producibility, and KCs, in accordance with industry best practices. Manufacturing maturity can be verified and validated by demonstrations of M&Q processes and procedures in a representative environment at the system, subsystem, item, and component level.

Prior to CDR the list of KCs may be reduced through producibility activities as the product design is refined to make KCs less sensitive to variation. As the KCs are finalized by CDR, the corresponding list of critical M&Q processes should also be completed. An assessment of manufacturing readiness to a system-level target of Manufacturing Readiness Level (MRL) 7 can be conducted to confirm manufacturing maturity for CDR.

The role of M&Q to influence the design culminates at CDR. Design decisions made at CDR related to M&Q have major impacts on future production and life cycle costs. These decisions should be documented in the SEP and the AS via updated M&Q Strategies and Plans. Post-CDR activities, including pilot line, will provide the basis for validation of the design and adequacy of the contractor's processes and capabilities including control of KCs.

A successful pilot line build provides validation of the system design, demonstrating the system design is complete. Outputs of the pilot line will produce articles subject to First Article Inspection (FAI) and/or First Article Test (FAT) and will provide validation that M&Q processes are stable, under control, and ready for LRIP.

M&Q cost estimates should be based on detailed M&Q processes and procedures according to industry best practices. Updates should be performed, as necessary, based on current program status and/or learning curves to develop a time-phased manufacturing cost. These updates will require analyses of contractor M&Q Plans regarding costs, cost controls, and cost drivers. As the design progresses to final design at CDR, cost estimates, cost models, and associated cost drivers should be updated with actual cost data from lower level (item and component) pilot lines and production.

Within any program there will be certain systems, subsystems, items, and components the cost of which will dramatically impact the overall system cost. These M&Q cost drivers originate with and evolve from:

- Emerging technologies
- Industrial base limitations and constraints

- Design producibility factors and impacts
- Maturing of M&Q processes (i.e., capability and control)
- Materials (e.g., sourcing, availability, handling, etc.)
- Environmental and Environmental, Safety, and Occupational Health (ESOH) impacts
- Security impacts
- M&Q management
- Supply chain management
- Workforce constraints
- Facilities, equipment, tooling, and test equipment constraints
- Program budget and funding resource limitations and constraints

M&Q should focus on producibility, planning, and risk and issue mitigation for reduction and mitigation of cost drivers.

M&Q should refine the learning curves for the system established in TMRR and collect data to maintain up-to-date cost estimates and budgeting through CDR. Learning curves are then validated by data collected on the pilot lines. Manufacturing cost estimates for LRIP should be based on the completed design, known manufacturing processes, execution of planned M&Q operations, and actual costs realized at the system level on a pilot line. Based on actual data, up to date M&Q cost estimates should be inputs to the program budget and spending plan.

One of the key elements in a successful program is aggressive materials management and planning. Materials management ranges from basic considerations of maturity and availability to understanding management of the supply chain and to details of government-furnished property (GFP), shelf life, security, safety, hazardous materials, storage environment, etc. All program M&Q materials risks, issues, and opportunities should be assessed based on contractor data and plans to meet program M&Q requirements

M&Q should obtain key knowledge on scale-up efforts, and potential supply chain risks and issues to meet CDR exit criteria. Manufacturing capability should be assessed to baseline needed industrial capability. Materials cost drivers must be updated, and appropriate management plans implemented by CDR. This includes assessments of the contractor's materials supply chain for application, implementation, and adherence to industry M&Q best practices, as well as compliance to contractor company policies, processes, procedures, and contracts. Materials and components lead times are critical to both meeting program schedules and defining program requirements for long lead and advanced buys. Lead times for defense materials and components can be long and volatile due to various reasons, such as imbalances between capacity and demand, competition from commercial customers, etc. Pilot line and LRIP procurement requirements (e.g., schedule and quantities), and associated mitigation plans should be developed and implemented for all procurement risks and issues by CDR.

In the EMD phase, M&Q should focus on improving process capability and maturity, reducing costs, maintaining (or improving) schedule, supporting the industrial base, and promoting competition by qualification of alternative sources. Based on pilot line results, M&Q should validate the identification of critical sources throughout the supply chain, including sources of key and/or critical subsystems, items, parts, and components.

In support of updates to Industrial Capabilities Assessment required for Milestone C, M&Q should assess and verify material availability for LRIP. This assessment should address risks, issues, and changes in long-lead procurement, supply chain, counterfeit parts, industrial security (physical and cyber), handling, transportation, storage, and environmental compliance, business climate, diminishing sources, and program plans for P^3I.

Successful completion of the EMD phase with a thorough understanding of materials capabilities, capacities, and limitations and the aggressive management of and planning for materials will ensure effective transition to LRIP and the P&D phase.

M&Q process capability and control should be an integral part of any development program. M&Q efforts should lead to a producible system with the objective of achieving effective and efficient manufacturing processes with process controls to satisfy program requirements with consistent and repeatable products at minimum manufacturing costs. Manufacturing process capabilities and the quality data collected must be measured, controlled, documented, and understood with up-to-date process capability information and indices.

Contractor modeling and simulation (M&S) tools and or products should be familiar to M&Q program personnel, if not, an understanding of the contractor tools, as well as the industry state-of-the-art and best practices for M&S is necessary. The contractor tools should be up-to-date and validated for applicability, adequacy, and consistency with industry best practices.

During the EMD phase the contractor will conduct demonstrations that include testing and analysis to ensure products meet the program requirements. These products will be built on pilot lines. The processes used on the pilot lines should be evaluated to understand the difficulties and quantify the risks to be mitigated for LRIP. Results of the pilot lines and the associated assessments should be incorporated to provide an up-to-date, accurate M&S of the system. Actual data collected on the pilot lines provide up-to-date data for yields and rates, and validation of all M&Q learning curves for the system and subsystems.

These assessments and demonstrations should provide an understanding of the contractor's process capabilities, M&S tools, and yields and rates, and support program M&Q planning, resource loading, facilities management, etc., for future phases.

An effective quality management system (QMS) is required for operationally safe, suitable, and effective systems. A quality management system compliant with industry standards ISO 9001 or

AS9100 is the foundation to producing products that meet requirements. The quality system ensures the as-delivered configuration is the same as the as-designed and as-tested configuration. In early EMD, during design development, programs should assess that the contractor's QMS supports and aligns with program M&Q strategy, objectives, and goals. This requires the use of process audits of the contractor's and supply chain activities, resources, and behaviors. Participation of DCMA will provide expert assistance in conducting these audits.

The M&Q Strategies should require quality assessments of the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a pilot line, prior to Milestone C. Revision to the quality strategy, plans, and objectives may be required based on the results of process audits and quality assessments. For CDR, an assessment of the allocated baseline against the initial product baseline should ensure that quality parameters (e.g., tolerance, process capability indices, etc.) for considerations such as weight, power, cooling, etc. have been appropriately specified in the detailed design. This includes completion of all drawings and specifications with tolerances and test points under configuration control for all KCs, Critical Safety Items (CSIs) and/or Critical Application Items (CAIs).

A system-level Functional Configuration Audit (FCA) should be conducted to assess performance of the system against the functional baseline and may be conducted in conjunction with the system-level System Verification Review (SVR). Quality and quality personnel should be an integral element in both the FCA and the SVR. The system-level FCA should assess the collected data, test results, analysis results, and M&S output and accuracy of the system after completion of development testing and pilot line. The SVR should address all changes or additions generated since CDR to ensure the as-tested product on the pilot line includes all Engineering Change Proposals, specification change notices and revisions, interface control changes, and all M&Q process changes.

Quality assessments and analyses of pilot lines demonstrate that the M&Q processes and capabilities required for production have matured with high confidence of success. These results should be used to finalize the Quality Strategy and Plan to build production configuration products in the P&D phase.

Workforce skills identification and plans provide inputs to program planning. Workforce planning should align the skills required to the scope of the effort required to develop, field, and sustain the system. In EMD, a comprehensive assessment of contractor manufacturing plans for system development is necessary to understand the requirements for workforce skills, capabilities, training, and certifications in support of pilot line and LRIP workforce requirements. Based on contractor execution of the pilot line and the M&Q workforce results, the program workforce plans contained in the M&Q Strategies should be updated.

Based upon the results of PDR and program progress during early EMD, M&Q personnel should assess the contractor and supply chain facility, tooling, test, and inspection equipment plans. This should include pre-CDR assessments and an update to the M&Q Strategies and Plans for EMD. The results of these assessments should identify, and document risks, issues, and opportunities arising from facility

and tooling shortfalls and document the required planning for mitigation prior to CDR. By CDR, plans should be finalized along with the associated risk and issue mitigation actions. M&Q plans must be finalized prior to execution of a pilot line.

Based on results of pilot line demonstrations, reassess facilities, tooling, equipment, and test equipment requirements, resource requirements, and schedules for LRIP and FRP using the actual data collected. Focused attention on facilities, tooling, equipment, and test equipment in EMD will decrease risk and can be a major factor in avoiding or preventing cost overruns and schedule delays for LRIP and FRP.

The Manufacturing Strategy and Plan are major aspects of development, test, initial production, and other activities essential for program success. During the EMD phase, the government may be working with new prime and subcontractors who will be responsible for completing the design and begin production on a pilot line production. Therefore, the contractor Manufacturing Management System should be assessed, and the M&Q strategies and Plans updated. This includes an assessment of the contractor, and their supply chain for adequacy and alignment of manufacturing with the program Acquisition Strategy (AS). A well-structured manufacturing management system requires effective implementation of industry best practices to include management and mitigation of risks, issues, and opportunities. Assessment of the contractor's manufacturing management system should be performed against the recognized industry best practice (i.e., AS6500).

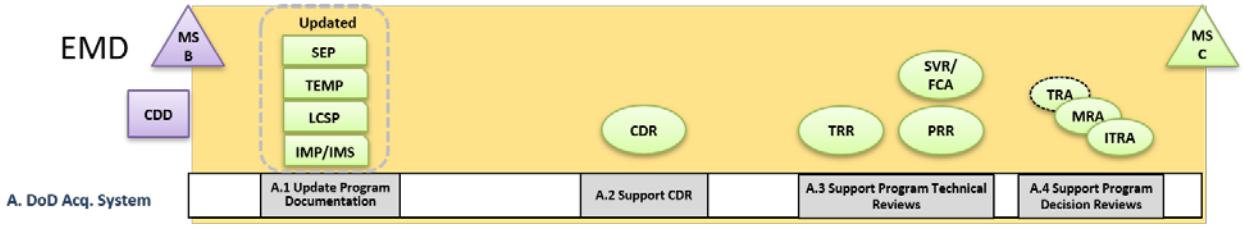
Contractor implementation of best practices should include processes and procedures for supply chain Management. This includes supply chain communications, risks and issues identification and mitigation, KCs control and management, management, control, and monitoring of Technical Performance Measures (and consequently Key Performance Parameters (KPPs), Key System Attributes (KSAs)), process control plans, cyber threat protection measures and manufacturing control systems, security, etc. Results of all these assessments are the basis for maintaining the currency of the program Manufacturing Strategy and Plans.

At CDR, the initial product baseline and documentation is transferred to the program for configuration control. This should include all drawings and specifications with tolerances and test points, all KCs, CSIs, and CAIs specifications, and may include process control plans, work instructions, etc. (i.e., the Technical Data Package (TDP)) to be incorporated in the Manufacturing Strategy and Plans. These should be sufficient, complete, and adequate to enable manufacture of all components and hardware with embedded software throughout the supply chain on a pilot line.

The contractor-designated pilot lines should be assessed for production realism and affordability in production of the system, subsystem, items, and components. Verification and validation of contractor and supply chain manufacturing plans, processes, and procedures should be analyzed during the demonstrations. Based upon these demonstrations and assessments, the Manufacturing Strategy and Plan should be updated, and the TDP should be finalized for LRIP.

The EMD phase ends when the design is stable, the system meets validated capability requirements demonstrated by developmental and initial operational testing as required in the TEMP, manufacturing processes have been effectively demonstrated and are under control, software sustainment processes are in place and functioning, industrial production capabilities are reasonably available, and the system has met or exceeds all directed EMD phase exit criteria and Milestone C entrance criteria.

A. DOD ACQUISITION SYSTEM



The EMD phase objective is to design, develop, and demonstrate on a pilot line a product capable of meeting system performance requirements within cost and schedule constraints. To complete all hardware and software detailed designs, mitigation and closure of open risks and issues, and building and testing of products and first articles, and verifying compliance with requirements, necessitates complete and thorough planning and documentation updates to the Acquisition Strategy, containing the M&Q Strategies, the Systems Engineering Plan (SEP), the TEMP, and plans for program reviews and pilot line demonstrations.

The EMD Acquisition Strategy should document the strategy for completing and verifying the system design and assessing the manufacturing and industrial base readiness. During EMD, industrial and manufacturing readiness should be assessed to include the effective demonstration of manufacturing processes in an appropriate environment, such as a pilot line environment, prior to Milestone C. The pilot line should incorporate key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in low-rate production, using the documented rate production processes planned to be used in LRIP. The Acquisition Strategy should describe the EMD phase plans to assess and demonstrate that manufacturing processes and/or capabilities have matured to a level of high confidence required for production products in the P&D phase.

EMD execution also requires appropriate planning updates in the SEP for all key program events. These reviews include the CDR, the Test Readiness Review (TRR), and after pilot line, the SVR/ FCA, and the end-of-phase Production Readiness Review (PRR) in preparation for transition to LRIP and the Milestone C Decision.

M&Q considerations should be important criteria at each decision point of the system life cycle, and manufacturing criteria used to ensure that a M&Q capabilities exist or will exist when required to produce the system. This capability includes the industrial base, factory, workers, processes, material,

sub-contractors, etc. that will be required to produce the system at rate and quality standards necessary to deliver the required capability. During early EMD phase, the producibility of the design and M&Q risks and issues are assessed and mitigated to support finalizing the design culminating in a CDR, which establishes the initial product baseline and transfers configuration control to the program.

M&Q should be a key contributor and participant in all technical reviews, providing documented inputs and recommendations based on results from assessments, analyses, and demonstrations. Post-CDR, the major technical reviews commonly conducted during EMD include the following:

- Test Readiness Review (TRR)
- Human Rating Certification, Flight Readiness Review (FRR), etc.
- System Verification Review (SVR)
- Functional Configuration Audit (FCA)
- Production Readiness Review (PRR)
- Manufacturing Readiness Assessment (MRA)
- Independent Technical Risk Assessment (ITRA)

During the post-CDR phase leading up to the Milestone C Decision, the contractor should demonstrate manufacturing of the system on a pilot line. While TRR, certification reviews, SVR/FCA occur sequentially, pilot line can occur simultaneously with any of these reviews, but all should be complete prior to PRR. In addition to these reviews, M&Q should support and participate in both an MRL assessment of the system using MRL 8 criteria (the target for Milestone C) and a PRR to support Milestone C.

Based on post-CDR, pilot line, and PRR assessment results, M&Q should also provide inputs on the myriad of statutory and regulatory program required updates per DoDI 5000.02 by Milestone C. These include the Acquisition Strategy (e.g., contracting strategy, industrial base considerations, intellectual property (IP) considerations; risk, issue, and opportunity management approach, etc.), the Acquisition Program Baseline, the Cost Analysis Requirements Description (CARD), the Program Protection Plan (PPP), the SEP, etc.

Based on the effective demonstrations of manufacturing processes conducted on the pilot line, M&Q should support and participate in the program's decision processes on acceptability of manufacturing and producibility risks, supplier qualifications, and verification of manufacturing processes under statistical process control required for a Milestone C decision.

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

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

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

A.1 Provide Updates to Program Documentation

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

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

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

Manufacturing and Quality Tasks

- Provide inputs and updates to the Acquisition Strategy (AS) based on results, action items, and resolutions pertaining to M&Q requirements, risks, issues, and opportunities from the PDR, CDR, pilot line, and PRR, (i.e., throughout EMD), to address technical progress and management strategy for:
    - Competition and contracting strategies
    - Program manufacturing priorities, allocations, and allotments, and justifications (Defense Priorities and Allocation System (DPAS) code)
    - Management of manufacturing, quality, supply chain, etc.
    - Design feasibility, producibility, KCs, critical characteristics, etc.
    - Implementation of new manufacturing technologies
    - Demonstrations of manufacturing processes in the appropriate environment prior to Milestone C
    - Application of Modular Open Systems Approach (MOSA)
    - Management of IP rights (including deliverables and associated license rights over the entire product life cycle)
    - Management of Materials (characteristics, sourcing, risks, etc.)
    - Manufacturing cyber threat protection measures (*See* L.2)
    - M&Q inputs Life-Cycle Sustainment Plan
    - M&Q process, rates, and quantities (capabilities, control, risks, etc.) (*See* H.1)
    - Facilities, Tooling, and Workforce (including government-furnished equipment (GFE)/government-furnished information (GFI), special test equipment (STE)/special inspection equipment (SIE), special requirements, etc.)
- Develop and provide detailed M&Q requirements and metrics in the Manufacturing Strategy and Plan and the Quality Strategy and Plan (for potential inclusion in appropriate program documentation and management reviews) for:
    - Manufacturing maturity and progress against M&Q goals required for each technical review (PDRs, CDRs, and at other appropriate reviews)
    - Production quantities per year and the total planned production quantity
    - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Environmental Safety and Health (ESOH) (Human safety and health)
    - Hazardous materials management and pollution prevention
    - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
    - Security (physical and cyber) for both hardware and software
    - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
    - Manufacturing supportability and sustainment

  - Management of commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and government-furnished equipment (GFE) (including diminishing manufacturing sources)
  - Management of parts, materials, and processes (PM&P)

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

- Provide M&Q industrial base (IB) capability analyses update for the AS (per DoDI 5000.02) and the RFP to include inputs on:
  - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical processes, parts, components, etc.)
  - Capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Impacts and interdependencies of the program on the NTIB and the analyses used to make this determination including management and future assessments
  - Government strategy and actions necessary to preserve the IB capabilities (e.g., incentivizing the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)

- Maintain M&Q inputs to Manufacturing Strategy and Plan and the Quality Strategy and Plan on ManTech and/or contractor manufacturing technology project implementation and status for high-risk manufacturing capabilities and processes (*See* D.2)
  - Include M&Q risks, issues, and opportunities
  - Include plans for insertion of the new manufacturing capability

- Provide and maintain updated M&Q inputs and plans to the IMP/IMS including:

  - Schedule for any planned use of government-furnished special test equipment, government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.)
  - Schedule impacts from the requirements for special materials and allotments with justification
  - M&Q internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
  - Inputs on reviews including the sub-tier level (including CDR, PRR, etc.), documentation inputs (e.g., CDD, TEMP, AS, SEP, CDR, PRR, etc.), production events, and deliveries

- Update the government Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan for EMD to include (*See* I.1 and L.1 for assessment of contractor and I.2 and L.2 for update considerations):
  - Updates to M&Q requirements
  - Definition and agreement on requirements for manufacturing environments pilot line, LRIP, and FRP
  - Up-to-date TDP
  - M&Q resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to M&Q organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
  - Changes to M&Q support organization required to meet program projected needs for P&D and subsequent phases including:
    - Earned Value Management requirements
    - Cost control requirements
    - Data collection, reporting, and management

- Update the M&Q requirements for the P&D contractor's Manufacturing Management System (MMS) and Quality Management System (QMS) to be included in the AS and the RFP.
  - Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
  - If M&Q standards are not specified, develop alternative requirements for program specific manufacturing management plan and quality management plan.
  - Identify M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle

- Ensure a joint M&Q comprehensive Risk, Issue, and Opportunity Management System that can identify, and tracking risks and associated mitigation plans is in place.

  - Ensure requirements are up-to-date and maintained for identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program
  - Analyze mitigation plans for adequacy and completeness, and potential impacts on EMD and subsequent phases to include:
    - Industry being unable to provide program design and/or manufacturing capabilities at planned cost and schedule
    - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
    - Required maturation of critical technologies and manufacturing processes to the appropriate level
    - M&Q cost and schedule impacts

- Ensure other agencies are providing inputs on strategies (e.g., DCMA, DLA, etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.
- Provide, update, and maintain M&Q inputs to the SEP and Test Engineering Master Plan (TEMP) to address technical progress and strategy including the following:
  - M&Q updates on KCs, critical characteristics, and Technical Performance Measures, and the associated impacts on KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Updates on significant activities to the EMD program schedule including:
    - Risk and issue mitigations
    - Manufacturing assessments
    - Critical Design Reviews (including supply chain)
    - Long-lead or advanced procurements
    - Prototype builds and demonstrations
    - Projected lots or phases
    - Production Readiness Reviews
    - Independent reviews and audits
    - Changes or impacts to the workforce (i.e., strikes), supply chain (i.e., disruptions)
    - Environmental impacts (e.g., floods, fires, earthquakes, etc.)
  - Updated outputs and status from the joint Risk, Issue, and Opportunity Management System and mitigations.
  - Updated M&Q inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
    - Compliance with DFARS, PPP, ITAR, etc.

        - Management of Controlled Unclassified Information
        - Technical approaches to cybersecurity and related M&Q security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
    - Application of up-to-date industry best practices for manufacturing to include:
        - Manufacturing Management System
        - Design for Manufacturing
        - Manufacturing Risk Identification (including mitigation)
        - Manufacturing Planning
        - Manufacturing Operations Management
    - Up-to-date inputs on the M&Q organization, billets and key assignments including:
        - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
    - Up-to-date M&Q planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
    - Up to date M&Q inputs to the configuration managed IMP/IMS including critical path
    - Requirements for manufacturing environments (e.g., pilot line, LRIP, FRP)
    - Requirements for the TDP (including IP)
- Provide M&Q requirements for sustainment (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.) and sustainment processes and activities for the LCSP.

Metrics

- The AS has been maintained and is up-to-date based on the results, action items, and resolutions pertaining to M&Q requirements, risks, issues, and opportunities and provides status for program technical progress and management strategy for:
    - Competition and contracting strategies
    - Program manufacturing priorities, allocations, and allotments, and justifications (DPAS code)
    - Management of manufacturing, quality, supply chain, etc.
    - Design feasibility, producibility, KCs, critical characteristics, etc.
    - Implementation of new manufacturing technologies
    - Demonstrations of manufacturing processes in the appropriate environment prior to Milestone C
    - Application of Modular Open Systems Approach (MOSA)
    - Management of IP rights
    - Management of materials

  - Manufacturing cyber threat protection measures
  - M&Q inputs Life-Cycle Sustainment Plan
  - M&Q process, rates, and quantities
  - Facilities, tooling, and workforce

- Manufacturing Strategy and Plan and the Quality Strategy and Plan document have detailed M&Q requirements and metrics for:
  - Manufacturing maturity and progress against M&Q goals required for each technical review
  - Production quantities per year and the total planned production quantity
  - Certifications (e.g., Flight Operations/Safety, Human Rating, etc.)
  - ESOH
  - Hazardous materials management and pollution prevention
  - Environmental parameters
  - Security (physical and cyber) for both hardware and software
  - Data management and software
  - Manufacturing supportability and sustainment
  - Management of COTS, GOTS, and GFE
  - Management of PM&P
- Manufacturing Strategy and Plan and the Quality Strategy and Plan have been updated and document the sustainment of industrial base capabilities and the required maturation to occur during the EMD and subsequent phases, including inputs on:
  - Product or component obsolescence, use and replacement of limited-life items, options for unique manufacturing processes and products, and the capability to convert off-the-shelf items to required specifications at the subsystems, item, and component levels
  - Products or components 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
  - DMSMS
  - Watch-list of critical items, parts, and components and their sources through a CCL
- An updated M&Q industrial base (IB) capability analyses has been completed and has been provided as input for the AS (per DoDI 5000.02) and the RFP to include:
  - IB capabilities, fragility, gaps, and risks
  - 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

- M&Q inputs to Manufacturing Strategy and Plan and the Quality Strategy and Plan have been maintained and are up-to date for ManTech and/or contractor manufacturing technology project implementations and status including:
  - M&Q risks, issues, and opportunities
  - Plans for insertion of the new manufacturing capability

- Updated M&Q inputs and plans have been provided 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

- Government Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan for EMD has been updated and includes:
  - 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
  - Potential changes to M&Q organization and staffing with 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

- M&Q requirements for the P&D contractor's MMS and QMS have been updated in the AS and the RFP, including:
  - Standards to be used for industry best practices
  - Alternative requirements for program specific manufacturing management plan and quality management plan, if M&Q standards are not specified

  - M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle

- A joint M&Q comprehensive Risk, Issue, and Opportunity Management System has been implemented, is in place, including:
  - Up-to-date and maintained identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities
  - Mitigation plans that adequately and completely address 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
- Other agencies are providing documented inputs on strategies (e.g., DCMA, DLA, etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.
- M&Q inputs to the SEP and TEMP have been maintained and provide up-to-date status for technical progress and strategy including:
  - 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 M&Q scheduled activities during EMD 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)

- M&Q requirements for sustainment (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.) and sustainment processes and activities have been documented and provided for the LCSP.

Tools

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

- Technology Readiness Level (TRL) Assessment Checklist
  - Manufacturing Maturation Plan
  - Quality Assurance Plan
- Test and Evaluation Master Plan (TEMP) Outline

Resources

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems
- CDD-CPD Writing Guide
- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities
- DoDI 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288, System and Software Engineering
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- ISO 9001:2015, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK Manufacturing Management Program Guide
- Risk, Issue, and Opportunity Management Guide for Defense Programs
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment (TRA) Deskbook
- Test and Evaluation Management Guide

A.2 Support Critical Design Review

M&Q personnel should be actively engaged in the organization and execution of the CDR during this phase. The CDR occurs roughly mid-point in the EMD phase. The CDR brings to closure design paths in detailed design. Any changes moving forward should only be accomplished through a formal Engineering Change Proposal (ECP). The completion of the CDR should provide:

- An established system initial product baseline
- An updated risk assessment for EMD
- An updated CARD based on the system product baseline
- An updated development schedule for fabrication, test and evaluation, software coding critical path drivers
- An approved Life Cycle Sustainment Plan

Manufacturing and Quality Tasks

- Ensure the program's Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan are updated for CDR.
    - Include program M&Q staffing, training, and certifications
    - Include an update to program M&Q processes and metrics
    - Ensure draft certification plans have been developed and cover all required system certifications (e.g., Flight Operations/Safety, Human Rating, etc.)
- Support an MRL assessment of the system using MRL 7 criteria as the target for CDR.
    - Assess and validate all threads including M&Q materials, facilities, tooling, etc.
- Ensure system baseline documentation for M&Q is under configuration control, and is sufficient, complete, and adequate to enable component manufacturing, hardware fabrication and software implementation to proceed.
    - Ensure all subsystem, item, and components are included in the system baseline
    - Ensure all KCs, CSIs, and CAIs have complete drawings and specifications under configuration control
    - Ensure all product data essential (e.g., drawings, specifications, interfaces, etc.) for component manufacturing has been released
- Ensure all M&Q inputs to the AS and the SEP are up to date for CDR (*See* A.1).
- Ensure all subsystem, item, and component CDRs are complete, under configuration control, and the results available for the system CDR.
    - Ensure all design maturity assessments are closed and approved for system CDR
    - Include all appropriate subsystem, item, and component reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.)
    - Include all system, subsystem, item, and component interfaces (internal and external)
- Ensure all M&Q trade studies and producibility assessments are complete and are incorporated into the system for CDR.
    - Include ongoing producibility enhancement efforts
- Ensure M&Q input to the schedule (IMP/IMS) and the associated critical path is up-to-date and is executable with acceptable risks.
    - Includes supply chain
    - Includes integration and test
- Ensure all key and critical manufacturing processes, including process control plans and metrics, have been defined, characterized, updated for the detailed design, and the capability to meet design tolerances and are tracked.
- Ensure M&Q data management system addresses:

  - Communications and availability
  - Data collection, capacity, processing, storage, and control
  - Security (physical and cyber), information security and access

- Analyze plans for make/buy and long-lead procurement requirements and incorporate results into procurement plans.
- Analyze the assessments of adequacy and completeness of M&Q requirements validation activities (*See* E.6):
  - Include prototypes and demonstrations in a representative environment at the system level for design maturity
  - Ensure all CSIs and/or CAIs are traceable to key and critical M&Q processes
  - Include demonstrations of manufacturing processes in appropriate environments for the required level of maturity (e.g., subsystem, item, and component)
  - Ensure all identified KCs, CSIs, and CAIs are incorporated into the Verification Cross-Reference Matrix (VCRM) for required testing and verification
- Ensure traceability of M&Q KCs to Critical Manufacturing Processes (CMP) to Technical Performance Measures (TPM) to allocated baseline requirements up to KPPs and KSAs.
- Support design reviews at all levels of the supply chain, assess adequacy and completeness of M&Q requirements verification and validation activities for system CDR including:
  - Producibility (subsystem, item, and component)
  - Product maturity
  - Technology maturity
  - Interoperability, interdependencies, and interfaces (internal and external)
  - Alternate sources to include availability and maturity
  - Systems Integration (HSI) and User interfaces
  - Environmental, Safety, and Occupational Health (ESOH)
  - Hazardous materials management and pollution prevention processes
  - Modular Open Systems Architecture (MOSA)
  - Commercial, Off-The-Shelf (COTS)
  - Non-Developmental Item (NDI)
  - Government-Furnished Equipment (GFE)
- Provide M&Q inputs to the Life Cycle Sustainment Plan for CDR.
- Ensure contractor M&Q management systems for M&Q metrics and data collection and tracking to the component level are in place and functional.
- Ensure M&Q inputs to DT&E processes and assessments are complete and up to date for CDR.
  - Including environments (e.g., thermal, vibrations, shock, and accelerated life testing, etc.)
  - Include required traceability

- Ensure M&Q plans support of OT&E requirements for data and traceability at CDR.
- Ensure the TEMP incorporates all M&Q subsystems, items, and components into plans for tests, test facilities, and test equipment.
    - Include all identified KCs, CSIs, and CAIs are incorporated into the required testing and verification plans
        - Include M&Q impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
    - Include planned significant activities from the up to date EMD program schedule (e.g., manufacturing assessments, long-lead or advanced procurements, prototype demonstrations, projected lots, or phases, PRRs, etc.)
    - Include up-to-date inputs to the joint Risk, Issue, and Opportunity Management System including industrial base, manufacturing, quality, engineering, software (firmware), and risk reduction and/or mitigation efforts
    - Updated planning for M&Q tests, assessments, and verification and validation activities to be conducted, facilities and test equipment to be used, metrics to be tracked, progress against goals, thresholds, and objectives, etc.
- Assess and validate contractor M&Q plans for pilot line requirements.
    - Include materials, facilities, workforce, equipment, test facilities and equipment, tooling, etc.
    - Include EMI control processes and procedures
- Ensure the M&Q considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - Systems Security Engineering (SSE), Communications Security (COMSEC), cybersecurity, and PPP
    - SEMP
    - TEMP
- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure M&Q design producibility improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (*See* E.4).
- Ensure M&Q plans, activities, and processes are executable within the existing M&Q budget to support the approved product baseline and critical path.

- Provide up to date M&Q inputs to the program budget and the CARD.
    - Update and allocate M&Q (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure M&Q cost data including required production costs and production schedule estimates (*See* F.1) are provide for all cost and budget estimates for CDR.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) for M&Q risks, issues, and opportunities and appropriate mitigation plans.
- Ensure adequacy and completeness of mitigation activities for mitigation of M&Q risks, issues, and opportunities in the joint government/ contractor Risk, Issue, and Opportunity (RIO) Management System, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment
- Analyze M&Q plans for adequacy and capability of achieving MRL 8 by initial production.

Metrics

- Program's Manufacturing Management Strategy and Plan and Quality Management Strategy and Plan have been updated for CDR, including:
    - Program M&Q staffing, training, and certifications
    - Program M&Q processes and metrics
    - Draft certification plans (e.g., Flight Operations/Safety, Human Rating, etc.)
- M&Q personnel have supported and provided documented inputs for the system MRL assessment to MRL 7 criteria.
- M&Q personnel have provided inputs to system baseline which is under configuration control and have documented sufficiency, completeness, and adequacy to enable component manufacturing, hardware fabrication and software implementation to proceed.
    - All subsystem, item, and components are included in the system baseline

  - All KCs, CSIs, and CAIs have complete drawings and specifications under configuration control
  - All product data essential (e.g., drawings, specifications, interface control documents, etc.) for component manufacturing has been released

- M&Q personnel have provided documented, up-to-date inputs to the AS and the SEP (*See* A.1).
- All subsystem, item, and component CDRs are complete, under configuration control, and the documented M&Q results available for the system CDR.
  - All M&Q design maturity assessments are closed and approved for system CDR
  - All M&Q data from appropriate subsystem, item, and component reviews are included
  - All M&Q system, subsystem, item, and component interfaces (internal and external) are included
- All M&Q trade studies and producibility assessments are complete and results are documented for the system CDR.
- M&Q personnel have provided up to date (executable with acceptable risks) inputs to the schedule (IMP/IMS) and the associated critical path.
- All key and critical manufacturing processes, including process control plans and metrics, have been updated and documented for the detailed design, and are being tracked.
- M&Q data management system has been assessed and the results document adequacy and sufficiency of:
  - Communications and availability
  - Data collection, capacity, processing, storage, and control
  - Security (physical and cyber), information security and access
- Plans for make/buy and long-lead procurement requirements have been assessed and recommendations documented for procurement plans.
- M&Q requirements validation activities have been assessed and document the adequacy and completeness of (*See* E.6):
  - Prototypes and demonstrations in a representative environment at the system level
  - Traceability of all CSIs and/or CAIs to key and critical M&Q processes
  - Demonstrations of manufacturing processes in appropriate environments for the required level of maturity (e.g., subsystem, item, and component)
  - The VCRM for all identified KCs, CSIs, and CAIs
- Traceability of M&Q KCs to CMPs to TPMs to allocated baseline requirements up to KPPs and KSAs has been established and documented for CDR.
- M&Q requirements verification and validation activities for system CDR have been assessed and document the adequacy and completeness (at all levels of the supply chain), including:
  - Producibility (subsystem, item, and component)

  - Product maturity
  - Technology maturity
  - Interoperability, interdependencies, and interfaces (internal and external)
  - Alternate sources to include availability and maturity
  - User interfaces and Human Systems Integration (HSI)
  - Environmental, Safety, and Occupational Health (ESOH)
  - Hazardous materials management and pollution prevention processes
  - MOSA
  - COTS, NDIs, and GFE

- M&Q personnel have provided documented inputs to the Life Cycle Sustainment Plan for CDR.
- Contractor M&Q management systems have been assessed and documented as in place and functional for M&Q metrics, data collection, and tracking to the component level.
- M&Q personnel have provided documented, up-to-date inputs to DT&E processes and assessments for CDR, including environments and traceability.
- M&Q personnel have provided documented plans for support of OT&E requirements for data and traceability.
- M&Q personnel have reviewed the TEMP for inclusion of:
  - All M&Q subsystems, items, and components
  - All identified KCs, CSIs, and CAIs (for required testing and verification)
    - Including M&Q impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Planned significant M&Q activities from EMD schedule (e.g., manufacturing assessments, long-lead or advanced procurements, prototype demonstrations, projected lots, or phases, PRRs, etc.)
  - Up to date M&Q inputs from the joint Risk, Issue, and Opportunity Management System including mitigation efforts
  - Updated planning for M&Q tests, assessments, and verification and validation activities to be conducted, facilities and test equipment to be used, metrics to be tracked, progress against goals, thresholds, and objectives, etc.
- Contractor M&Q plans for pilot line M&Q requirements have been assessed and the results with recommendations have been documented for CDR, including:
  - Materials, facilities, workforce, tooling, and equipment
  - Test facilities, equipment, tooling, etc.
  - EMI control processes and procedures
- Contractor's M&Q plans and inputs for CDR have been assessed, are up-to-date, and approved, and include documentation for:

  - Parts and Materials (Management) Plan (PMP)
  - Configuration Management Plan (CMP)
  - Software Development Plan (embedded software)
  - Quality Assurance Plan
  - SSE, COMSEC, cybersecurity, and PPP
  - SEMP
  - TEMP

- M&Q quantity estimates for subsystems, items, and components have been updated and documented for CDR based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- M&Q design producibility improvements have been documented and implemented in the system design and/or specifications according to the joint government/contractor schedule (*See* E.4).
- M&Q plans, activities, and processes have been assessed, documented, and are executable within the existing M&Q budget, the approved product baseline, and the critical path.
- Up to date M&Q inputs have been documented and provided for the Program budget and the CARD.
  - M&Q (production) cost models for subsystem, item, and component levels have been updated and are tracked against targets
- Up-to-date M&Q cost data including required production costs and production schedule estimates (*See* F.1) have been documented and provided for the CDR cost and budget estimates.
- Contractor and key supply chain have been assessed for M&Q risks, issues, and opportunities and appropriate mitigation plans (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) and the results are documented for CDR.
- Mitigation of M&Q risks, issues, and opportunities in the joint government/ contractor Risk, Issue, and Opportunity (RIO) Management System, have been assessed and the results document the adequacy and completeness of mitigation activities, including:
  - Key and critical manufacturing processes including embedding software
  - Materials and sourcing
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and hazardous materials management
  - Economic feasibility

  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment
- M&Q plans for achieving MRL 8 by LRIP have been documented.

Tools

- Critical Design Review (CDR) Checklist
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1521B, Jun 1985 (retired)
- NDAA FY 2017 (Public Law 114-328)

A.3 Support Program Technical Reviews

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

- Critical Design Review (CDR)
- Test Readiness Review (TRR)
- System Verification Review (SVR)
- Functional Configuration Audit (FCA)
- Production Readiness Review (PRR)
- Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)
- Independent Logistics Assessment (ILA)

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

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

Manufacturing and Quality Tasks

- Provide M&Q support and inputs to the Test Readiness Review to include:
  - SEP review and recommendations
  - TEMP review and approval process
  - Need for verification and validation of M&Q requirements for Critical Manufacturing Processes (CMP) (and therefore KCs)
  - Results of changes in M&Q processes (flowing from design changes since CDR, other than CMPs) impacting testing requirements and events
  - Requirements for M&Q configuration management of system, subsystem, item, and components (hardware and software) to be tested
  - Status of system, subsystem, item, and components manufacturing process maturity including:
    - Certification processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Process capability indices (C_{pk}) on demonstrated processes
  - Requirements for process capabilities (target $C_{pk)}$
  - Status of established bi-directional traceability (M&Q TPMs to CMPs to KCs
  - Definition of M&Q development test environments used (e.g., thermal, vibrations, shock, and accelerated life testing, etc.)
  - Requirements for M&Q security (physical, cyber, and industrial)
  - Processes, procedures, and documentation of the Failure Reporting, Analysis, and Corrective Action System (FRACAS)
  - Verification that system, subsystem, item, and component parts are produced to approved specifications
  - Direct support of quality personnel to test execution
- Participate in and support the SVR, including:
  - Provide verification that all M&Q CDR action items have been closed and any corrective actions have been successfully completed
  - Provide M&Q inputs on:
    - Verification of requirements from all system, subsystem, item, and component M&Q test data and analyses
    - Verification of performance to the function baseline based on M&Q data

        - Verification through analysis of M&Q data the adequate management and integrity of all critical program information (CPI) (e.g., performance data, yield, and rate data, etc.)
        - Verification that M&Q risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
        - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available M&Q test data, analysis, and inspection
        - Required "certification" activities (e.g., human rating, flight, space, etc.)
        - Analyses of support and maintenance requirements for incorporation into the LCSP
        - Risks of operational test failures during Initial Operational Test and Evaluation (IOT&E)
    - Provide M&Q inputs to:
        - Ensure adequate M&Q processes and metrics are in place
        - Analysis of contractor' s SEMP for appropriate incorporation of M&Q activities and data collection, analysis, and storage
        - Detailed M&Q planning and schedules (with required resources for proceeding into LRIP and IOT&E)
        - Updates of the SEP and contractor's SEMP for the production and deployment (P&D) phase
        - The CARD for up-to-date cost of quality inputs
        - The LCSP (is up to date)
        - The TEMP (i.e., up to date)
        - The Configuration Management Plan (CMP) (s up to date)
- Provide M&Q inputs and support of the FCA to include:
    - Support to program and the contractor agreements that development is complete and data from development tests (DT), analyses, and simulations are sufficient to achieve performance goals
    - M&Q inputs for:
        - Verification of M&Q performance to the baseline
        - Verification traceability documentation for each M&Q requirement
        - Validity and the completeness of embedded software and integration
    - M&Q verification of all approved engineering change proposals (ECP), requests for deviation, and requests for waiver impacting M&Q
    - Verification that all KCs, CSIs, and CAIs are identified, managed, and included in the Verification Cross-Reference Matrix (VCRM)
    - Ensure M&Q provides support to verification activities and tasks to include:
        - Each requirement listed in the VCRM is traceable and is verified with test data, analysis, and/or inspection

  - Demonstration of M&Q processes to provide the capability to satisfy TPMs, KPPs and KSAs thresholds
  - Review of acceptance test reports and deficiencies with root cause and closed corrective actions
  - Certification activities (e.g., human rating, flight/safety, etc.)

- Provide M&Q support and inputs to all Production Readiness Reviews (PRR) in accordance with industry best practices (e.g.., AS6500, AS9100, etc.) on a pilot line to include:
  - All M&Q processes including continuous improvement efforts
  - Manufacturing surveillance and quality data collection and analyses (including supply chain data for items and components)
  - Physical and functional interfaces
  - All work instructions, sequencing, and procedures
  - Process capabilities and process control plans
  - Production scheduling and control
  - Model and Simulations
  - Materials
  - Workforce capabilities
  - Manufacturing technology implementations
  - Tooling, work holding fixtures, jigs, etc.
  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
  - Facilities, transportation, storage, and handling equipment
  - Interdependencies (not all will be validated on the pilot line)
  - Safety processes, procedures, and compliance
  - ESOH processes, procedures, and compliance
  - Security processes, procedures, capabilities, and compliance
  - Risk and issue mitigation results and adequacy of resolution
  - M&Q costs, schedule, performance
  - Materials sources and selections
  - Integration of embedded software

- Provide for PRR results and recommendations of M&Q assessments of industrial base capability and support, conducted for CDR and pilot line demonstrations, for changes in:
  - Sources and alternatives
  - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
  - Vulnerabilities (supply chain)
    - Sole, single, foreign, etc.
    - Military
    - Counterfeit
    - Potential exploitation

        - Fragility and uncertainty of demand
    - Production capability and capacity
    - Security requirements (physical, cyber, and industrial)
    - Availability (e.g., materials, components, equipment, facilities, etc.)
    - Required COTS and NDIs
    - External dependencies
    - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
    - Required government and/or contractor Depot and Maintenance and Repair Operations
- Provide for PRR results and recommendations of M&Q assessments of outputs from the pilot line for adequacy and completeness and validate:
    - Process control plans, including key and critical processes
    - All Production Process Verifications (PPV) performed
    - Attainability of KCs (will be capable and under process control for LRIP)
    - Variability Reduction including updates based on process improvements
    - All FAIs and FATs against specifications, drawings, models, etc.
    - Design changes and process changes identified during pilot line operations, testing, and qualification
    - Certification processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
- Provide M&Q support and inputs to the Critical Design Review (CDR).
- Provide M&Q support and inputs to Manufacturing Readiness Assessments (MRAs).
- Provide M&Q support and inputs to Technology Readiness Assessments (TRAs).
- Provide M&Q support and inputs to Independent Technical Risk Assessments (ITRAs).

Metrics

- M&Q support and inputs to the Test Readiness Review has been documented and include the following:
    - SEMP review and recommendations
    - TEMP review and recommended changes
    - M&Q requirements verification and validation needs (CMPs and KCs)
    - Results of changes in M&Q processes impacting testing requirements and events
    - M&Q configuration management requirements for system, subsystem, item, and components (hardware and software) to be tested
    - Status of system, subsystem, item, and component certification M&Q processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Status of system, subsystem, item, and components manufacturing process maturity with process capability indices (C_{pk})

  - Requirements for process capabilities targets (C_{pk})
  - Status of established bi-directional traceability (M&Q TPMs to CMPs to KCs
  - Definition of M&Q development test environments used (e.g., thermal, vibrations, shock, and accelerated life testing, etc.)
  - Requirements for M&Q security (physical, cyber, and industrial)
  - Processes, procedures, and documentation of FRACAS implementation
  - Verification that system, subsystem, item, and component parts have been produced to approved specifications

- M&Q personnel have participated in and provided documented inputs to the SVR including:
  - Verification that all M&Q CDR action items have been closed and any corrective actions have been successfully completed
  - M&Q inputs on:
    - Verification of requirements from all system, subsystem, item, and component M&Q test data and analyses
    - Verification of performance to the function baseline based on M&Q data
    - Verification through analysis of M&Q data the adequate management and integrity of all CPI (e.g., performance data, yield, and rate data, etc.)
    - Verification that M&Q risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
    - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available M&Q test data, analysis, and inspection
    - Required “certification” activities (e.g., human rating, flight, space, etc.)
    - Results of support and maintenance requirements analyses for incorporation into the LCSP
    - Risks of operational test failures during IOT&E
  - M&Q inputs have been developed and document:
    - Adequate M&Q processes and metrics are in place
    - Adequacy of the contractor’ s SEMP with incorporation of M&Q activities; data collection, analysis, and storage; and any recommended changes
    - Detailed M&Q planning and schedules (with required resources for proceeding into LRIP and IOT&E)
    - Updates to the SEP for the production and deployment (P&D) phase
    - Changes to the CARD with up-to-dated cost of quality inputs
    - Updates for the LCSP, TEMP, and the Configuration Management Plan

- M&Q personnel have supported and participated in, and provided inputs to the FCA to include:

  - Documented support to program and the contractor agreements that development is complete and data from development tests (DT), analyses, and simulations are sufficient to achieve performance goals
  - Documented M&Q inputs to:
    - Verification of M&Q performance to the baseline
    - Verification traceability documentation for each M&Q requirement
    - Validity and the completeness of embedded software and integration
  - M&Q verification of all approved engineering change proposals (ECP), requests for deviation, and requests for waiver impacting M&Q
  - Verification that all KCs, CSIs, and CAIs have been identified, are managed, and documented, and are included in the VCRM
  - Documented M&Q input to verification activities and tasks which included:
    - Each requirement's traceability and verification with test data, analysis, and/or inspection
    - Demonstration of M&Q processes for meeting TPMs, KPPs and KSAs thresholds
    - Review of acceptance test reports and deficiencies with root cause and closed corrective actions
    - Certification activities (e.g., human rating, flight/safety, etc.)
- M&Q verification and validation of contractor pilot line has been successfully conducted and the results have been documented for PRR in accordance with industry best practices (e.g., AS6500, AS9100, etc.), including:
  - All M&Q processes with rigorous continuous improvement processes
  - Disciplined, functional, and accessible manufacturing surveillance and quality data collection system including supply chain
  - Documented, tested, and approved physical and functional interfaces
  - Functional work instructions, sequencing, and procedures
  - Process capabilities and process control plans
  - Functional production scheduling and control processes
  - Refined model and simulations
  - Materials
  - Confirmed workforce requirements, skills, and capabilities
  - Manufacturing technology implementations
  - Tooling, work holding fixtures, jigs, etc.
  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
  - Facilities, transportation, storage, and handling equipment
  - Pilot line interdependencies
  - Safety processes, procedures, and compliance
  - ESOH processes, procedures, and compliance

  - Security processes, procedures, capabilities, and compliance
  - Risk and issue closures and remaining mitigation plans
  - Confirmation of and updates to M&Q costs, schedule, performance
  - Materials sources and selections
  - Integration of embedded software

- Industrial base capability assessments have been updated by M&Q personnel based on results from CDR and pilot line demonstrations, and have been documented and provided to the PRR for changes in:
  - Sources and alternatives
  - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
  - Vulnerabilities (supply chain)
    - Sole, single, foreign, etc.
    - Military
    - Counterfeit
    - Potential exploitation
    - Fragility and uncertainty of demand
  - Production capability and capacity
  - Security requirements (physical, cyber, and industrial)
  - Availability (e.g., materials, components, equipment, facilities, etc.)
  - Required COTS and NDIs
  - External dependencies
  - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
  - Required government and/or contractor Depot and Maintenance and Repair Operations
- Results and recommendations from M&Q assessments of adequacy and completeness of outputs from the pilot line have been documented and validate the following:
  - Process control plans, including key and critical processes
  - All Production Process Verifications (PPV)
  - Attainability of KCs
  - Variability Reduction plans including updates based on process improvements
  - All FAIs and FATs against specifications, drawings, models, etc.
  - All design changes and process changes identified during pilot line operations, testing, and qualification
  - Certification processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
- M&Q personnel supported the CDR.
- M&Q personnel supported Manufacturing Readiness Assessments (MRAs).

- M&Q personnel supported Technology Readiness Assessments (TRAs).
- M&Q personnel supported Independent Technical Risk Assessments (ITRAs).

Tools

- Acquisition Strategy Outline
- Army Acquisition Logistician's Assessment Checklist v.5
- Critical Design Review (CDR) Checklist
- Functional Configuration Audit (FCA) Checklist
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Production Readiness Review (PRR) Checklist
- System Verification Review (SVR) Checklist
- Technology Readiness Assessment (TRA) Checklist
- Technology Readiness Assessment Calculator
- Test Readiness Review (TRR) Checklist

Resources

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- CDD-CPD Writing Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.7.4 Technical Reviews, and Chapter 12.5 Technical Reviews and Audits
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89 Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Independent Logistics Assessment Guidebook
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- ISO 9001:2015, Quality Management System
- Logistics Assessment Guidebook Tool
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896A, Manufacturing Management Program Guide
- Risk, Issue, and Opportunity Management Guide

- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide
- TRA Deskbook

A.4 Support Program Management Decision Reviews

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

Manufacturing and Quality Tasks

- Support an MRL assessment of the system using MRL 8 criteria as the target for the Milestone C decision.
    - Capture the results of M&Q processes, demonstrated on a pilot line, as inputs
    - Verify and validate attainability of KCs (i.e., will be capable and under process control for LRIP) including yields and rates
    - Incorporate results of the required Technology Readiness Assessment
    - Incorporate industrial base viability
    - Verify and validate producibility issues, design stability, and configuration management
    - Verify and validate all LRIP M&Q requirements (e.g., materials, supply chain, workforce, facilities, tooling, manufacturing planning and management, etc.)
- Assess the contractor-designated pilot lines for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:
    - Manufacturing readiness for manufacture of equipment
    - Materials, components, and tooling availability
    - Adequacy of M&Q workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
    - Capability to meet M&Q requirements for LRIP
    - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
    - Capability and capacity to meet rate production (ramp-up to FRP)
    - Capability and capacity to meet program objectives for cost and schedule

- Provide M&Q inputs and updates, for the Milestone C Decision following post-CDR, pilot line, and PRR assessment results (per DoDI 5000.02) to:
  - The Acquisition Strategy
    - Acquisition Approach
    - Benefit Analysis and Determination (required if no Milestone B decision)
    - Business Strategy
    - Contracting Strategy (type and termination liability)
    - Cooperative Opportunities (if necessary)
    - General Equipment Valuation
    - Industrial Base Considerations
    - Intellectual Property (IP) Considerations
    - Modular Open Systems Approach
    - Multiyear Procurement
    - Risk, Issue, and Opportunity Management Approach
    - Small Business Innovation Research/Small Business Technology Transfer
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives (regulatory)
  - Bandwidth Requirements Review
  - Capability Production Document
  - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - Life-Cycle Sustainment Plan (LCSP)
  - Programmatic Environmental Safety and Occupational Health Evaluation (PESHE)and National Environmental Policy Act (NEPA) compliance Schedule
  - Preservation and Storage of Unique Tooling Plan
  - Program Protection Plan (PPP)
  - Request for Proposal (RFP)
  - Should Cost Target
  - Spectrum Supportability Risk Assessment
  - Systems Engineering Plan (SEP)
  - Technology Readiness Assessment (TRA)
  - Test and Evaluation Master Plan (TEMP)
  - Validated On-line Life-cycle Threat (VOLT) Report
- Provide M&Q inputs, updates, and proposed changes for the proposed Production and Deployment (i.e., LRIP) contract, based on post-CDR, pilot line, and PRR assessment results.

- M&Q personnel provide support for the Program Manager's decision process for acceptability of manufacturing and producibility risks, supplier qualifications, and verification of manufacturing processes under statistical process control.
- M&Q personnel provide support for the Program Manager's modular approach to product design and IP.
- M&Q personnel provide verification and validation of adequacy and completeness of TDP (to include management of IP) for Production and Deployment
- M&Q personnel provide support to the corrosion prevention and control process to reduce, control, or mitigate corrosion in sustainment.
- M&Q personnel provide input to the Program Managers for assessment of ESOH risks and acceptance decisions.
- M&Q personnel provide updates to M&Q exit criteria metrics for EMD.
    - Update the M&Q personnel support plan for an assessment of manufacturing readiness and the mandated independent assessment
- Provide M&Q personnel updates to the joint Risk, Issue, and Opportunity Management System for the Milestone C decision.

Metrics

- An MRL assessment of the system using MRL 8 criteria as the target for the Milestone C decision has been conducted by trained SMEs and supported by program M&Q personnel and documents:
    - Results of M&Q processes, demonstrated on a pilot line
    - Attainability of KCs including yields and rates (i.e., will be capable and under process control for LRIP)
    - Results of the required Technology Readiness Assessment
    - Industrial base viability and/or recommendations for IB support activities
    - Closure and/or mitigation of producibility issues
    - Design stability
        - Detailed design of product features and interfaces is complete
        - All product data essential for system manufacturing has been released and is under configuration management
    - All LRIP M&Q requirements (e.g., materials, supply chain, workforce, facilities, tooling, manufacturing planning and management, etc.)
- Pilot lines have been assessed and documented for production realism and affordability of elements required to manufacture systems, subsystems, items, and components including:
    - Manufacturing readiness for manufacture of equipment
    - Materials, components, and tooling availability

  - Adequacy of M&Q workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
  - Capability to meet M&Q requirements for LRIP
  - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
  - Capability and capacity to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule

- M&Q inputs and updates for the Milestone C Decision have been documented and provided to support the following per DoDI 5000.02:
  - 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)
  - CARD, RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - LCSP
  - Programmatic Environmental Safety and Occupational Health Evaluation and National Environmental Policy Act Compliance Schedule
  - Preservation and Storage of Unique Tooling Plan
  - Request for Proposal (RFP)
  - Should Cost Target
  - Spectrum Supportability Risk Assessment
  - Systems Engineering Plan (SEP)
  - Manufacturing Readiness Assessment (MRA)
  - Test and Evaluation Master Plan (TEMP)

- M&Q inputs, updates, and proposed changes have been provided to program management for the proposed O&S contract.
- M&Q personnel have provided documented input to:
  - Program Manager's decision process, including:
    - Acceptability of manufacturing and producibility risks
    - Supplier qualifications
    - Verification of manufacturing processes under statistical process control
  - Program Manager's modular approach to product design and IP
  - Corrosion prevention and control processes to reduce, control, or mitigate corrosion in sustainment
  - Program Manager's for assessment of ESOH risks and acceptance decisions
- TDPs (to include management of IP) have been verified and validated by M&Q for adequacy and completeness and are up to date for P&D.
- M&Q personnel have provided documented updates to exit criteria metrics for EMD.
- M&Q personnel have provided updates to the joint Risk, Issue, and Opportunity Management System for the Milestone C decision.

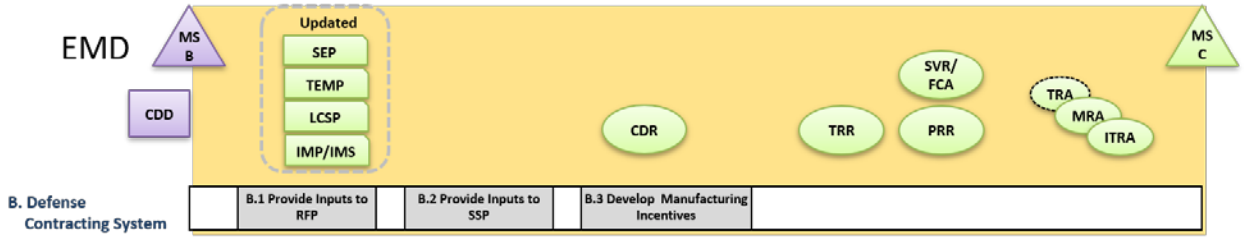
Tools

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

Resources

- DoDI 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
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook

B. DEFENSE CONTRACTING SYSTEM



During the latter part of the EMD phase an essential program activity is to prepare the Request for Proposal (RFP) for the milestone C decision and entrance to the P&D phase. This RFP will delineate what is required from the contractor to produce and deliver requirements compliant products to receiving military organizations. A cohesive effort between all program functional areas and Contracts is essential to managing and completing the steps in this phase of the contracting process.

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

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

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

During each stage of development, an organized and systematic pattern of events must take place if a design is to fully meet all its objectives. Implicit in these objectives is the requirement that a design achieve the highest possible degree of producibility. The requirements for the contractor to identify and describe in detail in the RFP their proposed specific processes and procedures, methods, and

actions to address manufacturing, producibility, and quality risks and issues associated with the proposed system should also be included.

M&Q inputs provided to the RFP development process should be used in development of the Source Selection Plan (SSP) and the Statement of Work (SOW) to ensure availability of the necessary disciplines from the contractor. This includes general and specific requirements for developing data packages, designing special purpose production equipment, and performing computer modeling or simulation of the manufacturing process.

Based on the SSP, proposal evaluation is an assessment of the proposal and the offeror's ability to perform the prospective contract successfully. The SSP evaluations generally include on or more of the following evaluations:

- Cost and/or Price
- Past performance
- Producibility
- Technical and Quality processes
- M&Q capabilities
- M&Q risks, issues, and opportunities
- Application of best practices for the MMS and QMS

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

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

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

- Producibility improvements
- Materials characterization in production relevant environment
- Manufacturing cost reduction efforts
- Manufacturing maturation plan risks burned down
- Variation and variability reduction

- Manufacturing process definition and characterization
- Progress in achieving the targeted MRL
- Progress in maturation and demonstration of KCs (i.e., meeting KPPs/KSAs)
- Progress in achieving specific yield and rate goals
- Progress in meeting the EMD exit criteria

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

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

- Cost (e.g., Cost reductions, Should Costs, Life Cycle Costs)
- Schedule (e.g., expedited development or delivery, early delivery, on-time delivery, etc.)
- Technical (e.g., quality, cycle-time reduction, product improvement, etc.)
- Management commitment
- Producibility processes
- Risk, Issue, and Opportunity Management processes
- Commercial best practices

Contractual incentives assist both government and contractor in understanding of program progress and expedites resolution of M&Q issues. This interaction can serve as a forcing function for the top contractor design personnel to communicate and coordinate decisions with their own manufacturing personnel.

B.1 Provide Input to Request for Proposal

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

Manufacturing and Quality Tasks

- Ensure that M&Q personnel are included in the RFPs writing and review teams.

- Ensure M&Q personnel support the development of RFP requirements, inputs, and outputs and provide M&Q requirements on:
    - Risk, Issue, and Opportunity Management System and processes
    - Design producibility, process capability, and manufacturability assessments, analyses, and reviews (i.e., CDR)
    - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
    - Prototypes, demonstrations, and development tests and analyses
    - Materials characterizations, scale-ups, and analyses
    - Make/buy processes, procedures, and analyses
    - Costs and budget analyses
    - Market research and analyses
    - M&S analyses
    - Process capability and production process verification analyses
    - ESOH, environmental, hazardous materials, safety, security analyses and risks
    - M&Q processes, procedures, and associated data (especially CMPs)
    - Workforce availability, training, and certification analyses
    - Work measurement/learning curve analyses
    - Industrial base assessments and analyses
    - ManTech projects
    - supply chain assessments and analyses
    - DCMA surveillance reports
- Specify the requirements for best practices for the contractor's Manufacturing Management System (MMS) (per Section L.2) and Quality Management System (QMS) (per Section I.2 and per FAR 52.246-11, Higher-Level Contract Quality Requirement) to be used (e.g., AS6500, ISO 9000, AS9100, etc.).
    - Specify the requirements for the contractor to identify and describe in detail their proposed specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and M&Q risks and issues associated with the proposed system
    - Specify a requirement for on-site government Quality personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA)
    - Specify a requirement for on-site government Quality personnel to have access to and inputs on:
        - Perform source inspections and data monitoring
        - Failures and Corrective Actions and resolutions (i.e., FRACAS)
        - Material Review actions and dispositions (i.e., Material Review Boards)
        - Requests for Variance actions and approvals
        - Engineering Change process and approvals

- If AS6500 is not invoked in the contract(s), the manufacturing management requirements cited in AS6500 should be the basis for specific contractual requirements for a contractor Manufacturing Management System and Plan. The requirements, at a minimum, should specify that the contractor addresses:
  - Manufacturing Management System
    - Documenting how, when, and by whom each requirement of their system is to be accomplished and define the authority and responsibility for each.
  - Design Analysis for Manufacturing
    - Conducting producibility analyses
    - Identifying and managing key and critical characteristics in the TDP
    - Implementing Variability Reduction (VR) to reduce part to part variation of key and critical characteristics
    - Identifying and managing key and critical manufacturing processes
    - Conducting Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
  - Manufacturing Risk Identification
    - Integrating manufacturing risk management activities into the program risk, issue, and opportunity management process to include the identification of manufacturing risk areas and the development and implementation of risk mitigation plans tracked to completion
    - Conducting and documenting manufacturing feasibility assessments for a competing design alternative
    - Identifying MRL targets and documenting manufacturing risks through the MRL assessments
  - Manufacturing Planning
    - Establishing and maintaining a manufacturing plan that includes supply chain and material management, manufacturing technology development, manufacturing M&S, manufacturing costs, manufacturing system verification, manufacturing workforce, and tooling, test equipment, and facilities.
  - Manufacturing Operations Management including:
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - Production Process Verification
    - First Article Inspections and First Article Tests

        - Supplier Management and Quality

- If ISO 9000 or AS9100 is not invoked in the contract(s), the quality management requirements cited in the standards should be the basis for specific contractual requirements for a contractor Quality Management System and Plan. The requirements, at a minimum, should specify that the contractor addresses:
    - Quality Management Leadership
        - Leadership and Commitment
        - Policy
        - Organizational Roles, Responsibilities, and Authorities
    - Quality Planning
        - Actions to Address Risks and Opportunities
        - Quality Objectives and Planning
        - Planning of Changes
    - Quality Support
        - Resources
        - Competence
        - Awareness
        - Communication
        - Documented Information
    - Operation
        - Operational Planning and Control
        - Requirements for Products and Services
        - Design and Development of Products and Services
        - Control of Externally Provided Processes, Products, and Services
        - Production and Service Provision
        - Release of Products and Services
        - Control of Non-conforming Outputs
    - Quality Performance
        - Monitoring, Measurement, Analyses, and Evaluation
        - Internal Audit
    - Quality Improvement
        - Nonconformity and Corrective Actions (i.e., FRACAS)
        - Root Cause Identification
        - Continual Improvement

- Identify appropriate M&Q Contract Data Requirements List (CDRL), Data Item Description (DID), etc. to support M&Q processes, include the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.)
    - Specify a requirement for on-site government Quality personnel will have access to perform source inspection of the plan (include on-site government Quality personnel (i.e., DCMA) in contractual distribution of the Program Quality Plan (ref. I.2))
- Provide M&Q inputs and support for specification of industry best practices for Systems Engineering to be used (e.g., IEEE 15288, -1, -2, etc.) in the RFP.
    - Include requirements for the contractors to identify and to describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Provide M&Q inputs and support to contractual requirements for:
    - Content for Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (*See* B.4)
    - Conducting M&Q reviews of engineering and software (with frequency of reviews)
    - IP and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
    - Identification and description of producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
    - Facilities, tooling, test equipment, and workforce
    - Supply chain management
    - Management of parts and materials (e.g., make/buy, planning, etc.) including:
        - Long-lead
        - Sources and risks (sole, single, foreign, fragile, and critical)
        - Handling and storage
        - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
        - Conservation of critical/strategic materials
        - Counterfeit avoidance
        - Obsolescence
        - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
        - Reduction/elimination of foreign dependency
        - Standardization of components, items, and parts
    - Configuration management
    - Life-Cycle Sustainment Plan (LCSP)
    - Performing analyses of failure mode effects and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
    - Traceability of CSIs and/or CAIs to all key and critical M&Q processes (CMP)

  - Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
  - Providing systematic application of statistical process controls and meeting required process capability (C_{pk}) goals
  - Providing a system for collection, storage, analysis, and management of M&Q data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
  - Manufacturing technology capability improvements
  - Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
  - A joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
  - M&Q Variability Reduction program to include root cause corrective action
  - Appropriate cyber threat protection program including:
    - Safeguarding M&Q information, designed in systems protection, supply chain risks, hardware, and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
    - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
    - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
    - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security
  - Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
  - COTS, GOTS, GFE, and NDIs
  - Metrics to be met as exit criteria

- Provide M&Q inputs and support to specialized system requirements and/or certifications, such as Flight Operations, Space Operations, etc.
- Specify the M&Q requirements that the contractor support and/or conduct, as required:
  - Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to Full-Rate Production Decision Review (FRPDR)
  - MRL assessments with trained personnel using the MRL criteria
  - Independent risk assessments as directed

  - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
  - Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities
- Provide M&Q inputs on requirements for the contractor to:
  - Support of on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
  - Address capital investments
  - Provide specific, detailed workforce, facilities, and capacity plans for LRIP and FRP including:
    - Relocations
    - Restarts
    - Changes in materials, manufacturing processes, and/or suppliers
    - Processes, procedures, improvements, etc.
  - Address meeting program schedule and critical path
  - Manage the supply chain (e.g., products, locations, capacities, capabilities, monitoring, etc.)
  - Manage tooling, Special Test Equipment (STE), and Special Inspection Equipment (SIE)
  - Support and conduct a Continuous Process Improvement (CPI) program
  - Use, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
  - Support and maintain the IMP/IMS including the critical path
- Provide M&Q inputs on requirements for the contractor to define manufacturing methods and production flow to include:
  - Advanced or unique manufacturing technologies required
  - Production flow including the planned fabrication and assembly key points
  - Production test and/or inspections
  - Planned flow of major manufacturing operations
  - Expected process yields and statistical or other methods for process control
- Provide M&Q inputs on requirements for contractor support and maintenance of and up-to-date TDP.

Metrics

- M&Q personnel have provided support for the development of RFP requirements, inputs, and outputs and provide M&Q requirements on:
  - Risk, Issue, and Opportunity Management System and processes

  - Design producibility, process capability, and manufacturability assessments, analyses, and reviews
  - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
  - Demonstrations and development tests and analyses
  - Materials characterizations, scale-ups, and analyses
  - Make/buy processes, procedures, and analyses
  - Costs and budget analyses
  - Market research and analyses
  - M&S analyses
  - Process capability and production process verification analyses
  - ESOH, environmental, hazardous materials, safety, security analyses and risks
  - M&Q processes, procedures, and associated data (especially CMPs)
  - Workforce availability, training, and certification analyses
  - Work measurement/learning curve analyses
  - Industrial base assessments and analyses
  - ManTech projects
  - Supply chain assessments and analyses
  - DCMA surveillance reports

- Requirements for best practices for the contractor's MMS (per Section L.2) and QMS (per Section I.2) to be used have been documented and specify:
  - Requirements for the contractor to describe in detail proposed specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and M&Q risks and issues associated with the proposed system
  - Requirements for on-site government Quality personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA)
  - Requirements for on-site government Quality personnel to have access to and inputs on:
    - Source inspections and data monitoring
    - FRACAS and resolutions
    - Material Review actions and dispositions (i.e., Material Review Boards)
    - Requests for Variance actions and approvals
    - Engineering Change process and approvals

- AS6500 manufacturing management requirements have been contractually specified as requirements for a contractor MMS and Plan. The requirements, at a minimum, specify that the contractor addresses:
  - Manufacturing Management System
  - Design Analysis for Manufacturing:
  - Manufacturing Risk Identification:
  - Manufacturing Planning:

  - Manufacturing Operations Management including:

- ISO 9000 or AS9100 quality management requirements have been contractually specified as requirements for a contractor QMS and Plan. The requirements, at a minimum, specify that the contractor addresses:
  - Quality Management Leadership
  - Quality Planning
  - Quality Support
  - Operation
  - Quality Performance
  - Quality Improvement
- Appropriate requirements for M&Q CDRLs, DIDs, etc. have been documented that specify support of M&Q processes, including the requisite approval and change process, including:
  - Requirement for on-site government Quality personnel access to perform source inspection of the plans
- M&Q inputs and support have been documented and provided for specification of industry best practices to be used for Systems Engineering in the RFP.
  - Requirements that the contractor describe their proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering are included
- M&Q personnel have documented and provided contractual inputs and/or requirements for:
  - Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (*See* B.4)
  - Conducting M&Q reviews of engineering and software (with frequency of reviews)
  - IP and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Identification and description of producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
  - Facilities, tooling, test equipment, and workforce
  - Supply chain management
  - Management of parts and materials (e.g., make/buy, planning, etc.) including:
    - Long-lead
    - Sources and risks (sole, single, foreign, fragile, and critical)
    - Handling and storage
    - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
    - Conservation of critical/strategic materials
    - Counterfeit avoidance
    - Obsolescence

  - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
  - Reduction/elimination of foreign dependency
  - Standardization of components, items, and parts
- Configuration management
- Life-Cycle Sustainment Plan (LCSP)
- Analyses of failure modes, effects, and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
- Traceability of CSIs and/or CAIs to all key and critical M&Q processes (CMPs)
- Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
- Systematic application of statistical process controls and meeting required process capability (C_{pk}) goals
- A system for collection, storage, analysis, and management of M&Q data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
- Manufacturing technology capability improvements
- Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- A joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
- M&Q Variability Reduction program to include root cause corrective action
- A cyber threat protection program including:
  - Safeguarding M&Q information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
  - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
  - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security
- Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
- COTS, GOTS, GFE, and NDIs
- Metrics to be met as exit criteria

- M&Q personnel have documented and provided inputs and support to specialized system requirements and/or certifications, such as Flight Operations, Space Operations, etc.
- M&Q requirements have been documented and specify that the contractor support and/or conduct:
    - 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
- M&Q personnel have documented inputs have been provided on contractor's requirements to:
    - Support of on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
    - Address capital investments
    - Provide specific, detailed workforce, facilities, and capacity plans for LRIP and FRP including:
        - Relocations
        - Restarts
        - Changes in materials, manufacturing processes, and/or suppliers
        - Processes, procedures, improvements, etc.
    - Address meeting program schedule and critical path
    - Manage the supply chain (e.g., products, locations, capacities, capabilities, monitoring, etc.)
    - Manage tooling, Special Test Equipment (STE), and Special Inspection Equipment (SIE)
    - Support and conduct a Continuous Process Improvement (CPI) program
    - Use, where applicable, a Material Management and Accounting System (MMAS) in accordance with DFARS 252.242-7004 (e.g., MRP, MRPII, ERP, etc.)
    - Support and maintain the IMP/IMS including the critical path
- M&Q personnel have documented inputs have been provided on requirements for the contractor to define manufacturing methods and production flow including:
    - Advanced or unique manufacturing technologies
    - Planned fabrication and assembly key points
    - Production test and/or inspections
    - Major manufacturing operations

  - Expected process yields and statistical or other methods for process control
- M&Q personnel have documented and provided inputs for contractor requirements to maintain an up-to-date TDP.

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IG5315.204-5(b), Section L Guide and Template
- IG5315.204-5(c), Section M Guide and Template
- ISO 9001, Quality Management System Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288, System and Software Engineering
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- ISO 9000, Quality Management System
- MIL-HDBK-896A, Manufacturing Management Program Guide
- MIL-STD-882, DoD System Safety
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems (ICS) Security

B.2 Provide Input to Source Selection Plan

FAR 15.101, “Best Value” section, states that an agency can obtain best value in negotiated acquisitions by using any one or a combination of source selection approaches. The Source Selection Plan (SSP) is a key document which specifies how the source selection activities will be organized, initiated, and conducted. The SSP serves as the guide for conducting the evaluation and analysis of

proposals, and the selection of contractor(s) for the acquisition. SSP must clearly and succinctly express the government's minimum needs (evaluation factors) and their relative order of importance. M&Q managers, as members of the Technical IPT, should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Ensure that M&Q personnel are included in the Source Selection Plan (SSP) writing and review teams.
- Specify metrics and scoring that at a minimum address the contractor(s) plans, processes, and procedures based on analyses of EMD M&Q outputs, for:
    - Quality Management System (QMS)
    - Risk, Issue, and Opportunity Management System and processes
    - Design producibility, process capability, and manufacturability assessments, analyses, and technical and management reviews
    - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
    - Demonstrations and development tests
    - Materials
    - Materials management (i.e., make/buy processes, procedures, and analyses)
    - Costs and budget estimates
    - Market research and analyses
    - Modeling and simulations
    - Process capability and production process verifications
    - ESOH, environmental, hazardous materials, 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 Quality Management System (QMS) and Plan (e.g., AS6500, ISO 9000, AS9100, etc.).
    - SSP should delineate and include metrics and scoring for preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and M&Q risks and issues associated with the proposed system
    - Plan should delineate and include metrics and scoring for accommodation and support of on-site government Quality personnel to have access to perform management and quality system audits (e.g., program office and/or DCMA) including:

        - Source inspections and data monitoring
        - Failures and Corrective Actions and resolutions (i.e., FRACAS)
        - Material Review actions and dispositions (i.e., Material Review Boards)
        - Requests for Variance actions and approvals
        - Engineering Change process and approvals

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

  - First Article Inspections and First Article Tests
  - Supplier Management and Quality

- Ensure that the requirements cited in quality standards (ISO 9001 or AS9100) are the basis for specific SSP metrics and scoring of the contractor(s) Quality Management System and Plan even if these standards are not called out in the contract. The SSP should delineate and specify metrics and scoring for:
  - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
  - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management
  - Quality support with resources, competence, awareness, communication, and documented information
  - Operation including operational planning and control, products and services requirements, and design and development
  - Control of externally provided processes, products, and services
  - Production and service provision
  - Release of products and services
  - Control of non-conforming outputs
  - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
  - Quality improvement including nonconformities and corrective actions, and continual improvement

- Specify metrics and scoring to rank contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment with program goals (and corrective actions and/or mitigation plans, if required) for managing M&Q CDRLs, DIDs, etc., including the requisite approval processes (e.g., Manufacturing Plan, Quality Assurance Plan, Producibility Plan, etc.).
- Specify in the SSP metrics and scoring for contractor(s) application of industry best practices for M&Q aspects of Systems Engineering management (e.g., IEEE 15288, -1, -2, etc.).
  - Include metrics and scoring for the contractors proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering

- Specify M&Q metrics and scoring for contractor(s) plans for timeliness, completeness, accuracy, and alignment to program goals (with corrective actions and/or mitigation, if required) to include:
  - Meeting each requirement in the Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (*See* B.4)
  - M&Q reviews of engineering and software (with frequency of reviews)

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

        - Safeguarding M&Q information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
        - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
        - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
        - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security
    - Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
    - Utilization of COTS, GOTS, GFE, and NDIs
    - M&Q in the Life-Cycle Sustainment Plan (LCSP)
    - Metrics to be met as exit criteria for LRIP

- Specify metrics and scoring to rank the contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specify M&Q metrics and scoring on timeliness, completeness, accuracy, and alignment with program objectives for contractor planning and processes to support and/or conduct as required M&Q:
    - Technical reviews and audits including Physical Configuration Audit (PCA), PRR, and other formal program reviews as requested prior to FRP Decision Review (FRPDR)
    - MRL assessments with trained personnel using the MRL criteria
    - Independent risk assessments as directed
    - Performance meetings to discuss quality, manufacturing, production, supply chain, engineering, software deficiencies and issues, proposed corrective actions, and status of ongoing actions
    - Joint Risk, Issue, and Opportunity Management System meetings to manage mitigation activities
- Specify M&Q metrics and scoring for the contractor(s) plans to:
    - Support on-site government personnel access to perform surveillance, inspections, and assessments (e.g., DMCA access and support)
    - Address capital investments

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

Metrics

- SSP M&Q metrics and scoring have been developed and documented that rank the contractor(s) plans, processes, and procedures for:
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, process capability, and manufacturability assessments, analyses, and technical and management reviews
  - Tooling, equipment, facilities assessments, demonstrations, and analyses (including COTS, GOTS, GFE, etc.)
  - Demonstrations and development tests
  - Materials
  - Materials management (i.e., make/buy processes, procedures, and analyses)
  - Costs and budget estimates
  - Market research and analyses
  - Modeling and simulations
  - Process capability and production process verifications
  - ESOH, environmental, hazardous materials, safety, and security (physical, cyber, and industrial)

  - M&Q and associated data management (especially CMPs)
  - Workforce management (e.g., availability, training, and certification)
  - Work measurement (i.e., learning curve analyses)
  - ManTech project implementation
  - Supply chain assessments and analyses

- M&Q metrics and scoring have been developed and documented in the SSP for application of best practices in the contractor(s) MMS and Plan and QMS and Plan including:
  - Preferred specific processes and procedures, methods, and actions to address manufacturing, producibility, quality, and M&Q risks and issues
  - Accommodation and support of on-site government Quality personnel to have access to perform management and quality audits 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)
    - Variance actions and approvals
    - Engineering changes and approvals
- If AS6500 was not invoked in the contract, then specific metrics and scoring have been documented and included in the SSP that rank the contractor(s) plans, processes, and procedures 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 modeling and simulation

        - 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
- If ISO 9000 or AS9100 was not invoked in the contract, then specific metrics and scoring have been documented and included in the SSP that rank the contractor(s) plans, processes, and procedures for:
    - Quality management leadership, commitment, policy, organizational roles, responsibilities, and authorities
    - Quality planning with actions to address risks and opportunities, quality objectives and planning, and change management
    - Quality support with resources, competence, awareness, communication, and documented information
    - Operation including operational planning and control, products and services requirements, and design and development
    - Control of externally provided processes, products, and services
    - Production and service provision
    - Release of products and services
    - Control of non-conforming outputs
    - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
    - Quality improvement including nonconformities and corrective actions, and continual improvement
- Specific metrics and scoring have been documented in the SSP that rank the contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment (corrective actions, if required) for managing M&Q CDRLs, DIDs, etc., including the requisite approval processes.

- Specific metrics and scoring have been documented in the SSP for contractor(s) application of industry best practices for M&Q aspects of Systems Engineering management (e.g., IEEE 15288, -1, -2, etc.).
    - Metrics and scoring include the contractor(s) proposed processes, methods, and actions to address technical processes, technical management processes, and essential specialty engineering
- Specific M&Q metrics and scoring have been documented in the SSP for contractor(s) plans (including timeliness, completeness, accuracy, and alignment to program goals) to include:
    - Meeting each requirement in the Statement of Work (SOW), Statement of Objectives (SOO), and contract sections C, L, M, and H, including incentives (*See* B.4)
    - M&Q reviews of engineering and software (with frequency of reviews)
    - IP management and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
    - Producibility efforts including cost sharing and incentive plans (i.e., Value Engineering)
    - Utilization of facilities, tooling, test equipment, and workforce
    - Supply chain management (e.g., products, locations, capacities, capabilities, monitoring, etc.)
    - Parts and materials management (e.g., make/buy, planning, etc.) including:
        - Long-lead
        - Sources and risks (sole, single, foreign, fragile, and critical)
        - Handling and storage
        - Capacity to support all production needs (e.g., expected, surge, mobilization, etc.)
        - Conservation of critical/strategic materials
        - Counterfeit avoidance
        - Obsolescence
        - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
        - Reduction/elimination of foreign dependency
        - Standardization of components, items, and parts
    - Configuration management
    - Analyses of failure mode effects and criticality (e.g., PFMEA, FMECA, etc.) from the system level down to the component level
    - Management (including traceability) of CSIs and/or CAIs to all key and critical M&Q processes (CMP)
    - Manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
    - Application of statistical process controls and meeting required process capability (C_{pk}) goals

  - Collection, storage, analysis, and management of M&Q data including process capabilities, costs, cost models, and cost estimates, rate, yields, quantities, etc. (including Cost of Quality)
  - Manufacturing technology capability improvements
  - Investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
  - Investments in workforce development including processes, work systems, and skill development
  - Joint Risk, Issue, and Opportunity Management System and mitigation program that includes manufacturing, quality, and industrial base
  - M&Q Variability Reduction program
  - Cyber threat protection including:
    - Safeguarding M&Q information, designed in systems protection, supply chain risks, hardware and software manufacturing network assurance (including suppliers), anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security in accordance with the PPP
    - Compliance with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
    - Periodic assessments to understand the risks to organizational operations, organizational assets, and individuals, resulting from the operation and the associated processing, storage, or transmission of Controlled Unclassified Information (CUI) by manufacturing information systems.
    - Compliance with NIST 800-82 Guide to Industrial Control Systems (ICS) Security
  - Management of materials and subcontractors including requirements for compliance with either DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System, or DFARS 252.246-7008, Sources of Electronic Parts
  - Utilization of COTS, GOTS, GFE, and NDIs
  - M&Q aspects of the Life Cycle Sustainment Plan (LCSP)
  - Metrics to be met as exit criteria for LRIP

- Specific M&Q metrics and scoring have been documented in the SSP to rank contractor(s) plans (including processes, and procedures) for timeliness, completeness, accuracy, and alignment for managing specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specific M&Q metrics and scoring (alignment with program objectives) have been documented in the SSP for contractor(s) plans 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

- Specific M&Q metrics and scoring have been documented in the SSP 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
- Specific M&Q metrics and scoring have been documented in the SSP for the contractor(s) plans for manufacturing methods and production flow to include:
  - Advanced or unique manufacturing technologies
  - Planned fabrication and assembly key points
  - Production test and/or inspections
  - Flow of major manufacturing operations
  - Process yields and statistical or other methods for process control

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- ISO 9001, Quality Management System Checklist
- Source Selection Plan Template, USMC

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoD Source Selection Procedures Memo
- IEEE 15288, System and Software Engineering
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Program
- ISO 9001:2015, Quality Management System
- MIL-HDBK 2450, DoD Handbook for Preparation of Statement of Work
- MIL-HDBK-896A Manufacturing Management Program Guide
- MIL-STD-882, DoD System Safety
- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- Source Selection Plan Guide, IG5315.303 SSP Guide

B.3 Develop Manufacturing Incentives

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

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

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

Manufacturing and Quality Tasks

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

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

Metrics

- M&Q Award or incentive fee criteria have been documented for:
    - Timely submission and approval of M&Q CDRLs, DIDs, etc.
    - Compliance with cyber-threat protection and industrial security requirements (e.g., PPP, DFARS 252.204-7012, NIST 800-82, etc.)
    - Mitigation of M&Q industrial base risks to schedule goals (#/%, milestones)
    - Manufacturing readiness progress (MRL assessments) against targets
    - M&Q risk and issues mitigations completion (schedule/#)
    - Manufacturing and producibility projects planned and implemented (#/%)

- Achievement 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/ %)
- Maturation and management of KCs to goals (% to goal and schedule progress)
- Management of Technical Performance Measures (TPMs) (% progress to schedule)
- Implementation of manufacturing processes and advanced manufacturing capability improvements (#/% to goals)
- Management of CSIs and CAIs to requirements
- Process Capability improvement (C_{pk} value to goals)
- Quality improvement projects completion (#/% to goals)
- Variation and Variability reduction (yields/rates/trends)
- Implementation of manufacturing improvement projects (#/% to goals)
- Management of parts and materials 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)
- Manufacturing Management System compliance to best practices and/or contract requirements (# to standard)
- Manufacturing Plan progress (cost and schedule)
- Manufacturing costs and cost reduction (schedule/#/%)
    - Cost sharing when goals are not met must also be specified.
- Quality Management System compliance to best practices and/or contract requirements (# to standard)
- Quality Plan progress (cost and schedule)
- Quality costs and cost reduction (including cost of quality) (schedule/#/%)
- M&Q safety system compliance (%)
- System Engineering compliance to best practices for M&Q technical processes, technical management processes, and essential specialty engineering (# to standard)
- Meeting schedule (IMP/IMS and critical path)
- Meeting required LRIP exit criteria

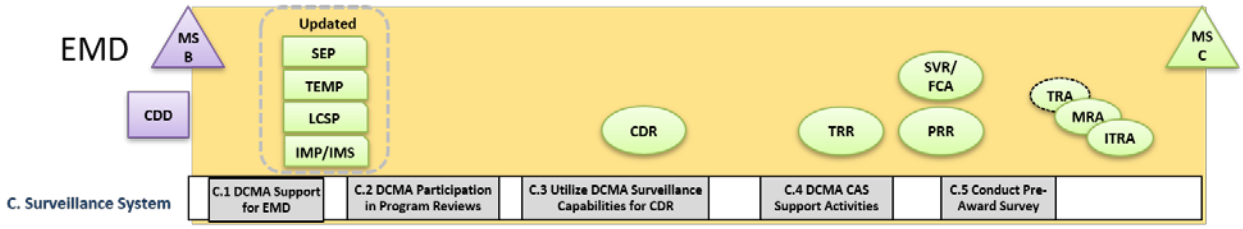
Tools

- Award Fee Template, USAF
- Award Fee/Incentive Fee Plan

Resources

- Air Force Award Fee Guide
- Army Award Fee Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoD Guidance on Using Incentive Contracts
- DoD/NASA Incentive Contracting Guide
- FAR Subpart 16.4, Incentive Contracts
- ISO 9001:2015, Quality Management System
- Navy Award Fee Guide
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)

C. SURVEILLANCE SYSTEM



The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DFAR subpart 242.3 identifies seventy-one (71) Contract Administration Services (CAS) functions that need to be accomplished and managed. Contractor surveillance is defined by several FAR and DFAR clauses. Many CAS activities fall under the umbrella of production or quality surveillance activities.

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

many CAS activities to DCMA as a best practice. This may require a Memorandum of Agreement (MOA) or a Letter of Delegation (LOD). The program office should coordinate with DCMA on required support, provided there is adequate manpower and funding to support the proposed MOA/LOD.

The Program Manager should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. This may require the program office to establish a Memorandum of Agreement (MOA) or a Quality Assurance Letter of Delegation (QALI) with DCMA. DCMA may then, based on manpower availability and funding, utilize a systematic approach deploying surveillance through the supply chain to evaluate the supply chain and supplier improvement initiatives. At resident and non-resident facilities DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes. Most contractors will have implemented a higher-level quality management process IAW AS9100 or ISO 900/9100 as a best practice. Some contractors, but not all, may have implemented a manufacturing management process IAW AS6500. No matter what management processes the contractor has implemented, DCMA personnel should have access to that data and should be reviewing it on a continuous basis.

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

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

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

process is the contractor's opportunity to provide evidence (i.e., Plan of Performance) that they can successfully fulfill the terms of the contract.

C.1 DCMA Support for EMD Activities

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

Manufacturing and Quality Tasks

- Ensure M&Q provides inputs to the program development of a Letter of Delegation for DCMA support.
- Ensure M&Q participates in the development of a Memorandum of Agreement (MOA) for DCMA support.
- Ensure M&Q provides inputs on contractual requirements for contractor and supply chain activities and functions to be monitored, tracked, and reported by DCMA and/or program personnel in support of EMD, including DCMA support for:
    - Surveillance of contractor and supply chain use and application of best practices (e.g., AS6500, AS9100, ISO 9000, etc.)
    - Participation in Post Award Orientation Conference
    - Verify closure of PDR actions supply chain (required in the PDR if the PDR was conducted in the TMRR phase)
    - Updates on supply chain CDRs, developmental testing, PCAs, FCAs, other "critical path" events, and notifications to the program office of potential or actual program milestone issues
    - Government surveillance of contractor and supply chain FAIs/FATs and Qualifications (QUAL)
    - Surveillance support of contractor's Earned Value Management System (EVMS)
        - Conduct cost, schedule, and technical performance variance evaluations
    - Surveillance of Human Rating Certification processes (e.g., Flight Operations, etc.) with unrestricted government access to inspect and/or test processes (i.e., Safety of Flight (SOF) characteristics)

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

Metrics

- M&Q has provided inputs to the program development of a Letter of Delegation for DCMA support.
- Memorandum of Agreement (MOA) has been executed with M&Q inputs and implemented between with program and DCMA.
- M&Q has provided documented contractual requirements for monitoring, tracking, and reporting of contractor and supply chain activities and functions by DCMA and/or program personnel in support of EMD, including:
  - 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
  - Verification of PDR actions closure for the entire supply chain
  - Supply chain CDRs, developmental testing, PCAs, FCAs, and other "critical Path" events
  - Government surveillance of contractor and supply chain FAIs/FATs and QUAL
  - Surveillance of contractor's EVMS
    - Monitor cost, schedule, and technical performance variances
  - Surveillance of Human Rating Certification processes
  - GCQA of engineering development models, engineering models, production prototypes, production representative models and articles, production readiness models and articles, etc.
  - Authority to accept or reject minor RFVs, MRB proposals for UAI, and repair non-conformances (after the final PBL is established post-CDR)

- Surveillance of the supplier's compliance to DFARS 252.242-7004, MMAS
- Verification of contractor and supply chain compliance with contractual SPIs for end item systems and spares
- Verification of contractor and supply chain compliance with 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.)
- CAS functions as outlined in FAR Subpart 42.3 CAS Functions have been performed as appropriate.

Tools

- DCMA Program Assessment Report
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-401, Industrial Analysis
- FAR Subpart 30.6, CAS Administration
- FAR Subpart 42.3, CAS Functions

C.2 DCMA Participation in Program Reviews

During the EMD phase there are eight formal technical reviews and audits and many informal reviews directed by the program office and other activities. M&Q managers as a member of the Technical IPT need to support these reviews and audits. DCMA personnel need to support these reviews if delegated CAS activities by the program office.

Manufacturing and Quality Tasks

- Requests DCMA support and participation in program reviews (e.g., IPRs, IPT meetings, etc.), including government only, to provide data on:
  - Contractor operations (technical, performance and financial)
  - Supply chain operations (technical, performance and financial)
  - Program goals and metrics

- M&Q managers should be a member of the Technical IPT that supports the following reviews and audits:
  - Integrated Baseline Review (IBR)
  - Test Readiness Review (TRR)
  - Flight Readiness Review (FRR)
  - System Verification Review (SVR)
  - Functional Configuration Audit (FCA)
  - Production Readiness Review (PRR)
  - Technology Readiness Assessment (TRA)
  - Manufacturing Readiness Assessment (MRA)
  - Independent Technical Risk Assessment (ITRA)
- Request DCMA input on ongoing M&Q contractor and supply chain activities concerning:
  - Technical Performance Measures (TPMs)
    - Including CIs, CSIs, KCs, and critical characteristics
  - Design status
  - Manufacturing capabilities and capacities
  - Quality assurance processes and procedures (i.e., compliance to best practices)
  - EVMS processes, procedures, and data
  - Government Property Control (e.g., GFE, GFP, etc.)
  - Transportation, storage, and packaging processes and controls
  - Security (physical, cyber, and industrial)
  - System Safety
  - Plant safety, materials handling, hazardous waste disposal, etc.
  - Environmental and Energy compliance with applicable policies and statutes
  - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
  - Configuration management processes and procedures
  - Software surveillance
  - Test planning, test equipment, and test results

Metrics

- M&Q managers supported the following reviews and audits:
  - Integrated Baseline Review (IBR)
  - Test Readiness Review (TRR)
  - Flight Readiness Review (FRR)
  - System Verification Review (SVR)
  - Functional Configuration Audit (FCA)
  - Production Readiness Review (PRR)

  - Technology Readiness Assessment (TRA)
  - Manufacturing Readiness Assessment (MRA)
  - Independent Technical Risk Assessment (ITRA)
- DCMA participation in program reviews was requested and DCMA did support and participate in those reviews, providing data on:
  - Contractor operations (performance and financial)
  - Supply chain operations (performance and financial)
  - Program progress to goals
- DCMA is providing data on contractor and supply chain M&Q activities for the following:
  - TPMs
    - Including CIs, CSIs, KCs, and critical characteristics
  - Design status
  - Manufacturing capabilities and capacities
  - Quality assurance processes and procedures (i.e., compliance to best practices)
  - EVMS processes, procedures, and data
  - Government Property Control (e.g., GFE, GFP, etc.)
  - Transportation, storage, and packaging processes and controls
  - Security (physical, cyber, and industrial)
  - System Safety
  - Plant safety, materials handling, hazardous waste disposal, etc.
  - Environmental and Energy compliance with applicable policies and statutes
  - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
  - Configuration management processes and procedures
  - Software surveillance
  - Test planning, test equipment, and test results

Tools

- DCMA Program Assessment Report
- Interactive MRL Users Guide (Checklist)
- Independent Technical Risk Assessments (ITRAs) Execution Guidance

Resources

- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning

- DCMA-INST-401, Industrial Analysis
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

C.3 Use DCMA Surveillance Capabilities for Critical Design Review

M&Q personnel from DCMA should be actively engaged in the organization and execution of the CDR during this phase along with program office personnel. The completion of the CDR should provide:

- An established system initial product baseline,
- An updated risk assessment for EMD,
- An updated CARD based on the system product baseline,
- An updated development schedule for fabrication, test and evaluation, software coding, critical path drivers, and
- An approved Life Cycle Sustainment Plan.

Manufacturing and Quality Tasks

- Use DCMA surveillance capabilities in monitoring, tracking, and reporting for contractor and supply chain use and application of M&Q best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.).
- Use DCMA surveillance capabilities to monitor M&Q FMECA contract requirements for contractor and supply chain for:
    - Identification of subsystems, items, components, characteristics and/or features, and processes, which if nonconforming, could result in a catastrophic or critical failure of the system:
        - Items and components will be designated as either a critical item (CI) or CSI
        - Product characteristics and/or features will be designated as either KCs or critical characteristics
        - Processes will be designated as critical manufacturing processes (CMPs)
    - Review of the FMECA and/or Critical Items List (CIL) for CIs, CSIs, KCs, and critical characteristics to specify the need for government surveillance of these items
    - Verification of updates of FMEA/FMECA based on FRACAS and developmental testing results
- Use DCMA surveillance capabilities to monitor M&Q aspects of System Safety contract requirements including:

  - Review Safety Assessment Reports (SARs) and/or CIL for CIs, CSIs, KCs, and critical characteristics

- Use DCMA surveillance capabilities to monitor M&Q aspects of Test and Evaluation contract requirements for surveillance of contractor's and supply chain's:
  - Physical Configuration Audits (PCAs) of the required subsystems/components identified in the contract. Perform government surveillance, as required
  - Functional Configuration Audits (FCAs) of the required subsystems/components identified in the contract. Perform government surveillance, as required
  - Developmental Testing for achievement of Critical Technology Elements (CTEs), KPPs, and KSAs
  - Software Testing, to include Software Acceptance Test (SAT)/Software Formal Qualification Test (SFQT), if conducted in the EMD phase
  - Environmental testing (e.g., Environmental Stress Screening (ESS), Highly Accelerated Life Testing (HALT), Highly Accelerated Stress Screen (HASS), Thermo-Cycling, Thermo-Shock, Pyrotechnic Shock, Vibration, etc.), if conducted
  - Live Fire Test and Evaluation), if applicable
  - Acceptance Testing
- Use DCMA surveillance capabilities to enhance M&Q monitoring of KPPs and KSAs progress and periodic review of TPMs.
- Use DCMA surveillance capabilities to monitor contractor's and supply chain's M&Q FRACAS contract requirements including:
  - Government personnel attending FRACAS meetings, or review minutes, and adjusting Government surveillance based on FRACAS results, as required
  - Verifying contractor and supply chain updates of FMEA/FMECA based on FRACAS result, when required
- Use DCMA surveillance capabilities to monitor M&Q contract requirements for contractor and supply chain compliance to M&Q aspects of Systems Engineering best practices as specified in IEEE 15288.2.
- Use DCMA surveillance capabilities to monitor M&Q Risk, Issue, and Opportunity (RIO) Management contract requirements.
- Use DCMA surveillance capabilities to monitor M&Q contract Parts Management requirements including:
  - Contractor's 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

Metrics

- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain use and application of M&Q best practices (e.g., AS6500, AS9100, IEEE 15288.2, ISO 9000, etc.) for CDR.
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q FMECA contract requirements for CDR including:
  - 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 CI or CSI
    - Product characteristics and/or features will be designated as either KCs or critical characteristics
    - Processes will be designated as CMPs
  - Review of the FMECA and/or 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
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q aspects of System Safety contract requirements for CDR including:
  - Review SARs and/or CIL for CIs, CSIs, KCs, and critical characteristics
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q aspects of Test and Evaluation contract requirements for CDR including:
  - PCAs of the required sub-systems/components identified in the contract. Perform government surveillance, as required

  - FCAs of the required subsystems/components identified in the contract. Perform government surveillance, as required
  - Developmental Testing for achievement of CTEs, KPPs, and KSAs
  - Software Testing, to include SAT/SFQT, if conducted in the EMD phase
  - Environmental testing (e.g., ESS, HALT, HASS, Thermo-Cycling, Thermo-Shock, Pyrotechnic Shock, Vibration, etc.), if conducted
  - LFT&E, if applicable
  - Acceptance Testing

- DCMA did and is monitoring, tracking, and reporting on M&Q aspects of KPPs and KSAs including progress and periodic reviews of TPMs for CDR.
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q FRACAS contract requirements for CDR including:
  - 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
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q aspects of Systems Engineering best practices as specified in IEEE 15288.2 for CDR.
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q RIO Management contract requirements for CDR.
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q Parts Management contract requirements (MIL-STD-11991A) for CDR including:
  - 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 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
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q Configuration Management contract requirements (e.g., SAE/EIA649B, Service specific policies, etc.) for CDR.
- DCMA did and is monitoring, tracking, and reporting on contractor and supply chain compliance to M&Q Software Development, Quality Assurance, Configuration Management and Testing contract requirements for CDR including:
  - Contractor's and supply chain compliance to software development, quality assurance, configuration management and testing requirements
  - Contractor's progress in performance of SAT/SFQT

Tools

- Critical Design Review Checklist
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DD 1423, Contract Data Requirements List
- Defense Acquisition Guidebook (DAG) Chapter 3-3.3.5, Critical Design Review
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD-11991A, General Standard for Parts, Materials, and Processes
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management
- SAE EIA 649B, Configuration Management Standard

C.4 DCMA Contract Administration, Management, and Support Activities

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

Manufacturing and Quality Tasks

- Request the following M&Q support from the appropriate (local) Contract Administration Office (CAO)/Contract Management Office (CMO) in attending, monitoring, and reporting on contractor reviews, performance, and meetings including:
    - Inputs from DMCA monitoring, tracking, and reporting on contractor and supply chain M&Q activities and functions to meet contractual requirements as delineated in C.3
    - Interim Program Reviews (IPRs) including supply chain
    - Performance of Physical Progress Reviews (PPRs) in support of Program Progress Payments
    - Corrective Action Board (CAB) or similar meetings (e.g., quality, manufacturing, supply chain, engineering, and software issues, corrective actions, and dispositions)

- Request M&Q support from the appropriate (local) CAO/CMO in monitoring, tracking, reporting on contractor performance and actions related to and including the following:
    - Estimates to Completion (EACs) as requested
    - Delivery delay notices to the customer
    - Performance Base Payment requests (validation and/or verification)
    - Support to customer priority delivery requests (DX rating)
    - Contractor and supply chain pilot lines
- Ensure M&Q provides inputs for updates to the Memorandum of Agreement (MOA) between the program and the government contract administration for necessary activities.

Metrics

- M&Q personnel did request the appropriate DCMA CAO/CMO support in attendance, monitoring, and reporting on contractor reviews, performance, and meetings including:
    - Contractor and supply chain M&Q performance to meet contractual requirements as delineated in C.3
    - Contractor and supply chain IPRs and results
    - PPRs in support of contractor progress payments
    - CABs or similar meetings (e.g., quality, manufacturing, supply chain, engineering, and software issues, corrective actions, and dispositions)
- M&Q personnel did request the appropriate DCMA CAO/CMO support in monitoring, tracking, reporting on contractor performance and actions related to and including the following:
    - Estimates to Completion (EACs)
    - Delivery delay notices
    - Performance Base Payment requests (validation and/or verification)
    - Priority delivery requests (DX rating)
    - Results of contractor and supply chain pilot lines
- M&Q personnel have provided inputs for updates to the MOA between the program and the government contract administration for changes based on fact-of-life program status.

Tools

- DCMA Pre-Award Survey System (PASS) review
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations

- DD 1423, Contract Data Requirements List
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD-11991A, General Standard for Parts, Materials, and Processes
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management
- SAE EIA 649B, Configuration Management Standard

C.5 Conduct Pre-Award Survey

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

Manufacturing and Quality Tasks

- Ensure M&Q personnel provide inputs for the request to DCMA to conduct Pre-award Surveys of potential LRIP contractor(s) (including their designated supply chain) for M&Q capabilities in the areas of:
    - Compliance to appropriate industry best practices (e.g., AS6500, AS9100, etc.)
    - Technical Performance including TPMs, CIs, CSIs, KCs, and critical characteristics
    - Design
    - Manufacturing capabilities and capacities
    - Quality assurance including processes and procedures compliance to best practices
    - EVMS processes, procedures, and data
    - Government Property management and control (e.g., GFE, GFP, etc.)
    - Transportation, storage, and packaging processes and controls
    - Security (physical, cyber, and industrial)
    - System Safety
    - Plant safety, materials handling, hazardous waste disposal, etc.
    - Environmental and Energy compliance with applicable policies and statutes
    - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Configuration management processes and procedures
    - Software surveillance
    - Test planning, test equipment, and test results

Metrics

- M&Q did document and provide inputs for the request Pre-award Surveys of potential LRIP contractor(s) including the supply chain for:
    - Compliance to appropriate industry best practices (e.g., AS6500, AS9100, etc.)
    - Technical Performance including TPMs, CIs, CSIs, KCs, and critical characteristics
    - Design
    - Manufacturing capabilities and capacities
    - Quality assurance including processes and procedures compliance to best practices
    - EVMS data and performance
    - Government Property management and control (e.g., GFE, GFP, etc.)
    - Transportation, storage, and packaging processes and controls
    - Security (physical, cyber, and industrial)
    - System Safety
    - Plant safety, materials handling, hazardous waste disposal, etc.
    - Environmental and Energy compliance with applicable policies and statutes
    - Certifications processes and procedures (e.g., Flight Operations/Safety, Human Rating, etc.)
    - Configuration management processes and procedures
    - Software surveillance
    - Test planning, test equipment, and test results

Tools

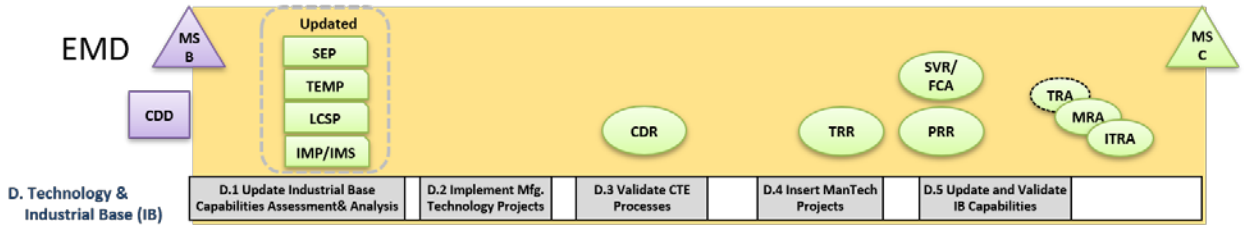
- DCMA Pre-Award Survey System (PASS) review
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan
- SF 1404 Pre-award Survey – Technical
- SF 1405 Pre-award Survey – Production
- SF 1406 Pre-award Survey – Quality Assurance
- SF 1407 Pre-award Survey – Financial Capability

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DD 1423, Contract Data Requirements List
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD-11991A, General Standard for Parts, Materials, and Processes
- Multiple DCMA standards, documents, and procedures
- NAVAIR 4130.1, Configuration Management

- Pre-Award Survey System (PASS) 2.0 (Online)
- Pre-Award Survey System Users Guide (Online)
- SAE EIA 649B, Configuration Management Standard

D. TECHNOLOGY AND INDUSTRIAL BASE



During the Engineering and Manufacturing Development (EMD) phase, industrial base (IB) readiness to support program objectives should be assessed to identify risks, issues, and opportunities. The M&Q Strategies, and subsequent inputs to the program Acquisition Strategy (AS), should highlight the strategy for assessing and mitigating any industrial and manufacturing risks as identified in any reports generated from the industrial base assessments. According to DODI 5000.02 Acquisition Strategies must consider industrial base capabilities at Milestones B and C and provide an update to the Analysis of Alternatives (AoA) conducted in the MSA phase which included an assessment of manufacturing feasibility and required an assessment of the industrial base capabilities.

Policy requires an analysis of the capabilities of the NTIB to support the design, development, production, operation, uninterrupted maintenance support of the system, and eventual disposal. Without this assessment, the program may find that the program cannot be accomplished within the defined cost and schedule thresholds because of incompatibilities between the system requirements and the NTIB available to support it.

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

A systematic process that assesses the maturity of Critical Technology Elements (CTEs) is a DoDI 5000.02 requirement for all acquisition programs. In completing the development of a system or incremental capability, one of the key tasks is to mature Critical Manufacturing Processes (CMPs) associated with KCs, and therefore with CTEs. Manufacturing process demonstrations include affordable and executable manufacturing processes, system fabrication, production of prototypes and

first articles that demonstrate system integration, interoperability, supportability, safety, and utility. The focus of demonstrations is on risk reduction in a pilot line environment.

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

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

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

D.1 Update Industrial Base Assessment and Analyses

The program office as a member of the Integrated Product Team (IPT) should update previous Industrial Base Assessments to satisfy the requirements of 10 USC 2440 and DFAR Subpart 207.1.

Manufacturing and Quality Tasks

- Support and provide updates to any previous Industrial Base Assessments of the capability of the national technology and industrial base to develop, produce, maintain, and support the program, including foreign dependency. The analyses should include the following components:
    - Relevant sources including identification of:
        - Unique manufacturing capabilities
        - Capabilities not readily accessible or available (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
        - Major systems and items available only from sources outside the national technology and industrial base

        - Alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base
        - Government and contractor Depot and Maintenance and Repair Operations (as part of the industrial base)
    - Vulnerabilities of and effect on the supply chain including sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
    - Capability to produce using existing manufacturing capabilities and capacities while meeting quality, production rate and cost requirements
    - Capability to protect program and system information and data (software and firmware) including system definition, design, and test, contracting, and competitive prototyping
    - Capability to protect industrial resources, materials, equipment, and control systems
    - Capability and capacity to cost-effectively design, develop, produce, maintain, and support the system with tooling, production and test equipment, and operation, maintenance, and sustainment of systems
    - Capability and capacity to meet rate and quantity changes that support a response to contingency and support objectives (surges and contractions)
    - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment required to include the availability of alternatives for obtaining such items from within the NTIB
    - Potential obsolescence of components, parts, and materials
    - Impacts of external dependencies and integration
    - New and unique capabilities and processes
    - Sources for key technologies, components, and processes, including known gaps and risks
    - Technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact the program
    - DCMA industrial analysis data and reports to include:
        - Industrial Capability Assessments
        - Appropriate Analytical Products
        - Defense Business and Economic Analysis
        - Acquisition Planning Support
- Update any Industrial Base Assessments and reports and maintain the relevance and applicability of M&Q inputs to the AS and SEP:
    - Include recommended actions or investments that address risks to cost, schedule, performance, and qualitative considerations that define and recommend how and when the actions would be incorporated into the budget and schedule and, if possible, identify budget offsets
    - Ensure the report is finalized for Milestone C

    - Note: If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components and approved by the Under Secretary of Defense For Acquisition, Technology, And Logistics per DoDI 5000.60.

- M&Q personnel will analyze, update, and maintain inputs to the joint Risk, Issues, and Opportunity Management System for industrial base capabilities and capacities throughout EMD and in support of LRIP and Production and Deployment,
    - Include manufacturing, re-manufacturing, and overhaul opportunities

Metrics

- M&Q personnel have supported and provided updates to all industrial base assessments of the national technology and industrial base to develop, produce, maintain, and support the program, including foreign dependency.
- Components of the analyses were maintained and documented for updates to the AS and the SEP include:
    - Relevant sources that identify:
        - Unique manufacturing capabilities
        - Difficult to access or obtain capabilities (e.g., capability is at maximum capacity, materials from a constrained source, etc.)
        - Major systems and items available only from “foreign” sources
        - Alternative “domestic” sources
        - Government and contractor Depot and Maintenance and Repair Operations (as part of the industrial base)
    - Vulnerabilities and effects from sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
    - Capability of existing manufacturing capabilities and capacities
    - Capability to protect program and system information and data (software and firmware) including system definition, design, and test, contracting, and competitive prototyping
    - Capability to protect industrial resources, materials, equipment, and control systems
    - Capability and capacity to cost-effectively design, develop, produce, maintain, and support the system with tooling, production and test equipment, and operation, maintenance, and sustainment of systems
    - Capability and capacity to meet rate and quantity changes (surges and contractions)
    - Availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment
    - Potential obsolescence of components, parts, and materials
    - External dependencies and integration
    - New and unique capabilities and processes

  - Sources for key technologies, components, and processes, including known gaps and risks
  - Technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact the program
  - Industrial analysis data and reports from DCMA
- M&Q inputs to all Industrial Base Assessments and reports have been updated for the AS and SEP and are being maintained for submission to the Milestone C decision.
  - Recommended actions or investments have been included to address risks to cost, schedule, performance, along with qualitative considerations that define and recommend how and when the actions should be incorporated into the budget and schedule with budget offsets
    - Note: If the required investment is greater than $10 million and is determined to affect more than one defense program must be coordinated within and across the Components and approved by the Under Secretary of Defense For Acquisition, Technology, And Logistics per DoDI 5000.60.
- M&Q personnel have documented and are maintaining up-to-date inputs to the joint Risk, Issues, and Opportunity Management System for industrial base capabilities and capacities including support of LRIP and Production and Deployment.
  - These inputs include manufacturing, re-manufacturing, and overhaul opportunities

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist) for Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoD 5000.60-H, Assesing Defense Industrial Capabilities
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook

D.2 Implement Manufacturing Technology Projects

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

Manufacturing and Quality Tasks

- Update program manufacturing technology plans, including approved and funded ManTech proposals, which should address:
  - Identified high-risk manufacturing process areas
  - Identified risks and issues with associated event-based mitigation plans
  - Identified manufacturing technology efforts to be funded other sources
  - Any new or emerging manufacturing technology gaps
  - Scheduled completion of manufacturing technology efforts to support program
  - Contractor/subcontractor participation in the project
  - Relevant data to support the plan (e.g., DCMA, Title III, etc.)
  - Review other program portfolios for potential alternatives/solutions (e.g., ManTech, Title III, DARPA, Procurement Technical Assistance Centers (PTAC), Manufacturing Extension Program (MEP), National Institute of Standards and Technology (NIST), etc.)
- Execute approved and funded manufacturing technology projects.
- Monitor and track progress of projects against the goals (e.g., process improvement, quality improvement, etc.)
- Monitor ongoing DoD/Service ManTech projects for potential applicability to program needs.

Metrics

- Approved manufacturing technology plans have been documented in the Manufacturing Plan and in the Risk, Issue, and Opportunity process, and funded ManTech proposals have been included in the budget that address:
  - High-risk manufacturing process areas
  - Event-based risk and issue mitigation planning and reduction
  - Manufacturing technology efforts funded by other sources
  - Any new or emerging manufacturing technology gaps
  - Completion of manufacturing technology efforts to support program schedule
  - Contractor/subcontractor participation in the project
  - Updated data to support the plan (e.g., DCMA, Title III, etc.)

  - Other program portfolios for potential alternatives/solutions (e.g., ManTech, Title III, Technical Assistance Centers, NIST, etc.)

- Approved and funded manufacturing technology projects are executed and monitored to schedule and the risk burn-down plan.
- Progress of projects against the goals is reported at program reviews.
- Ongoing DoD/Service ManTech projects are being monitored on a recurring basis for potential applicability to program needs.

Tools

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

Resources

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- Defense Production Act, Title III
- DoDD 4200.15, ManTech
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook
- Service ManTech guidance, e.g., Air Force Technology and Transition Strategy Guidebook
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.3 Validate Critical Technology Element Processes

The ManTech program focuses on advancing state-of-the-art manufacturing technologies and processes from the research and development environment (laboratory) to the production and shop floor environment. These technologies are often immature and have the process limitations of critical technologies need to be assessed and validated prior to inclusion into the next system level or element.

Manufacturing and Quality Tasks

- Update M&Q assessments to ensure all CTEs have been identified and all CTE risks and issues have been mitigated to acceptable levels.
  - Including integration, interdependencies, and associated risks and issues
  - Exceptions have matured alternative components or subsystems identified, approved, and budgeted

- Ensure all CTEs have been decomposed to specific M&Q processes.
    - Assess each M&Q processes for maturity (e.g., process capability, work instruction status, appropriate yield, etc.)
    - Validate CTEs for feasibility, affordability, and supportability

Metrics

- M&Q assessments have been conducted to ensure all CTEs have been identified and the results documented for program management and systems engineering.
- All CTE M&Q risks and issues have been mitigated to acceptable levels, including integration and interdependencies, and documented for the joint Risk, Issue, and Opportunity Management System.
    - Mature, approved, budgeted alternative components or subsystems have been included as required
- All CTEs have been decomposed and documented to specific M&Q processes.
    - Each M&Q process has been assessed and documented for its level of maturity (e.g., process capability, work instruction status, appropriate yield, etc.)
    - CTEs have been validated and documented for M&Q feasibility, affordability, and supportability in the Program Manufacturing Plan, and the Quality Plan

Tools

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

Resources

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

D.4 Insert Manufacturing Technology Projects

Accelerating the flow of technology to the warfighter is one of the top priorities of DoD, services, and agencies. Technology transition involves the maturation of technologies to the point where they are proven to be mature and ready of insertion into a system or element. M&Q managers as members of

the Technical IPT need to support the analysis of maturity and the insertion of technologies into production programs.

Manufacturing and Quality Tasks

- Update program manufacturing technology plans based on status (funding and schedule) and results of project, which should address:
    - Risk reduction manufacturing process areas
    - Improvements in manufacturing processes (cost and schedule)
    - Resulting quality improvements (e.g., C_{pk}s, yields, rates, etc.)
    - Other source manufacturing technology efforts (e.g., Title III, PTACs, MEPs, NIST, etc.)
    - Demonstrations of completed manufacturing technology projects to industry in the appropriate facility
    - Contractor/subcontractor level of participation in the project
    - Scheduled manufacturing technology project insertion at the contractor/subcontractor facility
    - Relevant data collected to support insertion (e.g., DCMA, Title III, etc.)
- Manage manufacturing technology projects to plan to ensure that the technologies are inserted into a system or element as appropriate.
- Conduct demonstrations of completed ManTech projects to industry in the appropriate facility.
- Implement, monitor, and track manufacturing technology projects at contractor/ subcontractor facility for effectiveness and performance.
    - Demonstrate manufacturing technology development solutions in a production representative environment
    - Continue manufacturing technology efforts for validation on the Pilot Lines

Metrics

- Program manufacturing technology plans have been implemented and are being updated based on status and interim results from the project, which address:
    - Manufacturing process area risk reductions and issue resolutions
    - Manufacturing process improvements (with documented cost and schedule improvements)
    - Quality improvements (with documented improvements in C_{pk}s, yields, rates, etc.)
    - Results, impacts, and initiatives documented and adapted from other source manufacturing technology efforts (e.g., Title III, Procurement Technical Assistance Centers, Manufacturing Extension Program, NIST, etc.)
    - Demonstrations to industry in the appropriate facility
    - Changes in contractor/subcontractor level of participation in the project

  - Changes in manufacturing technology project insertion scheduling by the contractor/subcontractor
  - Data collected to support insertion (e.g., DCMA, Title III, etc.)
- Progress of manufacturing technology projects are being assessed and reported at management reviews as required and the technologies have been inserted into a system or element as appropriate.
- Documentation of completed ManTech project industry demonstrations has been included in the Manufacturing Plan for implementation.
- Manufacturing technology projects have been implemented, are being monitored, and tracked at contractor/ subcontractor facility with data being collected (e.g., cost, schedule, yield, rate, etc.) to document effectiveness and performance in a production representative environment.
- Data collection and documentation to support continuing manufacturing technology validation on the Pilot Lines is ongoing (e.g., cost, schedule, yield, rate, etc.).

Tools

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

Resources

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development and Investments
- Defense Production Act, Title III
- DoDD 4200.15, ManTech Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook
- Service ManTech guidance (e.g., Air Force Technology and Transition Strategy Guidebook)
- Technology Readiness Assessment Guidance

D.5 Update and Validate Industrial Base Capabilities

The industrial base assessment (ICA) must be updated to evaluate the skills and knowledge, processes, facilities, and equipment needed to design, develop, manufacture, repair, and support DoD products. The purpose of the assessment is to identify potential IB/program risks.

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

Manufacturing and Quality Tasks

- Update and validate prior industrial base assessments based on CDR and Pilot Line demonstrations for program management and technical reviews (e.g., PRR, SVR, FCA, etc.) prior to LRIP for (*see* D.1) changes in:
    - Sources and alternatives
    - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
    - Vulnerabilities
        - Sole, single, foreign, etc.
        - Military
        - Counterfeit
        - Potential exploitation
        - Fragility and uncertainty of demand
    - Production capability and capacity
    - Security (threat physical and cyber)
    - Availability (e.g., materials, components, equipment, facilities, etc.)
    - LRIP required COTS and NDIs
    - External dependencies
    - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
    - Government and contractor Depot and Maintenance and Repair Operations
- Incorporate into the update changes in M&Q maturity of new and unique capabilities and processes that are included in the system.
    - Include technological developments, market trends, processes, environmental factors, and policies, etc.
- As part of the update, include reporting and analyses from DCMA and DLA on relevant industrial base capabilities, status, and trends.
- Assess effectiveness of actions or investments made to address M&Q industrial base risks to cost, schedule, performance; areas that should have been included are:
    - Capabilities required throughout the life of the system
    - Product or technology obsolescence
    - Business fragility for unique services, products, or M&Q capabilities
    - Industrial base resilience to rates, vulnerabilities, capacity,
    - Availability of system required material (e.g., materials, special alloys and composites, components, tooling, equipment, alternatives, etc.)

  - Maturation of new and unique capabilities

- Update the M&Q inputs to the joint Risk, Issues, and Opportunity Management System (to include mitigation status) for industrial base capabilities and capacities in support of LRIP and Production and Deployment phase.
- Update the M&Q inputs to the Industrial Base Capabilities Considerations Summary Report for Milestone (MS) C.

Metrics

- Industrial base assessments have been updated and validated by M&Q based on results from CDR and Pilot Line demonstrations and have been documented and provided to program management for technical reviews (e.g., PRR, SVR, FCA, etc.) for changes in:
  - Sources and alternatives
  - Obsolescence (e.g., market trends, environmental factors, policies, etc.)
  - Vulnerabilities
    - Sole, single, foreign, etc.
    - Military
    - Counterfeit
    - Potential exploitation
    - Fragility and uncertainty of demand
  - Production capability and capacity
  - Security (threat physical and cyber)
  - Availability (e.g., materials, components, equipment, facilities, etc.)
  - LRIP required COTS and NDIs
  - External dependencies
  - Capabilities to support the systems (e.g., tooling, production, equipment, test equipment, etc.)
  - Government and contractor Depot and Maintenance and Repair Operations
- Changes in M&Q maturity of new and unique capabilities and processes that are included in the system have been incorporated and documented.
  - Including technological developments, market trends, processes, environmental factors, and policies, etc.
- Reporting and analyses from DCMA and DLA on relevant industrial base capabilities, status, and trends have been included in the M&Q updates to program planning.
- Actions and/or investments made to address M&Q industrial base risks to cost, schedule, performance have been assessed the results documented and include the following:
  - Capabilities required throughout the life of the system
  - Product or technology obsolescence

- Business fragility for unique services, products, or M&Q capabilities
- Industrial base resilience to rates, vulnerabilities, capacity,
- Availability of system required material (e.g., materials, special alloys and composites, components, tooling, equipment, alternatives, etc.)
- Maturation of new and unique capabilities

- The joint Risk, Issues, and Opportunity Management System has been updated with M&Q inputs on industrial base capabilities and capacities in support of LRIP and Production and Deployment phase.
- M&Q inputs to the Industrial Base Capabilities Considerations Summary Report for Milestone C have been documented and provided.

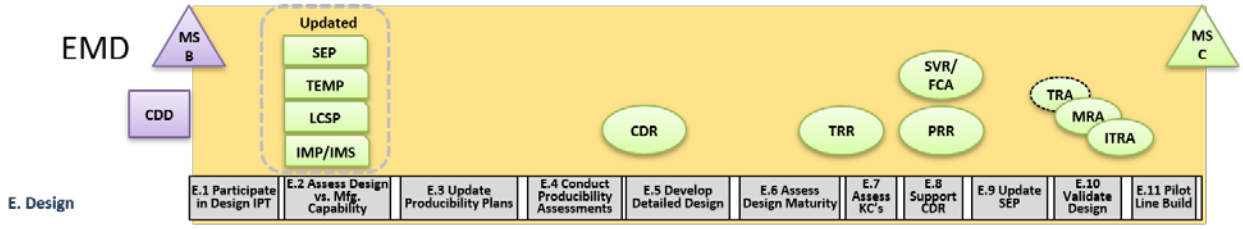
Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist) for Technology and Industrial Base thread
- Manufacturing Maturation Plan

Resources

- 10 USC 2440, Technology and Industrial Base
- 10 USC 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 USC 2503, Analysis of the Technology and Industrial Base
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60-H, Assessing Defense Industrial Capabilities
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook

E. DESIGN



During the EMD phase, by CDR, all the design information necessary to plan the detailed manufacturing operations for the system should be available. M&Q participation early in the design process through active participation in the Design IPT is the key to creating a producible design. Participants should support and provide inputs on design trade studies (producibility, materials, IB capabilities, etc.), analyses, testing, configuration control, design reviews, etc. This information should

be the basis for the Manufacturing Strategy and Plan and the Quality Strategy and Plan, which cover the issues of M&Q organization, make or buy planning, subcontract management, resources and capabilities, and the required detailed fabrication and assembly planning to include pilot line and ramp-up for LRIP. The contractors' and supply chain M&Q capabilities should be assessed throughout the EMD phase as these capabilities will be required in this phase and must be in place for LRIP.

Producibility planning started during the concept exploration phase and has influenced the entire design effort from that point on. The objectives of producibility include both engineering design criteria and the producibility planning requirements. The program is required to "reduce manufacturing risk and demonstrate producibility" prior to FRP (per DoDD 5000.01). This requires producibility plans to be assessed and updated on a periodic basis and producibility activities to be monitored and assessed on a continuing basis. Additionally, producibility planning in EMD should address all areas of M&Q impacting cost, schedule, and performance requirements such as KCs, selection of specific materials, specific M&Q processes, changes in requirements, changes in workforce, facilities, tooling, equipment, etc.

Producibility assessments of the design should be conducted at the contractor and in the supply chain using of a wide range of producibility tools, techniques, and procedures including M&S, Failure Mode and Effects Analyses (and Criticality), Design for Manufacture and Assembly, product and process capabilities with measurements using Statistical Process Control, etc. Results of M&Q design producibility assessments should generate recommendations for design improvements to be integrated into the detailed system design and/or system specifications according to a joint government/ contractor producibility schedule.

For EMD, to identify and obtain the required M&Q processes and resources, the design should be specified in detail. The final design (i.e., approved at CDR) results from performance requirements, outcomes of the testing accomplished, producibility studies, and other design influences related to cost, schedule, and performance. Prior to a system-level CDR, detailed design must be developed from the component level up to the system level with design reviews conducted to assure meeting design requirements and goals at all levels of the supply chain. Prior to release of drawings to manufacturing, the detailed design drawings, bills-of-material, and product and process specifications must be completed. Further, it is essential that assessments be conducted to ensure that the contractor is complying with requirements and meeting cost/design goals.

Many system-level risks evolve from immature designs and failure to consider design risks. Risks associated with M&Q processes will have a major impact on the maturity of design. M&Q must assess design maturity based on manufacturing feasibility, capability, producibility, and KCs, in accordance with industry best practices. Through support of all design reviews at all levels of the supply chain, the adequacy and completeness of M&Q requirements verification and validation activities can be determined. Additional design maturity can be achieved through demonstrations of M&Q processes and procedures in a representative environment at the system, subsystem, item, and component level.

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

As the design progresses from preliminary design to detailed design, the Design IPT must ensure that all design considerations are maturing on schedule for CDR and address all design risk contributors including trade studies, design policies, processes, and analyses, parts and materials selections, software design, testing, configuration control, and design reviews. The PDR and CDR are the systems engineering technical reviews that are used to measure design maturity. By CDR, the design should be mature, stable and with few engineering changes. Producibility is a best practice for ensuring that the design is producible and affordable.

Identification of KCs was initiated in the early phases of development, and the list of KCs should be continually updated and refined. In EMD phase, the list should matured to a final list of all KCs, corresponding to the finalized design at CDR. Prior to completing design, the list of KCs could be reduced through producibility activities as the product design is refined to make KCs less sensitive to variation. As the KCs are finalized, the corresponding list of critical M&Q processes should also be completed. Post-CDR activities, including pilot line, will provide the basis for validation and adequacy of the contractor's processes, capabilities, and control of KCs.

The role of manufacturing to influence the design culminates at CDR. M&Q design decisions have major impact on future production and life cycle costs. By the time, the CDR is held the production and life cycle costs commitment is approximately 90 percent. Therefore, manufacturing, quality, and other considerations must be finalized by CDR to enhance affordability. All key and critical manufacturing processes, including process control plans, should be defined, characterized, and up to date for the final detailed design. Government and contractor producibility analyses should identify M&Q risk and issues. The associated mitigation activities should be ongoing, up-to-date, and monitored in the joint government/contractor Risk, Issue, and Opportunity Management System for resolution prior to the Milestone C decision.

Programs prepare a SEP for each milestone review, beginning with Milestone A. It is intended to be a living document, tailored to the program, and a roadmap that defines comprehensive SE activities, addressing both government and contractor technical activities and responsibilities. Additionally, the SEP describes the timing, conduct, entrance criteria, and success/exit criteria of technical reviews. A well-managed, periodically maintained SEP should be updated post-CDR by M&Q to facilitate program success.

The M&Q Strategies should include assessments of the M&Q processes effective demonstrations in an appropriate environment, such as a pilot line environment, prior to Milestone C. These demonstrations on a pilot line should incorporate all key elements (equipment, personnel skill levels,

materials, components, work instructions, tooling, etc.) required to produce components, items, subsystems, or systems and validate meeting design requirements for LRIP. M&Q processes and procedures required for production must be matured to a level of high confidence for LRIP in the P&D phase.

A successful pilot line build provides the means to validate that system design is complete and sufficiently stable to enter LRIP. All materials, manpower, tooling, test equipment and facilities, STE/SIE, processes, and procedures are proven on the pilot line, meeting the planned LRIP schedule, and known M&Q risks are under control, posing no significant challenges. Outputs of the pilot line will produce articles subject to FAIs/FATs and will provide validation of the design and that M&Q processes are under control and ready for LRIP.

E.1 Participate in Design Integrated Product Team

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

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

Manufacturing and Quality Tasks

- M&Q personnel as Design IPT participants assess and monitor continuing adherence to M&Q design best practices (e.g., AS6500, AS9100, ISO 9001, etc.).
- Update M&Q requirements based on analyses of system requirements and design concepts from TMRR developments and the PDR including:
    - System capabilities and constraints
    - The required M&Q capabilities baseline
    - M&Q cost drivers and impact on schedule and performance
- Provide M&Q input to design trade studies (i.e., functional and performance requirements) that include criteria concerning:
    - KCs and the associated KPPs, KSAs, and APAs
    - M&Q process capabilities, limitations, and concerns
    - Materials, components, and items sourcing (e.g., domestic vs. foreign risks)
    - Embedded software and firmware development and re-use

  - Use of IP and proprietary data
  - Safety, handling, storage, and disposal considerations and restrictions
  - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
  - Manufacturing costs, materials, special tooling, and test equipment
  - Manufacturing facility and equipment capacity, workforce availability and capability, and schedule impacts

- M&Q personnel participation in the design producibility process provides:
  - Analyses of products and processes that would benefit from producibility analyses (i.e., DFM/DFA)
  - Monitoring and reporting on producibility processes and testing with respect to risks, issues, and opportunities
  - Integration of producibility with other design activities including software and firmware development and re-use
  - Analyses and results of producibility design trade studies to include process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
  - Assessment of additional innovative manufacturing technology opportunities (beyond current ManTech projects)

- Provide a focal point for producibility assessments and integration with other design activities (e.g., engineering, producibility, reliability, maintainability, costs, safety, manpower, schedule, etc.).
- Provide assessments of key and critical M&Q assembly and test processes to be evaluated and matured.
- Provide ongoing M&Q assessments of risks, issues, and opportunities (e.g., technologies, manufacturing, software development, and sustainment).
- Provide monitoring, reviews, analyses, and reports on multiple FMEAs (e.g., DFMEA, PFMEA, etc.) as part of the M&Q inputs to the FMECA process.
- For the Engineering and Manufacturing Development and demonstration process, M&Q participants should provide:
  - Inputs that establish, implement, and maintain appropriate processes to manage key and critical subsystems, components, and items including process controls for KCs
  - Criteria and metrics for design and production process verification, test, inspection, product verification and acceptance (including statistical techniques)
  - Monitoring and managing the data from the development process with acceptable frequency, quantity, and metrics
  - Criteria for and monitoring of M&Q development testing for validating design outputs (products)

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

- Update the analyses of M&Q design activity impacts and interdependencies to other functional areas or activities (e.g., engineering, producibility, reliability, maintainability, costs, safety, manpower, schedule, etc.).
- Perform re-assessments of M&Q risks, issues, and opportunities and the associated mitigation activities, based on the changes to and progress of the design, in meeting critical design entrance criteria (e.g., technology, manufacturing, cybersecurity, software development, and sustainment).
- Provide M&Q support to Design IPT participation in program reviews (e.g., PMRs, CDR, etc.).
- Assess and monitor the development of the system design for use of COTS, GOTS, GFP/GFE, and NDIs for impacts to M&Q, potential obsolescence requiring re-design and design changes, and sustainment (e.g., availability, storage, etc.)
- Provide updated M&Q inputs to program documentation (e.g., SEP, TEMP, Acquisition Strategy, CDD, etc.) based on design changes and progress:
  - Include inputs and support for CPD efforts
  - Include inputs for Manufacturing Plan updates (including changes, investments, etc.)
- M&Q participants should provide support to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.).
- Provide M&Q inputs to program management in support of assessments and reports mandated by Congress.
  - Inputs on M&Q risks associated with the program
  - Inputs on M&Q processes that need to be matured

Metrics

- M&Q personnel as Design IPT participants have assessed and are monitoring continuing adherence to M&Q design best practices (e.g., AS6500, AS9100, ISO 9001, etc.) and providing documented recommendations to program management and the contractor as appropriate.
- M&Q requirements, based on analyses of system requirements and design concepts from TMRR developments and the PDR, have been updated for the SEP and included inputs on:
  - System capabilities and constraints
  - The required M&Q capabilities baseline
  - Cost drivers and impacts to schedule and performance
- M&Q personnel have participated in and provided documented inputs to design trade studies including criteria concerning:

  - KCs and the associated KPPs, KSAs, and APAs
  - M&Q process capabilities, limitations, and concerns
  - Materials, components, and items sourcing (e.g., domestic vs. foreign risks)
  - Embedded software and firmware development and re-use
  - Use of IP and proprietary data
  - Safety, handling, storage, and disposal considerations and restrictions
  - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
  - Manufacturing costs, materials, special tooling, and test equipment
  - Manufacturing facility and equipment capacity, workforce availability and capability, and schedule impacts

- M&Q participants in the design producibility process have provided:
  - Reports to program management and the contractor with recommendations of products and processes that require producibility analyses performed
  - Monitoring, reporting, and status of mitigation of risks and issues, and progress on opportunities from producibility processes and testing
  - Analyses and documentation of the integration of producibility with other design activities (including software and firmware development and re-use)
  - Documentation of producibility design trade studies results and impacts, including process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
  - Analyses and recommendations for addition of new innovative manufacturing technology opportunities (beyond current ManTech projects)

- Documentation has been provided on producibility assessments and integration with other design activities to program management and Systems Engineering (e.g., engineering, producibility, reliability, maintainability, costs, safety, manpower, schedule, etc.).
- Key and critical M&Q assembly and test processes have been assessed for maturity with documented recommendations to finalize and implement in the Manufacturing Plan and potentially the SEP.
- M&Q participants have provided monitoring and reports on M&Q risks and issues mitigation status (burn-down), and opportunity activities progress.
- M&Q inputs to the FMECA process, reports on reviews, analyses, and status of multiple FMEAs (e.g., DFMEA, PFMEA, etc.) have been provided to rogram management and System Engineering.
- M&Q participants have provided and documented in the Manufacturing Plan for EMD and the demonstration process:
  - 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)
  - Future processes to monitor and manage data with acceptable frequency, quantity, and metrics based on ongoing monitoring and management activities
  - Criteria for M&Q development testing to validate the design
  - M&Q inputs for design configuration management
- 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.) have been updated and documented in the SEP and in the IMP/IMS.
- Re-assessments of M&Q risks, issues, and opportunities and the associated mitigation activities have been performed and documented for the joint RIO Management System based on design changes and progress in meeting critical design entrance criteria.
- M&Q Design IPT participants have provided support and documentation to program reviews (e.g., PMRs, CDR, etc.).
- The use of COTS, GOTS, GFP/GFE, and NDIs in the system design has been assessed and documented for impacts to M&Q as well as potential obsolescence requiring re-design and design changes and impacts on sustainment (e.g., availability, storage, etc.).
- Updated M&Q inputs have been provided to program documentation (e.g., SEP, TEMP, Acquisition Strategy, CDD, etc.) based on design changes and progress including:
  - Inputs and support for CPD efforts
  - Inputs for Manufacturing Plan updates (including changes, investments, etc.)
- M&Q participants have provided support and documentation (inputs) to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.).
- M&Q personnel have provided inputs to rogram management in support of Congressionally mandated assessments and reports including inputs on:
  - M&Q risks associated with the program
  - M&Q processes that need to be matured

Tools

- CDR Checklist
- CPD template
- Design for Manufacturing and Assembly (DFMA)
- FCA Checklist
- IMP/IMS template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Life Cycle Sustainment Plan template
- Manufacturing Maturation Plan

- PRR Checklist
- SVR Checklist
- Systems Engineering Plan (SEP) Outline
- TEMP template
- TRA Checklist
- TRR Checklist

Resources

- 10 USC 144B, Sections 2366 and 2448
- Acquisition Strategy Guide, DSMC
- CDD-CPD writing Guide
- Critical Design Review, DAG
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- Functional Configuration Audit, DAG
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- LCSP memo, and DAG
- Manufacturing Readiness Level (MRL) Deskbook
- Production Readiness Review, DAG
- System Verification Review, DAG
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment (TRA) Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide
- Test and Evaluation Master Plan (TEMP) Guide, and DAG

E.2 Assess Design vs. Manufacturing Capability

M&Q managers as members of the technical Integrated Product Team (IPT) should accomplish an assessment of the design and the capability of the factory floor to build to the design. This includes assessing manufacturing readiness and effective integration of industrial capability considerations into the design process. The first consideration is a need to understand current manufacturing capabilities to see if they match up against the design requirements so that the program can plan for the enhancements of capabilities where there is a gap between the design and factory floor capabilities.

Manufacturing and Quality Tasks

- Perform M&Q design trade studies and analyses on system, subsystems, items, and components for:

  - Interdependencies and interfaces
  - Design for Manufacturing and Assembly
  - M&Q “ilities”: (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.)

- Perform M&Q assessments of the contractor(s) and supply chain capability to mature and manufacture the design(s) within the program overall cost, schedule, and performance goals, including:
  - Design status and progress for CDR including exit criteria
  - Quantification of risks, issues, opportunities, and status of mitigation plans
    - Including shortfalls to the required baseline M&Q capability
    - Including materials, producibility, equipment, and schedule (e.g., availability, hazardous, long-lead, etc.)
  - All competing technologies, prototypes, systems, etc.
    - Including M&Q inputs to production unit cost and schedule estimates realism
  - M&Q processes and techniques, not yet part of the contractor’s baseline, development requirements driven by the design, including:
    - Facilities, equipment, manpower, quality technologies,
    - Planned and/or anticipated M&Q developmental testing and demonstration efforts
    - Capabilities with respect to safety, security, environmental, hazardous materials, etc.
- Update the list of KCs, critical characteristics, CAIs, Key M&Q processes, and CSIs, based on design trade studies and assessments, and PDR results.
- Assess required M&Q budget and investments for necessary capabilities (e.g., facilities, capital equipment, tooling, test equipment, ManTech, GFE processes, M&S, etc.)

Metrics

- M&Q design trade studies and analyses have been conducted and documented for system, subsystems, items, and components including:
  - Interdependencies and interfaces
  - Design for Assembly
  - M&Q “ilities”, (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.)
- Assessments of the contractor(s) and supply chain capability to mature the M&Q aspects and manufacture the design(s) within the program overall cost, schedule, and performance goals have been conducted and recommendations for changes have been documented and provided to the Design IPT, including:
  - Recommendations for achieving CDR exit criteria (*See* E.7)

  - Updated and quantified risks and issues mitigation plans, and potential opportunities which address:
    - Shortfalls to the required baseline M&Q capability
    - Materials, producibility, equipment, and schedule (e.g., availability, hazardous, long-lead, etc.)
  - Recommendations for each competing technology, prototype, system, etc. which include inputs to production unit cost and schedule estimates realism
  - Recommendations on M&Q processes and techniques that are not yet part of the contractor's baseline but are driven by the design, including:
    - Facilities, equipment, manpower, quality technologies,
    - Planned and/or anticipated M&Q developmental testing and demonstration efforts
    - Capabilities with respect to safety, security, environmental, hazardous materials, etc.
- The preliminary list of KCs, critical characteristics, CAIs, Key M&Q processes, and CSIs has been updated and provided to the Design IPT and System Engineering IPT, and recommendations provided for the contractor(s) SEMP based on the design trade studies and assessments, and the PDR results.
- M&Q budget and investments have been documented and provided to program management for necessary capabilities (e.g., facilities, capital equipment, tooling, test equipment, ManTech, GFE processes, M&S, etc.).

Tools

- CDR Checklist
- CPD template
- Design for Manufacturing and Assembly (DFMA)
- FCA Checklist
- IMP/IMS template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Life Cycle Sustainment Plan template
- Manufacturing Maturation Plan
- PRR Checklist
- SVR Checklist
- Systems Engineering Plan (SEP) Outline
- TEMP template
- TRA Checklist
- TRR Checklist

Resources

- 10 USC 144B, Sections 2366 and 2448

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- CDD-CPD writing Guide
- Critical Design Review, DAG Chapter 3
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- Functional Configuration Audit, DAG Chapter 3
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- LCSP memo, and DAG
- Manufacturing Readiness Level (MRL) Deskbook
- Production Readiness Review, DAG Chapter 3
- Risk, Issue, and Opportunity Management Guide
- System Verification Review, DAG Chapter 3
- Systems Engineering Plan (SEP) Outline
- Test and Evaluation Management Guide
- TRA Guidance

E.3 Update Producibility Plans

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

Manufacturing and Quality Tasks

- Review and analyze the contractor(s) design plans for scope, realism, completeness, and clarity of specific processes, methods, and actions to address manufacturing feasibility, producibility, and quality to include:
    - A schedule for regular reviews to monitor and support design progress
    - Delineation of responsibilities and management controls
    - Application of producibility design criteria
    - Interdependencies and integration factors
    - M&Q technology project insertion
    - Technology insertion opportunities, schedule, and budget

- Ensure updates to contractor producibility plans for identified and potential M&Q risks, issues, and opportunities to include:
    - KCs and critical design characteristics
    - M&S results from design, manufacturing, and production modeling
    - M&Q processes, capacity, capability, yield, rates, and variability
    - Materials and components (including embedded software)
    - Cost, schedule, and performance
    - Facilities, tooling, testing, and qualification
    - Workforce
- Ensure updated contractor producibility plans for design, manufacturing, and quality include:
    - Security (physical and cyber)
    - System safety and hazardous materials management criteria
    - Interdependencies and integration
    - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
    - Benchmarking
    - Costing
    - Management of M&Q data
    - Results of Failure Mode and Effects Analysis (FMEA)
        - Design Failure Mode and Effects Criticality Analysis (DFMECA)
        - System Failure Mode and Effects Criticality Analysis (SFMECA)
        - Process Failure Mode and Effects Analysis (PFMEA)
    - Results from prototype builds and demos
- Evaluate updated contractor producibility plans for the specific applications of producibility design tools such as:
    - Failure Mode and Effects Analyses (including Design, Process, and Criticality)
    - Design of Experiments (DOE)
    - Quality Functions Deployment (QFD)
    - Root Cause Analyses
    - Statistical Process Control (SPC)
    - Tolerance Analyses
    - Design for Manufacture/Assembly (DFMA)
    - Design for Six Sigma
    - Lean manufacturing
- M&Q personnel should evaluate contractor’s design producibility process for factors such as:
    - Robust tolerances (dimensions, mechanical, electrical)
    - Materials that provide optimum machinability, formability, and weldability
    - Economic use of shapes and forms designs for castings, stampings, extrusions, etc.

- Optimum inspection and test requirements
- Use of available and standard inspection equipment
- Economical methods and procedures
- Optimized requirements for manufacturing tooling and/or special skills

Metrics

- Assessment and review of contractor's ongoing producibility enhancement efforts documents cost and/or schedule improvements.
- Contractor(s) design plans have been evaluated for scope, realism, completeness, and clarity with respect to specific processes, methods, and actions that address manufacturing feasibility, producibility, and quality. Recommendations for and required actions or additions to the plans have been provided to program management and the contractor. Documented contractor plans should have included:
  - A schedule of regular reviews to monitoring and supporting design progress
  - Roles, responsibilities, and management controls
  - Producibility design criteria
  - Management of interdependencies and integration factors
  - Insertion points for M&Q technology projects
  - Schedule and budget for technology insertions
- Updates to the contractor producibility plans have been identified and documented recommendations provided to program management and the contractor for the following:
  - Updates to KCs and critical design characteristics
  - Results from design, manufacturing, and production modeling (i.e., M&S)
  - Changes in M&Q processes, capacity, capability, yield, rates, and variability
  - Changes in materials and components (including embedded software)
  - Updates to cost, schedule, and performance
  - Facilities, tooling, testing, and qualification updates
  - Workforce changes (e.g., skill sets, availability, training, turnover, etc.)
- Documented contractor producibility plans have been reviewed and approved, and should include the following design, manufacturing, and quality considerations:
  - Security (physical and cyber)
  - System safety and hazardous materials management criteria
  - Interdependencies and integration
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
  - Benchmarking
  - Costing
  - Management of M&Q data
  - Results of Failure Mode and Effects Analysis (FMEA)

        - Design Failure Mode and Effects Criticality Analysis (DFMECA)
        - System Failure Mode and Effects Criticality Analysis (SFMECA)
        - Process Failure Mode and Effects Analysis (PFMEA)
    - Results from prototype builds and demos
- Updated contractor producibility plans for use of specific design tools have been evaluated and analyses performed and documented to indicate expected results.
- Contractor's design producibility process has been evaluated and reported to program management, and should include producibility best practices of:
    - Robust tolerances (dimensions, mechanical, electrical)
    - Materials that provide optimum machinability, formability, and weldability
    - Economic use of shapes and forms designs for castings, stampings, extrusions, etc.
    - Optimum inspection and test requirements
    - Use of available and standard inspection equipment
    - Economical methods and procedures
    - Optimized requirements for manufacturing tooling and/or special skills

Tools

- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Producibility Engineering and Planning (PEP) Data Item Description
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- Defense Manufacturing Management Guide for Program Managers
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- MIL-HDBK-727, Design Guidance for Producibility
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering and Planning (PEP)
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center
- Systems Engineering Plan (SEP) Outline

E.4 Conduct Producibility Assessments

The Program Manger should reduce M&Q risk and demonstrate producibility prior to FRP. Producibility engineering and producibility assessments should be a part of the ongoing systems engineering process. Producibility is directly connected to the complexity of a system. As complexity

increases, so does the acquisition costs. Therefore, producibility programs are necessary as a management means for assuring that the cost increases associated with the growing complexity of systems are minimized. Producibility analysis accomplished by the PMO must be performed by a team of specialists assembled from the program office: and supporting organizations. M&Q managers are key to the successful implementation of a producibility program.

Manufacturing and Quality Tasks

- M&Q personnel as Design IPT participants support and/or perform producibility assessments using updated and approved contractor producibility plans and other contractor and/or programmatic information and data including the following factors in the assessments:
    - Planned producibility goals and metrics
    - Management roles, responsibilities, and controls
    - Updates to KCs and critical design characteristics
    - Contractor core capabilities and processes (e.g., M&Q technologies, design, and process disciplines, etc.)
    - Design analyses and testing (i.e., prototypes)
    - Results from design, manufacturing, and production modeling (i.e., M&S)
    - Changes in M&Q processes, capacity, capability, yield, rates, and variability
    - Changes in materials and components (including embedded software)
    - Build and test data (from subsystem, items, components, and/or the supply chain)
    - Updates to cost, schedule, and performance
    - Updates to interdependencies and integration
    - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
    - Risks, issues, and opportunities
    - Insertion points for M&Q technology projects
    - Technology insertion schedule and budget
    - Review of goals, realism, completeness, and clarity
    - Implementation of industry best practices, tools, and techniques
    - System safety design and hazardous materials management criteria
    - Security (physical and cyber) including all digital communications and connectivity for design, facilities, equipment, etc.
    - Facilities, tooling, testing, and qualification updates
    - Workforce changes (e.g., skill sets, availability, training, turnover, etc.)
    - GFE, etc.
- Incorporate and investigate producibility possibilities that exist in the industrial base outside the contractor's supply chain from the assessments of the IB. (*See* D.1)
- M&Q personnel as Design IPT participants monitor, recommend, and support use of a wide range of producibility tools, techniques, procedures that include:
    - State-of-the-art M&S software including element analyses software packages

  - Failure Mode and Effects Analyses (FMEA)
    - Design Failure Mode and Effects Criticality Analysis (DFMECA)
    - System Failure Mode and Effects Criticality Analysis (SFMECA)
    - Process Failure Mode and Effects Analysis (PFMEA)
  - Design for Manufacture and Assembly (DFMA)
  - Design of Experiments (DOE)
  - Design for Six Sigma (DSS)
  - Quality Function Deployment (QFD)
  - Value Stream Mapping (VSM)
  - Benchmarking
  - Materials and process design guides (e.g., standards organizations, materials supplier, industry association, etc.)
  - Interdependencies and integration analyses
  - Tolerance analyses (e.g., stacking, robustness, geometric, etc.)
  - Requirements validation analyses
  - Trade studies on alternative product and process designs
  - Product complexity analyses
  - Manufacturing process analyses (i.e., Lean Manufacturing)
  - Quality and quality process analyses
  - Costs, cost drivers, and controls analyses
  - Materials characterization and availability
  - Prototyping of component, item, subsystem, competitive, etc.
  - Learning curve goals and projections
  - Product, process capabilities, and measurements using Statistical Process Control (SPC)
  - Data and database management
  - Developmental testing

- Provide program M&Q support to design producibility analyses, to validate and recommend appropriate producibility improvements (by rank and/or priority) to be implemented in the system design and/or specifications.
- Prepare a joint government/contractor schedule for implementation of the producibility improvements based determined rank and priority.

Metrics

- M&Q personnel as Design Integrated Product Team (IPT) participants have provided support and/or performed producibility assessments using updated and approved contractor producibility plans and other contractor and/or programmatic information and data. Documented assessment results have been analyzed for potential design improvements (and possible ECPs) and include the following:
  - Status and progress toward producibility goals and metrics

  - Changes in management roles, responsibilities, and controls
  - Improved control of KCs and critical design characteristics
  - Incorporation of contractor core capabilities and processes (e.g., M&Q technologies, design, and process disciplines, etc.)
  - Design analyses and testing results (i.e., prototypes)
  - Improvements from design, manufacturing, and production modeling (i.e., M&S)
  - Improvements in M&Q processes, capacity, capability, yield, rates, and variability
  - Improvements in materials and components (including embedded software)
  - Analyses of build and test data (from subsystem, items, components, and/or the supply chain)
  - Improvements to cost, schedule, and performance
  - Reduction of interdependencies and integration considerations
  - Inclusion of MOSA interfaces and subsystems
  - Risks and issues mitigation, and opportunity planning
  - Scheduled insertion points for M&Q technology projects
  - Scheduled technology insertion
  - Review of goals, realism, completeness, and clarity or the design improvements
  - Industry best practices, tools, and techniques
  - Criteria for System safety design and hazardous materials management
  - Improvements in security (physical and cyber) including all digital communications and connectivity for design, facilities, equipment, etc.
  - Updates to facilities, tooling, testing, and qualifications
  - Workforce improvements (e.g., skill sets, availability, training, turnover, etc.)
  - Updates for use of GFE, etc.

- Producibility possibilities in the industrial base outside the contractor's supply chain have been analyzed and recommended for implementation. (*See* D.1)
- M&Q personnel as Design IPT participants have tracked and documented results and effectiveness of the wide range of producibility tools, techniques, procedures applied during system design. Documented reports include:
  - Lessons learned for further application within the program and future programs
  - Updates to learning curves (goals and projections)
  - Analyses of effectiveness and realism modeling and simulations used for both the system models and the manufacturing models
  - Recommended mitigations for both system and manufacturing risks identified from FMEAs
  - Design changes and improvements to product complexity, M&Q processes, and process capabilities recommended by results from application of DOE, DFMA, DSS, VSM, and Lean Manufacturing
  - QFD analyses ranking and validating the requirements and the subsequent impacts on the design

  - Comparisons of system, subsystems, items, and components designs to existing or under-development products (benchmarking) with appropriate data collection and recommendations for program actions
  - Analyses of system, subsystem, items, and components against design guides (e.g., standards organizations, materials supplier, industry association, etc.) and recommendations for design improvements
  - Analyses and impacts of interdependencies and integration down to the component level
  - Results and recommendations from tolerance analyses (e.g., stacking, robustness, geometric, etc.)
  - Results from trade studies on alternative product and process designs with recommendations
  - Results from analyses of materials characterization and availability with recommended actions or improvements
  - Results from developmental testing and prototyping of component, item, subsystem, competitive, etc.
  - Summary of impacts and improvements to costs, cost drivers, schedule, and performance
- M&Q personnel support to design producibility assessments and analyses have produced a report that validates and recommends appropriate producibility improvements by rank and/or priority to be implemented in the system design and/or specifications.
- A joint government/contractor implementation schedule for producibility improvements has been developed based determined rank and priority.

Tools

- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- MIL-HDBK-727, Design Guidance for Producibility
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering Standard Practice Manual, U.S. Army Belvoir R&D Center
- Systems Engineering Plan (SEP) Outline

E.5 Develop Detailed Design

Detailed product design includes the realization (build) effort down to the lowest level system elements and includes the fabrication/production processes required to complete the build effort. As a best practice, the Systems Engineer should develop an implementation plan that includes implementation procedures, fabrication processes, tools and equipment, implementation tolerances and verification uncertainties. M&Q managers/engineers need to be a part of the development and assessment of detailed design efforts.

Manufacturing and Quality Tasks

- M&Q personnel support and participate in design reviews at all possible levels of the supply chain to assure that the contractor is complying with the M&Q design requirements within the cost/design goals to include:
    - Adherence to M&Q best practices (e.g., AS6500, AS9100, ISO 9001, etc.)
    - Ensure all PDR action items are closed, and corrective actions completed.
    - Results of appropriate producibility studies including manufacturing technology improvements, recommended design changes, and recommended facilities and equipment changes
    - Results of ManTech projects
    - Detailed design drawings, bills-of-material, and product and process specifications are on track for completion by CDR
    - Performance requirements, the outcomes of the testing accomplished, producibility studies, and other design influences are part of the final design
    - Design is specified to the lowest level of detail to meet capability and capacity requirements
- As part of detailed design activities, M&Q personnel should identify and quantify risks with associated mitigation (e.g., re-direct, re-design, etc.) to minimize M&Q risks in the completed design for CDR.
- As part of detailed design, ensure KCs whose variation has a significant influence on product fit, performance, service life, or manufacturability are specified and monitored for CDR.
- M&Q personnel should identify requirements for in-process and acceptance testing to be included in M&Q processes.
- Ensure M&Q requirements for physical, digital, and industrial security follow DoD policies and NIST standards incorporated into the design and manufacturing system.
- Ensure that required M&Q products and processes comply with specified security (e.g., SSE, COMSEC, and PPP) requirements of the program including trusted production of products down to the component level.
- Assess requirements for required system certifications (e.g., statutory, safety, environmental, airworthiness, others as required) and the impacts on M&Q requirements and associated costs, budget, schedule, etc.

- Assess design requirements for the following (include associated costs, budget, schedule, etc.):
  - Incorporation of all ESOH, environmental, hazardous material, etc. requirements into the detailed design
  - EMI requirements and constraints for the design, control processes, procedures, and planned facilities and equipment (including EMI susceptibility)
  - Radiation hardening, thermal, vibration, and shock environments, all environmental parameters, and Highly Accelerated Life Testing (HALT) requirements for impacts to and requirements of M&Q (e.g., facilities, tooling, equipment, test equipment and facilities, processes, procedures, storage, waste disposal, etc.)
  - Impacts to and requirements of M&Q personnel (e.g., operators, assemblers, welders, platers, coatings specialists, etc.)
  - Corrosion, contamination, hazards, hazardous combinations of materials, and impacts on manufacturing processes, quality control processes, and procedures for both
  - Impacts on M&Q data requirements (e.g., collection, processing, storage, security, access, availability, etc.)
  - Impacts to M&Q from materials, components, and items maturity and availability; lead-times; source availability, capability, and capacity to include the supply chain
  - Necessary M&Q equipment, fixtures, tooling, work-holding, parts interim storage and handling equipment, ancillary equipment, etc.
- Assess the adequacy of M&Q sustainment requirements (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.) and processes, and activities being considered and addressed in the design specifications.
- Assess contractor's and supplier's configuration management systems for traceability, accuracy, sufficiency, and accessibility in preparation for CDR.
- As the system, subsystem, items, and components are being specified, analyze these to ensure M&Q constraints and requirements have been incorporated into design specifications and requirements.
- Analyze results of demonstrations in a relevant environment from the previous phases of all new technologies to be incorporated into the design to ensure they can be incorporated and integrated into a system with acceptable M&Q risks.
  - If not conducted, recommend demonstrations prior to CDR.
- Assess M&Q physical architectures, development specifications, and detailed designs for key manufacturing processes (i.e., KCs), CSIs and CAIs to be under contractor's configuration control and on track for completion by CDR.
- Ensure all long lead production requirements are identified for CDR.
- Assess the system design for parts, materials, and processes to ensure appropriate allocation of M&Q requirements in the detailed design.

- Based on the results of the detailed design development activities, M&Q personnel should provide updated inputs to the program Work Breakdown Structure (WBS).
- Prior to finalizing the design for CDR, M&Q personnel should assess: (*See* E.8)
    - Results of all design trade studies for M&Q impacts and changes to KCs and therefore associated KPPs to verify that all requirements are being met
    - Bi-directional traceability among all M&Q considerations:
        - Allocated and physical requirements
        - Engineering trade study results
        - Technical, schedule and cost risks, issues, and opportunities

Metrics

- M&Q personnel actively participated in and supported all design reviews at all possible levels of the supply chain and have documented contractor compliance to the M&Q design requirements and are within the M&Q cost and/or design goals to include:
    - Adherence to M&Q best practices (e.g., AS6500, AS9100, ISO 9001, etc.)
    - Closure of all PDR action items and corrective actions
    - Results of manufacturing technology improvements, design changes, and facilities and equipment changes
    - ManTech projects implementations
    - Updated design drawings, bills-of-material, and product and process specifications on track for completion by CDR
    - Performance requirements, the outcomes testing, producibility studies, and other design influences are part of the final design
    - Design specifications to the lowest level of detail to meet capability and capacity requirements
- M&Q personnel have identified, quantified, and documented risks with associated mitigation to be at an acceptable level (i.e., minimized M&Q risks) in the completed design for CDR.
- KCs have been specified and documented in the M&Q plans and are being tracked and monitored for CDR with risks and issues mitigation plans in place.
- M&Q personnel have identified and documented requirements for in-process and acceptance testing and have included these in the M&Q plans.
- M&Q requirements for physical, digital, and industrial security have been documented to follow DoD policies and NIST standards.
- M&Q products and processes including trusted production of products down to the component level have been documented to follow specified security requirements of the program (e.g., SSE, COMSEC, and PPP).

- Requirements for system certifications (e.g., statutory, safety, environmental, airworthiness, others as required) and the impacts on M&Q have been documented in the SEP with associated costs, budget, schedule, etc. in appropriated program documentation (e.g., IMP/IMS, etc.).
- Design with associated costs, budget, schedule, etc. has been analyzed and documents the following M&Q requirements:
    - ESOH, environmental, hazardous material, etc.
    - EMI consideration and constraints including control processes, procedures, and planned facilities and equipment
    - Radiation hardening, thermal, vibration, and shock environments, all environmental parameters, and HALT
    - Corrosion, contamination, hazards, hazardous combinations of materials
    - Data collection, processing, storage, security, access, availability, etc.
    - Materials, components, and items maturity and availability; lead-times; source availability, capability, and capacity to include the supply chain
    - M&Q facilities, tooling, test equipment and facilities, processes, procedures, storage, waste disposal, etc.
    - Item and component equipment, fixtures, work-holding, parts interim storage and handling equipment, ancillary equipment, etc.
    - M&Q workforce (e.g., operators, assemblers, welders, platers, coatings specialists, etc.)
    - Manufacturing processes, quality control processes, and procedures for both
- M&Q requirements for sustainment (e.g., stability, usability, scalability, accessibility, flexibility, agility, producibility, manufacturability, etc.) and sustainment processes and activities have been documented and provided for the LCSP.
- Contractor's and supplier's configuration management systems have been assessed and documented to follow M&Q contractual requirements for traceability, accuracy, sufficiency, and accessibility in preparation for CDR.
- M&Q constraints and requirements have been incorporated and documented in the design specifications and requirements for the system, subsystem, items, and components.
- Recommended demonstrations in a relevant environment have been conducted for all new technologies to be incorporated and integrated into the system and document an acceptable level of M&Q risks.
- Physical architectures, development specifications, and detailed designs have been assessed for key manufacturing processes, KCs, CSIs and CAIs and are under contractor's configuration control and are on track for completion by CDR.
- All long lead production requirements have been identified and documented in preparation for CDR.

- System design for parts, materials, and processes with the appropriate M&Q requirements allocation for the detailed design have been documented in the configuration management system and the requirements tracking system (i.e., DOORS) and are on schedule for completion by CDR.
- Results of all design trade studies for M&Q impacts and changes to KCs have been verified and documented that all requirements are being met for CDR. (*See* E.8)
- M&Q personnel have documented and provided updated inputs based on the results of the detailed design development activities to the program WBS.
- Completed detailed design demonstrates and documents M&Q bi-directional traceability among all allocated and physical requirements, engineering trade study results, and technical, schedule and cost risks, issues, and opportunities. (*See* E.8)

Tools

- CDR Checklist
- CPD template
- Design for Manufacturing and Assembly (DFMA)
- FCA Checklist
- IMP/IMS template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Life Cycle Sustainment Plan template
- Manufacturing Maturation Plan
- PRR Checklist
- SVR Checklist
- Systems Engineering Plan (SEP) Outline
- TEMP template
- TRA Checklist
- TRR Checklist

Resources

- 10 USC 144B, Sections 2366 and 2448
- Acquisition Strategy Guide, DSMC
- CDD-CPD writing Guide
- Critical Design Review, DAG Chapter 3
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- Functional Configuration Audit, DAG Chapter 3
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide

- LCSP memo, and DAG
- Manufacturing Readiness Level (MRL) Deskbook
- Production Readiness Review, DAG Chapter 3
- Risk, Issue, and Opportunity Management Guide
- System Verification Review, DAG Chapter 3
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- TEMP Guide, and DAG
- Test and Evaluation Management Guide

E.6 Assess Design Maturity

Prior to the CDR the contractor is finalizing the design as may be evidenced by a lot of design changes. The CDR assesses the systems final design as captured in the product specifications for each configuration item and ensures that the configuration item has been captured in the detailed design documentation. The CDR should be conducted when the product baseline has been achieved, allowing fabrication of hardware and coding of software deliverables to proceed. A rule of thumb is that 75 percent to 90 percent of (manufacturing quality) product drawings, software design specification(s) and associated instructions should be complete, and that 100 percent of all safety-critical component (Critical Safety Items and Critical Application Items) drawings are complete.

After CDR the design should be maturing and should be stable and mature by the Production and Operations phase and may be considered mature when the number and type (Class I and Class II) of engineering change traffic is tapering off and when the drawing packages have been released to manufacturing. Configuration of the item should be stable as should be the requirements. M&Q (M&Q) managers as a part of the Technical IPT should support the CDR and assessment of design maturity as the program approaches a Milestone C Decision.

Manufacturing and Quality Tasks

- M&Q personnel will assess design maturity based on assessments of manufacturing feasibility, capability analyses, producibility, and KC analyses, in accordance with industry best practices (e.g., AS6500, AS9100, etc.) and assess readiness for the CDR (per IEEE 15288).
- Update M&Q assessments of the contractor(s) and supply chain capability to mature and manufacture the detailed design within the overall cost, schedule, and performance goals (e.g., producibility, feasibility, and capability)
    - Assess manufacturing processes and quality results for each individual configuration item to verify each meets the stated performance requirements
    - Assess completeness of product data required for component manufacturing

  - Assess adequacy and robustness of the parts management and configuration control processes (e.g., design, engineering, and software)

- M&Q personnel support design reviews at all levels of the supply chain, assess adequacy and completeness of M&Q requirements verification and validation activities including demonstrations in a representative environment at the system, subsystem, item, and component levels.
  - Assess and verify product and technology requirements and features as ready for system CDR including
    - Products producibility (subsystem, item, and component)
    - Products and technology maturity
    - Alternate sources and products producibility, maturity, and availability (i.e., second sources)
    - MOSA
    - COTS, NDIs, and GFE
  - Assess M&Q results of TPM maturation activities to support design maturity
  - Assess and validate if product data essential for item and component manufacturing is under configuration control and has been released
  - Verify completion of physical and functional interface designs for the system
  - Verify long-lead production requirements have been established and are understood
  - Verify M&Q safety requirements are in the detailed design to include all safety hazards
  - Assess and validate prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software
  - Verify completion of subsystem design (with closure schedule for open items) and percentage of subsystems in current production

- Monitor and assess the maturity of KCs and critical characteristics, the associated M&Q processes, and associated mitigation activities.
  - Verify correctness, adequacy, and completeness of key and critical processes for KCs and critical characteristics (e.g., C_{pk}, tolerances, etc.)
  - Verify correctness, adequacy, and completeness of KCs and critical characteristics to the associated KPPs
  - Verify contractor M&Q engineering and management activities for adequacy and completeness (e.g., demonstrations, documentation, drawings, testing, data collection and management, etc.)
    - Analyze data from demonstrations of key and critical M&Q processes in a production-representative environment to satisfy design tolerances and meet objectives

- Monitor post-PDR M&Q mitigation measures and maintain the status of all mitigation measures up to date for all gaps, risks, and issues including those from:
    - Key and critical manufacturing processes including embedding software
    - Materials
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment
- Assess adequacy and completeness of mitigation activities for reducing M&Q risk, issues, and opportunities in the joint government/contractor RIO Management System.

Metrics

- M&Q personnel have assessed design maturity and provided input on M&Q readiness for the CDR based on assessments of manufacturing feasibility, capability analyses, producibility, and KC analyses, in accordance with industry best practices.
- M&Q assessments of the contractor(s) and supply chain have been conducted and document for CDR:
    - Capability to mature and manufacture the detailed design within the overall cost, schedule, and performance goals
    - Manufacturing processes and quality results for each individual configuration item have been verified to meet the stated performance requirements
    - Product data required for component manufacturing is complete
    - Parts management and configuration control processes are adequate and robust
- Adequacy and completeness of M&Q requirements verification and validation activities, throughout the supply chain, including demonstrations in a representative environment at the system, subsystem, item, and component levels, have been assessed, are reported in the appropriate documentation for CDR, and include the following:
    - Product and technology requirements and features as ready for system CDR including:
        - Products producibility (subsystem, item, and component)
        - Products and technology maturity

        - Alternate sources and products producibility, maturity, and availability (i.e., second sources)
        - MOSA
        - COTS, NDIs, and GFE
    - Maturation activities to support design maturity of M&Q TPMs
    - Product data essential for item and component manufacturing is under configuration control and has been released
    - Physical and functional interface designs for the system are complete
    - Long-lead production requirements have been established and are understood
    - All M&Q safety requirements are in the detailed design and include all manufacturing safety hazards
    - Results of prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software
    - Completed subsystem design (with closure schedule for open items) and percentage of subsystems in current production

- Maturation progress of KCs and critical characteristics, the associated M&Q processes, and associated mitigation activities have been assessed and documented for CDR to include:
    - Correctness, adequacy, and completeness of key and critical processes for KCs and critical characteristics (e.g., C_{pk}, tolerances, etc.)
    - Correctness, adequacy, and completeness of KCs and critical characteristics to the associated KPPs
    - Adequacy and completeness of contractor M&Q engineering and management activities (e.g., demonstrations, documentation, drawings, testing, data collection and management, etc.)
        - Results from demonstrations of key and critical M&Q processes in a production-representative environment that meet design tolerances and objectives

- Post-PDR M&Q mitigation measures have been monitored and the status of all mitigation measures is up-to-date, and is documented in the appropriate system documentation for CDR to include:
    - Key and critical manufacturing processes including embedding software
    - Materials
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management

  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment
- Adequacy and completeness of mitigation activities for the above mitigation efforts are included in the joint government/contractor RIO Management System (*See* A.1).

Tools

- Design for Six Sigma
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- MIL-STD 882E, System Safety
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.7 Assess Key Characteristics

AS9103 is the industry best practice of the identification and control of KCs and requires the producer to maintain documentation of KCs and control those manufacturing processes that directly influence variation of those KCs. KCs should be capable and have a Cpk of 1.33 or greater or as specified by the customer. The concept of identifying KCs is linked to the Pareto principle, which asserts that a relatively small number of features will have the most significant impact on performance. M&Q managers should be involved in the identification and assessment of KCs to see if they meet customer requirements and identify risks from not meeting those requirements.

Manufacturing and Quality Tasks

- Analyze and verify of the flow down of requirements to M&Q from the functional baseline to the lowest-level system detailed design element for all end items in the specification tree to ensure all are traced to specific manufacturing processes and quality metrics in the detailed design.

- Analyze all internal and external interface KCs (e.g., physical, electrical, digital, etc.) for M&Q specifications and requirements (e.g., flatness, attachment, connectivity, bi-directionality, compatibility, etc.) and changes since PDR to ensure acceptable risks for proceeding into fabrication, integration and testing.
- Analyze each specific manufacturing process and quality metric in the detailed design to verify that each is a KC (these should have been previously identified, but additional KCs may be identified).
    - Ensure each component level KCs is traceable to system design and is under control by the contractor specified in the documentation appropriately
- Analyze identified KCs for validity and adequacy using contractor tolerances and/or process capability indexes and supporting data.
- Ensure survivability and vulnerability threat (KPPs) allocations incorporated into the design down to the component level that are tied to specific manufacturing processes and quality metrics in the detailed design have been specifically identified by the contractor as such.
    - Ensure M&Q processes have been identified, analyzed, and are under configuration control
- Ensure that the contractor has established and is maintaining lists of Key and/or critical items, CSIs, and CAIs with the lists including:
    - Rationale for designation
    - Control and risk mitigation plan(s)
    - Where produced or accomplished (including potential changes)
- Ensure all identified KCs are incorporated into the Verification Cross-Reference Matrix (VCRM) for required testing and verification.

Metrics

- Flow down of requirements to M&Q from the functional baseline to the lowest-level system detailed design element for all end items in the specification tree have been verified and is documented in the Requirements System (i.e., DOORS) with each end item tied to specific manufacturing processes and quality metrics.
- All internal and external interface KCs (e.g., physical, electrical, digital, etc.) have been analyzed for M&Q specifications and requirements (e.g., flatness, attachment, connectivity, bi-directionality, compatibility, etc.) and all changes to ensure acceptable risks for proceeding into fabrication, integration and testing, and have been documented in all appropriate CDR documents for finalization at CDR.
- Each specific manufacturing process and associated quality metrics in the detailed design have been analyzed to verify that each is a KC.

  - Each component level KCs has been traced to system design and is under control by the contractor and documented appropriately

- Using contractor tolerances and/or process capability indexes and supporting data, KCs have been analyzed for validity and adequacy and the results and recommended changes have been documented.
- Survivability and vulnerability threat (KPPs) allocations incorporated into the design have been analyzed and tied to specific manufacturing processes and quality metrics and have been specifically identified by the contractor as such which have been placed under configuration control.
- Contractor has established and documented lists of Key and/or critical items, CSIs, and CAIs with the lists including:
  - Rationale for designation
  - Control and risk mitigation plan(s)
  - Where produced or accomplished (including potential changes)
- All identified KCs have been incorporated into the VCRM for required testing and verification.

Tools

- Critical to Quality Tree
- Failure Mode and Effects Analysis
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Level Assessment Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100 Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- JCIDS Manual
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Calculator
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

E.8 Support Critical Design Review

M&Q personnel should be actively engaged in the organization and execution of the CDR during this phase. The CDR occurs roughly mid-point in the EMD phase. The CDR brings to closure design paths in detailed design. Any changes moving forward should only be accomplished through a formal Engineering Change Proposal (ECP). The completion of the CDR should provide:

- An established system initial product baseline,
- An updated risk assessment for EMD,
- An updated CARD based on the system product baseline,
- An updated development schedule for fabrication, test and evaluation, software coding, critical path drivers, and
- An approved Life Cycle Sustainment Plan.

Manufacturing and Quality Tasks

- Ensure initial product baseline documentation for M&Q is sufficient, complete, and adequate to enable component manufacturing, hardware fabrication and software implementation to proceed.
    - Ensure all KCs, CSIs, and CAIs have completed drawings and specifications under configuration control
    - Ensure all product data essential (e.g., drawings, specifications, etc.) for component manufacturing has been released
- Ensure all M&Q design trade studies and producibility assessments are completed and incorporated into the design for CDR.
    - Ensure producibility enhancement efforts ongoing for optimized integrated system (e.g. Design for Manufacturability, Design for Assembly, etc.)
- Ensure all subsystem, item, and component CDRs are complete and the results available for the system CDR.
    - Analyze the results of design maturity assessments (*See* E.6) including all appropriate reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.) for closure or approved rationale to enter CDR without completion is documented and accepted by the program office.
- Ensure M&Q input to the schedule (IMP/IMS) is up-to-date and is executable with acceptable risks.
- Ensure M&Q plans, activities, and processes are executable within the existing M&Q budget to support the approved initial product baseline and critical path.
- Ensure all key and critical manufacturing processes, including process control plans, have been defined, characterized, updated for the detailed design, and the capability to meet design tolerances has been determined.

- Analyze contractor M&Q plans for materials, facilities, equipment, test facilities and equipment, and tooling to support the pilot line requirements.
- Analyze M&Q plans for adequacy and capability of achieving MRL 8 by initial production.
- Analyze plans for long-lead procurement requirements and incorporate results into procurement plans.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality, manufacturing management, ESOH, etc.) for M&Q risks, issues, and opportunities and appropriate mitigation plans.
- Analyze the assessments of adequacy and completeness of M&Q requirements validation activities (*See* E.6) which included prototypes and demonstrations in a representative environment at the system, subsystem, item, and component levels for design maturity.
    - Include demonstrations of manufacturing processes in a representative environment
    - Include demonstrations of M&Q processes for KCs, CSIs, and CAIs
- Provide M&Q inputs to the Life Cycle Sustainment Plan for CDR.
- Ensure contractor M&Q management systems for M&Q metrics and data collection and tracking to the component level are in place and functional.
- Ensure the TEMP incorporates all M&Q subsystems, items, and components into plans for tests, test facilities, and test equipment.
- Ensure the M&Q considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - PPP
    - SEMP
    - TEMP
- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure M&Q design producibility improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (*See* E.4).
- Provide up to date M&Q inputs to the program budget and the CARD.
    - Update and allocate M&Q (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure adequacy and completeness of mitigation activities for mitigation of M&Q risks, issues, and opportunities in the joint government/contractor RIO Management System, including:

- Key and critical manufacturing processes including embedding software
- Materials and sourcing
- Supply chain including multiple sources
- Production rates and yields
- Facilities
- Special tooling development
- Tests and demonstrations
- Security
- System safety and hazardous materials management
- Economic feasibility
- Schedule (i.e., IMP/IMS)
- Manufacturing capability obsolescence
- Manufacturing capability sustainment

Metrics

- Initial product baseline documentation for M&Q has been analyzed, validated, and approved for component manufacturing, hardware fabrication and software implementation to proceed.
  - All KCs, CSIs, and CAIs have completed drawings and documented specifications in the configuration management system
  - All essential product data for all components throughout the supply chain is in the configuration management system and released for manufacturing
- All M&Q design trade studies and producibility assessments have been completed and results incorporated into the system design for CDR.
  - Producibility enhancement efforts for optimizing the integrated system (e.g. Design for Manufacturability, Design for Assembly, etc.) are ongoing, documented, and progress monitored
- All subsystem, item, and component CDRs have been completed including closure of actions with the documented results, risks, and/or issues available for the system CDR.
  - Results of design maturity assessments (*See* E.6) and all appropriate reviews have been analyzed and documented
  - Inputs on the risks and issues have been provided to and accepted by the program office
- M&Q inputs to the schedule have been provided and included in the IMP/IMS.
- M&Q plans, activities, and processes have been analyzed as executable within the existing M&Q budget and documented to support the approved product baseline and critical path.
- All key and critical manufacturing processes have been analyzed and documented in the M&Q plans with associated risks and issues mitigation plans for the detailed design including:

  - Process control plans
  - Process definition characterization
  - Process capability to meet design tolerances

- Contractor M&Q plans have been analyzed and document adequacy, shortfalls, and recommendations to meet pilot line requirements for materials, facilities, equipment, test facilities and equipment, and tooling.
- M&Q personnel, have analyzed the system design and the contractor's M&Q plans for achieving MRL 8 criteria by initial production and have documented shortfalls and recommendations for CDR.
- Long-lead procurement requirements and plans have been analyzed and shortfalls and recommendations documented for CDR.
- Results of contractor and key supply chain assessments for M&Q risks, issues, and opportunities with appropriate mitigation plans have been analyzed and documented for consistency with Government assessments and include:

  - Costs, schedule, performance
  - Materials (e.g., lead-times, availability, etc.)
  - Subsystems, items, and components
  - M&Q management
  - Facilities, tooling, and test equipment
  - Developmental tests
  - Workforce
  - Transportation, storage, and handling
  - Security
  - Embedded software
  - ESOH
  - Industrial base risks and issues

- Assessments of the adequacy and completeness of M&Q requirements validation activities (*see* E.6) have been analyzed for design maturity and document the conduct of demonstrations, prototypes, and processes in a representative environment at all product levels for CDR, including KCs, CSIs, and CAIs.
- M&Q personnel have provided documented inputs to the Life Cycle Sustainment Plan for CDR.
- Contractor's M&Q management systems for M&Q metrics and data collection and tracking to the component level have been documented as in place, functional, and consistent with industry best practices for CDR.
- TEMP has been analyzed and results document inclusion of all M&Q subsystems, items, and components into plans for tests, test facilities, and the necessary test equipment.
- Contractor's plans and inputs have been assessed to include appropriate program M&Q requirements, are up-to-date, and approved for CDR, including:

  - Parts and Materials (Management) Plan (PMP)
  - Configuration Management Plan (CMP)
  - Software Development Plan (embedded software)
  - Quality Assurance Plan
  - PPP
  - SEMP
  - TEMP

- Subsystem, item, and component quantity estimates have been updated based on program system requirements, component yield and rate data, and results from prototype demonstrations and documented in the AS for CDR.
- M&Q design producibility improvements have been integrated into the system design and specifications, are being tracked, and are meeting the joint government/ contractor producibility implementation schedule (*See* E.4).
- Updated and documented M&Q inputs have been provided to the program budget and the CARD.
  - M&Q (production) cost models have been updated, allocated to lowest level, and tracked against targets
- Adequacy and completeness of mitigation activities has been included in the joint government/contractor RIO Management System, including:
  - Key and critical manufacturing processes including embedding software
  - Materials and sourcing
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and hazardous materials management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment

Tools

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

Resources

- AS6500, Manufacturing Management Program
- Defense Acquisition Guidebook (DAG), Critical Design Review
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline

Provide Updates to the Systems Engineering Plan

The SEP is a living document that details the execution, management, and control of the technical aspects of an acquisition program. The SEP outlines how the systems engineering process is applied and tailored to meet objectives for the program and is updated for each acquisition phase. M&Q managers, as members of the Technical IPT, should be providing input into the SEP.

Manufacturing and Quality Tasks

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

Metrics

- M&Q personnel have documented and provided updates to the SEP for the following:
    - System architectures and interfaces changes

- 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.
- Changes in program M&Q structure and organization including WBS, positions, staffing, etc.
- Changes to M&Q Technical Performance Measures and metrics with status including yields, rates, process capability indices, etc.
- Planned M&Q activities and schedule for the next phase including Value Engineering, ManTech, and other improvements, learning curves, initiating production, etc.
- Changes to M&Q requirements tracking and change processes including changes from prototypes, demonstrations, development testing, etc.
- Changes to M&Q configurations and proposed ECPs
- Changes to KCs and resulting impacts critical to the achievement of the program's technical requirements

Tools

- Critical to Customer/Critical to Quality Tree
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Manufacturing Plan (included in the SEP)
- Producibility Assessment Worksheet
- Quality Assurance Plan (included in the SEP)
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Systems Engineering Plan (SEP) Outline

E.10 Validate Design

Product design should have been stable by the time the CDR was conducted, however detailed design often continues well into the Production and Deployment phase. The Physical Configuration Audit (PCA) is a formal examination of the "as-built" configuration of the system or a configuration item

against its technical documentation to establish or verify its product baseline. A successful PCA provides the Milestone Decision Authority with evidence that the design is stable. At the conclusion of the PCA, the final product baseline is established, and all subsequent changes are processed by a formal engineering change action and under the control of configuration management practices. M&Q managers should support the validation of the design during the CDR and PCA.

Manufacturing and Quality Tasks

- Ensure all product level M&Q design requirements are defined and validated to be consistent with the specifications.
- Ensure all M&Q inputs to the product design support meeting the program requirements.
    - Verify M&Q requirements meet program cost, schedule, and performance requirements
    - Verify M&Q requirements are met at the subsystem, item, and component levels
- Assess prototypes and demonstrations, including system, subsystem, item, and component prototypes, for adequacy and completeness to include:
    - Verification that prototypes and demonstrations occur in the appropriate environment for the system, subsystem, or component (e.g., production representative, pilot line, or production line)
    - Verification and validation of M&Q specifications, processes, procedures, metrics, etc.
    - Verification and validation of KCs and critical characteristics and the associated key and critical manufacturing processes
    - M&Q validation activities to support proof of building the right product
    - Subsystem, item, and component development specifications
    - Verification of product and technology requirements and features necessary for system pilot line and/or LRIP including:
        - Producibility (subsystem, item, and component)
        - Products and technology maturity
        - Sources maturity and availability (including second sources)
        - MOSA
        - COTS, NDIs, and GFE
    - Verification of M&Q status and results of TPMs
    - Verify long-lead production requirements have been established and are understood
    - Verify completion of subsystem design (with closure schedule for open items)
- Analyze prototype demonstrations and M&Q demonstrations at the system, subsystem, item, and component levels for validation of:
    - Product data essential for item and component manufacturing
    - Physical and functional interface designs for the system
    - Interdependencies
    - M&Q safety processes and procedures

  - ESOH processes and procedures
  - Security processes, procedures, and compliance
  - Risks and issues mitigation
  - M&Q costs, schedule, performance
  - Materials sources and selections
  - Facilities, tooling, and test equipment requirements
  - Workforce requirements
  - Transportation, storage, and handling
  - Embedded software

- Ensure known producibility issues have been resolved and pose no significant risks or issues for pilot line and/or LRIP.
- Develop M&Q metrics and data requirement to support successful transition to pilot line, LRIP, and FRP
  - Metrics should provide the capability to assess, monitor, manage, and control the transition process
- Assess and update the M&Q inputs to the WBS for planning, execution, and control of the pilot line and LRIP based on demonstrations, prototypes, results of CDR.
- M&Q personnel should ensure that all product data essential for system manufacturing will be released for pilot line.
- M&Q personnel should ensure the adequacy and completeness of all mitigation activities in the joint government/contractor Risk, Issue, and Opportunity (RIO) Management Process, including:
  - Key and critical manufacturing processes including embedding software
  - Materials and sourcing
  - Supply chain including multiple sources
  - Production rates and yields
  - Facilities
  - Special tooling development
  - Tests and demonstrations
  - Security
  - System safety and hazardous materials management
  - Economic feasibility
  - Schedule (i.e., IMP/IMS)
  - Manufacturing capability obsolescence
  - Manufacturing capability sustainment

Metrics

- All product level M&Q design requirements have been defined, validated, and documented, and are consistent with the specifications detailed in the SEP.

- All M&Q inputs to the product design support meeting the program requirements.
  - M&Q requirements have been verified and documented to meet program cost, schedule, and performance requirements
  - M&Q requirements have been verified and documented at the system, subsystem, item, and component levels
- Assessments of prototypes and demonstrations at the system, subsystem, item, and component levels have been conducted and documented to verify and validate:
  - That prototype and other demonstrations occurred in the appropriate environment
  - M&Q specifications, processes, procedures, metrics, etc.
  - KCs and critical characteristics and the associated key and critical manufacturing processes
  - M&Q activities to support proof of building the right product
  - Subsystem, item, and component M&Q development specifications
  - Product and technology M&Q requirements and features necessary for system pilot line and/or LRIP including:
    - Producibility (subsystem, item, and component)
    - Products and technology maturity
    - Sources maturity and availability (including second sources)
    - MOSA
    - COTS, NDIs, and GFE
  - Status and results of M&Q TPMs
  - That M&Q long-lead production requirements have been established and are understood
  - Completion of subsystem design and closure schedule for open items
- Prototype and M&Q demonstrations have been analyzed and the results documented at the system, subsystem, item, and component levels for the validation of:
  - Product data essential for item and component manufacturing
  - Physical and functional interface designs for the system
  - Interdependencies
  - M&Q safety processes and procedures
  - ESOH processes and procedures
  - Security processes, procedures, and compliance
  - Risk and issue mitigations
  - M&Q costs, schedule, performance
  - Materials sources and selections
  - Facilities, tooling, and test equipment requirements
  - Workforce requirements
  - Transportation, storage, and handling
  - Embedded software

- Known producibility issues have been resolved and documented and pose no significant risks or issues for pilot line and/or LRIP.
- M&Q metrics and data requirement have been developed and documented to support successful transition to pilot line, LRIP, and FRP
    - Metrics provide the capability to assess, monitor, manage, and control the transition process
- M&Q inputs to the WBS for planning, execution, and control of the pilot line and LRIP have been updated and documented.
- All M&Q product data essential for system manufacturing has been documented and released for the pilot line.
- M&Q personnel have verified, validated, and documented the adequacy and completeness of all mitigation activities in the joint government/contractor RIO Management System for pilot line build, including:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment

Tools

- Functional Configuration Audit Checklist
- IMP/IMS Template
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- System Verification Review Checklist
- Systems Engineering Plan (SEP) Outline
- Test and Evaluation Template

Resources

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition

- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- Functional Configuration Audit, DAG Chapter 3
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Risk, Issue, and Opportunity Management Guide
- System Verification Review, DAG Chapter 3
- Systems Engineering Plan (SEP) Outline
- Test and Evaluation Management Guide

E.11 Pilot Line Build

Typically, the Pilot Line begins around the time the CDR has been completed. The Pilot Line should reflect the proposed production line and include all materials, manpower, tooling, test equipment, and facilities that will be on the production line. STE/SIE should be validated as part of pilot line validation in accordance with validation plans. M&Q processes and procedures should be proven on a pilot line and are under control and ready for low-rate production. Known producibility risks and issues should pose no significant challenges for low-rate production. Cost model and yield and rate analyses should have been updated with pilot line results. Supplier qualification testing and first article inspections should have been completed. The industrial base has been assessed for Milestone C and shows industrial capability is established to support LRIP.

Manufacturing and Quality Tasks

- Assess the contractor-designated pilot lines for production realism of elements required to manufacture systems, subsystems, items, and components.
    - Evaluate the M&Q readiness to manufacture of equipment, workforce skill levels, facilities, materials, components, initial work instructions, processes, tooling, temperature, cleanliness, lighting etc.
    - Evaluate capability to meet design requirements for LRIP
    - Evaluate the use of FRP processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
    - Evaluate production processes for capability to meet rate production (ramp-up to FRP)
    - Evaluate the production capability and capacity to meet program objectives for cost and schedule
- Validate the contractor's manufacturing processes for affordability and execution including work instructions.
- Evaluate contractor Production Process Verifications (PPVs) to verify process outputs for compliance to process capabilities and requirements.

- Capture necessary M&Q design and process changes identified during pilot line operations.
- Capture the results of M&Q processes, demonstrated on a pilot line, as inputs to the system MRL assessment, PRR, and to the Industrial Base Capabilities Considerations that are required for Milestone C.
- Assess contractor's LRIP verification and validation M&Q efforts in accordance with industry best practices (i.e., AS6500) on a pilot line including:
    - All M&Q processes including continuous improvement efforts
    - Manufacturing surveillance and quality data collection and analyses (including supply chain data for items and components)
    - Physical and functional interfaces
    - All work instructions, sequencing, and procedures
    - Process capabilities and process control plans
    - Production scheduling and control
    - Model and Simulations
    - Materials
    - Workforce capabilities
    - Manufacturing technology implementations
    - Tooling, work holding fixtures, jigs, etc.
    - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
    - Facilities, transportation, storage, and handling equipment
    - Interdependencies (not all will be validated on the pilot line)
    - Safety processes, procedures, and compliance
    - ESOH processes, procedures, and compliance
    - Security processes, procedures, capabilities, and compliance
    - Risk and issue mitigation results and adequacy of resolution
    - M&Q costs, schedule, performance
    - Materials sources and selections
    - Integration of embedded software
- Assess contractor's conduct of FAIs/FATs and the outputs for M&Q impacts.
- Based on pilot line operations and demonstrations, assess all M&Q risks and issues for impacts to LRIP (e.g., producibility, quality, manufacturability, etc.)
    - Include newly identified risks, issues, and opportunities
- Based on the results of the Pilot Line build, finalize the TDP including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Metrics

- Pilot line has been assessed for production realism of elements required to manufacture systems, subsystems, items, and components and documents the following:
    - M&Q readiness to manufacture of equipment, workforce skill levels, facilities, materials, components, initial work instructions, processes, tooling, temperature, cleanliness, lighting etc.
    - Capability to meet design requirements for LRIP
    - Employment of FRP processes with little or no reliance on laboratory environment or personnel
    - Capability to meet rate production (ramp-up to FRP)
    - Capability and capacity to meet program objectives for cost and schedule
    - Pilot line risks, issues, and potential opportunities to be included in Risk, Issue, and Opportunity Management System
- Contractor's manufacturing processes for affordability and execution, including work instructions, have been assessed as adequate and validated, documented in M&Q Plans for PRR.
- Contractor PPVs have been verified for compliance with process capability requirements and documented for the PRR.
- Necessary M&Q design and process changes have been captured during pilot line operations and documented for potential ECPs and for the PRR.
- Results of demonstrations of M&Q processes on a pilot line have been documented as inputs to the system MRL assessment, the PRR, and to the Industrial Base Capabilities Considerations (required for Milestone C).
- In accordance with industry best practices, M&Q verification and validation of contractor pilot line has been successfully conducted and the results have been documented for PRR, SVR/FCA, and Milestone C the including:
    - All M&Q processes with rigorous continuous improvement processes
    - Disciplined, functional, and accessible manufacturing surveillance and quality data collection system including supply chain
    - Documented, tested, and approved physical and functional interfaces
    - Functional work instructions, sequencing, and procedures
    - Process capabilities and process control plans
    - Functional production scheduling and control processes
    - Refined model and simulations
    - Materials
    - Confirmed workforce requirements, skills, and capabilities
    - Manufacturing technology implementations
    - Tooling, work holding fixtures, jigs, etc.

  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
  - Facilities, transportation, storage, and handling equipment
  - Pilot line interdependencies
  - Safety processes, procedures, and compliance
  - ESOH processes, procedures, and compliance
  - Security processes, procedures, capabilities, and compliance
  - Risk and issue closures and remaining mitigation plans
  - Confirmation of and updates to M&Q costs, schedule, performance
  - Materials sources and selections
  - Integration of embedded software
- Contractor's FAIs and/or FATs and the outputs for M&Q have been assessed and analyzed for impacts and the results documented for PRR.
- At the conclusion of pilot line operations and demonstrations, all M&Q risks and issues have been assessed and analyzed for impacts to LRIP and known producibility issues and risks understood (i.e., pose no significant challenges or have been accepted)
- TDP has been finalized based on the results of the Pilot Line build and includes the applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Tools

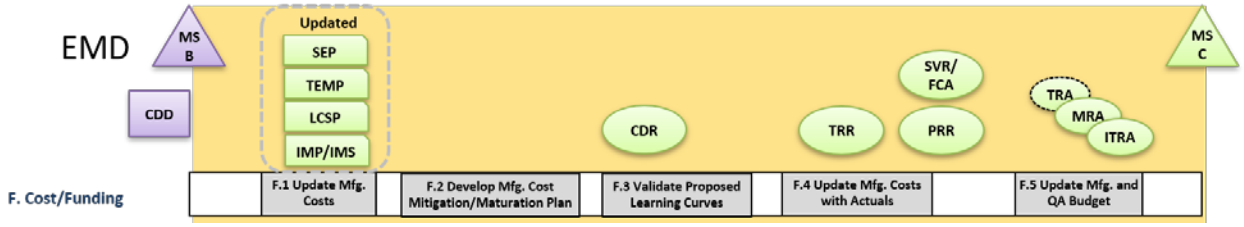
- First Article Inspection Checklist
- First Article Test Checklist
- Interactive MRL Users Guide (Checklist) for the Design thread
- Manufacturing Maturation Plan
- Production Part Approval Process (PPAP) Checklist
- Production Verification Test
- Systems Engineering Plan (SEP) Outline

Resources

- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- AS6500, Manufacturing Management System
- DCMA Instruction 302, First Article and Production Lot Testing
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook

- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline

F. COST/FUNDING



M&Q cost estimates require updating regularly, based on the increasing degree of detail available from work completed during EMD, the M&Q Strategies and Plans, and progress toward final design. These estimates should be based on detailed M&Q processes and procedures to industry best practices with updates to be performed and adjusted, as necessary, for current program status and/or learning curves to develop a time-phased manufacturing cost. This will require analyses of contractor M&Q Plans regarding costs, cost controls, and cost drivers. As the design progresses, cost estimates, cost models, and associated cost drivers should be updated with actual cost data from lower level (item and component) pilot lines and production.

Using the DoD funding and management approach, both the should-cost and will-cost analyses, and the cost reduction and/or control plans should be updated based on the results of CDR and maintained current. Tracking and monitoring of the contractor's planning and ongoing efforts is intended to not only evaluate proposed contractor costs, but to track and monitor costs and to identify further savings opportunities that will lead to further cost reductions. Using this process M&Q cost mitigation and/or maturation plans are maintained current to include the schedule (i.e., IMP/IMS).

Based on data collected post-PDR through CDR, established learning curves (cost improvement curve, or experience curve) should be up-to-date and validated by data collected on the pilot line. M&Q should continue to refine the learning curves for the system and the plans for data collection to support up-to-date cost estimates and budgeting. Manufacturing cost estimates for LRIP are based on the completed design, known manufacturing processes, and execution of planned M&Q operations. Actual costs at the system level are realized for the first time on a pilot line. Once the system is being produced or constructed, the actual cost method can be accumulated for budgeting.

A program's approved cost estimate is often used to create the budget and spending plan. Since resources are not infinite, budgeting requires the rate of spending matches the resources and funding available. This requires M&Q costs to be as accurate as possible, based on actual data. This process facilitates the development of realistic cost estimates for the Program.

F.1 Update Manufacturing Costs

DoDD 5000.01 requires the preparation of realistic program life cycle cost estimates as a part of a program managers focus on affordability. M&Q managers need to support to development and update of various government cost estimates and the assessment of contractor cost estimates to include:

- Affordability Analysis and Cap Estimate
- DoD Component Cost Estimate
- DoD Component Cost Position
- Independent Cost Estimate (ICE)
- Economic Analysis
- Cost Analysis Requirements Description (CARD)
- Should Cost Target and Will Cost

Manufacturing and Quality Tasks

- M&Q personnel should support the analysis of design changes for technical content and impact on M&Q processes, and costs for all cost documents based on results of the PDR and MS B activities and ensure that the program can achieve the approved system specification and budget for CDR to include:
    - Include updates to the Affordability Analysis and/or Cap estimate
    - Include updates to the DoD Component Cost Estimate
    - Include updates to the DoD Component Cost Position
    - Include updates to the Independent Cost Estimate
    - Include updates to the Economic Analysis
    - Include updates to the CARD
    - Include updates to the should cost and will-cost models based on industry best practices
    - Include updates to M&Q cost sensitivity analyses
- M&Q personnel should support the analysis of design changes, and program progress, analyze and update M&Q cost drivers derived from manufacturing, quality, materials, and/or unique requirements, and associated risks, issues, and opportunities for the CDR to include:
    - Identified subsystems, parts, items, and components
    - Sourcing risks from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
    - Should-cost and will-cost analyses
    - Required trade studies and engineering change requests
    - Updates to predicted life cycle estimates and their associated models
    - Interdependencies
    - Uncertainties from quantification of cost drivers

- Analyze the contractor M&Q Plans for costs and cost drivers based on:
  - Processes and procedures (i.e., best practices)
  - Producibility program and plans
  - Supplier Chain management
  - Materials (e.g., processing, handling, storage, etc.)
  - Workforce (e.g., availability, training, etc.)
  - Facilities (e.g., location, condition, maintenance, etc.)
  - Capital equipment, tooling, and test equipment, etc.
  - Special handling and environmental compliance (including disposal)
  - Security (physical and cyber), etc.
  - Updates for the cost of quality
  - Updates for costs and impacts of testing
  - Impacts from other work performed throughout the supply chain
- Ensure cost estimates, cost models, and associated cost drivers are updated with actual cost data from lower level (item and component) from subsystem and system-level prototypes and demonstrations including:
  - Systems and subsystems produced in a production representative environment
  - Production plant layout and design
  - Obsolescence solutions
  - Rolled up manufacturing system and subsystem actual costs vs. targets
- Update Learning Curves based on results of PDR and actual M&Q data collected from prototypes, and demonstrations.
- Ensure the updated cost estimates and associated drivers include the costs associated with the M&Q risks, issues, and associated mitigation plans and activities, and opportunities.
- Update the contract to include cost monitoring by DCMA throughout the contractor's facilities and supply chain.
- Update the letter of delegation to DCMA to include cost monitoring and tracking.
- Ensure updated M&Q costs including costs for outstanding M&Q risks, issues, and mitigations for CDR and estimates for meeting manufacturing readiness requirements for Milestone C are included in all budget estimates.
- If an Independent Cost Estimate (ICE) or verified Program Office Economic Analysis is requested, provide M&Q inputs and support.
  - Provide validated M&Q capability requirements
  - Provide M&Q inputs on required funding for the FYDP
  - Verify M&Q compliance with affordability goals for production and sustainment

Metrics

- M&Q design changes have been analyzed for technical content and cost inputs and required updates have been provided as inputs to the CARD including:
  - Updates to the Affordability Analysis and/or Cap estimate
  - Updates to the DoD Component Cost Estimate
  - Updates to the DoD Component Cost Position
  - Updates to the Independent Cost Estimate
  - Updates to the Economic Analysis
  - Updates to the CARD
  - Updates to the should cost and will-cost models based on industry best practices
  - Updates to M&Q cost sensitivity analyses
  - Updates to maintain consistency with the approved system specification and budget for CDR
  - Updates to the will-cost model based on industry best practices
  - Updates to M&Q cost sensitivity analyses
- M&Q cost drivers derived from manufacturing, quality, materials, and/or unique requirements (e.g., processes, procedures, techniques, etc.), and associated risks, issues, and opportunities have been updated and documented for the CDR including drivers from:
  - Subsystems, parts, items, and components
  - Sourcing (e.g., sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources)
  - Should-cost and will-cost analyses
  - Trade studies and engineering change requests
  - Lifecycle estimates and their associated models
  - Interdependencies
  - Uncertainties
- Contractor M&Q Plans have been analyzed for costs and cost drivers and results and recommendations documented for CDR based on:
  - Processes and procedures (i.e., best practices)
  - Producibility program and plans
  - Supplier Chain management
  - Materials (e.g., processing, handling, storage, etc.)
  - Workforce (e.g., availability, training, etc.)
  - Facilities (e.g., location, condition, maintenance, etc.)
  - Capital equipment, tooling, and test equipment, etc.
  - Special handling and environmental compliance (including disposal)
  - Security (physical and cyber), etc.
  - Updates for the cost of quality

  - Updates for costs and impacts of testing
  - Impacts to schedule and resources from other work performed throughout the supply chain (i.e., other programs in the same facility)
- Comparison of rolled up manufacturing system and subsystem actual costs vs. targets has been conducted and documented for CDR, and actual cost data has been used to update cost estimates, cost models, and associated cost drivers for CDR including data from:
  - Systems and subsystems produced in a production representative environment
  - Items and components produced on pilot and production lines
  - Production plant layout and design
  - Obsolescence solutions
- Learning Curves have been updated based on results of PDR and actual M&Q data collected from pilot lines, prototypes, and demonstrations, and have been documented for CDR.
- Costs associated with the M&Q risks, issues, and associated mitigation plans and activities, and opportunities have been used to update and document cost estimates and associated drivers for CDR.
- Contract includes cost monitoring by DCMA throughout the contractor's facilities and supply chain.
- Letter of delegation to DCMA includes cost monitoring and tracking.
- Updated M&Q costs including those outstanding for M&Q risks, issues, and mitigations have been updated and documented for CDR and estimates for meeting manufacturing readiness requirements for Milestone C have been included in all budget estimates.
- If an Independent Cost Estimate (ICE) or verified Program Office Economic Analysis has been requested, M&Q personnel have provided documented inputs and support including:
  - Validated M&Q capability requirements
  - Inputs on required M&Q funding for the FYDP
  - M&Q compliance with affordability goals for production and sustainment

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost/Schedule Control System Criteria (*See* EVM)
- Design to Cost Estimates
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- *See also* CAPE website for tools

Resources

- CARD Website and process

- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- MIL-HDBK-766, Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook
- Should-cost and Affordability Memo

F.2 Develop Manufacturing Cost Mitigation Plan

Affordability is always a concern for the DoD. M&Q managers need to support the development and implementation of cost mitigation plans. Cost mitigation plans are often focus on manufacturing cost drivers and continuous improvement opportunities.

Manufacturing and Quality Tasks

- Ensure appropriate inputs are provided for required investments and planning for contractor and supply chain M&Q capabilities (e.g., facilities, equipment, tooling, hardware, firmware, software, etc.) based on M&Q planning for CDR.
- Update the should-cost and will-cost analyses, and cost reduction and/or control plans using the outputs from CDR to include:
    - Coordinated, in-depth review of the contractor's planning and ongoing efforts against best practices
    - Up-to-date cost drivers
    - Up to date tracked and monitored costs to support further savings opportunities
    - Risks and issues mitigation plans and activities
- Ensure DCMA cost monitoring and tracking data are used to develop and/or update M&Q cost mitigation plans.
- Update M&Q cost targets, post CDR, to include assessments of:
    - Producibility
    - M&Q process capabilities, implementations, obsolescence, and sustainment including key and critical processes
    - Schedule (i.e., IMP/IMS)
    - Supply chain, materials, and sourcing availability
    - Environmental management and disposal impacts
    - Process capability and throughput (setup, yield, scrap, rework, Work in Progress)
    - Data management (collection, storage, cyber security, etc.)

  - M&Q risks and issues including Supplier Chain
  - Workforce risks and issues
  - Tooling, equipment availability, capacity, and constraints
  - Facilities and facility conditions (e.g., temperature control, cleanliness, lighting, factory floor, process flows, assembly lines, cycle times, etc.)
  - Yields and rates (e.g., projected, and actual throughputs)
  - Inventory (e.g., WIP, backlog, customer demand, etc.)
  - System security, cyber protection, safety, and hazardous materials management
  - Testing and test equipment (including in-process tests)
  - Transportation, storage, and handling
  - New equipment and new manufacturing technologies
  - Life cycle sustainment
- Update M&Q cost models based on outputs from CDR to include:
  - Updated cost targets
  - Actuals, where available, in place of estimates
  - Cost impacts of specific design changes, production process changes, or changes in materials
- Monitor and track contractor performance of M&Q activities in meeting the Earned Value Management System (EVMS) requirements including the critical path as an input to cost mitigation planning.
- Develop Manufacturing Maturation Plans (MMPs) for any areas assessed that do not comply with the appropriate MRL criteria.

Metrics

- M&Q personnel have provided appropriate budget planning inputs to program investment plans for contractor and supply chain M&Q capabilities (e.g., facilities, equipment, tooling, hardware, firmware, software, etc.).
- M&Q personnel have updated and documented in the SEP, the Acquisition Strategy, and the CARD, the should-cost analyses, will-cost analyses, and cost reduction and/or control plans including:
  - Contractor's planning and ongoing efforts against best practices
  - Up-to-date cost drivers
  - Up to date tracked and monitored costs
  - Mitigation plans and activities
- DCMA cost monitoring and tracking data has been documented in appropriate program documentation and used to develop and/or update cost mitigation plans in the M&Q Plans.

- M&Q cost targets have been assessed, updated, and documented in the M&Q Strategies and Plans and appropriate program budget documents including targets derived from or impacted by:
    - Producibility
    - M&Q process capabilities, implementations, obsolescence, and sustainment including key and critical processes
    - Schedule (i.e., IMP/IMS)
    - Supply chain, materials, and sourcing availability
    - Environmental management and disposal impacts
    - Process capability and throughput (setup, yield, scrap, rework, Work in Progress)
    - Data management (collection, storage, cyber security, etc.)
    - M&Q risks and issues including Supplier Chain
    - Workforce risks and issues
    - Tooling, equipment availability, capacity, and constraints
    - Facilities and facility conditions (e.g., temperature control, cleanliness, lighting, factory floor, process flows, assembly lines, cycle times, etc.)
    - Yields and rates (e.g., projected, and actual throughputs)
    - Inventory (e.g., WIP, backlog, customer demand, etc.)
    - System security, cyber protection, safety, and hazardous materials management
    - Testing and test equipment (including in-process tests)
    - Transportation, storage, and handling
    - New equipment and new manufacturing technologies
    - Life cycle sustainment
- M&Q cost models have been updated, documented, and maintained current in the program cost model to include:
    - Up-to-date cost targets
    - Actuals as they become available replacing of estimates
    - Updated cost impacts from changes to design, manufacturing, and quality processes and/or materials, etc.
- Contractor performance of M&Q activities is being tracked and monitored to meet the EVMS requirements including the critical path.
- Manufacturing Maturation Plans have been developed for all areas assessed that do not meet the appropriate MRL cost thread criteria.

Tools

- Parametric, Engineering and Actual estimating techniques
- CARD - Cost Analysis Requirements Description (*See* CAPE website for tools)
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Maturation Plan

- Cost/Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Manufacturing Cost Estimating Worksheet

Resources

- 10 USC Sec. 2334 Independent Cost Estimation and Cost Analysis
- DoDI 5000.73 Cost Analysis Guidance and Procedures
- Public Law 114-328, §807, Cost, Schedule, and performance of major defense acquisition programs
- CARD - Cost Analysis Requirements Description Template (*See* CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide
- DODI 5000.73 Cost Analysis Guidance and Procedures
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook

F.3 Validate Proposed Learning Curves

Most manufacturing cost estimates include learning curves. During the EMD phase the initial manufacturing cost estimate should be updated on a regular basis to reflect the increasing degree of detail available. These estimates should be based upon application of detailed manufacturing standards to the operations to be performed and adjusted, as necessary, by realization factors and/or learning curves to develop the time phased manufacturing cost. Learning curves are a graphical representation of how an increase in learning decreases the amount of time to accomplish a task. Initial learning curves need to be identified and applied on the Pilot line and then validated to see of the correct level of learning is occurring. Since the program is in EMD the pilot line may not have shown much learning in the on the few items that are being or have been produced.

Manufacturing and Quality Tasks

- Update all M&Q learning curves for the system and subsystems based on CDR results, contractor and supply chain improvements, program progress to date to include:
    - Contractor and supply chain data as required by contract
    - DCMA data to validate contractor data for the learning curve updates
    - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
    - Design changes
    - Producibility program results
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.

  - Planning and scheduling
  - Throughput (yield and rates)
  - Labor efficiency and ergonomics
  - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
  - Handling, transportation, and storage (including WIP)
  - Supply chain changes
  - Standardization and common processes

- Use data from pilot line production for validation of learning curves.
- Plan for collection of data in LRIP to support learning curve refinement that includes the following factors, improvements, and investments (at a minimum):

  - Update of cost models
  - Workforce learning, worker, and supervisor
  - Process, line, and workstation
  - Machinery, equipment, and tooling
  - Design producibility changes
  - Reduced Engineering Change activities
  - Mitigations of risks and issues
  - Work methods and processes
  - Planning and scheduling processes
  - Lot and batch sizing (increases) and optimization (just-in-time)
  - Engineering and test activities and changes
  - Quality inspections/tests sampling requirements
  - Reduction in Scrap and Rework
  - Inventory levels and storage
  - Operation sequencing and synchronization
  - Pre-Planned Product Improvement (P^3I) program and processes

Metrics

- All M&Q learning curves for the system and subsystems have been assessed and updated based on CDR results, contractor and supply chain improvements, program progress to date which includes:

  - Contractor and supply chain data
  - DCMA data to validate contractor data
  - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
  - Design changes
  - Producibility program results
  - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
  - Planning and scheduling

  - Throughput (yield and rates)
  - Labor efficiency and ergonomics
  - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
  - Handling, transportation, and storage (including WIP)
  - Supply chain changes
  - Standardization and common processes

- Learning curves have been validated using data from pilot line production.
- Plans for collection of data in LRIP have been developed, documented, and are in place to support learning curve refinement that includes the following:
  - Up-to-date cost models
  - Workforce learning, worker, and supervisor
  - Process, line, and workstation improvements and investments
  - Machinery, equipment, and tooling improvements and investments
  - Design producibility changes
  - Reduced Engineering Change activities
  - Results of mitigations of risks and issues
  - Work methods and processes
  - Planning and scheduling processes
  - Lots and batch sizes (optimization)
  - Engineering and test activities and changes
  - Quality inspections/tests sampling requirements
  - Reduction in Scrap and Rework
  - Inventory levels and storage
  - Operation sequencing and synchronization
  - P^3I program and processes

Tools

- Learning Curve Calculator (Estimator)
- Manufacturing Cost Estimating Spreadsheet
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Maturation Plan

Resources

- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8 Learning Curve

F.4 Update Manufacturing Costs with Pilot Line Actuals

During the EMD phase, more and more manufacturing costs should be based on actual cost data provided by the contractor. This is especially true after the Critical Design Review and the implementation of the Pilot line. Cost drivers could be high-cost items, or items that have high manufacturing costs due to several factors (long processing times, low yield rates, etc.). These cost drivers need to be updated.

Manufacturing and Quality Tasks

- Ensure cost models are updated and maintained current with up-to-date information based on data collected for updated cost drivers and learning curves (*See* F.3) including results from pilot line, and:
    - Drivers and estimates
    - Roll up of all tracked M&Q costs from the component level
    - Engineering change requests
    - Cost reduction and avoidance strategies
    - Mitigation of risks and issues
    - Analyses (of pilot line actual costs)
    - Analyses of proposed changes to M&Q processes and procedures
- Analyze and update M&Q cost inputs based on the results of CDR and the pilot line, for consistency with the current Cost Analysis Requirements Document (CARD); and provide updates, if necessary.
- Provide inputs to the program life cycle cost estimate and schedule (IMP/IMS) for PRR based on validated stable detailed design and supply chain (from pilot line).
- Provide M&Q cost estimate and realistic production unit cost goals for the P&D budget process.

Metrics

- Cost drivers (*See* F.2) and learning curves (*See* F.3) have been updated with results from pilot line, and cost models are maintained up to date to include:
    - Drivers and estimates
    - All M&Q cost data
    - Engineering change requests
    - Cost reduction and avoidance results
    - Risks and issues mitigation results
    - Pilot line actual costs
    - Changes to M&Q processes and procedures
- M&Q cost inputs have been analyzed and updated for the CARD.

- M&Q inputs to the program life cycle cost estimate and schedule (IMP/IMS) have been provided and documented for PRR.
- M&Q cost estimates and realistic production unit cost goals have been documented and provided to the P&D budget process.

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost/Schedule Control System Criteria (*See* EVM)
- Design to Cost Estimates
- Manufacturing Cost Estimating Spreadsheet
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Maturation Plan
- *See* CAPE website for tools

Resources

- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- MIL-HDBK-766, Design to Cost
- Should-cost and Affordability Memo
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- CARD website and process

F.5 Update Manufacturing and Quality Budget

Budget estimates are developed to provide the financial resources to needed to improve affordability, reduce risks, mature emerging technologies for insertion and to help resolve several manufacturing related issues. The budget estimate needs to be updated to support the program through EMD. M&Q managers need to support the review and update of M&Q budgets.

Manufacturing and Quality Tasks

- Ensure all M&Q Milestone C risks and issues (i.e., MRL 8) are understood with approved and budgeted mitigation plans in place including:
    - A reasonable budget estimate for achieving required M&Q capability by the FRP decision point (i.e., MRL 9)
    - Investment required for LRIP and FRP
- Provide M&Q cost estimates for the P&D budget process (LRIP and FRP) including the following considerations:

- Ongoing cost reduction initiatives.
- M&Q costs and cost drivers
- Updated M&Q learning curves
- Validation of M&Q processes (from pilot line) for affordability and executability
- Results of analyses of M&Q risks, issues, and the status of mitigations
- Required facilities, equipment, tooling, test equipment, GFE, etc. for scale-up to LRIP quantity production
- Results of analyses of the contractor's proposed manufacturing labor hours and material costs for adequacy, reasonableness, and necessity
- Recommended M&Q cost reduction and avoidance initiatives
- Results of cost performance analyses and trends
- Manufacturing investment opportunities for future manufacturing improvement and development efforts (*See* F.3)
- Funding and budgeting requests for applicable and/or emerging M&Q initiatives
- Industrial base investment programs that create, expand, or preserve assured, affordable, robust, and commercially viable M&Q capabilities and capacities for LRIP and FRP

Metrics

- All M&Q Milestone C risks and issues (i.e., MRL 8) are understood and have approved and budgeted mitigation plans in place including:
  - A reasonable budget estimate for achieving required M&Q capability by the FRP decision point (i.e., MRL 9)
  - Investment required for LRIP and FRP
- M&Q cost estimates have been developed for the P&D budget process (LRIP and FRP) and include:
  - Ongoing cost reduction initiatives
  - M&Q costs and cost drivers
  - Updated M&Q learning curves
  - Validated of M&Q processes (affordability and executability)
  - Results and status of mitigations of M&Q risks and issues
  - LRIP scale-up requirements for facilities, equipment, tooling, test equipment, GFE, etc.
  - Realistic contractor proposed manufacturing labor hours and material costs (adequacy, reasonableness, and necessity)
  - Detailed M&Q cost reduction and avoidance initiatives/plans
  - Cost performance trends and recommendations as required
  - Investment opportunities for future manufacturing improvements and development efforts
  - Budgeting requests for emerging M&Q initiatives

- Industrial base investment programs for commercially viable M&Q capabilities and capacities for LRIP and FRP

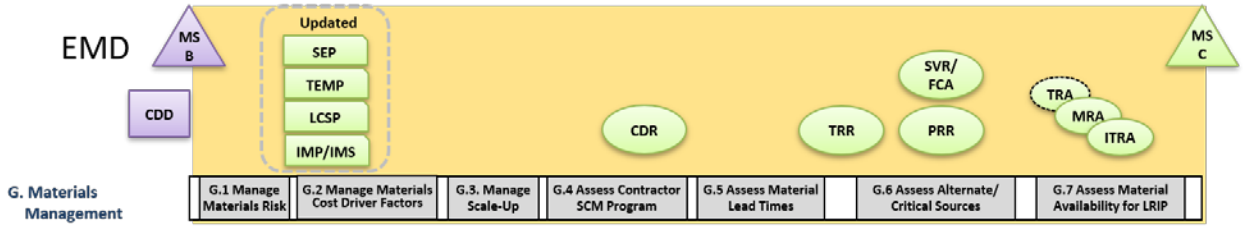
Tools

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

Resources

- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Technology Readiness Assessment Guidance
- Public Law 114-328, §807
- Manufacturing Readiness Level (MRL) Deskbook

G. MATERIALS MANAGEMENT



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, hazardous materials, storage environment, etc. All program M&Q materials risks, issues, and opportunities should be assessed based on contractor data and plans to meet program M&Q requirements.

The assessment should include analyses for materials fluctuations, rarity, availability, capacity, regulatory issues, ITAR, anti-tamper, and military vulnerability, as well as alternate materials that may mitigate known risks and issues. Additionally, M&Q risks, issues, and opportunities based on potential materials obsolescence and lack of availability from business climate impacts (e.g., business failures, market changes, political, etc.) should be included in assessments. Results of these assessments should be incorporated into recommended changes and updates for appropriate government/contractor mitigation plans.

For CDR, materials cost drivers must be updated, and appropriate management plans implemented for control of all aspects of materials costs (actual and planned) for both the government and contractor. The industrial and manufacturing capability should be assessed to baseline needed industrial capability

and to obtain key knowledge on scale-up efforts, and potential supply chain issues. Managing scale-up for EMD should include planning that addresses new M&Q processes and techniques, meeting delivery dates, critical and long-lead materials, facility, equipment, tooling availabilities and capabilities, tests and demonstrations, conservation of critical and strategic materials, and transportation and security including ITAR considerations. Management also includes planning for mitigation of risks and issues, as well as exploiting opportunities. M&Q should assess the contractor's materials supply chain for application, implementation, and adherence to industry M&Q best practices, as well as contractor's compliance with Company policies, processes, procedures, and contracts.

The materials and components lead times are extremely critical to both meeting program schedules and defining requirements for long lead and advanced buys. Lead times for defense materials and components can be long and volatile due to various reasons, such as imbalances between capacity and demand, competition from commercial customers, testing cycles, materials availability, budgeting, funding and contracting processes, transportability, workforce issues, etc. All of these can have an impact on capacity, quality, and schedule, thus driving lead times and the program must maintain visibility of the status and the forecast changes in lead times.

The program's objectives should be to improve capabilities and quality and reduce costs by maintaining (or improving) schedule, supporting the industrial base, and promoting competition by qualification of alternative sources. There are many factors that can interfere with these objectives, requiring alternative sources. Natural disasters, such as earthquakes and tsunamis can severely disrupt production operations for many industries as can counterfeit parts and the loss of sources of items or material. Additionally, programs must account for Diminishing Manufacturing Sources and Material Shortages (DMSMS) to mitigate risks to life cycle support and viability of the weapon system or equipment. As a resource for this process, the Government-Industry Data Exchange Program (GIDEP) was established as the central repository within the DOD for all parts discontinuance and counterfeit notices. GIDEP receives notices from manufacturers and participants and distributes alerts to DOD and to private industry.

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

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

Future requirements (i.e., Operations and Support phase) for items which represent recurring spare parts requirements and substantial cost for annual buys, require aggressive action to develop alternative sources of supply. These sources ensure continuing part availability and competitive sources for these parts. The process of establishing competitive sources for these parts starts early in the production phase and continues as long as the parts are in the supply system. Based on pilot line results, M&Q should validate the identification of critical sources throughout the supply chain. Include sources of key and/or critical subsystems, items, parts, and components, including KCs, Configuration Items (CIs), and CSIs, required to meet program requirements.

Based on updates to Industrial Capabilities Assessments in support of Milestone C, M&Q should assess and verify material availability for LRIP, include availability risks, issues, and mitigations, costs and schedule updates, long-lead procurement risks, mitigation, and status, obsolescence, Supply chain management including first, second, and lower tier suppliers, counterfeit detection and avoidance, physical, cyber, and industrial security, special handling, transportation, storage, and environmental compliance risks and issues, etc. This assessment should consider emerging technology advancements in materials and processes, changes in Government statute, policy, and regulations, changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.), changes in environmental impacts (e.g., natural disasters, etc.), DMSMS, and program plans for P^3I in LRIP.

Successful completion of EMD with a thorough understanding of materials capabilities, capacities, and limitations and the aggressive management of and planning for materials will ensure effective transition to LRIP and Production and Deployment phase.

G.1 Manage Materials Risk

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

Manufacturing and Quality Tasks

- Analyze the contractor's plans to meet M&Q requirements for maturity of materials by CDR, including:
    - Risks and issues
    - Associated cost drivers (*See* G.2)
    - Design requirements
    - Configuration Management
    - Materials processes maturity

  - Materials specifications
  - Emerging materials
  - Cost reduction and avoidance
  - Materials availability and lead times
  - Environmental factors
  - Management of the supply chain
  - Counterfeit parts and obsolescence
  - Security, required special handling, physical and cyber protection
  - Facilities, capital equipment, tooling, and test equipment
  - Storage, handling, transportation, etc.
- Assess all materials for M&Q risks, issues, and opportunities Based contractor data:
  - Update evaluation of material maturity and availability from TMRR for adequacy to support pilot line
    - Assess validity and maturity of emerging materials for manufacturability
    - Assess maturity in a production environment
  - Update the M&Q evaluation of lead times including:
    - Long lead materials
    - Impacts to schedule, budget, and critical path, etc.
    - Impacts from fluctuations, availability, capacity, regulatory issues, ITAR, Anti-Tamper, etc.
  - Identify opportunities for alternative materials (to avoid or mitigate known risks and issues)
- Assess and identify M&Q risks, issues, and opportunities for materials obsolescence and lack of availability based on analyses of the business climate (e.g., business failures, market changes, political, etc.) for the CDR including:
  - Availability from single or sole sources (domestic or foreign), within the NTIB, only from sources that are outside the NTIB, vulnerable to foreign acquisition
  - Disruptive business climate conditions (e.g., natural disasters, strikes, etc.)
  - Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
  - Counterfeit Parts
- Develop risk mitigation plans as appropriate (specified in the program SEP) for:
  - Known risks to critical and strategic materials
  - Availability issues to be addressed for pilot line and LRIP builds
- Monitor contractor mitigation processes and plans as specified in the contractor SEMP for alignment with the program SEP.

- Analyze and assess the contractor's Make/Buy process for adequacy and completeness including capabilities, capacities, and processes for:
  - Key and/or critical subsystems, items, parts, and components to include volatility
  - Management of the supply chain (including other divisions)
  - Vendors to meet quality requirements, schedule, and cost targets
  - Identification and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
  - Management of GFE, GFM, etc.
- Analyze and assess the contractor's hazardous and special handling, storage, and environmental compliance procedures for risks and issues to include:
  - Regulatory requirements
  - Hazardous materials and handling procedures
  - Security requirements (physical, cyber, industrial, etc.)
  - Transportation, storage, and shelf life
  - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
  - Disposal

Metrics

- Contractor's plans to meet M&Q requirements for material maturity by CDR have been assessed and recommended approvals, changes, updates, and appropriate government and contractor mitigation plans have been documented for the following:
  - Risks and issues
  - Associated cost drivers (*See* G.2)
  - Design requirements
  - Configuration Management
  - Materials processes maturity
  - Materials specifications
  - Emerging materials
  - Cost reduction and avoidance
  - Materials availability and lead times
  - Environmental factors
  - Management of the supply chain
  - Counterfeit parts and obsolescence
  - Security, required special handling, physical and cyber protection
  - Facilities, capital equipment, tooling, and test equipment
  - Storage, handling, transportation, etc.

- All materials have been assessed for M&Q risks, issues, and opportunities based on contractor data, and recommended changes, updates, and appropriate government/contractor mitigation plans have been documented for program management for:
  - Adequacy of material maturity and availability to support pilot line including:
    - Validity and maturity of emerging materials
    - Use in a production environment
  - Capability and capacity to meet required availability (lead times) including:
    - Long lead materials
    - Schedule, budget, and critical path, etc. impacts
    - Fluctuations, regulatory issues, ITAR, Anti-Tamper, etc.
  - Opportunities for alternative materials (to avoid or mitigate known risks and issues)
- M&Q risks, issues, and opportunities for materials obsolescence and availability have been assessed for CDR based on analyses of the business climate (e.g., business failures, market changes, political, etc.), and the results documented for CDR with recommended mitigations for:
  - Single or sole sources (domestic or foreign), and sources vulnerable to foreign acquisition
  - Disruptive business climate conditions (e.g., natural disasters, strikes, etc.)
  - DMSMS/Obsolescence
  - Counterfeit Parts
- M&Q inputs to Government materials risks and issues mitigation plans have been provided for:
  - Known risks to critical and strategic materials
  - Availability issues to be addressed for pilot line and LRIP builds
- Contractor M&Q mitigation processes and plans, as specified in the contractor SEMP, have been assessed for compliance with the program SEP and recommendations for changes to the SEMP and/or SEP have been documented and provided to program management.
- Contractor's Make/Buy process has been assessed for adequacy and completeness of capabilities, capacities, and processes and recommended changes, updates, and appropriate government/contractor mitigation plans have been documented for program management for:
  - Key and/or critical subsystems, items, parts, and components
  - Management of the supply chain (including other divisions)
  - Vendors capability to meet quality requirements, schedule, and cost targets
  - Process for counterfeit parts and materials detection and avoidance (e.g., end items, components, parts, or assemblies)
  - Management of GFE, GFM, etc.

- Contractor's hazardous and special handling, storage, and environmental compliance procedures for risks and issues have been assessed for adequacy and completeness and recommended M&Q changes, updates, and appropriate government/contractor mitigation plans have been documented for CDR to include:
    - Regulatory requirements
    - Hazardous materials and handling procedures
    - Security requirements (physical, cyber, industrial, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal

Tools

- DCMA Material Management and Accounting System Audit
- PESHE Assessment/Template
- ISO 14001 Gap Analysis Toolkit
- DMSMS Product Life Cycle Assessment (DLA)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist) for the Materials thread
- Manufacturing Maturation Plan
- Supply chain Management Risk Assessment Checklist
- Producibility Assessment Worksheet
- TRL Assessment Questionnaire

Resources

- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- ESOH in Acquisition Guide
- ISO 14001 Environmental Management Systems
- DMSMS Guidebook, SD-22
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60-H, Assessing Defense Industrial Capabilities
- DoDM 4140.01, DoD Supply Chain Management Procedures
- Manufacturing Readiness Level (MRL) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Producibility Systems Guidelines, NAVSO P-3687

G.2 Manage Materials Cost Drivers

Production costs are driven by product complexity (design), rate of production and total numbers produced. Direct labor and direct material cost often make up a large portion of product costs and must be assessed. Material cost drivers could include long-lead items, items that require special handling, storage, or treatment. Some materials are just more expensive (titanium vs steel), and other materials are harder to work with or have low yield rates. M&Q managers need to pay special attention to materials that are cost drivers and manage those as these cost drivers make themselves known on the Pilot Line.

Manufacturing and Quality Tasks

- Analyze and update M&Q materials cost drivers for the CDR based on manufacturing, quality, and unique and/or specialized requirements, specifications, and tolerances, and associated risks and issues to include:
    - Contractor plans for materials, materials processes, rates, and quantities (including lot buys),
    - Risk mitigation processes (ongoing, identification, reduction, etc.)
    - Supplier Chain (e.g., capability, capacity, quality, etc.)
    - Special handling and training
    - Environmental compliance and training,
    - Materials security (physical, cyber, industrial, etc.)
    - Planned subsystems, parts, items, and components (supply chain commodities) to include alternative sources
    - Planned rates and quantities for pilot line and LRIP
    - Updated “should-cost” analyses and actuals
    - Updated materials cost driver uncertainties (based on actuals)
    - Cost drivers’ updates impacted by conservation critical and strategic materials
    - Cost drivers for mitigation of supply disruptions
    - Updated estimates for the cost of quality
    - Updated estimates for the cost of materials testing
- Analyze and update the contractor planning (producibility) with respect to materials cost drivers and associated risks (*See* G.1) for the CDR to include:
    - Design requirements
    - Configuration management
    - Emerging materials
    - Price stability, cost reduction and avoidance
    - Rates and quantities
    - Materials process maturity including quality processes
    - Materials specifications

  - Materials availability (lead times)
  - Cost reduction and avoidance
  - Environmental factors and compliance
  - Management of supply chain
  - Processes and quality
  - Counterfeit parts avoidance
  - Obsolescence
  - Security, required special handling, physical, cyber, and industrial
  - Facilities, capital equipment, tooling, and test equipment
  - Storage, handling, and transportation, etc.

- Assess and identify M&Q materials cost drivers based on industrial base analyses of the business climate (e.g., business failures, acquisitions, market changes, political changes, etc.) for the CDR including:

  - Materials availability only from single or sole sources, foreign sources (only from sources that are outside the NTIB), and sources vulnerable to foreign acquisition
  - Disruptive business climate conditions (e.g., natural disasters, strikes, etc.)
  - Materials subject to Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
  - Materials market stability (commodities)

Metrics

- M&Q materials cost drivers for the CDR have been analyzed and updated 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
  - 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

- Contractor planning with respect to materials cost drivers and associated risks (*See* G.1) has been assessed and based on the results M&Q recommendations, changes, and updates have been documented for the CDR to include:
  - Design requirements
  - Configuration management
  - Emerging materials
  - Price stability, cost reduction and avoidance
  - Rates and quantities
  - Materials process maturity including quality processes
  - Materials specifications
  - Materials availability (lead times)
  - Cost reduction and avoidance
  - Environmental factors and compliance
  - Management of supply chain
  - Processes and quality
  - Counterfeit parts avoidance
  - Obsolescence
  - Security, required special handling, physical, cyber, and industrial
  - Facilities, capital equipment, tooling, and test equipment
  - Storage, handling, and transportation, etc.
- M&Q personnel have participated in and provided support for assessments and analyses of the industrial base business climate materials cost drivers (e.g., business failures, acquisitions, market changes, political changes, etc.) and has provided documented recommendations and changes on the following:
  - Materials availability (e.g., single, or sole sources, foreign sources, and sources vulnerable to foreign acquisition)
  - Business climate conditions (e.g., natural disasters, strikes, etc.)
  - Market changes from technological evolution
  - Business changes (e.g., political, etc.)
  - Materials subject to Diminishing Manufacturing Sources and Materials Shortages (DMSMS)
  - Materials market stability (commodities)

Tools

- Earned Value Management (EVM)
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Interactive MRL Users Guide (Checklist) for the Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment

Resources

- Cost/Schedule Control System Criteria
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328

G.3 Manage Scale-Up Risk

As programs starts to establish a Pilot Line, M&Q managers are forced to deal with issues and concerns relating to scaling up. The Pilot Line is just being formed and the program is collecting data on initial production units and preparing the line for LRIP. The entire factory floor including the 5Ms (manpower, machines, materials, methods, and measurement) must be capable of responding adequately to the requirements imposed by scaling up and M&Q managers need to be able to manage scale-up risks.

Manufacturing and Quality Tasks

- Analyze and update materials producibility assessments, manufacturing processes, techniques, procedures, capacity, and availability to meet program requirements (scale-up for pilot line, LRIP, and FRP) and assess materials risks, issues, and opportunities including:
    - New materials (to the industry, to the program, to the suppliers)
    - Supply chain and/or source capability and capacity
    - Source criticality and fragility (e.g., sole, or single sources, foreign sources, domestic foreign owned, etc.)
    - Workforce (e.g., knowledge, availability, etc.)
    - Lead times for required quantities (un-proven suppliers)
    - Rates that are higher and/or lower than typical
    - Introduction of counterfeit materials
    - Obsolescence due to product improvements and market/technology changes
    - Regulatory requirements and impacts (e.g., US law, ITAR, environmental, REACH concerns, etc.)
    - Testing aspects throughout the production processes and supply chain
    - Security (e.g., special handling, physical, cyber, industrial, etc.)
    - Facilities, equipment, and tooling
    - Transportation, storage, and handling
- Update and ensure M&Q plans for CDR address scale-up risks, issues, and opportunities to include:
    - Manufacturing processes, techniques, and procedures (including special handling)

- Meeting schedule
- Addressing impacts from critical and long-lead time materials
- Addressing facility, equipment, and tooling availability (acquisition and/or scheduling)
- Cost models, drivers, and schedules
- M&Q materials alternatives
- Required testing
- Conservation of critical and strategic materials
- Workforce
- DMSMS
- Counterfeit avoidance
- Supply disruption
- Regulatory requirements and impacts (e.g., environmental, HAZMAT, etc.)
- Security (e.g., special handling, physical, cyber, industrial, etc.)
- Transportation, storage, and handling

Metrics

- M&Q personnel have assessed, updated, and/or validated materials producibility, manufacturing processes, techniques, procedures, capacity, and availability assessments for the capability to meet program scale-up requirements and materials risks, issues, and opportunities results have been documented in the Manufacturing Strategy and Plan and Quality Strategy and Plan (for CDR) for pilot line, LRIP, and FRP including:
  - New materials (to the industry, to the program, to the suppliers)
  - Supply chain and/or source capability and capacity
  - Source criticality and fragility (e.g., sole, or single sources, foreign sources, domestic foreign owned, etc.)
  - Workforce (e.g., knowledge, availability, etc.)
  - Lead times for required quantities (un-proven suppliers)
  - Rates that are higher and/or lower than typical
  - Introduction of counterfeit materials
  - Obsolescence due to product improvements and market/technology changes
  - Regulatory requirements and impacts (e.g., US law, ITAR, environmental, REACH concerns, etc.)
  - Testing aspects throughout the production processes and supply chain
  - Security (e.g., special handling, physical, cyber, industrial, etc.)
  - Facilities, equipment, and tooling
  - Transportation, storage, and handling
- Program Manufacturing Strategy and Plan and Quality Strategy and Plan (*See* L.2 and I.2) have been updated to mitigate and/or eliminate risks and issues and address opportunities for pilot line, LRIP, and FRP material scale-up requirements to include:

- Manufacturing processes, techniques, and procedures (including special handling)
- Schedule
- Impacts from critical and long-lead time materials
- Facility, equipment, and tooling availability (acquisition and/or scheduling)
- Cost models, drivers, and schedules
- M&Q materials alternatives
- Testing
- Conservation of critical and strategic materials
- Workforce
- DMSMS
- Counterfeit avoidance
- Supply disruption
- Regulatory requirements and impacts (e.g., environmental, HAZMAT, etc.)
- Security (e.g., special handling, physical, cyber, industrial, etc.)
- Transportation, storage, and handling

Tools

- Interactive MRL Users Guide (Checklist) for the Materials thread
- ManTech Strategic Plan
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet

Resources

- Air Force Technology Development and Transition Strategy Guidebook
- EC 1907/2006, Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)
- Manufacturing Readiness Level (MRL) Deskbook DoD Directive 4200.15, ManTech Program
- Producibility Systems Guidelines, NAVSO P-3687

G.4 Assess Contractor Supply Chain Management Program

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then Supply Chain Management (SCM) becomes a pivotal task. Often program problems originate in the supply chain, but do not manifest themselves until the component is integrated into the system. Program offices and contractors often have efforts to identify and manage problems at the first tier, but do not do well below that level. M&Q managers need to routinely review and assess contractors supply chain and procurement activities and efforts.

Manufacturing and Quality Tasks

- Assess the contractor's materials supply chain Management (SCM) program for implementation and adherence to industry M&Q best practices to include:
  - Manufacturing management standards (e.g., AS6500, MIL-STD-896A, etc.)
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)
  - Configuration management (EIA-649-1, MIL-HDBK-61A, etc.)
  - Systems Engineering standards (e.g., IEEE 15288, etc.)
- Assess the contractor's materials supply chain Management (SCM) program for:
  - Management of suppliers and sub-tier materials manufacturing processes and procedures, especially suppliers performing key and/or critical materials manufacturing processes impacting KCs
  - Implementation and compliance to security processes, plans, and procedures for materials including:
    - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
    - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
  - Materials special handling, storage, safety, and environmental compliance procedures to include:
    - Regulatory requirements
    - Hazardous materials and handling procedures
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal
  - Materials supplier sourcing processes for:
    - Supplier evaluation, qualification, approval, re-qualification, and removal
    - Management of sole or single sources, foreign sources, domestic foreign owned, etc.
    - Management of capabilities and capacities
  - Development of strategic partnerships with vendors and suppliers
  - Materials sub-contract management for:
    - Monitoring sub-tier compliance to M&Q contractual requirements
    - Monitoring sub-tier processes (e.g., configuration management, parts management, obsolescence, counterfeit parts management, electro-static discharge program, etc.)
    - Communications (e.g., two-way flow of quality data, requirements, forecasting data, etc.)
    - Materials data (e.g., testing, analyses, storage, and traceability, etc.)

        - Quality program implementation (e.g., SPC, process capabilities, predictive indicators, variability reduction, etc.)
    - Materials procurement processes for:
        - Specification of requirements (e.g., drawings, revisions, packaging, kitting, identification, etc.)
        - Specification of quality standards and metrics
        - Scheduling, quantities, etc.
        - Supplier assistance programs
        - Monitoring and evaluations
        - Deficiencies and corrective actions (i.e., FRACAS)
    - Internal logistics and inventory management processes for materials including:
        - Production scheduling, kitting, identification, etc.
        - Pre- and post-production storage, scheduling, kitting, packaging, environmental, security, etc.
        - Transportation methods, special handling, packaging, environmental controls, identification, and tracking, etc.
        - Vendor Managed Inventory (e.g., quality, schedule, quantity, packaging, kitting, identification, and tracking, etc.)
    - Integration of supply chain risks and issues for KCs, security, compliance, sourcing (counterfeit, obsolescence, etc.), and procurement into the joint contractor's Risk, Issue, and Opportunity System
- Assess the contractor M&Q materials processes for compliance with or adherence to Company policy, process, and contracts, using DCMA support (requires a Letter of Delegation) to include:
    - Implementation of industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
    - Performing first article/qualification(s) (i.e., AS9103)
    - SCM of interdependencies
    - Sourcing to minimize risks, criticality, and obsolescence
    - Supplier qualification, approval, and monitoring processes to include
        - Suppliers with known risks
        - Supplier parts usage and sources (i.e., GIDEP prohibited)
    - Processes for data flow (two-way)
        - Program reviews, milestones, and metrics
        - Demand Planning
        - Quality, safety, technical, and inspection requirements and changes
        - Key and critical characteristics

  - Make or buy decision analysis processes
  - Counterfeit and DMSMS management processes
  - Inventory management
  - FRACAS process
  - Security processes
  - ESOH management
  - Material waiver process (should only be used in limited circumstances)
  - Implementation of supply chain Management oversight processes
    - Vendor survey requirements
    - Identification and management of risks, issues, and opportunities
    - Surveillance

- Ensure assessments of critical first, second, and lower tier supply chain for compliance to purchase order/subcontract quality, manufacturing/ production, engineering, and software requirements are completed.
- Initiate SCM planning for EMD, production, developmental and operational test, and life-cycle sustainment.

Metrics

- Contractor's materials SCM program has been assessed for implementation and adherence to industry M&Q best practices with documented changes and recommendations provided to program management on the following:
  - Manufacturing management standards (e.g., AS6500, MIL-STD-896A, etc.)
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)
  - Configuration management (EIA-649-1, MIL-HDBK-61A, etc.)
  - Systems Engineering standards (e.g., IEEE 15288, etc.)
- Contractor's materials SCM program has been assessed for specific M&Q requirements, processes, and procedures with documented recommendations and changes provided to program management on the following:
  - Key Characteristic (KC) management, including suppliers and sub-tier materials manufacturing processes and procedures
  - Compliance with security processes, plans, and procedures for materials including:
    - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
    - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
  - Special handling, storage, safety, and environmental compliance for materials to include:
    - Regulatory requirements
    - Hazardous materials and handling

- Transportation, storage, and shelf life
- GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
- Disposal

- Supplier sourcing processes for:
  - Supplier evaluation, qualification, approval, re-qualification, and removal
  - Management of sole or single sources, foreign sources, domestic foreign owned, etc.
  - Management of capabilities and capacities
- Vendor and supplier strategic partnerships
- Contract management for sub-tier including:
  - Compliance monitoring for M&Q contractual requirements
  - Process monitoring (e.g., configuration management, parts management, obsolescence, counterfeit parts management, electro-static discharge program, etc.)
  - Communications (e.g., two-way flow of quality data, requirements, forecasting data, etc.)
  - Materials data management (e.g., testing, analyses, storage, and traceability, etc.)
  - Quality (e.g., SPC, process capabilities, predictive indicators, variability reduction, etc.)
- Materials procurement including:
  - Requirements (e.g., drawings, revisions, packaging, kitting, identification, etc.)
  - Quality standards and metrics
  - Scheduling, quantities, etc.
  - Supplier assistance programs
  - Monitoring and evaluations
  - Deficiencies and corrective actions (i.e., FRACAS)
- Internal logistics and inventory management including:
  - Production scheduling, kitting, identification, etc.
  - Pre- and post-production storage, scheduling, kitting, packaging, environmental, security, etc.
  - Transportation methods, special handling, packaging, environmental controls, identification, and tracking, etc.
  - Vendor Managed Inventory (e.g., quality, schedule, quantity, packaging, kitting, identification, and tracking, etc.)
- Integration of supply chain risks and issues for KCs, security, compliance, sourcing (counterfeit, obsolescence, etc.), and procurement into the joint contractor’s Risk, Issue, and Opportunity System

- Contractor's M&Q materials processes have been assessed using DCMA support for compliance with or adherence to Company policies, processes, procedures, and contracts with documented recommendations and changes provided to program management on the following for CDR:
  - Company adherence to industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
  - First article inspections and qualification(s) (i.e., AS9103)
  - SCM of interdependencies
  - Sourcing to minimize risks, criticality, and obsolescence
  - Supplier qualification (approval and monitoring) including
    - Suppliers with known risks
    - Supplier parts usage and sources (i.e., GIDEP prohibited)
  - Management of data flow (two-way)
    - Program reviews, milestones, and metrics
    - Demand Planning
    - Quality, safety, technical, and inspection requirements and changes
    - Key and critical characteristics
  - Make or buy decision analysis
  - Counterfeit and DMSMS management
  - Inventory management
  - FRACAS
  - Security
  - ESOH management
  - Material waivers
  - Implementation of SCM oversight including:
    - Vendor survey requirements
    - Identification and management of risks, issues, and opportunities
    - Surveillance
- Assessments of critical first, second, and lower tier supply chain for compliance to purchase order/subcontract quality, manufacturing/ production, engineering, and software requirements have been completed and are documented for CDR.
- Program SCM planning for the M&Q Strategies and Plans has been documented to include EMD, production, developmental and operational test, and life-cycle sustainment for CDR.

Tools

- AS5553, Supply Chain Assessment
- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist) for the Materials thread

- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronics Parts
- AS6500, Manufacturing Management Systems
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- AS9103, Variation Management of Key Characteristics
- AS9133, Qualification Procedure for Aerospace Standard Parts
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896A Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security

G.5 Analyze Material Lead Times

Lead time analysis can be a trick endeavor, especially for long lead items. Contractors and government managers have many tools available to them to support forecasting and lead time analysis to include:

- Straight Line based on historical data and constant growth rate
- Moving Average based on historical data and repeated forecast
- Simple Linear Regression based on a sample of relevant observations and comparing one independent variable with one dependent variable
- Multiple Linear Regression based on a sample of relevant observations and comparing several independent variables with one dependent variable

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

additional cost and risks. M&Q managers need to be able to support the analysis of lead times for materials.

Manufacturing and Quality Tasks

- Perform an analysis of contractor's M&Q schedule and quantities for subsystems, items, and components to meet program IMP/IMS and critical path requirements.
- Analyze results of assessments of contractor and key supply chain to ensure identification of M&Q risks, issues, and opportunities associated with scheduling procurement of materials (e.g., subsystems, items, and components) to include:
    - Long-lead Items
    - Lead time fluctuations
    - Impacts from single or sole sources, sources that are outside the NTIB, and sources vulnerable to foreign acquisition
    - Business climate conditions (e.g., acquisitions and mergers, natural disasters, strikes, policies and political changes, etc.)
    - Market changes (e.g., technological changes and obsolescence, workforce, etc.)
    - Impacts from scale-up
    - Impacts from regulatory issues, ITAR, Anti-Tamper, etc.
- Assess pilot line and LRIP procurement requirements (e.g., schedule and quantities).
- Ensure government M&Q funding supports contractor schedule and procurement requirements.
- Ensure mitigation plans are developed and implemented for all identified procurement risks and issues for CDR.

Metrics

- Contractor's M&Q schedule and quantities for subsystems, items, and components have been assessed for meeting program schedule and critical path requirements and recommendations and changes have been documented for the contractor plans and/or the IMP/IMS and provided for CDR.
- Contractor and key supply chain assessment results have been analyzed and document for CDR M&Q risks, issues, and opportunities associated with scheduling procurement of materials (e.g., subsystems, items, and components) including:
    - Long-lead Items
    - Lead time fluctuations
    - Impacts from single or sole sources, sources that are outside the NTIB, and sources vulnerable to foreign acquisition
    - Business climate conditions (e.g., acquisitions and mergers, natural disasters, strikes, policies and political changes, etc.)
    - Market changes (e.g., technological changes and obsolescence, workforce, etc.)

  - Impacts from scale-up
  - Impacts from regulatory issues, ITAR, Anti-Tamper, etc.
- Pilot line and LRIP procurement requirements for schedule and quantities have been assessed and documented for CDR.
- Government M&Q funding support for the contractor schedule and procurement requirements has been verified and confirmed for CDR.
- Mitigation plans have been developed and are in place for mitigation of all procurement risks and issues for CDR.

Tools

- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Manufacturing Readiness Level (MRL) Deskbook

G.6 Assess Alternate/Critical Sources

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole source, single source and foreign sources of supply come with a lot of risks. In addition, suppliers come and go in the marketplace. One day there might have four sources of supply and the next one or none. Diminishing Manufacturing Sources and Obsolescence is a very real problem on DoD programs, even programs that are pushing the state of the art may have components that are past their prime. One way to mitigate those risks and to increase competition (reduce cost) is to identify and develop alternative sources of supply. But this is not a quick or a cheap fix as the new supplier will probably need to go through a qualification program and prove that they have the capability to produce one, the capacity to produce all that is needed and the financial stability to be able to perform for the entire contract period of performance.

Manufacturing and Quality Tasks

- Analyze the contractor's M&Q sourcing plans, policies, and procedures (e.g., make/buy, alternate sources, etc.) for subsystems, items, and components for:
  - Meeting qualification requirements
  - Contingency planning (e.g., capacity, economic/political impacts, disaster impacts, etc.)
  - Competitive sources (e.g., dual source, GFE, etc.)
  - Costs (e.g., per unit, investment, storage, and handling, etc.)
  - Materials with environmental or ESOH concerns

  - Vulnerability mitigation for single, sole, foreign, foreign-owned domestic, fragile, critical, etc.
  - Materials only available outside the NTIB
  - Quality, schedule, transportation, fulfillment, etc.
  - Hazardous materials
  - Difficulty to obtain and/or process materials
  - Meeting Government requirements for support of the NTIB
  - Counterfeit detection and prevention (including GIDEP data)

- Review, and update assessment of the contractor's Make/Buy process for adequacy and completeness including capabilities, capacities, and processes based on pilot line results for: (*See* G.1)
  - Key and/or critical subsystems, items, parts, and components to include volatility
  - Management of the supply chain (including other divisions)
  - Vendors to meet quality requirements, schedule, and cost targets
  - Identification and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
  - Management of GFE, GFM, etc.
- Assess the Bill of Materials (BOM) for LRIP to include:
  - Make/buy process and decisions
  - Identification of key and/or critical items, parts, and components
    - All configuration items (CIs)
    - All CSIs
    - All KCs
  - Identification of risks, issues, and opportunities
- Review and update the Manufacturing Strategy and Plan and Quality Strategy and Plan (from CDR) based on pilot line results for changes to the contractor's:
  - Materials planning and control systems
  - Bill of Materials and make/buy decisions
  - Materials processes and procedures
  - Facilities, equipment, tooling
  - Tests, test facilities and equipment
- Ensure required material maturity has been proven and validated for LRIP based on pilot line assessments and results, including:
  - Properties and characteristics
  - Material producibility, predictability, manufacturability, etc.

- Develop recommendations for alternate sources and options for pilot line, LRIP, and O&S, based on M&Q analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, including:
    - Emerging technology advancements in materials and processes
    - Changes in Government statute, policy, and regulations
    - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
    - Changes in environmental impacts (e.g., natural disasters, etc.)
    - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Ensure alternate materials sources and/or materials mitigate current risks and issues and/or do not introduce new risks and issues to the program.
- Ensure contractor's alternate M&Q sourcing plans, policies, and procedures are consistent with program plans for program plans for Product Improvement (P^3I).
- Ensure continuing parts and materials availability for future requirements (i.e., Operations and Support phase) by assessing the supply chain for its long-term viability and competitive sourcing.

Metrics

- Contractor's M&Q sourcing plans, policies, and procedures (e.g., make/buy, alternate sources, etc.) have been assessed and document recommended updates and changes to subsystems, items, and components for:
    - Meeting qualification requirements
    - Contingency planning (e.g., capacity, economic/political impacts, disaster impacts, etc.)
    - Competitive sourcing (e.g., dual source, GFE, etc.)
    - Costs (e.g., per unit, investment, storage, and handling, etc.)
    - Materials with environmental or ESOH concerns
    - Mitigation for sources that are single, sole, foreign, foreign-owned domestic, fragile,
- Contractor's Make/Buy process has been assessed for adequacy and completeness including capabilities, capacities, and processes for: (*See* G.1)
    - Key and/or critical subsystems, items, parts, and components to include volatility
    - Management of the supply chain (including other divisions)
    - Vendors to meet quality requirements, schedule, and cost targets
    - Identification and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
    - Management of GFE, GFM, etc.
- Bill of Materials (BOM) for LRIP has been assessed and includes:
    - Make/buy process and decisions
    - Identification of key and/or critical items, parts, and components

        - All configuration items (CIs)
        - All CSIs
        - All KCs
    - Identification of risks, issues, and opportunities
- Manufacturing Strategy and Plan and Quality Strategy and Plan has been assessed for changes to the contractor's:
    - Materials planning and control systems
    - Bill of Materials and make/buy decisions
    - Materials processes and procedures
    - Facilities, equipment, tooling
    - Tests, test facilities and equipment
- Material maturity has been proven and validated for LRIP, including:
    - Properties and characteristics
    - Material producibility, predictability, manufacturability, etc.
- Recommendations for alternate sources and options for pilot line, LRIP, and O&S have been developed including:
    - Emerging technology advancements in materials and processes
    - Changes in Government statute, policy, and regulations
    - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
    - Changes in environmental impacts (e.g., natural disasters, etc.)
    - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Alternate materials sources and/or materials risks have been mitigated and current risks and issues and/or do not introduce new risks and issues to the program.
- Contractor's alternate M&Q sourcing plans, policies, and procedures have been assessed and are consistent with program plans for program plans for Product Improvement (P^3I).
- Parts and materials availability for future requirements (i.e., P&D and O&S phases) have been assessed for long-term viability and competitive sourcing.

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material

- Contractor Purchasing System Review (CPSR) Guidebook
- DFAR 15.407-2, Make or Buy Programs
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- Manufacturing Readiness Level (MRL) Deskbook
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328

G.7 Assess Material Availability for LRIP

Material Management is concerned with the ability of a program to have the right materials, at the right place, at the right time, at the right cost and quality levels. This includes raw materials, components, semi-finished parts, and subassemblies. Material availability is a major concern and supply chain managers need to constantly assess their sources of supply. M&Q managers need to support assessments of material availability and ramp up from the pilot line to LRIP.

Manufacturing and Quality Tasks

- Assess and verify material availability for LRIP, based on updates to Industrial Capabilities Assessments (*See* D.5 in support of Milestone C), including the following considerations:
    - Availability risks, issues, and mitigations (including for FRP)
    - Costs and schedule
    - Long-lead procurement risks and mitigation
    - Obsolescence
    - Long lead procurements
    - Supply chain
    - Effective supply chain management processes (including first, second, and lower tier suppliers as necessary)
    - Counterfeit detection and avoidance
    - Security (physical, cyber, industrial, anti-tamper, etc.)
    - Make/Buy decisions
    - Special handling, transportation, storage, and environmental compliance risks and issues
    - GFE, GFF, etc.
- Assess, and verify material availability for LRIP, based on M&Q analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, including the following considerations:
    - Emerging technology advancements in materials and processes
    - Changes in Government statute, policy, and regulations
    - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
    - Changes in environmental impacts (e.g., natural disasters, etc.)
    - Diminishing Manufacturing Sources and Material Shortages (DMSMS)

- Assess materials availability to for contractor's M&Q materials plans to meet program plans for P^3I in LRIP.

Metrics

- Material availability has been assessed and the capability to meet LRIP requirements has been documented based on updates from the industrial base assessments, for PRR including:
  - Availability from industrial base sources including risk and issue mitigations
  - Ability to meet costs and schedule
  - Obsolescence plans are in place.
  - Procurements of long lead materials
  - Effective supply chain management processes in place with assessment of critical first tier supply chain completed
  - Adequacy of supply chain to support LRIP with assessment of critical second and lower tier supply chain completed
  - Counterfeit detection and avoidance
  - Security (physical, cyber, industrial, anti-tamper, etc.)
  - Completed Make/Buy decisions.
  - Special handling, transportation, storage, and environmental compliance mitigations in place
  - All GFE, GFF, etc.
- Recommendations for materials sourcing and options for LRIP have been documented for PRR based on M&Q analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Materials sources and/or materials have been assessed to mitigate current risks and issues, do not introduce new risks and issues to the program for LRIP, and have been documented for PRR.
- Contractor's M&Q materials sourcing plans, policies, and procedures have been assessed and changes and/or recommendations for consistent with program plans for P^3I for LRIP have been documented for PRR.

Tools

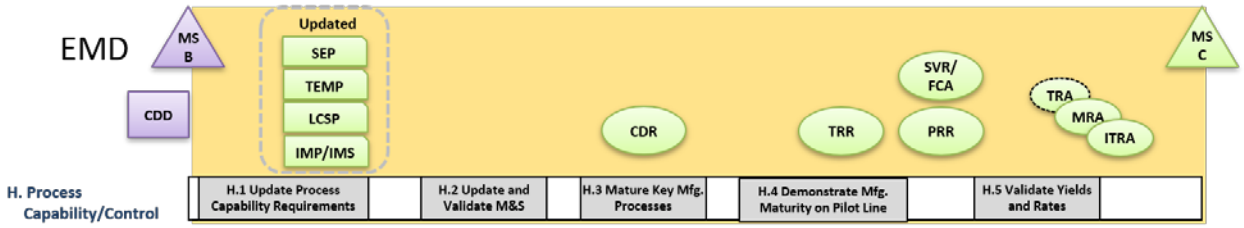
- DCMA Material Management and Accounting System Audit
- Interactive MRL Users Guide (Checklist) for the Materials thread

- Manufacturing Maturation Plan
- Supply Chain Management Risk Assessment Checklist

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System

H. MRL DESKBOOK PROCESS CAPABILITY/CONTROL



M&Q process capability and control should be an integral part of any development program. M&Q efforts should lead to a producible system with the objective of achieving effective and efficient manufacturing processes with process controls to satisfy program requirements with consistent and repeatable products at minimum manufacturing costs.

M&Q process capability and control should be a part of any development program. A process is “in control” if it is stable. A stable process does not mean that the contractor is producing only good product, it means that the process is predictable. A capable process is one that is producing conforming product. Process capability is usually measured using either a Capability Ratio (Cp) or a Capability Index (Cpk). Contractors should be working to get their processes to be both capable and in control.

In preparation for CDR, previously identified M&Q process capabilities should be refined and updated based on data collected and the contractor’s plans, processes, and procedures to identify the process capabilities required for the system. During the development process, additional studies at the system, subsystem, item, and component levels will be conducted to define the appropriate level of process capability and control. A thorough knowledge of a contractor’s and supply chain's process capabilities is critical to developing a successful system. Process capabilities and data must be understood, measured, controlled, and documented, and process capability information must be up to date.

Program M&Q personnel should understand the contractor’s M&S tools or products, as well as the industry state-of-the-art and best practices manufacturing and production M&S. The contractor should have and be using M&Q M&S tools which must be validated for applicability, adequacy, and consistency. Additionally, program M&Q personnel must assess and understand the correlation of demonstration results with M&S results and ensure M&Ss are updated to reflect maturity of M&Q systems, systems performance, and capability.

During the EMD phase the contractor will conduct pilot line demonstrations that will include testing and analysis to ensure products meet the program requirements. These products will be built on pilot lines. This means all of the key production realism elements (e.g., equipment, personnel skill levels, facilities, materials, components, work instructions, processes, tooling, temperature, cleanliness, lighting, etc.) required to manufacture products (e.g., items, subsystems, or systems) meet requirements for LRIP and have been incorporated into the demonstrations. The processes used on the pilot lines should be evaluated to understand the difficulties and quantify the risks to be mitigated for LRIP. Results of the pilot lines and the associated assessments should be incorporated into the appropriate M&Ss to provide an up-to-date, accurate M&S of the system.

Pilot line demonstrations of system and subsystem M&Q processes, and production line M&Q data for components and items provide opportunity to collect up-to-date data for yield and rate analyses. These analyses should be used to validate all M&Q learning curves for the system and subsystems to include evaluation of yields and rates against pilot line and LRIP targets, goals, and projections for rate production.

These assessments and demonstrations should provide an understanding of the contractor's process capabilities, M&S tools, and yields and rates, and support program M&Q planning, resource loading, facilities management, etc. for future phases.

H.1 Update Process Capability Requirements

One of the goals of manufacturing is to have uniform, defect-free product. In order to achieve that goal, the production processes must be capable, that is the outcome of the production process is a product that meets spec. M&Q managers need to be working continuously on production processes to identify where variation has the most impact, reduce variation and make the process robust to design requirements. Process control studies are often accomplished when the contractor finds that they are producing product that does not meet spec. But why wait for bad outcomes when the program can plan for success. Identify upfront and early what the design requirements are and make the processes capable of meeting those requirements even before the start of production.

Manufacturing and Quality Tasks

- Analyze process capability index (C_{pk}) goals for each key manufacturing process throughout the supply chain for support to M&Q program goals.
    - Review contractor and supply chain processes, process control plans, process yields, and Process Failure Modes and Effects Analyses (PFMEAs) for identification of appropriate key and/or critical manufacturing processes and verify the need for and validity of process capability index (C_{pk}) goals and targets

- Update M&Q process capability risks, issues, and opportunities for the Manufacturing Strategy and Plan and the Quality Strategy and Plan, and the SEP, using results of the PDR and current program status, including:
    - KCs
    - New equipment and new manufacturing technologies (including ManTech)
    - Potential M&Q cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - ESOH and Safety
    - Testing and qualification
    - Security
    - Environmental, transportation, storage, etc.
    - Data management (collection, storage, cyber security, etc.)
- Update and maintain required M&Q process capability requirements for consistency with product design as design progresses to CDR including producibility, manufacturability, supportability, affordability, etc.
- Ensure system-level manufacturing processes will be demonstrated in a production representative environment by CDR with subsystem, item, and component processes, at a minimum, demonstrated on a pilot line.
    - Ensure subsystems, items, and components manufacturing processes and equipment process capabilities from variability studies and analyses meet pilot line targets
- Continue to collect, monitor, manage, and analyze (or estimate where necessary) process capability data from subsystem, item, and component processes to include:
    - Subsystems, items, and components that are currently or have been previously manufactured for other systems by the supply chain
    - Data collected from supply chain yields, rates, and process capabilities from other similar subsystems, items, components, and prototype builds
- Refine process capability requirements based on collected data from manufacture of subsystems, items, and components (e.g., production representative, pilot lines, etc.).
- Ensure DCMA support and/or external agency support for Government surveillance of and updates to M&Q process capability requirements is requested and used (for the entire supply chain).

Metrics

- Process capability index (C_{pk}) goals for each key manufacturing process throughout the supply chain have been analyzed for support of M&Q program goals.

  - Contractor and supply chain processes, process control plans, process yields, and PFMEAs have been reviewed for updates and/or identification (inclusion) of key and/or critical manufacturing processes and verification of process capability index (C_{pk}) goals and targets

- Program, contractor, and supply chain M&Q process capability risks, issues, and opportunities have been assessed and updated in the Manufacturing Strategy and Plan and the Quality Strategy and Plan (and therefore the Acquisition Strategy), and the SEP, based on results of the PDR and current program status to include:
  - KCs
  - New equipment and new manufacturing technologies (including ManTech)
  - Potential M&Q cost and schedule impacts
  - Producibility
  - Tooling and facilities
  - ESOH and Safety
  - Testing and qualification
  - Security
  - Environmental, transportation, storage, etc.
  - Data management (collection, storage, cyber security, etc.)
- Required M&Q process capabilities are up-to-date and reflect product design and maintained in the M&Q Plans as design progresses to CDR including producibility, manufacturability, supportability, affordability, etc.
- Plans for system-level manufacturing process demonstrations in a production representative environment have been documented and implemented to be conducted and completed by CDR with subsystem, item, and component processes, at a minimum, demonstrated on a pilot line.
  - Variability studies have been conducted and completed on subsystems, items, and components manufacturing processes and equipment process capabilities for CDR and meet pilot line targets
- Process capability data from subsystem, item, and component processes is being collected, monitored, managed, analyzed (or estimated where necessary), and maintained under configuration control to include:
  - Subsystems, items, and components that are currently or have been previously manufactured for other systems by the supply chain
  - Data collected from supply chain yields, rates, and process capabilities from other similar subsystems, items, components, and prototype builds
- Collected data has been used to update and refine process capability index requirements (C_{pk}s) and documented in the M&Q Strategies and Plans.

- DCMA support and/or external agency support for Government surveillance of process capability data and support to updates of M&Q process capability requirements and indices has been requested and is being used (for the entire supply chain).

Tools

- AS6500, Manufacturing Management Assessment
- AS9100, Quality Management System Assessment
- AS9103, Variation Management Assessment
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Study (Cp and Cpk assessment)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- AS9103, Variation Management of Key Characteristics
- AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- MIL-HDBK-896A Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

H.2 Update and Validate Models and Simulations

The DoD uses M&S to deliver new or enhanced capability better, faster, and cheaper. M&S can be used to understand manufacturing processes and their capability and capacity to produce compliant products. Early M&S studies based on prototypes need to be updated and validated during the EMD phase as the design matures and the factory floor processes become realized on the pilot line. M&Q managers need to support the update and validation of M&S for manufacturing systems and processes.

Manufacturing and Quality Tasks

- Assess contractor M&S system prior to product and/or process implementation for the capability to model (product and processes) and assess the system for CDR and pilot line to include:
    - Integration with supply chain M&S Systems
    - Integration with CAD, MRP, scheduling, time standards, work instructions, planning, etc.
    - Yield and rate modeling to predict first pass yields including key design and process attributes
    - Manufacturing ergonomics M&S to ensure human factors considerations are applied in manufacturing

  - Production process M&S addressing material flow, surges, processing times, scrap, rework, and repair levels, etc.
  - Supply chain M&S including impacts of disruptions, supplier capabilities and yields, learning curve effects, obsolescence issues, etc.
  - Other tools such as:
    - Value stream mapping completes with all types of information, material, parts, physical processing times, physical movements, wait times, etc.
    - Factory simulations for system production including facility, production lines, transportation, storage, handling, security, etc.
    - Lean Manufacturing, Six-Sigma, etc.
  - Capability to evaluate the design and manufacturing processes to meet program M&Q objectives including quantification of risk and issue mitigation including:
    - Factory floor, process flows, assembly lines, yields/ throughput/variability, cycle times, etc. with estimated quantities of tooling, personnel, and inventory
    - Throughput concurrent with other ongoing production
  - Capability to provide estimated yields, rates, cycle times, schedule, and cost performance to meet program M&Q goals
    - Use data from production of subsystems, items, and components to validate M&S System
    - Use data from production of subsystems, items, and components to identify of M&Q bottlenecks or constraints
    - Validate M&Q cycle times achievability

- Assess the results and data from M&Q demonstrations, tests, production of items and components, etc. by the contractor and supply chain in production representative environment to validate M&S of subsystems, components, and items for CDR, including:
  - A mix of mature hardware, prototypes, and models and simulations
  - Interfaces, integration, and interdependencies
  - Ergonomics
  - Identification of constraints
  - Performance
  - Throughput
  - Sufficient complexity to match the complexity of the system

Metrics

- Contractor M&S System has been assessed prior to product and/or process implementation and documents the capability to model and assess the system for CDR and pilot line to include:

- Integration and/or utilization of supply chain M&S Systems
- Integration with other systems (e.g., CAD, MRP, scheduling, time standards, work instructions, planning, etc.)
- Yield and rate model predictions of first pass yields
- Manufacturing ergonomics models to include human factors in manufacturing
- Production process models (e.g., material flow, surges, processing times, scrap, rework, and repair levels, etc.)
- Supply chain models (e.g., impacts of disruptions, supplier capabilities and yields, learning curve effects, obsolescence issues, etc.)
- Other tools such as:
  - Value stream mapping
  - Factory simulations (e.g., processes, facilities, production lines, transportation, storage, handling, security, etc.)
  - Lean Manufacturing, Six-Sigma, etc.
- Capability to meet program M&Q objectives with quantification of risk and issue mitigation
- Capability to evaluate both the design and supporting manufacturing processes including:
  - Factory floor, process flows, work cells, assembly lines, etc.
  - Yields, throughputs, variability, cycle times, etc.
  - Tooling, personnel, and inventory requirements, etc.
  - Throughput concurrent with other ongoing production
- Capability to estimate yields, rates, cycle times, schedule, and cost performance, etc. to meet program M&Q goals and using data to:
  - Validate the M&S System
  - Identify of bottlenecks or constraints
  - Validate cycle times

- Results and data from M&Q demonstrations, tests, production of items and components, etc. by the contractor and supply chain in production representative environment have been assessed and validation M&S of subsystems, components, and items has been documented for CDR, to include the following factors:
  - Mature hardware, prototypes, and models and simulations
  - Interfaces, integration, and interdependencies
  - Ergonomics
  - Constraints
  - Performance
  - Throughput
  - Complexity (reflecting system complexity)

Tools

- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Plant M&S tools (FlexSim, SimFactory, etc.)
- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)
- System Capabilities Analytic Process (SCAP)

Resources

- AS6500, Manufacturing Management Program
- MIL-HDBK-896A Manufacturing Management Program Guide
- Modeling and Simulation Guidance for the Acquisition Workforce
- Manufacturing Readiness Level (MRL) Deskbook

H.3 Mature Key Manufacturing Processes

Immature processes are a major source of risks on acquisition programs, especially during the EMD phase when most production are just emerging and starting to mature. As a program moves forward process maturity takes on greater importance. According to DoDI 5000.02 the EMD Milestone C decision requires that there be no significant manufacturing risks, that industrial production capabilities are reasonably available, and that the maturity of critical manufacturing processes has been assessed to ensure that they are affordable and executable. If these processes are not capable, in control and affordable, then the program office needs to continue to mature those processes.

Manufacturing and Quality Tasks

- Define and document the appropriate M&Q production representative and pilot line environments to be placed on contract, and used for process demonstrations and maturations, verifications and validations, qualifications, first articles, etc., based on contractor, supply chain, Government IPT, and contracting personnel interactions.
    - Ensure provisions for Government surveillance of contractor and supply chain “proof-of-builds” and/or “product/process walkthroughs” are included
- For CDR, assess demonstrations of M&Q processes in an environment with as much production realism as possible, considering the maturity of the design throughout the supply chain including:
    - Equipment (e.g., capability, capacity accuracy, calibration, age and condition, suitability, etc.)
    - Workforce (i.e., training, skills, and certifications)

  - Human factors (i.e., noise, vibrations, ergonomics)
  - Environmental conditions (i.e., temperature, humidity, air quality)
  - Testing and test equipment
  - Capability to meet the cost, schedule, and performance requirements
  - Estimates of costs, yields, rates, etc.
- Assess risks, issues, and impacts of the manufacturing environment (i.e., production representative) on M&Q processes and develop recommended mitigation plans for both the contractor and the supply chain for CDR.
- Collect data from process demonstrations and production of components and items in a production representative environment throughout the supply chain to support verification, validation, and authentication of M&S for CDR.
  - Ensure data is under configuration control
- Update status of the comprehensive M&Q Plans based on demonstrations of M&Q processes in a production representative environment for CDR
  - Include all M&Q risks and issues
  - Use Process Failure Modes and Effects Analyses (PFMEAs) on all M&Q processes
  - Update plans for achieving pilot line process capability targets
- Ensure key M&Q processes are sufficiently mature by conducting a system-level MRL assessment in support of CDR.
  - System-level target should utilize MRL 7 criteria and metrics
  - Subsystem, item, and components targets should utilize MRL 8 and/or MRL 9 criteria and metrics

Metrics

- M&Q production representative and pilot line environments have been documented and placed on contract, and are being used for process demonstrations and maturations, verifications and validations, qualifications, first articles, etc.
  - Provisions for DCMA or program surveillance of contractor and supply chain "proof-of-builds" and/or "product/process walkthroughs" are on contract
- Demonstrations of M&Q processes in a production representative environment, at a minimum, or a more mature environment based on the maturity of the design, have been assessed throughout the supply chain and document implementation for CDR of mature processes in accordance with industry best practices, including those for:
  - Equipment (e.g., accuracy, calibration, age and condition, suitability, capacity, etc.)
  - Workforce (i.e., training, skills, and certifications)
  - Human factors (i.e., noise, vibrations, ergonomics)
  - Environmental conditions (i.e., temperature, humidity, air quality)

  - Testing and test equipment
  - Capability to meet the cost, schedule, and performance requirements
  - Estimates of costs, yields, rates, etc.
- Risks, issues, and impacts of the manufacturing environment (e.g., production representative, etc.) on M&Q processes have been assessed and recommended mitigation plans developed and documented for both the contractor and the supply chain for CDR.
- Data has been collected from process demonstrations and production of components and items in a production representative environment throughout the supply chain and documented as supporting verification, validation, and authentication of M&S for CDR.
  - Data is under configuration control
- M&Q Plans have been updated based on demonstrations of M&Q processes in a production representative environment for CDR including:
  - All M&Q risks and issues
  - PFMEAs on all M&Q processes
  - Updated plans to achieve pilot line process capability targets
- A system-level MRL assessment has been conducted to confirm key M&Q processes are sufficiently mature by CDR.
  - System-level meets MRL 7 target (criteria and metrics)
  - Subsystem, item, and components meet MRL 8 and/or MRL 9

Tools

- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Assessment
- Production Part Approval Process (PPAP)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DoDI 5000.02, Operation of the Defense Acquisition System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook ISO 9001:2015, Quality Management System

H.4 Demonstrate Manufacturing Maturity on Pilot Line

A Pilot line is an environment that incorporates all of the key production realism elements (equipment, personnel skill levels, facilities, materials, components, work instructions, processes, tooling, temperature, cleanliness, lighting etc.) required to manufacture production configuration items, subsystems or systems that meet design requirements in low-rate production. To the maximum extent practical, the pilot line should utilize FRP processes. The Pilot Line is where the demonstration of manufacturing maturity should take place.

Manufacturing and Quality Tasks

- Assess the progress and status of pre-CDR mitigations (i.e., production representative environment) for risks, issues, and impacts during pilot line demonstrations of M&Q processes, procedures, and schedules.
    - Update or develop mitigation plans for LRIP
- Assess demonstrations of manufacturing processes in an environment with all the key production realism elements required to manufacture production configuration items, subsystems or systems that meet design requirements in low-rate production (i.e., pilot line) including:
    - Equipment (e.g., accuracy, calibration, age and condition, suitability, capacity, etc.)
    - Personnel skill levels
    - Facilities, storage and handling, waste disposal, etc.
    - Hazmat
    - Security and safety
    - Materials and components
    - Work instructions and processes (e.g., cleaning, heat treating, ESD protection, clean rooms, etc.)
    - Tooling
    - Testing and test equipment
    - Environmental conditions (e.g., temperature control, cleanliness, lighting etc.)
    - Costs, yields, rates, etc.
- Collect data from pilot line demonstrations of M&Q processes and production line M&Q processes for components and items to support verification, validation, and authentication of system-level M&S for PRR and Milestone C.
- Verify that the contractor conducts process capability studies that meet program targets (C_{pk}s) to include:
    - All manufacturing processes for KCs and critical characteristics
    - Process capability studies conducted throughout the supply chain

- Based on process capability targets and pilot line results, update the comprehensive M&Q Plans for P&D to
  - Maintain currency of M&Q M&S
  - Maintain all M&Q risks, issues, and mitigations status
  - Update PFMEAs for all M&Q processes from pilot line changes
  - Update plans for achieving LRIP process capability targets in P&D
- Ensure key M&Q processes are sufficiently mature by conducting an MRL assessment to support PRR and Milestone C.
  - System-level target should utilize MRL 8 criteria and metrics
  - Subsystem, item, and components targets should utilize MRL 9 criteria and metrics
- Ensure Government surveillance of contractor and supply chain key and/or critical manufacturing processes for compliance to best practices or AS6500 (depending on contract).
- Ensure all policies, procedures, processes, work instructions, data, plans, metrics, tooling, equipment, and documentation are under program configuration management and control.

Metrics

- Progress of production representative environment mitigations for risks, resolution of issues, and associated impacts have been assessed and status and completeness has been documented during pilot line demonstrations of M&Q processes, procedures, and schedules.
  - Mitigation plans for ongoing risks and issues (i.e., LRIP) have been updated and documented.
- Demonstrations of M&Q processes have been assessed for impacts and documented with data collected for capability studies (*See* H.4) in a pilot line environment with all elements required to manufacture items, subsystems or systems (configuration controlled) that meet design requirements in LRIP including:
  - Equipment (e.g., accuracy, calibration, age and condition, suitability, capacity, etc.)
  - Personnel skill levels
  - Facilities, storage and handling, waste disposal, etc.
  - Hazmat
  - Security and safety
  - Materials and components
  - Work instructions and processes (e.g., cleaning, heat treating, ESD protection, clean rooms, etc.)
  - Tooling
  - Testing and test equipment
  - Environmental conditions (e.g., temperature control, cleanliness, lighting etc.)
  - Costs, yields, rates, etc.

- Data collected from pilot line demonstrations and production line processes supports verification, validation, and authentication of system-level M&S for PRR and Milestone C.
- Contractor and supply chain process capability data has been collected and analyzed, and meets program pilot line targets (C_{pk}s) including:
    - All processes for KCs and critical characteristics
    - Supply chain process capabilities for subsystems, items, and components
- The comprehensive M&Q Plans for P&D have been updated based on process capability targets and pilot line results including:
    - M&Q M&S
    - M&Q risks, issues, and mitigations status
    - Updated PFMEAs for all M&Q process changes
    - Updated plans to achieve LRIP process capability targets in P&D
- An MRL assessment has been conducted and documented to meet targets to support PRR and Milestone C:
    - System-level target meets MRL 8 criteria and metrics
    - Subsystem, item, and components targets meets MRL 9 criteria and metrics
- DCMA is providing Government surveillance of contractor and supply chain key and/or critical manufacturing processes for compliance to best practices or AS6500 (depending on contract).
- Program configuration control system includes, tracks, and documents all policies, procedures, processes, work instructions, data, plans, metrics, tooling, equipment, and documentation (i.e., CDRLs).

Tools

- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Pilot Line Demonstration and Assessment

Resources

- AS6500, Manufacturing Management Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Systems
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896A Manufacturing Management Program Guide

H.5 Validate Yields and Rates

Companies often look closely at their yield and defect rates as a measure of factory floor performance and ability to produce uniform, defect-free product that meets the warfighters requirements and is affordable. Typical quality measures of output include first pass yield, cost of quality, scrap, rework, and repair rates. M&Q managers need to be able to estimate their quality measures early and then validate those estimates during the pilot line build.

Manufacturing and Quality Tasks

- Collect up-to-date data from system and subsystem pilot line demonstrations of M&Q processes, and production line M&Q data for components and items as the basis for yield and rate analyses to validate "as is" status.
    - Rate of quality processes (actual time to complete) vs. planned
    - Quality data actuals vs. estimated
    - Quality process yield actuals vs. planned
    - Changes in processes (actual vs. planned)
    - Cost of quality actuals vs. desired
- Validate all M&Q learning curves for the system and subsystems based on pilot line results, contractor and supply chain improvements, program progress to date to include:
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
    - Planning and scheduling
    - Throughput (yield and rates)
    - Labor efficiency and ergonomics
    - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
    - Materials handling, transportation, and storage (including WIP)
    - Supply chain changes
    - Standardization and common processes
- As a potential impact on yields and rates, validate completeness of all related risk mitigation activities or acceptance of these risks (included in the joint Risk, Issue, and Opportunity Management Process), including:
    - Key and critical manufacturing processes including embedding software (KCs)
    - Supply chain, materials, and sourcing, including multiple
    - Facilities, tooling, and equipment
    - Testing, test equipment, and in-process tests
    - System security, safety, and hazardous materials 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

Metrics

- 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 has been collected and documented in the program configuration controll management system as the basis for yield and rate analyses to validate “as is” status including:
    - Rate of quality processes (actual time to complete) vs. planned
    - Quality data actuals vs. estimated
    - Quality process yield actuals vs. planned
    - Changes in processes (actual vs. planned)
    - Cost of quality actuals vs. desired
- All M&Q learning curves for the system and subsystems based on collected and documented pilot line results, contractor and supply chain improvement results, and program progress to date have been updated and include:
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
    - Planning and scheduling
    - Throughput (yield and rates)
    - Labor efficiency and ergonomics
    - Improvements in materials, methods, processing, equipment, tools, automation (i.e., manufacturing technology)
    - Materials handling, transportation, and storage (including WIP)
    - Supply chain changes
    - Standardization and common processes
- Risk mitigation activities have been validated as satisfactory (or program has accepted these risks) and have been analyzed and the documented impacts on yields and rates are acceptable, 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 hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)

- Manufacturing capability, obsolescence, and sustainment

- All yields and rates from pilot line and lower level production products have been validated to meet pilot line targets:
  - Analyses support or indicate achievability of LRIP targets, goals, and projections with refinements as required
  - Improvement plans have been developed and implemented, as required

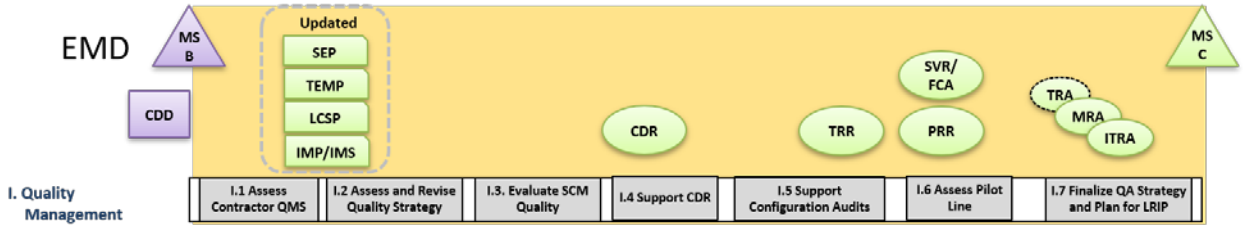
Tools

- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturation Plan
- Yield Rate Assessment

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems
- AS9103, Variation Management of Key Characteristics

I. MRL DESKBOOK QUALITY MANAGEMENT



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

Most contractors have Quality Management Systems (QMSs) certified to industry standards (best practices) and should not need assessment for compliance as ongoing audits are part of the certification process. Program should assess that the contractor's QMS supports and aligns with Program strategy, objectives, goals, and the contract. This will involve the use of process audits as to whether the

contractor's and supply chain activities, resources, and behaviors are being managed efficiently and effectively including participation of DCMA, KCs control and management, use of acceptance testing, application of Statistical Process Controls (SPCs), etc., which are more than just evaluations of the sequential steps and interactions of a process within the QMS. Similarly, these audits should be conducted on the supply chain, as necessary.

The M&Q Strategies should require quality assessments of the manufacturing processes to ensure they have been effectively demonstrated in an appropriate environment, such as a pilot line, prior to Milestone C. Revision to the quality strategy, plans, and objectives may be required based on the results of process audits and quality assessments.

For CDR, initial product baseline documentation for quality, included in the Quality Strategy and Plans, should be sufficient, complete, and adequate to enable inspections and testing of all components, hardware, and embedded software throughout the supply chain. The system-level CDR assesses the system design as captured in product specifications for each subsystem, item, and component in the system's initial product baseline, and helps ensure that each has been captured in the detailed design and quality documentation. Assessment of the allocated baseline against the initial product baseline should assure that quality parameters (e.g., tolerance, process capability indices, etc.) for considerations such as weight, power, cooling, etc. have been appropriately specified in the detailed design. This includes drawings and specifications with tolerances and test points under configuration control for all KCs, CSIs, and CAIs having been completed.

A system-level FCA should be conducted to assess performance of the system against the functional baseline and may be conducted in conjunction with the SVR. Quality and quality personnel should be an integral element in both the FCA and the SVR. The main difference between the two activities is that a system-level FCA focuses primarily on verification of the functional baseline, while SVR assesses system functionality as well as other details to include program readiness to proceed into the Production and Deployment phase. This includes assessments for quality of all program, contractor, and supply chain policies, processes, and procedures.

The system-level FCA should assess the collected data, test results, analysis results, and M&S output and accuracy of the system after completion of development testing and pilot line and verifies that actual system performance satisfies quality requirements. For quality requirements that cannot be completely verified during pilot line, tests or simulations using approved methods can provide valid data that LRIP performance will be met with acceptable risks.

The SVR should address all changes or additions generated since CDR to ensure the as-tested product on the pilot line includes all Engineering Change Proposals, specification change notices and revisions, interface control changes, and all M&Q process changes.

As the pilot line environment incorporates all key equipment, personnel skill levels, materials, components, work instructions, tooling, etc. required to manufacture the product, quality analyses

should be performed during pilot lines to provide verification and validation of actual yields, rates, and costs to be realized during LRIP. The environment should utilize production processes forecasted to be used in LRIP. Based on quality analyses of program, contractor, and supply chain, quality assessments of maturity, quality analyses of affordability and quality costs, quality risks, issues, and opportunities, all demonstrate that the M&Q processes and capabilities required for production have matured with high confidence of success in building production configuration products in the P&D phase.

The combination of a robust quality management system and advanced quality and defect prevention practices are critical to successful program execution, and it is mandated under Federal Acquisition Regulation (FAR) Part 46.202-4.

I.1 Assess Contractor Quality Management System

FAR Part 46 is used by quality managers to identify contractual quality requirements. Most DoD programs will require a higher-level quality clause. ISO 9001 and AS9100 both satisfy the requirements for a higher-level quality management system or QMS. Often contractors will note in their proposal that they will follow one of the two QMS's identified above and it is up to the procuring activity to assess the contractor and their implementation to see if it does in fact satisfy their requirements and will result is conforming product.

Manufacturing and Quality Tasks

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

- Ensure that the results of an analyses of corporate strategic vision, objectives, policies, plans, processes, and procedures has been documented in the Acquisition Strategy (AS), M&Q Plans, the SEP, program documentation for CDR, and other appropriate program documentation.
- Conduct a process audit of the contractor's QMS including assessment of:
  - Quality processes and supply chain quality including:
    - Identification, control, and auditing of critical manufacturing processes
    - Role and participation of DCMA (contractor and supply chain)
    - KCs control and management
    - Acceptance testing including software
    - In-process and final inspection functionality
    - Statistical process controls, rates, and yields (and management of same)
    - Execution of and adherence to quality plans including control plans and quality improvement plans
    - Certification processes (e.g., flight safety, man-ratings, etc.)
    - Continuous process improvement results
    - Software quality assurance results
    - Data storage, management, and security (physical and cyber)
    - Management of safety, environmental, transportation, storage, etc.
    - Use of COTS items, GOTS items, and NDIs
    - GFE/GFP management (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
    - Internal and supply chain audits and verification results
  - Processes for management, control, and monitoring of KPPs, KSAs, and KCs, CSIs, and CAIs, and their integration into the QMS.
  - FRACAS processes for sufficiency and adequacy including results of dispositions (i.e., material review boards and processes)
  - QMS impacts on tasks, costs, schedules, and outcomes
  - QMS compliance to standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
  - Planning, integration, and execution of the Risk, Issue, and Opportunity Management System processes
- Request DCMA support and assistance to assess adequacy and completeness of contractor and supply chain QMSs application to system, subsystems, items, and components.

Metrics

- Contractor's and supply chain Quality Management Systems (QMSs) have been analyzed and assessed for alignment to contracted program needs and industry best practices, including:

  - An 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
  - A process established for communication of organizational direction and values regarding quality throughout the supply chain
  - Management structures and resources supporting full implementation of the quality management system
  - Management solicitation of, and action on, quantitative and qualitative feedback on the effectiveness and efficiency of quality management system
  - Procedures for periodic internal review of the quality management system with established goals and objectives throughout the organization for customer satisfaction and continuous improvement
  - Procedures for independent reporting of quality functions and audits
  - Management accountability with emphasis on quality results and customer satisfaction

- Results from the above analyses of corporate strategic vision, objectives, policies, plans, processes, and procedures have been documented in the Acquisition Strategy (AS), M&Q Plans, the SEP, program documentation for CDR, and other appropriate program documentation.
- Process audits (adequacy and sufficiency) of the contractor's and supply chain QMSs have been conducted and results documented for updates to the Quality Strategy and Plan (*See* I.2) including:

  - Role and participation of DCMA (contractor and supply chain)
  - Control and management of KCs, CSIs, and CAIs
  - Acceptance testing including software
  - Effectiveness of in-process and final inspections
  - Application and effectiveness of statistical process controls
  - Management of processes for measurement of rates and yields
  - 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 improvements and results
  - Software quality assurance and results
  - Data storage, management, and security (physical and cyber)
  - Safety, environmental, transportation, storage, etc. management, processes, and procedures
  - For use of COTS items, GOTS items, and NDIs
  - Management, control, and security of GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Internal and supply chain audits, verification of results, and any subsequent corrective actions

  - Processes for management, control, and monitoring of Key Performance Parameters (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)
  - Impacts on tasks, costs, schedules, and outcomes
  - Compliance to standards and best practices (e.g., AS9100, ISO 9000, industry product standards, MIL-STDs, etc.)
  - Risk, Issue, and Opportunity Management System processes for planning, integration, and execution with the QMS
- DCMA support and assistance has been requested and the Letter of Delegation and DCMA personnel have supported the assessment of adequacy and completeness of contractor and supply chain QMSs application to system, subsystems, items, and components.

Tools

- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist) for the Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102 First Article Inspection
  - AS9103 Variation Management of Key Characteristics
  - AS9133 Qualification Procedure for Aerospace Parts
  - AS9134 Supply Chain Management Guidelines
  - AS9136 Root Cause Analysis and Problem Solving
  - AS9138 Statistical Process Acceptance
  - AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- DoD Risk, Issue, and Opportunity Management Guide
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896A, Manufacturing Management Program Guide

I.2 Assess and Revise Quality Strategy

M&Q managers support the development and updates to the Acquisition Strategy by providing their inputs into the SEP. Quality managers can look to the FAR Part 46 and 52 to understand potential

contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and ultimately to the success of a program.

Manufacturing and Quality Tasks

- Update and revise the program Quality Management Strategy based on the contractor's QMS, and quality strategy and plans to include:
    - The contractor's strategy and plan to address compliance to established industry standards and best practices (e.g., AS9100, ISO 9000, etc.)
    - Alternatively, the contractor's quality management strategy and plans should address:
        - Leadership responsibilities and requirements
        - Quality management system requirements and planning
        - Support and resource management requirements
        - Operational requirements (e.g., risk management, design, and development, purchasing, etc.)
        - Risks, issues, and opportunities
        - Performance evaluation including measurement, analysis, and improvement requirements
- Update and revise the program Quality Management Strategy and Plan based on the results from process audits (adequacy and sufficiency) of the contractor's and supply chain QMSs conducted (*see* I.1).
- Develop required contract modifications or updates to ensure alignment of contractor with program Quality Management Strategies and Plans based on results of quality audits conducted (*see* I.1).
- M&Q should conduct internal audits at planned intervals to ensure the program quality management system conforms to the program's requirements and is effectively implemented and maintained.
- M&Q personnel should review and revise program quality objectives for adequacy and sufficiency at the appropriate levels, and for the appropriate processes to meet program objectives. The quality objectives should consider applicable requirements and be:
    - Consistent with the quality policy
    - Measurable
    - Monitored
    - Communicated
    - Updated, as appropriate
- M&Q personnel should verify and update the program Quality Management Strategy and Quality Plan to ensure they include:

  - All required quality technologies and processes (state of the art), unique product quality requirements, metrics, and the frequency of review
  - Compliance with FAR 52.246-11, Higher-Level Contract Quality Requirements
  - The quality aspects of contractor compliance to industry best manufacturing practices (i.e., AS6500)
  - Management, measurement, and control of key and critical characteristics and processes
  - Addresses use of and appropriate quality requirements for COTS items, GOTS items, and non-developmental items (NDIs) and their incorporation into the contractor's QMS (i.e., shock and vibe requirements beyond normal COTS design envelope)
  - Requirements for supply chain:
    - Focused supplier quality management requirements
    - Quality management planning
    - Use of best practices and standards (e.g., AS9100, ISO 9000, etc.)
    - Metrics and review frequency
    - Solutions, tools, techniques, and procedures
    - Use of Government furnished quality and testing equipment and assets
  - Appropriate agreements, delegations, and contracts with other agencies, e.g., the DCMA and/or DLA throughout the supply chain
  - Software and firmware development quality assurance and configuration management

- M&Q personnel should assess the program's quality management system, at planned intervals for continuing suitability, adequacy, effectiveness, and alignment with the strategic direction of the program. The assessment should include:
  - Status of actions from previous assessments
  - Changes in external and internal issues that are relevant to the QMS
  - Performance and effectiveness of the QMS, including:
    - Extent to which quality objectives have been met
    - Process performance and conformity of products
    - Nonconformities and corrective actions
    - Monitoring and measurement results
    - Audit results
    - Performance of the supply chain
  - Adequacy of resources
  - Effectiveness of actions taken to address risks, issues, and opportunities
  - Opportunities for improvement

Metrics

- Program Quality Management Strategy has been updated based on assessments of the contractor's QMS, and contractor quality strategy and plans to include:

  - The contractor's strategy and plan to address compliance to established industry standards and best practices (e.g., AS9100, ISO 9000, etc.)
  - Alternatively, the contractor's quality management strategy and plans to address:
    - Leadership responsibilities and requirements
    - Quality management system requirements and planning
    - Support and resource management requirements
    - Operational requirements (e.g., risk management, design, and development, purchasing, etc.)
    - Risks, issues, and opportunities
    - Performance evaluation including measurement, analysis, and improvement requirements

- Program Quality Management Strategy and Plan has been revised based on the results from process audits (adequacy and sufficiency) of the contractor's and supply chain QMSs.
  - Recommended contract modifications or updates have been submitted to program management to ensure alignment of contractor with program Quality Management Strategies and Plans with program strategies and plans

- M&Q personnel have conducted internal audits as planned and documented the program quality management system effective implementation, conformance, and support of the program's requirements, or corrective actions, as appropriate.
- M&Q personnel have reviewed, documented, and will maintain documentation on the adequacy and sufficiency of program quality objectives to meet program objectives. The quality objectives consider applicable requirements and are:
  - Consistent with the quality policy
  - Measurable
  - Monitored
  - Communicated
  - Updated, as appropriate

- M&Q personnel have verified and updated where necessary the program Quality Management Strategy and Quality Plan ensuring inclusion of:
  - All required quality technologies and processes (state of the art), unique product quality requirements, metrics, and the frequency of review
  - Compliance with FAR 52.246-11, Higher-Level Contract Quality Requirements
  - The quality aspects of contractor compliance to industry best manufacturing practices (i.e., AS6500)
  - Management, measurement, and control of key and critical characteristics and processes
  - Appropriate quality requirements for COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS (i.e., shock and vibe requirements beyond normal COTS design envelope)

  - Requirements for supply chain:
    - Focused supplier quality management requirements
    - Quality management planning
    - Use of best practices and standards (e.g., AS9100, ISO 9000, etc.)
    - Metrics and review frequency
    - Solutions, tools, techniques, and procedures
    - Use of Government furnished quality and testing equipment and assets
  - Appropriate agreements, delegations, and contracts with other agencies, e.g., the DCMA and/or the Defense Logistics Agency (DLA) throughout the supply chain
  - Software and firmware development quality assurance and configuration management
- M&Q personnel have assessed and documented the program's quality management system for continuing suitability, adequacy, effectiveness, and alignment with the strategic direction of the program including:
  - Status of actions from previous assessments
  - Changes in external and internal issues that are relevant to the QMS
  - Performance and effectiveness of the QMS, including:
    - Extent to which quality objectives have been met
    - Process performance and conformity of products
    - Nonconformities and corrective actions
    - Monitoring and measurement results
    - Audit results
    - Performance of the supply chain
  - Adequacy of resources
  - Effectiveness of actions taken to address risks, issues, and opportunities
  - Opportunities for improvement

Tools

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

Resources

- AFMC Instruction 63-145, Manufacturing and Quality
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace

  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- DSMC Acquisition Strategy Guide
- DoDI 5000.88, Engineering of Defense Systems
- FAR 52.246-11, Quality
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook DAG Chapter 14.3.1.3.6 Quality Plans

I.3 Evaluate Supply Chain Quality

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then the development and execution of a Supplier QA program becomes a pivotal task. Often program problems originate in the supply chain, but do not manifest themselves until the component is integrated into the system. This is especially a problem as the program ramps up production from the pilot line build to the LRIP environment. Program offices and contractors often have efforts to identify and manage problems at the first tier, but do not do well below that level. QA managers need to routinely review and assess contractors supply chain and procurement activities and efforts.

Manufacturing and Quality Tasks

- Ensure that the contractor supplier management system for subsystems, items, and components requires QMS processes and procedures are in alignment with industry best practices (e.g., AS9100, ISO 9000, AS9134 Supply Chain Management Guidelines, etc.) to include elements such as:
  - Management responsibility requirements
  - Quality management system requirements
  - Resource management requirements
  - Product Realization requirements (e.g., risk management, design, and development, purchasing, etc.)
  - Risks, issues, and opportunities
  - Measurement, analysis, and improvement requirements
- Assess the contractor's supply chain management system capabilities for performance of M&Q processes and procedures in accordance with industry best manufacturing practices (i.e., AS6500, AS9134 Supply Chain Management Guidelines, etc.) including:
  - Effectiveness of prime and subcontractor communications and interactions to include:

        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Design and engineering changes traceability and compliance
        - Quality data exchange, analysis, storage, and traceability processes
        - The joint Risk, Issue, and Opportunity Management System
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions and program feedback
    - Management of KCs and critical characteristics (CSIs and CAIs)
    - Supplier risk, issue, and opportunity, and mitigation management processes for quality (e.g., technical, schedule, material, facility, scale-up, financial impacts, etc.)
    - Make/buy processes for supplier quality performance and impacts
    - Qualification, approval, and removal processes for suppliers, monitoring and tracking of supplier performance, and periodic re-assessment
    - Utilization of processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
    - Verification of supplier's processes and procedures to control quality, including suppliers performing key and/or critical manufacturing processes and changes to those processes
    - Process control plans for variability reduction
    - Statistical control of process capabilities (i.e., C_{pk}s)
    - Production process verification
    - Predictive indicators to provide early detection of potential quality problems
    - Subsystem, item, and component First Article Inspections (FAIs) and First Article Tests (FATs)
    - Continuous manufacturing surveillance and effective metrics to monitor, evaluate, verify, improve processes, and prevent defects
- Collect and analyze supply chain quality data from the production representative environment for subsystems, items, and components and utilize analyses results to develop recommended improvement plans.
- Ensure control plans are in place for management of KCs.
- Ensure development of test and inspection plans underway for EMD prototypes.

Metrics

- Contractor's supplier management system for subsystems, items, and components has been assessed and results document QMS processes and procedures compliance with industry best practices (e.g., AS9100, ISO 9000, AS9134 Supply Chain Management Guidelines, etc.) to include elements such as:
    - Management responsibility requirements
    - Quality management system requirements
    - Resource management requirements

  - Product Realization requirements (e.g., risk management, design, and development, purchasing, etc.)
  - Risks, issues, and opportunities
  - Measurement, analysis, and improvement requirements

- Contractor's supply chain management system has been assessed and the results document compliance with industry best manufacturing practices (i.e., AS6500, AS9134 Supply Chain Management Guidelines, etc.) including:
  - Effective prime and subcontractor communications and interactions including:
    - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
    - Design and engineering changes traceability and compliance
    - Quality data exchange, analysis, storage, and traceability processes
    - The joint Risk, Issue, and Opportunity Management System
    - Responses, status, and reports for cost, schedule, and performance actuals
    - Corrective and preventative actions and program feedback
  - Management of KCs and critical characteristics (CSIs and CAIs)
  - Risk, issue, and opportunity, and mitigation management processes for quality (e.g., technical, schedule, material, facility, scale-up, financial impacts, etc.)
  - Make/buy processes that include supplier quality performance
  - Supplier management and monitoring that includes qualification, approval, performance, and removal processes with periodic re-assessment
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
  - Suppliers processes and procedures for control of quality, key and/or critical manufacturing processes, and changes
  - Process control plans for variability reduction
  - Statistical control of process capabilities (i.e., C_{pk}s)
  - Production process verification
  - Use of predictive indicators to provide early detection of potential quality problems
  - FAIs and FATs for subsystems, items, and components
  - Manufacturing surveillance and effective metrics to monitor, evaluate, verify, continuously improve processes, and prevent defects

- Quality data from the supply chain for production representative subsystems, items, and components has been collected and analyzed and recommended improvement plans have been developed and documented.
- Control plans for management of KCs have been completed and are in place and are being tracked by the contractor.
- Test and Inspection plans have been developed and documented for EMD prototypes.

Tools

- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Supplier QA Questionnaire

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6081, Fraudulent/Counterfeit Electronic Parts: Avoidance Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9134, Supply Chain Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Risk, Issue, and Opportunity Guide
- Manufacturing Readiness Level (MRL) Deskbook

I.4 Support Critical Design Review

M&Q personnel should be actively engaged in the organization and execution of the CDR during this phase. The CDR occurs roughly mid-point in the EMD phase. The CDR brings to closure design paths in detailed design. Any changes moving forward should only be accomplished through a formal Engineering Change Proposal (ECP). The completion of the CDR should provide:

- An established system initial product baseline,
- An updated risk assessment for EMD,
- An updated CARD based on the system product baseline,
- An updated development schedule for fabrication, test and evaluation, software coding, critical path drivers, and
- An approved Life Cycle Sustainment Plan.

Manufacturing and Quality Tasks

- Ensure Quality Strategy and Plan, including initial product baseline documentation for quality, is sufficient, complete, and adequate to enable inspections and testing of components, hardware, and embedded software in support of the CDR.
    - Ensure all KCs, CSIs, and CAIs have completed drawings and specifications with tolerances and test points under configuration control
    - Ensure all product data essential for component quality has been released
- Provide quality inputs on program, contractor, and supply chain implementation status of industry best practices (e.g., ISO 9000, AS9100, and other standards on quality management and quality management systems) in support of the CDR.
- Ensure all quality design trade studies and assessments are completed and incorporated into the design for CDR.
    - Ensure quality enhancement efforts ongoing for optimized integrated system (e.g., Design for Inspection and Testability, Design for Six Sigma, etc.)
- Ensure all subsystem, item, and component CDRs are complete and the results impacting quality available for the system CDR.
    - Analyze the results of design maturity assessments (*See* E.6) including all appropriate reviews (e.g., All CDRs, PPRs, PCAs, FCAs, etc.) for closure or approval of quality related risks, issues, and opportunities
- Ensure quality inputs to the schedule (IMP/IMS) are up-to-date and are executable with acceptable risks.
- Ensure quality plans, activities, and processes are executable within the existing quality budget to support the approved initial product baseline and critical path.
- Ensure all key and critical manufacturing processes process control plans, have been analyzed, updated, and approved for the capability to meet design tolerances.
- Analyze contractor quality plans for materials, facilities, equipment, test facilities and equipment, and tooling to support the pilot line requirements.
- Analyze the contractor FRACAS for adequacy to meet needs based on the Quality Plan.
- Analyze quality plans for adequacy and capability of achieving MRL 8 by initial production.
- Analyze results of contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality management, ESOH, etc.) for quality risks, issues, and opportunities and appropriate mitigation plans.
- Analyze the assessments of adequacy and completeness of quality requirements validation activities (*see* E.6), which included prototypes and demonstrations in a representative environment at the system, subsystem, item, and component levels for design maturity.
    - Include demonstrations of quality processes in a representative environment
    - Include demonstrations of quality processes for KCs, CSIs, and CAIs

- Provide quality inputs to the Life Cycle Sustainment Plan for CDR.
- Ensure contractor quality management systems for M&Q metrics and data collection and tracking to the component level are in place and functional.
- Ensure the TEMP incorporates all subsystems, items, and components into plans for tests, test facilities, and test equipment.
- Ensure the quality considerations and aspects of contractor's plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - PPP
    - SEMP
    - TEMP
- Analyze and update subsystem, item, and component quantity estimates based on program system requirements, component yield and rate data, and results from prototype demonstrations.
- Ensure quality design improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (*See* E.4).
- Provide up-to-date cost of quality inputs to the program budget and the CARD.
    - Update and allocate quality (production) cost models to subsystem, item, and component levels, and track against targets
- Ensure adequacy and completeness of mitigation activities for mitigation of quality risks, issues, and opportunities in the joint Government/ contractor Risk, Issue, and Opportunity Management System, including quality risks to:
    - Key and critical manufacturing processes including embedding software
    - Materials and sourcing
    - Supply chain including multiple sources
    - Production rates and yields
    - Facilities
    - Special tooling development
    - Tests and demonstrations
    - Security
    - System safety and hazardous materials management
    - Economic feasibility
    - Schedule (i.e., IMP/IMS)
    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment

Metrics

- Quality Strategy and Plan, including initial product quality baseline, has been documented for CDR as sufficient, complete, and adequate to enable inspections and testing of components, hardware, and embedded software.
    - All KCs, CSIs, and CAIs have completed drawings and specifications with tolerances and test points under configuration control
    - All product data essential for component quality has been released
- Quality inputs on program, contractor, and supply chain implementation status of industry best practices (e.g., ISO 9000, AS9100, and other standards on quality management and quality management systems) has been documented and provided for CDR.
- All quality design trade studies and assessments have been completed and the results have been documented into the design for CDR.
    - Continuous quality enhancement efforts are in place and monitored
- All subsystem, item, and component CDRs are complete and all results impacting system quality are documented and available for CDR.
    - Documented results from all design maturity reviews with closures and/or acceptances of quality related risks, issues, and opportunities are included
- Quality inputs to the schedule (IMP/IMS) are documented up-to-date and executable with acceptable risks.
- Quality plans, activities, and processes have been analyzed and are executable within the existing quality budget and the results support the approved initial product baseline and critical path.
- All key and critical manufacturing processes process control plans, have been analyzed, updated, and approval documented for the capability to meet design tolerances for CDR
- Contractor quality plans have been analyzed for materials, facilities, equipment, test facilities and equipment, and tooling and document the capability to support the pilot line.
- Contractor FRACAS has been analyzed for adequacy and documented to meet needs based on the program Quality Plan.
- Contractor and Government Quality Plans have been analyzed and the results document the adequacy and capability to achieve MRL 8 by initial production.
- Contractor and key supply chain assessments (e.g., sourcing, materials, subsystems, items, components, lead-times, quality management, ESOH, etc.) have been conducted and the results analyzed, and document required mitigation plans for quality risks, issues, and opportunities.

- Adequacy and completeness of quality requirements validation activities (*See* E.6) which included prototypes and demonstrations in a representative environment at the system, subsystem, item, and component levels have been analyzed and assessed for design maturity and results provided for CDR.
    - Demonstrations included quality processes in a representative environment
    - Demonstrations included quality processes for KCs, CSIs, and CAIs
- Quality inputs to the Life Cycle Sustainment Plan have been developed and documented for CDR.
- Contractor quality management systems for M&Q metrics and data collection and tracking to the component level have been assessed for adequacy, are documented as in place and functional.
- Tests, test facilities, and test equipment for all subsystems, items, and components have been documented in the TEMP for CDR.
- Contractor's quality plans and inputs are up-to-date and approved for CDR, including:
    - Parts and Materials (Management) Plan (PMP)
    - Configuration Management Plan (CMP)
    - Software Development Plan (embedded software)
    - Quality Assurance Plan
    - PPP
    - SEMP
    - TEMP
- Subsystem, item, and component quantity estimates have been analyzed and updated based on program system requirements, component yield and rate data, and prototype demonstrations and provided as input for CDR.
- Quality design improvements have been implemented in the system design and/or specifications according to the joint government/contractor schedule (*See* E.4).
- Up-to-date cost of quality inputs have been documented and provided for the program budget and for the CARD.
- Updated and allocated quality cost models to subsystem, item, and component levels have been included, and track against targets
- Adequacy and completeness of quality risk mitigation activities have been assessed and documented in the joint Government/ contractor Risk, Issue, and Opportunity (RIO) 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 hazardous materials management
- Economic feasibility
- Schedule (i.e., IMP/IMS)
- Manufacturing capability obsolescence
- Manufacturing capability sustainment

Tools

- Critical Design Review Checklist
- Interactive MRL Users Guide (Checklist) for the Quality thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- Defense Acquisition Guidebook (DAG) Chapter 3-3.3.5 Critical Design Review
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook

I.5 System and Program Configuration Audits

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

formal engineering change action and under the control of configuration management practices. M&Q managers should support the validation of the design during the CDR and PCA.

Manufacturing and Quality Tasks

- Ensure M&Q personnel participate in and support program, contractor, and supply chain system audits to be performed in accordance with the process focused requirements in AS9101 for (but not limited to):
    - Risk, Issue, and Opportunity System
    - Supply chain management system
    - Development test operations and evaluations
    - Quality Management System
    - Development (hardware and software)
    - Production control
    - Security (physical and cyber)
    - ESOH
    - Hazardous and/or special materials
    - Human Machine Interface
    - EVM system
    - Transportation, handling, and storage
    - Workforce management
    - Facilities
    - Documentation and data management
- Ensure M&Q personnel participation in, inputs to, and support of the FCA to include:
    - Support to program and the contractor agreements that development is complete and data from development tests (DTs), analyses, and simulations are sufficient to achieve performance goals
    - Provide quality input to:
        - Verification of performance to the baseline
        - The verification traceability documentation for each M&Q requirement
        - The validity and the completeness of embedded software and associated documentation
    - Verify all approved engineering change proposals (ECP), requests for deviation, and requests for waiver impacting M&Q have been incorporated into the M&Q Plans
    - Verification that all KCs, CSIs, and CAIs are identified, managed, and included in the Verification Cross-Reference Matrix (VCRM)
    - Ensure quality provides support to verification activities and tasks to include:
        - Ensuring each requirement listed in the VCRM is traceable and has been verified with test data, analysis, and/or inspection

    - Ensuring demonstration M&Q processes to provide the capability to satisfy TPMs, KPPs and KSAs thresholds
    - Review of acceptance test reports and deficiencies with root cause and closed corrective actions

- Ensure M&Q participates in the Configuration Control Boards (CCBs) to ensure changes are in accordance with program direction, program Quality Strategy, and are consistent with industry quality standards and best practices, supplier instructions, processes, and procedures, etc.
- Participate in and support the System Verification Review (SVR) including:
    - Provide verification that all M&Q CDR action items have been closed and any corrective actions have been successfully completed
    - Provide quality inputs on:
        - Verification of requirements from all system, subsystem, item, and component quality test data and analyses
        - Verification of performance to the function baseline based on quality data
        - Verification through analysis of quality data the adequate management and integrity of all critical program information (CPI) (e.g., performance data, yield, and rate data, etc.)
        - Verification that quality risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
        - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available quality test data, analysis, and inspection
        - Required certification activities
        - Support and maintenance analyses for incorporation into the LCSP
        - Risks of operational test failures during IOT&E
    - Provide quality inputs to:
        - Ensure adequate quality processes and quality metrics are in place
        - Analysis of contractor' s SEMP for appropriate incorporation of quality activities and data collection, analysis, and storage
        - Detailed planning and schedules with required resources for proceeding into LRIP and IOT&E
        - Updates of the SEP and contractor's SEMP for the production and deployment (P&D) phase
        - The CARD for up-to-date cost of quality inputs
        - The LCSP
        - The TEMP (i.e., up to date)
        - The Configuration Management Plan (CMP) (i.e., up to date)

Metrics

- M&Q personnel have participated in and supported program, contractor, and supply chain system audits (IAW AS9101) that document meeting the process focused requirements for (but not limited to):
  - Risk, Issue, and Opportunity System
  - Supply chain management system
  - Development test operations and evaluations
  - Quality Management System
  - Development (hardware and software)
  - Production control
  - Security (physical and cyber)
  - ESOH
  - Hazardous and/or special materials
  - Human Machine Interface
  - EVM system
  - Transportation, handling, and storage
  - Workforce management
  - Facilities
  - Documentation and data management
- M&Q personnel have supported and participated in, and provided inputs to the FCA to include:
  - Documented support to program and the contractor agreements that development is complete and data from development tests (DTs), analyses, and simulations are sufficient to achieve performance goals
  - Documented quality inputs to:
    - Verification of performance to the baseline
    - The verification traceability documentation for each M&Q requirement
    - The validity and the completeness of embedded software and associated documentation
  - Verification that all approved ECPs, requests for deviation, and requests for waiver impacting M&Q have been documented in the M&Q Plans
  - Verification that all KCs, CSIs, and CAIs have been identified, managed, and documented, and are included in the Verification Cross-Reference Matrix (VCRM)
  - Documented input to verification activities and tasks which included:
    - Each requirement's (listed in the VCRM) traceability and verification with test data, analysis, and/or inspection
    - Demonstrations of M&Q processes for meeting TPMs, KPPs and KSAs thresholds

        - Review of acceptance test reports and deficiencies with root cause and closed corrective actions

- M&Q personnel continue to support and participate in CCBs to ensure quality changes are in accordance with program direction, program Quality Strategy, and are consistent with industry quality standards and best practices, supplier instructions, processes, and procedures, etc.
- M&Q personnel have participated in and provided documented inputs to the SVR including:
    - Verification that all M&Q CDR action items have been closed and any corrective actions have been successfully completed
    - Quality inputs on:
        - Verification of requirements from all system, subsystem, item, and component quality test data and analyses
        - Verification of performance to the function baseline based on quality data
        - Verification through analysis of quality data the adequate management and integrity of all CPI (e.g., performance data, yield, and rate data, etc.)
        - Verification that quality risks are included in the Risk, Issue, and Opportunity Management process and mitigation plans
        - Demonstration of system capability to meet all TPMs, KPPs, and KSAs (thresholds) based on all available quality test data, analysis, and inspection
        - Required certification activities status
        - Support and maintenance analyses results for incorporation into the LCSP
        - Risks of operational test failures during IOT&E
    - Quality inputs that ensure adequate quality processes and quality metrics are in place
    - Results of analyses of contractor' s SEMP for appropriate incorporation of quality activities and data collection, analysis, and storage
    - Quality inputs to detailed planning and schedules with required resources for proceeding into LRIP and IOT&E
    - Updates of the SEP and contractor's SEMP for the production and deployment (P&D) phase
    - Updates to the:
        - CARD for the cost of quality
        - LCSP
        - TEMP
        - CMP
        - SEP

Tools

- Functional Configuration Audit Checklist

- Interactive MRL Users Guide (Checklist) for the Quality thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- AS9101, Quality Management Systems – Audit Requirements for Aviation, Space, and Defense Organizations
- Defense Acquisition Guidebook (DAG), System Verification Review/System Configuration Audit
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook

I.6 Assess Pilot Line

Typically, the Pilot Line begins around the time the CDR has been completed. The Pilot Line should reflect the proposed production line and include all materials, manpower, tooling, test equipment, and facilities that will be on the production line. STE/SIE should be validated as part of pilot line validation in accordance with validation plans. M&Q processes and procedures should be proven on a pilot line and are under control and ready for low-rate production. Known producibility risks and issues should pose no significant challenges for low-rate production. Cost model and yield and rate analyses should have been updated with pilot line results. Supplier qualification testing and first article inspections should have been completed. The industrial base has been assessed for Milestone C and shows industrial capability is established to support LRIP.

Manufacturing and Quality Tasks

- Assess contractor and supply chain pilot lines and demonstrations for quality verification and validation efforts including:
  - Quality processes and procedures including continuous improvement efforts

  - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)
  - Quality and process controls in place (e.g., plans, audits, process capabilities (C_{pk}s), SPC, FRACAS, etc.)
  - Adequacy and completeness of acceptance and qualification testing for LRIP
  - All quality instructions, sequencing, in-process tests, and test procedures (including those in work instructions)
  - Quality scheduling and control
  - Quality model and simulations
  - Quality workforce capabilities
  - Implementations of quality technologies
  - Tooling, work holding fixtures, jigs, etc. for inspection and test
  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment (STE/SIE) validation in accordance with plans)
  - Quality processes for transportation, storage, and handling equipment
  - Potential requirements for additional quality tools, equipment, and software
  - Safety of quality processes and procedures
  - Quality of ESOH processes and procedures
  - Quality of security processes, procedures, capabilities, and compliance
  - Impacts from direct and indirect infrastructure
  - Mitigation results of quality and adequacy of risks and issues resolutions
  - Quality costs (and impacts to schedule and performance)
  - Quality of materials' sources and selections
  - Quality of embedded software (integration)

- Analyze quality processes performed during the pilot lines operations, (including simulations) to include:
  - Rate of quality processes (actual time to complete) vs. planned
  - Quality data actuals vs. estimated
  - Quality process yield actuals vs. planned
  - Changes in processes (actual vs. planned)
  - Cost of quality actuals vs. desired
- Assess process control plans, including all plans for process control of key and critical processes, for adequacy and completeness on the pilot line.
- Assess all work instructions for required quality outputs (e.g., data, in-process inspections and tests, process capability indices, etc.) based on build-to documentation and information gathered during the pilot line.
  - Verify updated work instructions, processes, drawings, etc.
  - Include KCs and their control plans

- Assess quality outputs from the pilot line and demonstrations for adequacy and completeness and validate:
  - All Production Process Verifications (PPVs) performed
  - Implementation of manufacturing technology solutions (including ManTech)
  - Attainability of KCs (will be capable and under process control for LRIP)
  - Data collected for the Variability Reduction program
    - Data should demonstrate progress to metrics
    - Include updates based on process improvements
  - All FAIs and FATs against specifications, drawings, models, etc.
  - Continuous improvement plans.
    - Include assessment of quality targets (gaps)
- 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.

Metrics

- Quality assessments of contractor and supply chain pilot lines and demonstrations have been conducted and the results document verification and validation of the following for the program Quality Strategy and Plans and the PRR:
  - Quality processes and procedures including continuous improvement efforts
  - Quality surveillance and quality data collection and analyses (including supply chain data)
  - Quality and process controls in place
  - Adequacy and completeness of acceptance and qualification testing for LRIP
  - All quality instructions, sequencing, in-process tests, and test procedures
  - 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 STE/SIE)
  - 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 (impacts to schedule and performance)
  - Quality of materials' sources and selections
  - Quality of embedded software (integration)

- Pilot line quality process results, including simulations, have been analyzed and used for recommended updates to plans and targets including:
  - Rate of quality processes (actual time to complete)
  - Quality data targets
  - Process yields
  - Process changes
  - Cost of quality
- Assessments of pilot line process control plans, including all plans for process control of key and critical processes, for adequacy and completeness have been conducted and results used to recommend updates to plans, process capability indices (C_{pk}s), SPC processes, FRACAS processes, and other metrics, etc.
- All work instructions have been assessed for required quality outputs incorporating all up-to-date build-to documentation and information gathered during the pilot line and recommended changes documented and provided to Configuration Management.
  - Include KCs and their control plans
- Quality outputs from the pilot line and demonstrations have been assessed for adequacy and completeness and document validation of:
  - All PPVs
  - 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)
- A Letter of Delegation or Memorandum of Agreement has been approved and provided to DCMA for support to, witness of, and assessment of demonstrations, pilot line operations, FAIs and/or FATs, etc.

Tools

- AS9100 Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread

- ISO 9001 QMS Audit Checklist
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
  - AS9145, Requirements for Advanced Product Quality Planning and Production Part Approval Process
- DoD Risk, Issue, and Opportunity Management Guide
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896A Manufacturing Management Program Guide

I.7 Finalize Quality Strategy and Plan for LRIP

M&Q managers in planning for LRIP should support the development and updates to the Acquisition Strategy by providing their inputs into the SEP. Quality managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and ultimately to the success of a program.

Manufacturing and Quality Tasks

- Verify and validate the quality processes capability for LRIP (including simulations) based on analyses of quality processes performed for the pilot line, and update the Quality Strategy and Plan accordingly to include:
  - Rate of quality processes (actual time to complete) vs. planned
  - Quality data actuals vs. estimated
  - Quality process yield actuals vs. planned
  - Changes in processes
  - Cost of quality actuals vs. desired

  - Potential requirements for additional equipment
  - Continuous improvement process and requirements

- Ensure process control plans, including all plans for process control for key and critical processes, are updated from pilot line and in place for LRIP.
- Verify Quality Strategy and Plan are updated based on all build-to documentation from the pilot line, including KCs and critical characteristics and their control plans for LRIP.
  - Include updates based on process capability data collected for those processes affecting KCs and critical characteristics
  - Include process stability data for key and critical processes and provide estimates for those with insufficient data
- Adjust Quality Strategy and Plan based on validated data collected for the Variability Reduction program
  - Data should indicate progress to metrics
  - Include updates based on process improvements
- Update Quality Strategy and Plan to include all First Article Inspections and First Article Tests (completed with plans in place to correct findings).
- Ensure that the Quality Strategy and Plan for LRIP requires:
  - Includes Letter of Delegations for DCMA support at the appropriate levels of the supply chain
  - Adequate acceptance and qualification testing
  - Continuous collection and periodic review of quality data to identify areas for improvement (i.e., Continuous Process Improvement (CPI)).
  - Supplier risk and issue mitigation planning complete and being implemented
  - Periodic supplier process control verification and validation
  - Periodic assessment of Variability Reduction processes
  - Implementation of Six Sigma, lean manufacturing processes, etc.
- Update the Program Quality Strategy and Plan (i.e., AS6500) based on contractor's M&Q system verification and validation efforts, including pilot line and demonstrations, and direct and indirect infrastructure, including:
  - Quality processes including continuous improvement efforts
  - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)
  - All quality instructions, sequencing, in-process tests, and procedures (including those in work instructions)
  - Process capabilities (C_{pk}s) and process control plans
  - Quality scheduling and control
  - Quality model and simulations

  - Quality workforce capabilities
  - Implementations of quality technologies
  - Tooling, work holding fixtures, jigs, etc. for inspection and test
  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment validation in accordance with plans)
  - Quality processes for transportation, storage, and handling equipment
  - Safety of quality processes and procedures
  - Quality of ESOH processes and procedures
  - Quality of security processes, procedures, capabilities, and compliance
  - Mitigation results of quality and adequacy of risks and issues resolutions
  - Quality costs (and impacts to schedule and performance)
  - Quality of materials' sources and selections
  - Quality of embedded software (integration)

- Develop recommendations for sourcing and options for LRIP based on quality analyses of program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages
- Ensure contractor's quality plans, policies, and procedures are consistent with program plans for program Plans for Product Improvement for LRIP.
- Update all quality risks, issues, and mitigation plans for LRIP based on pilot line operations, demonstrations, and simulations.
- Ensure mitigations of current risks and issues are on track and/or do not introduce new risks and issues to the program for LRIP.
- Finalize the TDP including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details based on the results of the Pilot Line build.

Metrics

- Pilot line quality processes have been analyzed and the results document verification and validation of LRIP quality processes capability. Quality Strategy and Plan has been updated accordingly including:
  - Rate of quality processes (actual time to complete) vs. planned
  - Quality data actuals vs. estimated
  - Quality process yield actuals vs. planned
  - Changes in processes

  - Cost of quality actuals vs. desired
  - Potential requirements for additional equipment
  - Continuous improvement process and requirements

- Assessments of process control plans, including all plans for process control of key and critical processes, for adequacy and completeness have been conducted and results used to recommend updates to LRIP plans, process capability indices (C_{pk}s), SPC processes, FRACAS processes, and other metrics, etc.
- LRIP Quality Strategy and Plan have been updated based on all build-to documentation from the pilot line, to include all KCs and their control plans for LRIP:
    - Process capability updates
    - Process stability estimates (if data insufficient)
- The Quality Strategy and Plan has been updated based on validated data collected for the Variability Reduction program
    - Data depicts progress to metrics
    - Updates include process improvements
    - Updates include results of all FAIs and FATs
    - Plans in place to correct findings
- The LRIP Quality Strategy and Plan documents and includes:
  - Letters of Delegation for DCMA support at the appropriate levels of the supply chain
  - Requirements for acceptance and qualification testing
  - Quality surveillance and quality data collection and analyses (including supply chain data for items and components)
  - Quality processes including CPI with continuous quality data collection and periodic reviews
  - Mitigation results of quality and adequacy of risks and issues resolutions
    - Up-to-date supplier risk and issue mitigation plans and actions
  - Periodic supplier process control verification and validation
  - Periodic assessment of Variability Reduction processes
  - Implementation of Six Sigma, lean manufacturing processes, etc.
  - All quality instructions, sequencing, in-process tests, and procedures (including those in work instructions)
  - Process capabilities (C_{pk}s) and process control plans
  - Quality scheduling and control
  - Quality model and simulations
  - Quality workforce capabilities
  - Implementations of quality technologies
  - Tooling, work holding fixtures, jigs, etc. for inspection and test

  - Test equipment and test facilities (including Special Test Equipment/Special Inspection Equipment validation in accordance with plans)
  - Quality processes for transportation, storage, and handling equipment
  - Safety of quality processes and procedures
  - Quality of ESOH processes and procedures
  - Quality of security processes, procedures, capabilities, and compliance
  - Quality costs (and impacts to schedule and performance)
  - Quality of materials' sources and selections
  - Quality of embedded software (integration)

- Recommendations for sourcing and options for LRIP have been developed and documented based on quality analyses of program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages
- Contractor's quality plans, policies, and procedures have been assessed and recommendations and changes have been documented to maintain consistency with program P^3I plans for LRIP.
- All updated quality risks, issues, and mitigation plans have been documented and provided for the joint program/contractor RIO Management System for LRIP.
  - Mitigations of current risks and issues are assessed to be on track and do not introduce new risks and issues to the program for LRIP
- The final quality input to the TDP has been provided, including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details based on the Pilot Line Build.

Tools

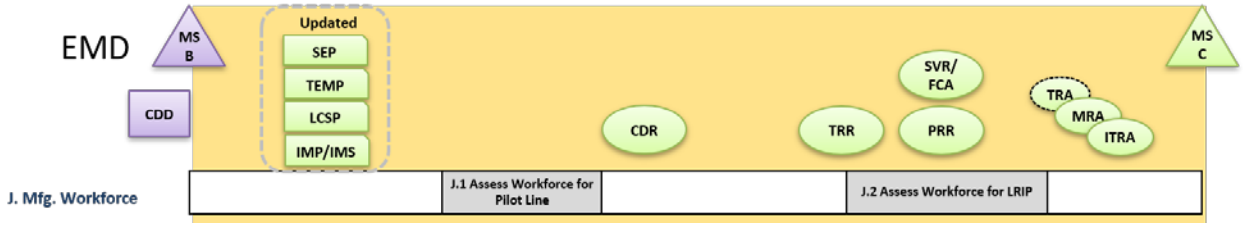
- Acquisition Strategy Template
- AS9100, Audit Checklist
- Interactive MRL Users Guide (Checklist), Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan

Resources

- AFMC Instruction 63-145 Manufacturing and Quality

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9134, Supply Chain Management Guidelines
  - AS9136, Root Cause Analysis and Problem Solving
  - AS9138, Statistical Process Acceptance
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- FAR 52.246-11, Quality
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896A, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DAG, Quality Plans

J. MANUFACTURING WORKFORCE



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

A comprehensive assessment of contractor manufacturing plans for system development is necessary to understand the requirements for workforce skills, capabilities, training, and certifications. In support of pilot line workforce requirements, contractor plans should be assessed for human resource policies, processes, and procedures, forecasts for the number of workers, skills, and capabilities, etc. Additionally, the current training, certifications, and education, sourcing availability and stability, demographics of the contractor and supply chain should be evaluated for adequacy, as well as their

capability and capacity to expand the workforce, through hiring, training, and certification, for pilot line and LRIP.

Based on contractor execution of the pilot line and the M&Q workforce results, update the program workforce plans contained in the M&Q Strategies for required skills, capabilities, training, and certifications for LRIP in the P&D phase.

J.1 Assess Workforce for Pilot Line

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on a regular and on-going basis. Two major focus areas are:

- Workforce Skills availability
- Workforce Skills capability

A 2018 Deloitte research report "2018 and The Manufacturing Institute Skills Gap and Future of Work Study" reveals that *"the skills gap may leave an estimated 2.4 million positions unfilled between 2018 and 2028, with a potential economic impact of 2.5 trillion."* Part of the problem is the aging of the manufacturing workforce, and part of the problem is that many young people are no longer interested in manufacturing jobs. This is due in part to the elimination of shop classes from most high schools and thus many students are not exposed to it. Manpower skills availability and capability should have been assessed to ensure that there is enough capability to meet the demands of the Pilot Line.

Manufacturing and Quality Tasks

- Assess the contractor's M&Q Plans for manufacturing, quality, and supporting pilot line workforce requirements for adequacy and capacity to meet program requirements and schedule including:
    - Human resource policies, processes, and procedures to include forecasting and scheduling
    - Number of workers by category by schedule
    - Skillsets and capabilities by category by schedule
    - Current level and forecasting for training, certifications, and education
    - Capacity and capability to train, certify, etc.
    - Labor regulations, relations, union agreements, etc.
    - Labor Sourcing – internal and external
    - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
    - Demographics (e.g., citizenship, retirement eligibility, etc.)
    - Security

- Assess contractor's facility and personnel statistics (e.g., turnover, accidents, ESOH violations, etc.) and M&Q Plans for M&Q workforce risks, issues, and opportunities for the Pilot Line.

Metrics

- Contractor's M&Q Plans has been assessed and documents the adequacy and capacity of manufacturing, quality, and supporting pilot line workforce to meet program requirements and schedule, and/or recommended changes, including:
  - Human resource policies, processes, and procedures to include forecasting and scheduling
  - Number of workers by category by schedule
  - Skillsets and capabilities by category by schedule
  - Current level and forecasting for training, certifications, and education
  - Capacity and capability to train, certify, etc.
  - Labor regulations, relations, union agreements, etc.
  - Labor Sourcing – internal and external
  - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
  - Demographics (e.g., citizenship, retirement eligibility, etc.)
  - Security
- Contractor's facility and personnel statistics and M&Q Plans have been assessed for M&Q workforce risks, issues, and opportunities with results and recommendations documented for the joint Risk, Issue, and Opportunity Management Plan.

Tools

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

- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Systems
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896A, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

J.2 Assess Workforce for LRIP

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on a regular and on-going basis. Two major focus areas are:

- Workforce Skills availability
- Workforce Skills capability

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

Manufacturing and Quality Tasks

- Based on pilot line results, assess the updated contractor's M&Q Plans for manufacturing, quality, and supporting LRIP and/or FRP workforce scale-up requirements for adequacy and capacity to meet program requirements and schedule including updates to the following:
    - Human resource policies, processes, and procedures to include forecasting and scheduling
    - Number of workers by category by schedule
    - Skillsets and capabilities by category by schedule
    - Current level and forecasting for training, certifications, and education
    - Capacity and capability to train, certify, etc.
    - Labor regulations, relations, union agreements, etc.
    - Sourcing – internal and external
    - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
    - Demographics (e.g., citizenship, retirement eligibility, etc.)
    - Security

- Update contractor's facility and personnel statistics (e.g., turnover, accidents, ESOH violations, etc.) for M&Q workforce risks, issues, and opportunities for LRIP and/or FRP.

Metrics

- Based on pilot line results, the updated contractor's M&Q Plans for manufacturing, quality, and supporting LRIP and FRP scaled-up workforce has been assessed and documents the adequacy and capacity to meet program requirements and schedule, and/or recommended updates to the following:
    - Human resource policies, processes, and procedures to include forecasting and scheduling
    - Number of workers by category by schedule
    - Skillsets and capabilities by category by schedule
    - Current level and forecasting for training, certifications, and education
    - Capacity and capability to train, certify, etc.
    - Labor regulations, relations, union agreements, etc.
    - Sourcing – internal and external
    - Labor availability and stability (e.g., local unemployment, competition for skills, turnover, etc.)
    - Demographics (e.g., citizenship, retirement eligibility, etc.)
    - Security
- Contractor's updated facility and personnel statistics and M&Q Plans have been assessed for M&Q workforce risks, issues, and opportunities with results and recommendations documented for the joint Risk, Issue, and Opportunity Management Plan.

Tools

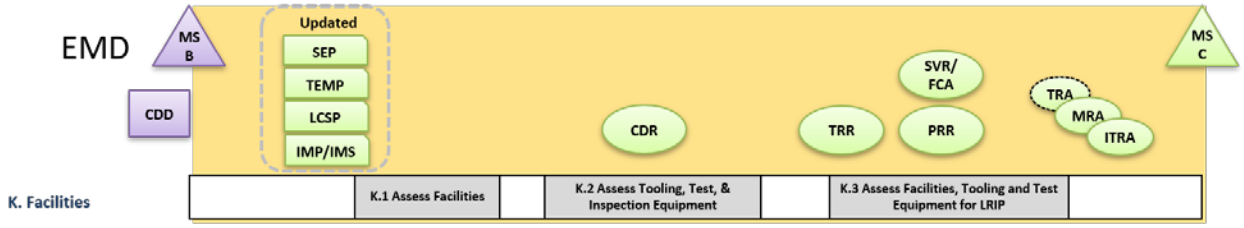
- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Interactive MRL Users Guide (Checklist), Workforce thread
- Learning Curve Calculator (Estimator)
- Line of Balance Template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

- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Systems
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896A Manufacturing Management Program Guide

K. MRL DESKBOOK FACILITIES



Based upon the results of PDR and program progress during early EMD, M&Q personnel should assess the contractor and supply chain facility and tooling plans developed for the pilot line and LRIP. This should include pre-CDR assessments of proposed production (e.g., pilot line, LRIP, FRP, etc.) facilities, and an update to the M&Q Strategies and Plans for EMD and future phases.

Based on the system design and results of assessments of existing assets, new facilities, tools, and equipment may be required to meet rates and schedules. Additionally, depending on final CDR design, new materials, new technologies, new processes, and new tooling and equipment may be required. The program and the contractor(s) need to address the assessment results, current and known future facility workload (i.e., other programs), and any new requirements, and plan accordingly for the capability and capacity to develop, produce, maintain, and support the program throughout the supply chain.

The assessments conducted for EMD should include subcontractors and key suppliers identified in the contractor's Manufacturing Management Plan, which should include tooling and facilities plans with utilization, and any relocation/consolidation considerations, schedules, and requirements for manufacturing maturity. These assessments should be conducted on-site and can be included as part of the MRL assessment. These should include all "special test equipment" and "special tooling" as defined in FAR 2.101 in assessments conducted.

The results of these assessments should identify, and document risks, issues, and opportunities arising from facility and tooling shortfalls and document the required planning for mitigation. Prior to CDR and pilot line, the program Tooling Plan for facilities, tooling, equipment, and test equipment (part of the M&Q Strategies and Plans) should be finalized along with the associated risk and issue mitigation

actions. Final validation of M&Q plans must be accomplished prior to CDR, prior to execution of a pilot line.

Facilities, tooling, equipment, and test equipment requirements, resource requirements, and schedules should be re-assessed based on results of pilot line demonstrations and assessments for LRIP and FRP. Using the actual data collected from pilot line assess equipment capability, capacity, and availability for scale-up. Additionally, assess M&Q operations and environmental requirements, floor space utilization and expansion requirements, facility data requirements, and equipment maintenance requirements for LRIP and FRP. Focused attention on facilities, tooling, equipment, and test equipment in EMD will decrease risk and can be a major factor in avoiding or preventing cost overruns and schedule delays for LRIP and FRP.

K.1 Assess Facilities

Manufacturing facilities assessment includes an analysis if the capabilities and capacity of the key production facilities to include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur. This assessment is looking at the capabilities and capacity for the Pilot Line and preparations for ramping up production during LRIP.

Manufacturing and Quality Tasks

- Identify facility and resource requirements by phase and schedule (e.g., pilot line, LRIP, and FRP) to include the following:
    - Current facility availability, capacity (including surge), capitalization plan, and expansion potential
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and scale-up
    - Floor space requirements (including feeding, storage, transportation, re-work, work-in-process, etc.) and expansion
    - Manufacturing facility data requirements (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
    - Maintenance requirements (facilities and spares)
- Assess contractor’s Manufacturing, Quality, and supply chain Plans for proposed facilities and required resources for meeting pilot line and LRIP requirements to include:
    - Current and future facility availability and capacity
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.)
    - Floor space requirements (including feeding, storage, transportation, re-work, work-in-process, etc.) and planned expansion
    - Maintenance requirements (facilities and spares)

Metrics

- Facility requirements have been assessed by phase and schedule (e.g., pilot line, LRIP, and FRP) and documents the following for CDR:
    - Current facility availability, capacity (including surge), capitalization plan, and expansion potential
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and scale-up
    - Floor space requirements (including feeding, storage, transportation, re-work, work-in-process, etc.) and expansion
    - Manufacturing facility data capability and capacity (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
    - Maintenance requirements (facilities and spares)
- Contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and resources for pilot line and LRIP have been assessed and the results and recommendations documented for CDR including:
    - Current and future facility availability and capacity
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.)
    - Current floor space (including feeding, storage, transportation, re-work, work-in-process, etc.) and required expansion
    - Maintenance requirements (facilities and spares)

Tools

- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist), Facilities thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Systems
- DCMA-INST-204 Manufacturing and Production
- DoDI 5000.02, Operation of the Defense Acquisition System
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896A Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- Risk, Issue, and Opportunity Management Guide

K.2 Assess Tooling, Test, and Inspection Equipment

Manufacturing tooling, test and inspection equipment assessment includes an analysis if the capabilities and capacity of production tooling, special test equipment, special inspection equipment to include those at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur. This assessment is looking at the capabilities and capacity for the Pilot Line and preparations for LRIP.

Manufacturing and Quality Tasks

- Develop M&Q equipment, tooling, test, and inspection equipment maintenance strategy:
  - Include processes and procedures in accordance with industry best practices (i.e., AS9100)
  - Include objectives and requirements for tooling, testing, funding, resources, and scheduling
- Update the TMRR Tooling Plan for EMD to include:
  - Tooling and Special Test Equipment/Special Inspections Equipment requirements for development (i.e., pilot line ramp up to LRIP, ramp up to FRP)
    - Limited quantity or soft tooling
    - Rate quantity or hard tooling
    - Necessary only for development (pilot)
    - Necessary only for production (LRIP/FRP)
    - Necessary for Operations and Sustainment support
    - Available government assets (GFE)
  - Tooling used for the development or production of supplies or parts or to the performance of functions for the program to include:
    - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
    - Requirements for identification, calibration, frequency, and traceability to international or national measurement standards
    - Requirements for collection, monitoring, and maintenance of data and a register for validation purposes
    - Requirements for safeguarding from adjustments, damage, or deterioration
  - Use and application of single or multipurpose integrated specialized test equipment (STE/SIE) (e.g., engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items, assemblies of equipment including inter-connected or interdependent, foundations and similar improvements, etc.)
  - Use and application of GFE, COTS, etc.
  - Tooling and STE/SIE test and validation plans (including demonstrations)

- Ensure that production tooling and test equipment design and development efforts are underway.
- Perform a M&Q assessment of the contractor's and supply chain tooling, test, and inspection equipment resources provided for:
  - Suitability for the specific type of monitoring and measurement activities required
  - Maintenance and accountability to required standards with appropriate documentation
- Assess contractor and supply chain demonstrations of tooling and STE/SIE for subsystems, item, and components in the appropriate production environment (e.g., representative, pilot line, production line) for functionality, sufficiency, and capacity.

Metrics

- M&Q personnel have developed an equipment, tooling, test, and inspection equipment maintenance strategy to be implemented in the Tooling Plan for the Pilot Line, to include:
  - Processes, procedures, and demonstrations that implement industry best practices (i.e., AS9100)
  - Policy, objectives, goals, and desired outcomes for tooling, testing, funding, resourcing, and scheduling
- The TMRR Tooling Plan has been updated for the Pilot Line and documented in the M&Q Plans to include:
  - Detailed requirements for tooling and STE/SIE for pilot line ramp up to LRIP and LRIP ramp to FRP (e.g., soft, hard, development, production, O&S, GFE, etc.)
  - Detailed requirements for:
    - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
    - Identification, calibration, frequency, and traceability to international or national measurement standards
    - Collection, monitoring, and maintenance of data and a register for validation purposes
    - Safeguarding from adjustments, damage, or deterioration
    - single or multipurpose integrated STE/SIE
    - Use and application of COTS, etc.
    - Test and validation plans (including demonstrations)
- Production tooling and test equipment design and development efforts have been approved and are underway.
- Contractor's and supply chain tooling, test, and inspection equipment resources have been assessed for adequacy and completeness and results document during the CDR and other assessments for:

  - Suitability for the specific type of monitoring and measurement activities required
  - Maintenance and accountability to required standards with appropriate documentation maintained as evidence of fitness for purpose
- Contractor and supply chain demonstrations of tooling and STE/SIE for subsystems, item, and components in the appropriate production environment (e.g., representative, pilot line, production line) have been assessed for functionality, sufficiency, and capacity and document completion of validation plans.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist) for the Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Material Requirements Planning
- Plant Design and Facility Layout Software Evaluation Tools
- Rough Cut Capacity Planning Spreadsheet

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DCMA-INST-204 Manufacturing and Production
- DoDI 5000.88, Engineering of Defense Systems
- FAR Part 2, §2.101 Definitions
- ISO 9000, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896A Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

K.3 Assess Facilities, Tooling, and Test Equipment for LRIP

Manufacturing facilities and tooling assessment includes an analysis if the capabilities and capacity of the key production facilities, special tooling, special test, and special inspection equipment to include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur. This assessment is looking at the capabilities and capacity in preparation for LRIP and the ramp up in production.

Manufacturing and Quality Tasks

- Based on pilot line demonstrations and assessments, assess facilities, facilities resource requirements, and facilities schedules for LRIP and FRP to include the following:
    - Current facilities availability, capacity (including surge), and expansion requirements
    - Facilities capitalization plan
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and scale-up
    - Manufacturing operations and environmental requirements (e.g., noise, lighting, vibrations, temperature, humidity, cleanliness, dust, foreign object detection (FOD), etc.)
    - Floor space utilization (including processes and requirements for feeding, storage, transportation, re-work, work-in-process, etc.) and expansion requirements
    - Manufacturing facility data requirements (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
    - Manufacturing equipment maintenance requirements (facilities, spares, and frequency)
- Assess contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and required facilities resources for LRIP and FRP to include:
    - Current and future facility availability and capacity
    - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and requirements for additional resources
    - Environmental and manufacturing operations (regulatory and program) requirements (e.g., noise levels, lighting levels, vibration and isolation, temperature and humidity control, cleanliness requirements, FOD and preventions requirements, etc.)
    - Floor space utilization (including processes and requirements for feeding, storage, transportation, re-work, work-in-process, etc.) and expansion requirements
    - Maintenance requirements (facilities and spares)
- Support assessments of manufacturing workplace safety for compliance with applicable statutes, regulations, and policies.
- Assess results of M&Q equipment, tooling, test and inspection equipment maintenance strategy demonstration and adequacy on the pilot line for:
    - Processes and procedures implementation according to industry best practices (i.e., AS9100)
    - Tooling, testing, resources, and scheduling meeting requirements
- In accordance with validation plans, validate tooling and STE/SIE based pilot line demonstrations and results.
- Based on pilot line demonstrations and results, update the program Tooling Plan for LRIP to include:

  - Tooling and STE/SIE requirements for ramp up to LRIP and FRP (e.g., soft, hard, development, production, O&S, GFE, etc.)
  - Updated detailed requirements for:
    - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
    - Identification, calibration, frequency, and traceability to international or national measurement standards
    - Collection, monitoring, and maintenance of data and a register for validation purposes
    - Safeguarding from adjustments, damage, or deterioration (physical security)
    - Digital safeguarding from tampering (cyber security) (i.e., Additive Manufacturing (AM) software and firmware)
    - Tooling and STE/SIE test, validation maintenance, and re-validation plans
  - Use and application of single or multipurpose integrated STE/SIE
  - Use and application of GFE, COTS, etc.
- Ensure that LRIP tooling, inspection, and test equipment efforts are complete, and FRP tooling and test equipment efforts are underway.
- Update the M&Q assessment of the contractor's and supply chain tooling, test, and inspection equipment LRIP resources based on pilot line demonstrations and results for:
  - Suitability for the specific type of monitoring and measurement activities required
  - Maintenance and accountability to required standards with appropriate documentation
- Update the assessment of contractor and supply chain tooling and STE/SIE for subsystems, item, and components in the appropriate production environment (e.g., production line for LRIP or FRP) for functionality, sufficiency, and capacity based on pilot line demonstrations and results.

Metrics

- Facilities, facilities resource requirements, and facilities schedules have been assessed with recommended changes and updates implemented. Based on pilot line demonstrations and implementation of changes, manufacturing facilities have been assessed as adequate for LRIP with plans are in place for transition to FRP including:
  - Current facilities availability and capacity (including surge) with expansion requirements
  - Facilities capitalization plan
  - Equipment capability, capacity, and availability (machines, processes, storage, etc.) with scale-up
  - Manufacturing operations and environmental conditions (e.g., power, noise, lighting, vibrations, temperature, humidity, cleanliness, FOD, dust, etc.)

  - Floor space utilization (including processes and requirements for feeding, storage, transportation, re-work, work-in-process, etc.) with expansion requirements
  - Manufacturing facility data capability and capacity (e.g., infrastructure, handling, communications, processing, storage, security, etc.)
  - Manufacturing equipment maintenance (facilities, spares, and frequency)

- Contractor's Manufacturing, Quality, and supply chain Plans for proposed facilities and required facilities resources have been assessed for adequacy and completeness for LRIP and FRP and recommended changes and updates have been documented for:
  - LRIP and future FRP facility availability and capacity
  - Equipment capability, capacity, and availability (machines, processes, storage, etc.) and requirements for additional and/or future resources
  - Environmental and manufacturing operations (regulatory and program) requirements (e.g., noise levels, lighting levels, vibration and isolation, temperature and humidity control, cleanliness requirements, FOD and preventions requirements, etc.)
  - Floor space utilization (including processes and requirements feeding, storage, transportation, re-work, work-in-process, etc.) and expansion requirements
  - Maintenance requirements (facilities and spares)
- Workplace safety has been assessed, with M&Q support, for compliance with applicable statutes, regulations, and policies and required changes have been documented and implemented.
- Equipment, tooling, test, and inspection equipment maintenance strategy has been demonstrated on the pilot line and results assessed as adequate and/or recommendations and changes documented in the M&Q Plans for:
  - Implementation of processes and procedures according to industry best practices (i.e., AS9100)
  - Meeting requirements for tooling, testing, resources, and scheduling
- Tooling and STE/SIE has been validated in accordance with validation plans and results and/or recommended changes have been documented in the Quality Plan and implemented based pilot line demonstrations and results.
- Tooling Plan for LRIP has been assessed and updated based on pilot line demonstrations and results including:
  - Tooling and STE/SIE requirements for ramp up to LRIP and FRP (e.g., soft, hard, development, production, O&S, GFE, etc.)
  - Updated detailed requirements for:
    - Jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items (including foundations and similar improvements)
    - Identification, calibration, frequency, and traceability to international or national measurement standards

        - Collection, monitoring, and maintenance of data and a register for validation purposes
        - Safeguarding from adjustments, damage, or deterioration (physical security)
        - Digital safeguarding from tampering (cyber security) (i.e., Additive Manufacturing (AM) software and firmware)
        - Tooling and STE/SIE test, validation maintenance, and re-validation plans
    - Use and application of single or multipurpose integrated STE/SIE (e.g., engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items, assemblies of equipment including inter-connected or interdependent, foundations and similar improvements, etc.)
    - Use and application of GFE, COTS, etc.
- LRIP tooling, inspection, and test equipment efforts, proven on a pilot line, have been assessed, are complete and/or additional requirement identified for LRIP
    - FRP tooling and test equipment efforts are underway, and documented up to date in the Tooling Plan, the IMP/IMS, and the TEMP.
- Contractor's and supply chain tooling, test, and inspection equipment LRIP resources have been assessed and recommended changes and updates have been documented based pilot line demonstrations and results, for:
    - Capability to perform the specific type of monitoring and measurement activities required by the program
    - Meeting required standards for maintenance and accountability with appropriate documentation
- The assessment of contractor and supply chain tooling and STE/SIE has been updated for all subsystems, items, and components with results of demonstrations for functionality, sufficiency, and capacity in the appropriate production environments. Recommendations for changes and additional updates have been documented.
    - Incomplete or insufficient demonstrations of capability are documented for independent assessment according to statute

Tools

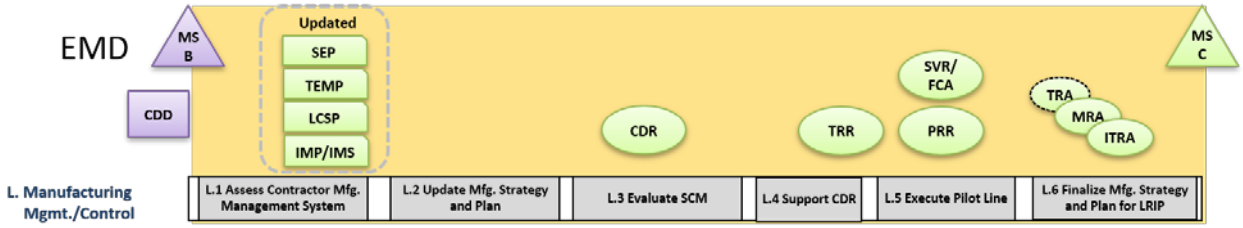
- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist) for the Facilities thread
- Manufacturing Maturation Plan

- Manufacturing Resource Planning (MRPII)
- Material Requirements Planning
- Plant Design and Facility Layout Software Evaluation Tools
- Rough Cut Capacity Planning Spreadsheet

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DCMA-INST-204 Manufacturing and Production
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- FAR Part 2, §2.101 Definitions
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896A, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Public Law 114-328

L. MANUFACTURING MANAGEMENT/CONTROL



The Manufacturing Strategy and Plan are major aspects of development, test, initial production, and other activities essential for program success. With the potential for a new contractor or contractors responsible for engineering and manufacturing development through completion of pilot line production, updated M&Q strategies will be required. This begins with an assessment of the contractor(s), and their supply chain(s), manufacturing plans for adequacy and alignment with the program Acquisition Strategy (AS).

Manufacturing is a complex combination of resources consisting of facilities, materials, machines, manpower, methods, measurement systems, and capital that are used in converting or transforming raw materials and component parts into end products. The contractor must have an effective combination of people and systems to plan for, monitor, and control these manufacturing resources, as well as a well-structured manufacturing management system. This requires effective implementation of industry best practices. Assessment of the contractor's manufacturing management system (and

quality management system) should be performed against the recognized industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.).

Many acquisition programs experience difficulties in smoothly transitioning from development to production and fielding supportable systems. Assessments of the contractor's manufacturing strategy and planning should ensure adequacy and sufficiency of their manufacturing planning and capability to perform the final design and manufacturing work scope to achieve production. These should include processes, procedures, and work instructions encompassing the supply chain and supply chain communications, KCs control and management, management, control, and monitoring of KPPs, KSAs, CSIs, and CAIs, process control plans, control or avoidance of obsolescent items, high-risk sources, counterfeit parts and materials, etc. Additionally, the government requires implementation of cyber threat protection measures and manufacturing control systems which include safeguarding M&Q information, designed in systems protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper (AT), and security-related activities such as physical security and industrial security. Implementing all these protections and controls is the basis for maintaining the currency of the program Manufacturing Strategy and Plans.

For CDR, initial product baseline documentation for manufacturing, included in the Manufacturing Strategy and Plans, should be sufficient, complete, and adequate to enable manufacture of all components and hardware with embedded software throughout the supply chain on a pilot line.

At CDR manufacturing capability and capacity of the contractor and supply chain are assessed for the system design for each subsystem, item, and component in the system's initial product baseline. This assessment should include all key and critical manufacturing processes, and their process control plans, for definition, characterization, and currency to the detailed design, and the capability to meet requirements. Additionally, the assessments should include contractor plans for meeting schedule, rates, yields, long-lead procurement requirements, demonstration requirements, safety and security, test, etc. on a pilot line. This means a detailed review of contractor production plans for ramping up to LRIP and then to FRP.

The government and contractor-designated pilot lines should be assessed for production realism and affordability in production of the system, subsystem, items, and components. Verification and validation of contractor and supply chain manufacturing plans, processes, and procedures should be analyzed during the demonstrations. Additionally, process control plans, work instructions, facilities, tooling, manufacturing data output, etc. should be included. Based upon these assessments and demonstrations, the Manufacturing Strategy and Plan should be updated, and the TDP should be finalized for LRIP

L.1 Assess Contractor Manufacturing Management System

A Manufacturing Management System (MMS) is used to implement manufacturing management practices aimed at promoting timely development, production, modification, fielding, and sustainment

of affordable products by addressing manufacturing throughout the programs live cycle. The industry best practice for manufacturing management is AS6500 Manufacturing Management Program. Even if not called out on contract, the requirements of AS6500 are worth reviewing while assessing a contractors manufacturing management program.

Manufacturing and Quality Tasks

- Assess the contractor's Manufacturing Management Strategy and Plan for:
    - Incorporation of industry and government M&Q best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
    - Compliance with policy directives and regulations
    - The Risk, Issue, and Opportunity Management plans
    - Development and incorporation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
    - Development and incorporation of system required technologies (and constraints)
    - Requirements and schedules for manufacturing development projects
    - Design feasibility, methodology, and producibility initiatives
    - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
    - Management of key and critical characteristics
    - Configuration management and control
    - Costs and schedule requirements, including IMP/IMS with critical path
    - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues
    - Management of the supply chain
    - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
    - Processes and process capability control requirements
    - Workforce needs, capabilities, training, certifications, availability, etc.
    - Facilities, Tooling, and Test Equipment (including GFE and assets) requirements
    - Acceptance testing
    - Environmental, security, and safety requirements
- Assess and audit (where necessary) the contractor's Manufacturing Management System (MMS) capability to perform the final design and manufacturing work scope in accordance with industry best practices (e.g., AS6500, AS9100, ISO 9000, etc.) and program policies, objectives, and goals including:
    - Effective implementation and integration of the QMS processes throughout the MMS and supply chain to include (*See* I.1):
        - Organization direction, values, policies, and procedures
        - Management commitment, resources, communications, feedback, and accountability

- Effectiveness of program and contractor communication and interaction processes to include:
  - Cost, schedule, and performance requirements and timely notification of changes
  - Manufacturing data management processes (to include responses, status, and reports for cost, schedule, and performance actuals)
  - Integration of risk, issue, and opportunity management processes
  - Failures, corrective, and preventative actions, communication processes
  - Specification and production of prototypes
- Design analyses for manufacturing to include:
  - Producibility and manufacturing feasibility
  - Failure mode analyses
  - KCs
- Risk, issue, and opportunity management processes (to include quality, technical, schedule, material, facility, scale-up, financial impacts, and audits if necessary, etc.)
- Processes, procedures, and work instructions for the following:
  - KC control, management, and inclusion in the TDP
  - Management, control, and monitoring of Key Performance Parameters (KPPs), Key System Attributes (KSAs), and KCs, CSIs, and CAIs
  - Process control plans including statistical process controls, rates, yields, and management of process capabilities (C_{pk}s)
  - Make/buy (to include performance and impacts)
  - Control or avoidance of items and components that could become obsolete or are from a diminishing or fragile manufacturing source
  - Control or avoidance of sources that are sole, single, foreign, or vulnerable to interruption, interference, or compromise
  - Prevention and/or detection of counterfeit parts and materials (*See* AS5553 and AS6174)
  - Continuous process improvement (CPI)
  - Effective metrics management to include monitoring, evaluating, and verifying
  - Conduct of Process Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
  - Support of the FRACAS and the associated corrective actions (i.e., manufacturing process changes)
- Supply chain management system that tracks and reports supplier performance and supplier quality assessment processes
- A system for manufacturing verification that verifies the proposed production processes, tooling, and test equipment meet program requirements (including Special Tooling and Special Test Equipment)

  - Systematic manufacturing self-assessments and supply chain assessments to measure progress in manufacturing maturation and risk and issue reduction
  - MRL assessments throughout the supply chain and independent assessments as required by statute.
  - Manufacturing management processes including roles and responsibilities for:
    - Materials management and control, including availability and lead-times
    - Data storage, management, and security (physical and cyber)
    - Safety, environmental, transportation, storage, etc.
    - COTS items, GOTS items, and NDIs
    - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Production Process Verifications (PPVs) that verify manufacturing processes, tooling, and equipment are statistically capable of producing required parts and assemblies
  - Variability Reduction (VR) plan for incorporation of mature processes and techniques
  - Manufacturing software and firmware management processes and integration (including the program Software Development Plan (SDP), and Software Configuration Management Plan (SCMP)
  - Manufacturing processes for inclusion of in-process and acceptance tests encompassing:
    - Prototypes, first articles, hardware, software, and firmware
    - First Article Inspections (FAIs)/First Article Tests (FATs)
    - Test procedures including test equipment
    - Quality plans including control plans and quality improvement plans (included in the TEMP)

- Assess the contractor's MMS processes for the management, execution, and maintenance of the IMP/IMS.
  - Include MMS impacts on critical path, schedule, costs, and outcomes
- Assess the contractor's MMS for capability to support a Life-Cycle Sustainment Plan (if required) which includes planning for production, developmental and operational test, deployment, and life-cycle sustainment.
- Verify the contract and the subcontractor management plan includes right of access for both the contractor and the Government to supplier facilities and documentation, where applicable.
- Request DCMA support and assistance to assess in conducting assessments and audits of contractor and supply chain MMSs.

Metrics

- The contractor's Manufacturing Management Strategy and Plan have been assessed and the results document the inclusion of the following for use in updating appropriate program documentation (*See* L.2):
  - Incorporation of industry and government M&Q best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
  - Compliance with policy directives and regulations
  - The Risk, Issue, and Opportunity Management plans
  - Development and incorporation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
  - Development and incorporation of system required technologies (and constraints)
  - Requirements and schedules for manufacturing development projects
  - Design feasibility, methodology, and producibility initiatives
  - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
  - Management of key and critical characteristics
  - Configuration management and control
  - Costs and schedule requirements, including IMP/IMS with critical path
  - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues
  - Management of the supply chain
  - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Processes and process capability control requirements
  - Workforce needs, capabilities, training, certifications, availability, etc.
  - Facilities, Tooling, and Test Equipment (including GFE and assets) requirements
  - Acceptance testing
  - Environmental, security, and safety requirements
- Contractor's Manufacturing Management System (MMS) has been assessed for the capability to perform the final design and manufacturing work in accordance with industry best practices and program policies, objectives, and goals; the assessment results are documented in program Manufacturing Strategy, Plans, and other program processes and procedures, and include the following:
  - Documented implementation and integration of the QMS processes throughout the MMS and supply chain to include (*See* I.1):
    - Organization direction, values, policies, and procedures
    - Management commitment, resources, communications, feedback, and accountability
  - Verified implementation of effective program and contractor communication and interaction processes to include:

- Cost, schedule, and performance requirements and timely notification of changes
- Manufacturing data management processes (to include responses, status, and reports for cost, schedule, and performance actuals)
- Integration of risk, issue, and opportunity management processes
- Failures, corrective, and preventative actions, communication processes
- Specification and production of prototypes

- Documented design analyses for manufacturing including analyses for:
  - Producibility and manufacturing feasibility
  - Failure modes
  - KCs and associated manufacturing processes
- Documented risk, issue, and opportunity management and mitigation processes (to include quality, technical, schedule, material, facility, scale-up, financial impacts, and audits if necessary, etc.)
- Documented and implemented processes, procedures, and work instructions for:
  - KC control, management, and inclusion in the TDP
  - Management, control, and monitoring of KPPs, KSAs, and KCs, CSIs, and CAIs
  - Process control plans including statistical process controls, rates, yields, and management of process capabilities (C_{pk}s)
  - Make/buy (to include performance and impacts)
  - Control or avoidance of items and components that could become obsolete or are from a diminishing or fragile manufacturing source
  - Control or avoidance of sources that are sole, single, foreign, or vulnerable to interruption, interference, or compromise
  - Prevention and/or detection of counterfeit parts and materials (*See* AS5553 and AS6174)
  - Continuous process improvement (CPI)
  - Effective metrics management to include monitoring, evaluating, and verifying
  - Conduct of Process Failure Modes Effects Analysis (PFMEA) on critical manufacturing processes
  - Support of the FRACAS and the associated corrective actions (i.e., manufacturing process changes)
- A functional supply chain management system that tracks and reports supplier performance and supplier quality assessment processes
- A system for manufacturing verification that is in place and documents proposed production processes, tooling, and test equipment that meet program requirements (including Special Tooling and Special Test Equipment)
- Documented systematic process for manufacturing self-assessments and supply chain assessments to measure progress in manufacturing maturation and risk and issue reduction

  - Documented process for performing MRL assessments throughout the supply chain and independent assessments as required by statute.
  - Documented manufacturing management processes including roles and responsibilities for:
    - Materials management and control, including availability and lead-times
    - Data storage, management, and security (physical and cyber)
    - Safety, environmental, transportation, storage, etc.
    - COTS items, GOTS items, and NDIs
    - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Documented systematic application of PPVs ongoing to verify manufacturing processes, tooling, and equipment are statistically capable of producing required parts and assemblies
  - Documented VR plan for application of mature processes and techniques
  - Documented management processes for manufacturing software and firmware, and integration (including the program SDP, and SCMP)
  - Documented manufacturing processes for in-process and acceptance tests that encompass:
    - Prototypes, first articles, hardware, software, and firmware
    - FAIs and FATs
    - Test procedures (including test equipment)
    - Quality plans including control plans and quality improvement plans (in the TEMP)
- Contractor's MMS processes for the management, execution, and maintenance of the IMP and IMS have assessed and approved.
  - MMS impacts on critical path, schedule, costs, and outcomes have been included
- Contractor's MMS has been assessed and the results document the capability to support a Life-Cycle Sustainment Plan.
- Contract and the subcontractor management plan have been verified to include the right of access for both the contractor and the Government to supplier facilities and documentation, when necessary.
- DCMA support and assistance in conducting assessments and audits of contractor and supply chain MMSs has requested through a Letter of Delegation or Memorandum of Agreement.

Tools

- AS6500 Manufacturing Management Assessment
- Interactive MRL Users Guide (Checklist), Manufacturing Management thread
- Manufacturing Maturation Plan
- Material Management and Accounting System Audit

Resources

- AS5553, Counterfeit Electronic Parts
- AS6174, Counterfeit Material
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DFAR 242.72 Contractor Material Management and Accounting System
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- IEEE 15288, Technical Reviews and Audits on Defense Programs
- Manufacturing Maturation Plan
- MIL-HDBK-896A, Manufacturing Management Program Guide
- Public Law 114-328

L.2 Update Manufacturing Strategy and Plan

A manufacturing strategy is developed as part of the program acquisition strategy and often includes considerations such as competition. Manufacturing voids, deficiencies, and dependencies on critical foreign source materials should be addressed. The producibility of each system design concept should be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and industrial base goals and thresholds.

Manufacturing planning is about understanding everything it takes to produce all the items required by the contract, on time, on budget, and with the right performance features. It includes considerations of all the 5Ms, at the prime contractor and throughout the supply chain.

Manufacturing and Quality Tasks

- Update the manufacturing inputs to the program Manufacturing Strategy and Plan (government) for EMD based on the results of assessment of the contractor's Manufacturing Strategy and Plans and to include:
    - Implementation of industry and government M&Q best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
    - Requirements for compliance with policy directives and regulations
    - Requirements for the EMD AS and RFP
    - Government IB risk and issue mitigation plans (complementary to contractor plans)
    - The joint Risk, Issue, and Opportunity Management plans
    - Implementation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
    - Implementation of system required technologies (and constraints)
    - Requirements and schedules for implementing ManTech projects

  - Requirements for IP management and control, and impacts to the TDP
  - Results of producibility initiatives
  - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
  - Management of key and critical characteristics
  - Costs, schedule, budgets, and affordability requirements, including IMP/IMS with critical path
  - Updates to requirements for program management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
  - Updates to requirements for and approach to program management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
    - Including DCMA and DLA support and data
  - Updates for schedule contingencies, variances, and risks
  - Updates to program plans and methodologies for prototypes, competitive or dual sources, co-production, etc.
  - Updates to program requirements for process capability control
  - Additional program workforce requirements for program personnel capabilities, SMEs, training, certifications, availability, etc.
  - Updates to program GFE and assets requirements for facilities, tooling, and test equipment
  - Manufacturing updates for the program Manufacturing Plan and Schedule (IMP/IMS) for integration of independent or Service testing (DoD)
  - Updates to manufacturing requirements for environmental, security, and safety
- Provide updated manufacturing inputs based on results of assessments of the contractor's MMS and plans for security to:
  - Program Manufacturing Strategy and Plan for industrial security and anti-tamper including risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Program security (physical, digital, and cyber) strategies, plans, processes, and procedures (e.g., SSE, COMSEC, and PPP)
- Update manufacturing inputs to manufacturing requirements in the Life-Cycle Sustainment Plan for the program and updates the program Manufacturing Strategy accordingly based on results of assessments and audits.
- Provide manufacturing updates for the program Manufacturing Strategy and AS to include appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, etc.) for support and inputs based on results of assessments of the contractor's MMS and plans.

- Provide updates to manufacturing inputs for the program Configuration Management Plan based on results of assessments.
- Provide manufacturing recommendations for required contract modifications or updates to ensure alignment of contractor with program Manufacturing Management Strategy and Plans (*See* I.1 and L.1) based on results of assessments of the contractor's Manufacturing Management Plan (MMS) and program/technical plans.
- Provide manufacturing updates for the program Manufacturing Strategy to address status or completion of all mitigation measures for all gaps, risks, and issues (*See* E.6) based on monitoring of post-PDR M&Q mitigation measures.

Metrics

- Updated manufacturing inputs to the Program Manufacturing Strategy and Plan (government) for EMD have been documented and provided based on the results of assessments of the contractor's Manufacturing Strategy and Plans including:
    - Implementation of industry and government M&Q best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896A, etc.)
    - Requirements for compliance with policy directives and regulations
    - Requirements for the EMD Acquisition Strategy and RFP
    - Plans for Government IB risk and issue mitigation (complementary to contractor plans)
    - Plans for the joint Risk, Issue, and Opportunity Management System
    - Implementation of enabling manufacturing technologies (e.g., advanced simulations, additive technologies, etc.)
    - Implementation of system required technologies (and constraints)
    - Requirements and schedules for implementing ManTech projects
    - Requirements for IP management and control, and impacts to the TDP
    - Results of producibility initiatives
    - Planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
    - Management of key and critical characteristics
    - Costs, schedule, budgets, and affordability requirements, including IMP/IMS with critical path
    - Requirements for program management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
    - Requirements for and approach to program management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
        - Including DCMA and DLA support and data
    - Schedule contingencies, variances, and risks
    - Program plans and methodologies for prototypes, competitive or dual sources, co-production, etc.

  - Program requirements for process capability control
  - Additional program workforce requirements for program personnel capabilities, SMEs, training, certifications, availability, etc.
  - Program GFE and assets requirements for facilities, tooling, and test equipment
  - Manufacturing updates for the Program Manufacturing Plan and schedule (IMP/IMS) for integration of independent or Service testing (DoD)
  - Requirements for manufacturing environmental, security, and safety
- Updated manufacturing inputs have been provided from documented results of assessments of the contractor's MMS and plans for security including updates to:
  - Program Manufacturing Strategy and Plan for industrial security and anti-tamper including risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Program security (physical, digital, and cyber) strategies, plans, processes, and procedures (e.g., SSE, COMSEC, and PPP)
- Updated manufacturing inputs have been provided from documented results of assessments and audits for manufacturing requirements in the Life-Cycle Sustainment Plan for the program and update the Program Manufacturing Strategy accordingly.
- Up-to-date manufacturing inputs have been provided for and documented in the Program Configuration Management Plan.
- Manufacturing recommendations for required contract modifications or updates have been documented and provided to Program management to ensure alignment of contractor with Program Manufacturing Management Strategy and Plans (*See* I.1 and L.1).
- Monitoring of post-PDR M&Q mitigation measures is ongoing and has provided documented manufacturing updates for the Program Manufacturing Strategy that address status of all mitigation measures (*See* E.6).
- Manufacturing updates have been documented and provided for the Program Manufacturing Strategy and AS to include appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, etc.) for support and input.

Tools

- Acquisition Strategy Template
- Interactive MRL Users Guide (Checklist), Manufacturing Management thread
- Manufacturing Maturation Plan

Resources

- Acquisition Plan Preparation Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.02, Cybersecurity
- DoDI 5000.02, Operation of the Defense Acquisition System
- DSMC Acquisition Strategy Guide
- IEEE 15288, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896A, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- Service-specific policies and regulations (i.e., AFI 63-145)

L.3 Evaluate Program/System supply chain Management

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then Supply Chain Management and the implementation of a Manufacturing Management System (MMS) throughout the supply chain becomes a pivotal task. Often program problems originate in the supply chain, but do not manifest themselves until the component is integrated into the system. Program offices and contractors often have efforts to identify and manage problems at the first tier, but do not do well below that level. M&Q managers need to routinely review and assess contractors MMS activities and efforts at the prime contractor level and below.

Manufacturing Tasks

- Ensure that the contractor supply chain management system for subsystems, items, and components requires MMS processes and procedures are in alignment with industry best practices (i.e., AS6500) to include elements such as:
    - Manufacturing Management System
    - Design Analysis for Manufacturing including producibility analyses, KCs, and Failure Mode Effects Analyses (DFMEA and PFMEA)
    - Manufacturing Risk Identification including manufacturing feasibility and MRL assessments, and Production Readiness Reviews
    - Manufacturing Planning including:
        - Supply chain and material management
        - Manufacturing technology development
        - Manufacturing cost
        - Modeling and simulations
        - Manufacturing system verification
        - Manufacturing workforce

    - Tooling, test equipment and facilities
  - Manufacturing Operations Management including:
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - PPVs
    - FAIs and FATs
    - Sub-tier supplier management
    - Sub-tier supplier quality
- Assess the contractor's supply chain management system capabilities for performance of manufacturing processes and procedures including:
  - Subcontractor audit process with an emphasis on critical manufacturing processes
  - Effectiveness of contractor, supplier, and sub-tier communications and interactions including:
    - Flow down of cost, schedule, and performance requirements to sub-tier suppliers and timely notification of changes
    - Design and engineering changes traceability and compliance
    - Manufacturing data exchange, analysis, storage, and traceability processes
    - The joint Risk, Issue, and Opportunity Management System
    - Responses, status, and reports for cost, schedule, and performance actuals
    - Corrective and preventative actions and feedback
  - Management of KCs and critical characteristics (CSIs and CAIs)
  - Supplier and sub-tier risk, issue, and opportunity mitigation management processes for manufacturing (e.g., schedule, material, facility, scale-up, financial impacts, etc.)
  - Make/buy processes for supplier and sub-tier manufacturing capability, capacity, performance, and impacts
  - Qualification, approval, re-qualification, and removal processes for suppliers, monitoring and tracking of supplier performance, and periodic re-assessment
  - Supplier and sub-tier manufacturing assistance and mentoring program
  - Utilization of processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
  - Verification of suppliers and sub-tier manufacturing processes and procedures, especially suppliers performing key and/or critical manufacturing processes
  - Manufacturing process control plans
  - Appropriate application of statistical control techniques for manufacturing

  - Predictive processes and systems to provide early detection of manufacturing issues (e.g., tooling wear indicators, tracking, predictive and preventative maintenance, etc.)
  - Continuous manufacturing surveillance and effective metrics
- Collect and analyze supply chain manufacturing data from the subsystems, items, and component production to:
  - Develop and recommend manufacturing process improvements
  - Meet planned rates and schedules (includes processes, surges, tooling, make/buy, etc.)
- Assess the supply chain for manufacturing security processes, plans, and procedures including:
  - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
- Assess the supply chain for implementation and compliance with Program manufacturing processes and requirements for:
  - Configuration Management
  - ESOH
  - Environmental, safety, hazardous materials, waste handling, etc.
  - Testing, qualifications, and certifications (e.g., TEMP, etc.)
  - The LCSP
  - Facilities and tooling (GFE/GFP)
- Request DCMA perform Government surveillance of supplier and sub-tier compliance to manufacturing management program contract requirements.

Metrics

- Contractor's supply chain (for subsystems, items, and components) MMS processes and procedures have been assessed for implementation of industry best practices, with documented recommendations for changes if necessary, for the following elements (*See* AS6500):
  - Manufacturing Management System
  - Design Analysis for Manufacturing
    - Producibility analyses
    - KCs
    - Failure Mode Effects Analyses (DFMEA and PFMEA)
  - Manufacturing Risk Identification
    - Manufacturing feasibility assessments
    - MRL assessments

        - Production Readiness Reviews
    - Manufacturing Planning including supply chain:
        - Materials management
        - Manufacturing technology development
        - Manufacturing cost
        - Modeling and simulations
        - Manufacturing system verification
        - Manufacturing workforce
        - Tooling, test equipment and facilities
    - Manufacturing Operations Management including:
        - Production Scheduling and Control
        - Manufacturing Surveillance
        - Continuous Improvement
        - Process Control Plans
        - Process Capabilities
        - PPVs
        - FAIs and FATs
        - Sub-tier supplier management
        - Sub-tier supplier quality
- Contractor's supply chain management system has been assessed for specific capabilities in performance of manufacturing processes and procedures and documented for adequacy, completeness, and sufficiency including:
    - Communications effectiveness for contractor, supplier, and sub-tier interactions including:
        - Flow down of cost, schedule, and performance requirements to sub-tier suppliers and timely notification of changes
        - Design and engineering changes traceability and compliance
        - Manufacturing data exchange, analysis, storage, and traceability processes
        - The joint Risk, Issue, and Opportunity Management System
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions and feedback
    - Management of KCs and critical characteristics (CSIs and CAIs)
    - Mitigation management processes for supplier and sub-tier risks, issues, and opportunities for manufacturing (e.g., schedule, material, facility, scale-up, financial impacts, etc.)
    - Make/buy processes for supplier and sub-tier manufacturing capability, capacity, performance, and impacts

  - Processes for qualification, approval, re-qualification, and removal of suppliers, monitoring and tracking of supplier performance, and periodic re-assessment
  - Supplier and sub-tier manufacturing assistance and mentoring program
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials (i.e., adherence to AS5553, AS6174, and AS9100)
  - Processes and procedures for verification of suppliers and sub-tier manufacturing, especially suppliers performing key and/or critical manufacturing processes
  - Manufacturing process control plans
  - Application of statistical control techniques for manufacturing
  - Predictive processes and systems to provide early detection of manufacturing issues (e.g., tooling wear indicators, tracking, predictive and preventative maintenance, etc.)
  - Continuous manufacturing surveillance and effectiveness of metrics
- Supply chain manufacturing data has been collected from the subsystems, items, and component production and has been assessed with recommendations provided for:
  - Manufacturing process improvements
  - Meeting and/or improving planned rates and schedules
- Supply chain has been assessed for manufacturing security processes, plans, and procedures and results document compliance with Program requirements including:
  - Industrial security and anti-tamper for risks, issues, processes, industrial control systems, resources, organization, and metrics
  - Physical, digital, and cyber security (associated with SSE, COMSEC, and PPP)
- Supply chain has been assessed for implementation of Program manufacturing processes and document compliance with Program requirements and/or recommendations for updates for:
  - Configuration Management
  - ESOH
  - Environmental, safety, hazardous materials, waste handling, etc.
  - Testing, qualifications, and certifications (e.g., TEMP, etc.)
  - The LCSP
  - Facilities and tooling (GFE/GFP)
- DCMA Letter of Delegation or Memorandums of Agreement have been sent for performance of Government surveillance of supplier and sub-tier compliance to manufacturing management program contract requirements.

Tools

- Interactive MRL Users Guide (Checklist), Manufacturing Management thread
- Manufacturing Maturation Plan
- Supply Chain Assessment

Resources

- AS5553, Counterfeit Electronic Parts
- AS6174, Counterfeit Material
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.228-7001, Ground and Flight Risk
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DoD Supply Chain Management Guide
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management Systems
- MIL-STD-882
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82 Guide to Industrial Control Systems Security

L.4 Execute Pilot Line

A Pilot line is an environment that incorporates all of the key production realism elements (equipment, personnel skill levels, facilities, materials, components, work instructions, processes, tooling, temperature, cleanliness, lighting etc.) required to manufacture production configuration items, subsystems or systems that meet design requirements in low-rate production. To the maximum extent practical, the pilot line should utilize FRP processes. The Pilot Line is where the demonstration of manufacturing maturity should take place.

Manufacturing and Quality Tasks

- Assess the contractor-designated pilot lines for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:
    - Manufacturing readiness for manufacture of equipment
    - Materials, components, and tooling availability,
    - Adequacy of workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
    - Capability to meet design requirements for LRIP

  - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
  - Capability and capacity to meet rate production (ramp-up to FRP)
  - Capability and capacity to meet program objectives for cost and schedule

- Ensure contractor and supply chain manufacturing plans, processes, and procedures are demonstrated, verified, and validated on the pilot line in accordance with industry best practices (i.e., AS6500) to include the following:
  - Continuous process improvement efforts
  - Manufacturing surveillance, data collection, and analyses (including supply chain data for items and components)
  - Manufacturing process controls in place (e.g., plans, process capabilities (C_{pk}s), SPC, etc.)
  - Adequacy and completeness of acceptance processes for LRIP
  - All manufacturing work instructions, sequencing, and in-process tests (including quality test points and procedures)
  - Manufacturing scheduling, workflow, and optimization
  - Manufacturing resource planning, and scheduling
  - Physical and functional interfaces
  - Manufacturing models and simulations
  - Manufacturing workforce capabilities, skills, and training
  - Implementations of manufacturing technologies including ManTech
  - Tooling, work holding fixtures, jigs, etc.
  - Manufacturing equipment and facilities (including GFE, etc.)
  - Manufacturing processes for movement, storage, and handling equipment
  - Manufacturing safety processes and procedures
  - Manufacturing ESOH processes and procedures
  - Manufacturing security processes, procedures, capabilities, and compliance
  - Impacts from direct and indirect infrastructure
  - Mitigation results for manufacturing risks and issues resolutions
  - Manufacturing cost changes (and impacts to schedule and performance)
  - Adequacy of materials sources and selections
  - Integration (manufacturing processes) of embedded software

- Analyze manufacturing processes performed during the pilot lines operations, (including simulations) to include:
  - Rate of manufacturing processes (actual time to complete) vs. planned
  - Manufacturing data actuals vs. estimated
  - Process yield actuals vs. planned
  - Changes in processes (actual vs. planned)
  - Cost of manufacturing actuals vs. desired

- Assess process control plans, including all plans for process control of key and critical processes, for adequacy and completeness on the pilot line.
- Assess all work instructions for required outputs and changes based on build-to documentation and information gathered during the pilot line.
    - Verify updated work instructions, processes, drawings, etc.
    - Include KCs, Critical Manufacturing Processes, and their control plans
- Assess manufacturing output from the pilot line for adequacy and completeness and validate:
    - All Production Process Verifications (PPVs) performed
    - Attainability of KCs (will be capable and under process control for LRIP)
    - Manufacturing data collected for the Variability Reduction program
        - Data should demonstrate progress to metrics
        - Include updates based on process improvements
    - All FAIs and FATs against specifications, drawings, models, etc.
    - Requirements for design changes and process changes identified during pilot line operations, testing, and qualification
- Capture the results of manufacturing processes, demonstrated on a pilot line, as inputs to the system MRL assessment, PRR, and to the Industrial Base Capabilities Considerations that are required for Milestone C.
- Based on the results of the Pilot Line build, finalize the TDP including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.
- Provide manufacturing input for a Letter of Delegation to DCMA for support to, witness of, and assessment of demonstrations, pilot line operations, FAIs and/or FATs, etc.

Metrics

- Contractor-designated pilot lines have been assessed and documented in an MRL assessment and/or for PRR for production realism and affordability of elements required to manufacture systems, subsystems, items, and components to include evaluation of:
    - Manufacturing readiness for manufacture of equipment
    - Materials, components, and tooling availability,
    - Adequacy of workforce skill levels, facilities, materials, work instructions, processes, tooling, temperature, cleanliness, lighting etc.
    - Capability to meet design requirements for LRIP
    - Production processes (little or no reliance on laboratory environment or personnel, i.e., non-production resources)
    - Capability and capacity to meet rate production (ramp-up to FRP)
    - Capability and capacity to meet program objectives for cost and schedule

- Contractor and supply chain manufacturing plans, processes, and procedures have been demonstrated on a pilot line and the results documented in the Program management information system and/or CDRL to validate industry best practices were followed to include:
    - Continuous process improvement efforts
    - Manufacturing surveillance, data collection, and analyses (including supply chain data for items and components)
    - Manufacturing process controls in place (e.g., plans, process capabilities (C_{pk}s), SPC, etc.)
    - Adequacy and completeness of acceptance processes for LRIP
    - All manufacturing work instructions, sequencing, and in-process tests (including quality test points and procedures)
    - Manufacturing scheduling, workflow, and optimization
    - Manufacturing resource planning, and scheduling
    - Physical and functional interfaces
    - Manufacturing models and simulations
    - Manufacturing workforce capabilities, skills, and training
    - Implementations of manufacturing technologies including ManTech
    - Tooling, work holding fixtures, jigs, etc.
    - Manufacturing equipment and facilities (including GFE, etc.)
    - Manufacturing processes for movement, storage, and handling equipment
    - Manufacturing safety processes and procedures
    - Manufacturing ESOH processes and procedures
    - Manufacturing security processes, procedures, capabilities, and compliance
    - Impacts from direct and indirect infrastructure
    - Mitigation results for manufacturing risks and issues resolutions
    - Manufacturing cost changes (and impacts to schedule and performance)
    - Adequacy of materials sources and selections
    - Integration (manufacturing processes) of embedded software
- Manufacturing processes performed during the pilot lines operations, (including simulations) were assessed for actuals against plans and the results documented for:
    - Rates
    - Manufacturing data
    - Process yields
    - Changes in processes
    - Costs of manufacturing
- Process control plans, including all plans for process control of key and critical processes, have been assessed on the pilot line and the results document adequacy and completeness for PRR and LRIP.

- All work instructions have been assessed and updated for required outputs and changes and results documented for PRR.
    - Updated work instructions, processes, drawings, etc. have been verified completeness and accuracy
    - KCs, Critical Manufacturing Processes, and their control plans have been validated and documented
- Pilot line output has been assessed for adequacy and completeness and documentation for PRR and LRIP shows verification and validation of:
    - All Production Process Verifications (PPVs)
    - Attainability of KCs (i.e., capable and under process control for LRIP)
    - Variability Reduction program
        - Data demonstrates progress to metrics
        - Includes all process improvements
    - All FAIs and FATs completed (e.g., specifications, drawings, models, etc.)
    - Design and process required by pilot line operations, testing, and qualification
- Results of manufacturing processes, demonstrated on a pilot line, have been documented as manufacturing inputs to the system MRL assessment, PRR, and to the Industrial Base Capabilities Considerations that are required for Milestone C.
- The TDP has been updated and finalized to include all applicable technical data (e.g., models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation, and packaging details).
- Manufacturing input for a Letter of Delegation or Memorandums of Agreement to DCMA have been provided to obtain support to, witness of, and assessment of demonstrations, pilot line operations, FAIs, or FATs, etc.

Tools

- Interactive MRL Users Guide (Check), Manufacturing Management thread
- Manufacturing Maturation Plan

Resources

- AS6500, Manufacturing Management Program
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896A, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

L.5 Finalize Manufacturing Strategy and Plan for LRIP

A manufacturing strategy should be updated prior to LRIP and often includes considerations such as competition. Manufacturing voids, deficiencies, and dependencies on critical foreign source materials should be addressed. The producibility of each system design concept should be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and industrial base goals and thresholds.

The Manufacturing Plan should be updated for LRIP and is about understanding everything it takes to produce all the items required by the contract, on time, on budget, and with the right performance features. This is especially a problem as the program ramps up production from the pilot line build to the LRIP environment. It includes considerations of all the 5Ms, at the prime contractor and throughout the supply chain.

Manufacturing and Quality Tasks

- Update and finalize the Program Manufacturing Strategy and Plan for Production and Deployment (P&D) to include updates for:
    - Results from pilot line and the resulting manufacturing updates
    - Results from FAIs, FATs, and FRACAS activities
    - Findings, results, and direction from the SVR/FCA
    - Final TDP
    - Requirements from the CPD
    - Findings from the MRL assessment
    - Direction and results from a completed PRR (e.g., date, open items, issues, etc.)
    - Requirements for P&D from the RFP
    - The joint Risk, Issue, and Opportunity System
    - Maturity and plans for manufacturing development
    - Manufacturing maturity and plans for system required new technologies
    - Results of pilot line design updates and producibility improvements
    - Results from continuous process improvement efforts
    - Management of IP and data rights
    - Actual rates and schedules (includes processes, tooling, make/buy, etc.)
    - Verification and validation of models and simulations
    - Estimates for Learning Curves, LRIP (subsequent ramp-up to rate), surges, etc.
    - Changes to management of KCs and critical characteristics and associated processes
    - Manufacturing inputs on costs, schedule, budgets, affordability requirements, and IMP/IMS critical path
    - Management of materials (e.g., critical and controlled, lead-times, long-lead, sourcing, risks, issues, sole, single, foreign, counterfeit, obsolescence, etc.)
    - DMSMS strategies and plans

  - Use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
  - Finalized process capability requirements
  - Requirements for in-process and acceptance tests, test procedures, and test equipment (hardware and software)
  - Program and contractor workforce needs, capabilities, training, certifications, availability, etc.
  - Changes in contractor facilities, manufacturing equipment and tooling, and test equipment requirements
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials
  - ESOH, environmental, security, and safety requirements
  - Management of ITAR and anti-tamper
  - Plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations

- Ensure the Program Manufacturing Strategy for P&D includes industry best manufacturing practices (in accordance with AS6500) to include:
  - Manufacturing Management System
  - Design for Manufacturing including:
    - Producibility analyses
    - KCs
    - Failure Mode Effects Analyses (DFMEA and PFMEA)
  - Manufacturing Risk Identification including:
    - Manufacturing feasibility assessments
    - MRL assessments
    - Production Readiness Reviews
  - Manufacturing Planning including:
    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing costs
    - Modeling and simulations
    - Manufacturing system verification
    - Manufacturing workforce
    - Tooling, test equipment and facilities
  - Manufacturing Operations Management including:
    - Production Scheduling and Control
    - Manufacturing Surveillance

  - Continuous Improvement
  - Process Control Plans
  - Process Capabilities
  - PPVs
  - FAIs and FATs
  - Sub-tier supplier management

- Update the Program Manufacturing Management Strategy and Plan for manufacturing management of software and firmware.
- Provide updated manufacturing inputs to the PPP for considerations of contractor compliance, risks, and issues for P&D.
- Update the Program Manufacturing Strategy and Plan for P&D for required agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, National Test Facilities, etc.).
- Update the Manufacturing Strategy and Plan to include the contractual definition and agreement to manufacturing environments for LRIP and FRP.
- Ensure the WBS adequately defines the tasks to be accomplished for LRIP in P&D.
- Develop recommendations for sourcing and options for LRIP based on manufacturing analyses of Program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, including:
  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Ensure contractor's manufacturing plans, policies, and procedures are consistent with Program plans for Program Plans for Product Improvement (P^3I) for LRIP.
- Update all manufacturing risks, issues, and mitigation plans for LRIP based on pilot line operations, demonstrations, and simulations.
  - Ensure mitigations of current risks and issues are on track and/or do not introduce new risks and issues to the Program for LRIP.
- Finalize the TDP including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details based on the results of the Pilot Line build.

Metrics

- Program Manufacturing Strategy and Plan has been updated for P&D and includes and documents the following:
  - Results from pilot line and the resulting manufacturing updates

  - Results from FAIs, FATs, and FRACAS activities
  - Findings, results, and direction from the SVR/FCA
  - Final TDP
  - Requirements from the CPD
  - Findings from the MRL assessment
  - Direction and results from a completed PRR (e.g., date, open items, issues, etc.)
  - Requirements for P&D from the RFP
  - The joint Risk, Issue, and Opportunity System
  - Maturity and plans for manufacturing development
  - Manufacturing maturity and plans for system required new technologies
  - Results of pilot line design updates and producibility improvements
  - Results from continuous process improvement efforts
  - Management of IP and data rights
  - Actual rates and schedules (includes processes, tooling, make/buy, etc.)
  - Verification and validation of models and simulations
  - Estimates for Learning Curves, LRIP (subsequent ramp-up to rate), surges, etc.
  - Changes to management of KCs and critical characteristics and associated processes
  - Manufacturing inputs on costs, schedule, budgets, affordability requirements, and IMP/IMS critical path
  - Management of materials (e.g., critical and controlled, lead-times, long-lead, sourcing, risks, issues, sole, single, foreign, counterfeit, obsolescence, etc.)
  - DMSMS strategies and plans
  - Use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
  - Finalized process capability requirements
  - Requirements for in-process and acceptance tests, test procedures, and test equipment (hardware and software)
  - Program and contractor workforce needs, capabilities, training, certifications, availability, etc.
  - Changes in contractor facilities, manufacturing equipment and tooling, and test equipment requirements
  - Processes and procedures for prevention or detection of counterfeit parts and materials
  - ESOH, environmental, security, and safety requirements
  - Management of ITAR and anti-tamper
  - Plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations

- Program Manufacturing Strategy for P&D documents the requirements for and the implementation of industry best manufacturing practices including:
  - Manufacturing Management System
  - Design for Manufacturing including:

        - Producibility analyses
        - KCs
        - Failure Mode and Effects Analyses (DFMEA and PFMEA)
    - Manufacturing Risk Identification including:
        - Manufacturing feasibility assessments
        - MRL assessments
        - Production Readiness Reviews
    - Manufacturing Planning including:
        - Supply chain and material management
        - Manufacturing technology development
        - Manufacturing costs
        - Modeling and simulations
        - Manufacturing system verification
        - Manufacturing workforce
        - Tooling, test equipment and facilities
    - Manufacturing Operations Management including:
        - Production Scheduling and Control
        - Manufacturing Surveillance
        - Continuous Improvement
        - Process Control Plans
        - Process Capabilities
        - PPVs
        - FAIs and FATs
        - Sub-tier supplier management
- Program Manufacturing Management Strategy and Plan has been updated and documents manufacturing management of software and firmware.
- Updated manufacturing inputs have been documented and provided for the PPP for evaluations of contractor's capability for compliance, risks, and issues for P&D.
- Program Manufacturing Strategy and Plan documents updated requirements for P&D agreements, delegations, and contracts with other agencies (e.g., DCMA, DLA, National Test Facilities, etc.).
- Manufacturing Strategy and Plan documents the contractual definition of an agreement to manufacturing environments for LRIP and FRP.
- Contractor WBS has adequately documented tasks to be accomplished for LRIP in P&D.
- Recommendations for sourcing and options for LRIP have been developed and documented based on manufacturing analyses of Program progress and assessments of maturity, affordability and costs, availability and capability, risks, issues, and opportunities, including:

  - Emerging technology advancements in materials and processes
  - Changes in Government statute, policy, and regulations
  - Changes in business climate conditions (e.g., mergers and acquisitions, failures, etc.)
  - Changes in environmental impacts (e.g., natural disasters, etc.)
  - Diminishing Manufacturing Sources and Material Shortages (DMSMS)
- Contractor's manufacturing plans, policies, and procedures have been assessed and recommendations and changes have been documented to maintain consistency with Program P^3I plans for LRIP.
- All updated manufacturing risks, issues, and mitigation plans have been documented and provided for the joint program/contractor RIO Management System for LRIP.
  - Mitigations of current risks and issues are assessed to be on track and do not introduce new risks and issues to the Program for LRIP
- The final manufacturing input to the TDP has been provided, including applicable technical data such as models, drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, software documentation and packaging details.

Tools

- AS6500, Manufacturing Management Program Assessment
- Interactive MRL Users Guide (Checklist), Manufacturing Management thread
- Manufacturing Maturation Plan
- Material Management and Accounting System Audit

Resources

- AS6174, Counterfeit Material
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- ASISO5553, Counterfeit Electronic Parts
- DFAR 242.72, Contractor Material Management and Accounting System
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288, Systems and Software Engineering
- MIL-HDBK-896A Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

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Appendix A: Abbreviations and Acronyms

A_m	Materiel Availability
A_o	Operational Availability
AAF	Adaptive Acquisition Framework
ADM	Acquisition Decision Memorandum
AFRL	Air Force Research Laboratory
AM	Additive Manufacturing
ANSI	American National Standards Institute
AoA	Analysis of Alternatives
APA	Additional Performance Attributes
APB	Acquisition Program Baseline
APQP	Advanced Product Quality Planning
AS	Acquisition Strategy
ASME	American Society of Mechanical Engineers
ASR	Alternative Systems Review
AT	Anti-Tamper
ATE	Automatic Test Equipment
AUPC	Average Unit Procurement Cost
BCA	Business Case Analysis
BER	Beyond Economical Repair
BoK	Body of Knowledge
BOM	Bill of Materials
C/SCSC	Cost/Schedule Control Systems Criteria
C4I	Command, Control, Communications, Computers, and Intelligence
CAB	Corrective Action Board
CAE	Component Acquisition Executive
CAI	Critical Application Item
CAIG	Cost Analysis Improvement Group
CAIV	Cost as an Independent Variable
CAPE	Cost Assessment and Program Evaluation
CARD	Cost Analysis Requirements Description
CAS	Contract Administration Services
CBA	Capabilities-Based Assessment

CCB	Configuration Control Board
CDD	Capability Development Document
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CI	Configuration Item
CI	Critical Item
CJCS	Chairman of the Joint Chiefs of Staff
CLIN	Contract Line Item Number
CM	Configuration Management
CMO	Contract Management Office
CMP	Configuration Management Plan
CMP	Critical Manufacturing Process
COE	Center of Excellence
COMSEC	Communications Security
CONOPS	Concept of Operations
COSSI	Commercial Operations and Support Savings Initiative
COTS	Commercial Off-the-Shelf
CPAR	Contractor Performance Assessment Report
CPC	Corrosion Prevention and Control
CPD	Capability Production Document
CPFF/CPIF	Cost Plus Fixed Fee/Cost Plus Incentive Fee
CPI	Continuous Process Improvement
Cp / Cpk	Process Capability
C/SCSC	Cost and Schedule Control Systems Criteria
CSI	Critical Safety Item
CTC	Critical to Customer
CTE	Critical Technology Element
CTQ	Critical to Quality
CUI	Controlled Unclassified Information
DAE	Defense Acquisition Executive
DAG	Defense Acquisition Guidebook
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University
DCMA	Defense Contract Management Agency

DD, ENG	Deputy Director for Engineering
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
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
DSMC	Defense Systems Management College
DSS	Design for Six Sigma
DTRAM	Defense Technical Risk Assessment Methodology
DTC	Design to Cost
DT&E	Developmental Test and Evaluation
EAC	Estimate at Completion
ECP	Engineering Change Proposal
EMC	Electromagnetic Compatibility
EMD	Engineering and Manufacturing Development
EMI	Electromagnetic Interference
EOQ	Economic Order Quantity
ERP	Enterprise Resource Plan
ESOH	Environment, Safety, and Occupational Health
ESS	Environmental Stress Screening
EVMS	Earned Value Management System
FA	First Article

FAI	First Article Inspection
FAR	Federal Acquisition Regulation
FAT	First Article Test
FCA	Functional Configuration Audit
FDD	Full Deployment Decision
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
FPIF	Fixed Price Incentive Fee
FRACAS	Failure Reporting, Analysis, and Corrective Action System
FRP	Full-Rate Production
FYDP	Future Years Defense Program
GAO	Government Accountability Office
GCQA	Government Contract Quality Assurance
GFE	Government-Furnished Equipment
GFF	Government-Furnished Facility
GFI	Government-Furnished Information
GFM	Government-Furnished Material
GFP	Government-Furnished Property
GIDEP	Government-Industry Data Exchange Program
GOTS	Government Off-the-Shelf
HALT	Highly Accelerated Life Testing
HASS	Highly Accelerated Stress Screen
HSI	Human Systems Integration
HVAC	Heating, Ventilation, and Air Conditioning
HWCIs	Hardware Configuration Items
IB	Industrial Base
IC	Intelligence Community
ICA	Industrial Capabilities Assessments
ICD	Initial Capabilities Document
IEEE	Institute of Electrical and Electronics Engineers
IG	Inspector General

IPT	Integrated Product Team
ILA	Independent Logistics Assessment
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOC	Initial Operational Capability
IP	Intellectual Property
IPS	Integrated Product Support
IPT	Integrated Product Team
IRAD	Independent Research and Development
ISO	International Organization for Standardization
ISR	In-Service Review
ITAR	International Trafficking in Arms Regulation
ITRA	Independent Technical Risk Assessment
JCIDS	Joint Capabilities Integration and Development System
JROC	Joint Requirements Oversight Council
KC	Key Characteristics
KLP	Key Leadership Position
KPP	Key Performance Parameter
KSA	Key System Attribute
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LCSP	Life Cycle Sustainment Plan
LOD	Letter of Delegation
LFT&E	Live-Fire Test and Evaluation
LRIP	Low-Rate Initial Production
5Ms	Manpower, Machines, Materials, Methods, Measurement
ManTech	Manufacturing Technology
MATE	Multi-Attribute Trade Space Exploration
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDD	Materiel Development Decision
MEP	Manufacturing Extension Program
MIL-STD	Military Standard
MMAS	Material Management and Accounting System

MMP	Manufacturing Maturation Plan
MMS	Manufacturing Management System
MOA	Memorandum of Agreement
MOE	Measure of Effectiveness
MOSA	Modular Open Systems Approach
MP	Mission Profile
M&Q	Manufacturing and Quality
MRA	Manufacturing Readiness Assessment
MRB	Material Review Board
MRL	Manufacturing Readiness Level
MRO	Maintenance, Repair, and Overhaul
MRP	Material Requirements Planning
MRPII	Manufacturing Resource Planning
M&S	Modeling and Simulation
MS A	Milestone A
MS B	Milestone B
MS C	Milestone C
MSA	Materiel Solution Analysis
MSRA	Manufacturing Systems Risk Assessment
MTA	Middle Tier of Acquisition
MTBF	Mean Time Between Failure
NAVSO	National Association of Veteran-Serving Organizations
NDAA	National Defense Authorization Act
NDI	Non-Developmental Item
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NRL	Navy Research Laboratory
NSPAR	Non-Standard Parts Approval Request
NTIB	National Technology and Industrial Base
O&A	Over and Above
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
OIPT	Overarching Integrated Product Team
O&M	Operations and Maintenance

OMS	Operational Mode Summary
O&S	Operations and Support
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
OTRR	Operational Test Readiness Review
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
P3I/P^3I	Preplanned Product Improvement
PAOC	Post-Award Orientation Conference
PAW	Producibility Assessment Worksheet
PBL	Performance-Based Logistics
PCA	Physical Configuration Audit
PCD	Process Control Document
PCO	Procurement Contracting Officer
P&D	Production and Deployment
PDR	Preliminary Design Review
PEP	Producibility Engineering and Planning
PESHE	Programmatic Environmental, Safety, and Occupational Health Evaluation
PFMEA	Process Failure Modes and Effects Analysis
PHL	Preliminary Hazard List
PHST	Packing, Handling, Storage, and Transportation
PM	Program Manager
PMP	Parts, Materials, and Processes
PMR	Program Management Review
PMO	Program Management Office
POE	Program Office Estimate
Pp / Ppk	Process Performance
PPAP	Production Part Approval Process
PPC	Production Planning and Control
PPP	Program Protection Plan
PQM	Production, Quality, and Manufacturing
Pre-MDD	Pre-Materiel Development Decision
PRR	Production Readiness Review
PSA	Program Support Assessment
PSM	Product Support Manager

PSS	Product Support Strategy
PTAC	Procurement Technical Assistance Center
PWBS	Preliminary Work Breakdown Structure
QA	Quality Assurance
QALI	Quality Assurance Letter of Instruction
QDR	Quality Deficiency Report
QFD	Quality Function Deployment
QMS	Quality Management System
QSP	Quality Surveillance Plan
R&D	Research and Development
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RIO	Risk, Issue, and Opportunity
RFI	Request for Information
RFP	Request for Proposal
RFP DP	Request for Proposal Release Decision Point
RFV	Request for Variation
R&M	Reliability and Maintainability
SAE	Society of Automotive Engineers
SAR	Safety Assessment Report
SAT	Software Acceptance Test
SCD	Surveillance Criticality Designator
SCM	Supply Chain Management
SCMP	Software Configuration Management Plan
SCOR	Supply Chain Operations Reference
SCRM	Supply Chain Risk Management
SDP	Software Development Plan
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SEP	Systems Engineering Plan
SF	Standard Form
SFMEA	System Failure Modes and Effects Analysis
SFQT	Software Formal Qualification Testing
SFR	System Functional Review
SIE	Special Inspection Equipment

SLEP	Service Life Extension Program
SME	Society of Manufacturing Engineers
SOO	Statement of Objectives
SOW	Statement of Work
SPC	Statistical Process Control
SPI	Special Packaging Instructions
SQAP	Software Quality Assurance Plan
SRR	System Requirements Review
SSA	System Safety Assessment
SSE	Systems Security Engineering
SSP	Source Selection Plan
ST	Special Tooling
S&T	Science and Technology
STE	Special Test Equipment
STEM	Science, Technology, Engineering, and Math
SVR	System Verification Review
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TBD	To Be Determined
TDP	Technical Data Package
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TMRR	Technology Maturation and Risk Reduction
TO	Technical Order
TOC	Total Ownership Cost
TOC	Theory of Constraints
TPM	Technical Performance Measure
TRA	Technology Readiness Assessment
TRIZ	Theory of Innovative Problem Solving
TRL	Technology Readiness Level
TRR	Test Readiness Review
USAFA	United States Air Force Academy
USD(R&E)	Under Secretary of Defense for Research and Engineering
U.S.C.	United States Code
VCRM	Verification Cross-Reference Matrix

VOLT	Validated Online Lifecycle Threat
VR	Variability Reduction
VSM	Value Stream Mapping
V&V	Verification and Validation
WBS	Work Breakdown Structure
WIP	Work in Progress

Appendix B: References

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

AFI 10-601, Operational Capability Requirements Development
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https://static.e-publishing.af.mil/production/1/saf_aq/publication/afi63-145/afi63-145.pdf

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https://static.e-publishing.af.mil/production/1/saf_aq/publication/afi63-145/afi63-145.pdf

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Analysis of Alternative (AoA) Handbook, Office of Aerospace Studies, Aug 2017
https://afacpo.com/AQDocs/AoAHandbook.pdf

Application of Learning Curve Theory to Systems Acquisition, Defense Acquisition University (DAU) Teaching Note, Feb 2011
https://www.dau.edu/cop/ce/DAU%20Sponsored%20Documents/B5%20Application%20of%20Learning%20Curve%20Theory%20Feb%2011.pdf

AR 700-90, Army Industrial Base Process, Feb 2020
https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN20450_AR_700-90_FINAL.pdf

AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition, Mar 2019, SAE International
https://www.sae.org/standards/content/as5553/

AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel, Jul 2014, SAE International
https://www.sae.org/standards/content/as6174/

AS6500, Manufacturing Management Program, Nov 2014, SAE International
https://www.sae.org/standards/content/as6500/

AS9100D: 2016, Quality Management Systems - Requirements for Aviation, Space and Defense Organizations, Sep 2016. SAE International
https://www.sae.org/standards/content/as9100d/

AS9102, First Article Inspection Requirement, Oct 2014, SAE International
https://www.sae.org/standards/content/as9102/

AS9103, Variation Management of Key Characteristics, Oct 2001, SAE International
https://www.sae.org/standards/content/as9103/

AS9133, Qualification Procedure for Aerospace Standard Products, Jul 2002, SAE International
https://www.sae.org/standards/content/as9133/

AS9134, Supply Chain Risk Management Guidelines, Feb 2014, SAE International
https://www.sae.org/standards/content/arp9134/

AS9136, Root Cause Analysis and Problem Solving, Nov 2016, SAE International
https://www.sae.org/standards/content/arp9136/

AS9138, Quality Management Systems Statistical Product Acceptance, Jan 2018, SAE International
https://www.sae.org/standards/content/as9138/

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https://www.congress.gov/bill/114th-congress/senate-bill/2943/text

National Defense Authorization Act (NDAA) for Fiscal Year 2017 (Public Law 114-328), Section 807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
https://uscode.house.gov/statutes/pl/114/328.pdf

National Defense Authorization Act (NDAA) for Fiscal Year 2017 (Public Law 114-328), Section 807, Sect 2448b, Independent Technical Risk Assessments
https://uscode.house.gov/statutes/pl/114/328.pdf

NAVSO P-3687 Producibility Systems Guidelines
http://everyspec.com/USN/NAVY-General/NAVSO_P-3687_8510/

NIST Documents, National Institute of Standards and Technology
https://csrc.nist.gov/publications

NIST 800-82, Guide to Industrial Control Systems Security, May 2015
https://csrc.nist.gov/publications/detail/sp/800-82/rev-2/final

NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations, Rev 2, Feb 2020
https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-171r2.pdf

O&S Cost Estimating Guide, CAPE, Mar 2014
https://www.cape.osd.mil/files/OS_Guide_v9_March_2014.pdf

O&S Cost Management Guide, DAU, Mar 2016
https://www.dau.edu/tools/t/Operating-and-Support-(OandS)-Cost-Management-Guidebook

Parametric Estimating Handbook, DAU, Apr 2008
https://www.dau.edu/tools/Lists/DAUTools/Attachments/112/Parametric%20Handbook%204th%20Edition.pdf

Performance-Based Logistics (PBL) Guidebook, DAU Apr 2016
https://www.dau.edu/tools/t/Performance-Based-Logistics-(PBL)-Guidebook

Pre-Materiel Development Decision (MDD) Analysis Handbook, Jul 2010, Office of Aerospace Studies, Kirtland AFB, NM. ***Note:*** *This document was replaced with The Measures Handbook, Aug 2014, Office of Aerospace Studies, Kirtland AFB*
https://daytonaero.com/wp-content/uploads/USAF_The-Measures-Handbook_6Aug2014.pdf

Preservation and Storage of Tooling for MDAPs, DUSD Memo, Aug 2009
https://www.acq.osd.mil/dpap/pdi/uid/docs/DrCarterSignedMemo.pdf

Process Capability Control and Improvement Requirements – Process Control Plan Reference Guide, Picatinny Arsenal
https://ac.ccdc.army.mil/organizations/QESA/_files/PCCI_Review_Guide_Rev-1.pdf

Producibility Engineering and Planning (PEP) Program Management Guide, Jan 1985
https://apps.dtic.mil/sti/citations/ADA153730

Producibility Engineering Standard Practice Manual, US Army Belvoir, R&D Center, Sep 1993
http://everyspec.com/ARMY/ARMY-General/PRODUCIBILITY_STD_PRACTICE_MANUAL_SEP1993_34552/

Producibility Systems Guidelines, NAVSO P-3687, Dec 1999
http://everyspec.com/USN/NAVY-General/NAVSO_P-3687_8510/

Product Support Manager Guidebook, DAU, Dec 2019
https://www.dau.edu/tools/t/Product-Support-Manager-(PSM)-Guidebook

Public Law 114-328, §807, Cost, Schedule and Performance of Major Defense Acquisition Programs
https://www.govinfo.gov/content/pkg/PLAW-114publ328/html/PLAW-114publ328.htm

Quality Function Deployment, IEEE article, Kenneth Crow, DRM Associates, Los Angeles, CA
https://www.ieee.li/tmc/quality_function_deployment.pdf

Request for Proposal Evaluation Guide, Reform Support Network, no date, used by state and local education agencies to evaluate proposals
https://www2.ed.gov/about/inits/ed/implementation-support-unit/tech-assist/request-proposals-evaluation-guide.pdf

Requirements Traceability Matrix Guide, Jan 2012
https://www.dau.edu/cop/pqm/_layouts/15/WopiFrame.aspx?sourcedoc=/cop/pqm/DAU%20Sponsored%20Documents/CDD-CPD%20Writing%20Guide,%20Feb%202015.pptx&action=default

Requirements Traceability Matrix Tool (excel), DAU
https://www.dau.edu/tools/Documents/SAM/resources/RTM_Risk_Register.html

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

Robust Design and Taguchi Methods
https://www.dau.edu/cop/risk/DAU%20Sponsored%20Documents/Robust%20Design%20and%20Taguchi%20Methods.pdf

SAE EIA 649B-2011, Configuration Management Standard
https://webstore.ansi.org/Standards/SAE/SAEEIA649B2011EIA649B?gclid=EAIaIQobChMI6NS4yPOL6wIVxf7jBx0qGQxrEAAYAiAAEgLSmPD_BwE

SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA) and Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA) Reference Manual, SAE International, Jan 2009
https://www.sae.org/standards/content/j1739_200006/

SD-5 Market Research, Defense Standardization Program, Jan 2008
http://acqnotes.com/wp-content/uploads/2014/09/SD-5-Market-Research.pdf

SD-22, DMSMS Guidebook
https://www.dsp.dla.mil/Programs/DMSMS

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

Section M Guide - IG5315,204-5(c)
https://far.affinitext.com/public/book?id=18966&toc_id=5280626#PG_5280775_60387757

SF 1403 Preaward Survey of Prospective Contractor
http://www.acqnotes.com/Attachments/Standard%20Form%201403.pdf

SF 1404 Preaward Survey of Prospective Contractor – Technical
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-technical

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

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

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

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

Should-Cost Affordability Memo, Aug 2011
https://www.acq.osd.mil/fo/docs/Should-cost%20and%20Affordability.pdf

Source Selection Procedure, DoD Memo, Apr 2016
http://acqnotes.com/wp-content/uploads/2014/09/DoD-Source-Selection-Procedures-31-Mar-2016.pdf

Strategic and Critical Materials Stockpiling Act, 1939
https://uscode.house.gov/view.xhtml?req=(title:50%20section:98%20edition:prelim)

Supply Chain Metrics Guide, Mar 2016
https://www.acq.osd.mil/log/SCI/.policy_vault.html/Supply_Chain_Metrics_Guide_signed_3Mar2016.pdf

Supply Chain Operations Reference (SCOR) Model, Association for Supply Chain Management
https://www.apics.org/apics-for-business/frameworks/scor

Sustainability Analysis Guidance: Integrating Sustainability into Acquisition Life Cycle Assessment
https://www.denix.osd.mil/esohacq/home/dod-guidance/dod-sustainability-analysis-guidance/OSD-ATL%20SA%20Guidance%20v5%20508%20Additions.pdf

Systems Engineering Plan (SEP) Outline, May 2017
www.acqnotes.com/acqnote/acquisitions/systems-engineering-plan

Technology Readiness Assessment (TRA) Deskbook, Jul 2009
http://www.acqnotes.com/Attachments/Technology%20Readiness%20Assessment%20Deskbook.pdf

Technology Readiness Assessment Guide, GAO Report: GAO-20-48G, Jan 2020
https://www.gao.gov/assets/710/703694.pdf

Technology Transition Managers Guide (Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment), DAU, Jun 2005
https://apps.dtic.mil/dtic/tr/fulltext/u2/a484102.pdf

Test and Evaluation Management Guide (TEMG), DAU, Aug 2016
https://www.dau.edu/tools/t/Test-and-Evaluation-Management-Guide-(TEMG)

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Appendix C: Tools

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

AS6500, Manufacturing Management Program Checklist
Internet Search

AS9100, Quality Management System Checklist
Internet Search

AS9100, Quality Audit Checklist
Internet Search

AS9103, Variation Management of Key Characteristics Assessment
Internet Search

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

AS9134, Supply Chain Risk Management Guidelines
Internet Search

AS9137, Advanced Quality Assurance Procedure (AQAP) Checklist
Internet Search

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

Assembly Chart
Internet Search

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

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

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

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

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

Benchmarking
Internet Search

Bill of Material Assessment
Internet Search

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

Bottleneck Analysis (Theory of Constraints)
Internet Search

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)
https://www.dcma.mil/
User must register on the DCMA 360 portal to obtain access

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

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

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

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

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

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

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

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

Cost of Quality (CoQ) Estimates
Internet Search

Critical Chain Project Management
Internet Search

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

Critical Path Template
Internet Search

Critical to Customer Template
Internet Search

Critical to Quality Tree Template
Internet Search

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

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

DCMA Industrial Capability Assessment Survey
https://www.dcma.mil/
User must register on the DCMA 360 portal to obtain access

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
https://www.dcma.mil/
User must register on the DCMA 360 portal to obtain access

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)
https://www.dcma.mil/
User must register on the DCMA 360 portal to obtain access

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
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)
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, 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

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

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