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

Chapter 3
Technology Maturation and Risk Reduction (TMRR) Phase

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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 Executive Director, Systems Engineering and Architecture (ED, SE&A) prepared the BoK and will update the work periodically to reflect current policy, guidance, tools, and best practices. This document does not supersede DoD policy, guidance, or law.

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

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

The BoK includes 6 chapters:

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

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

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

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

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

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

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

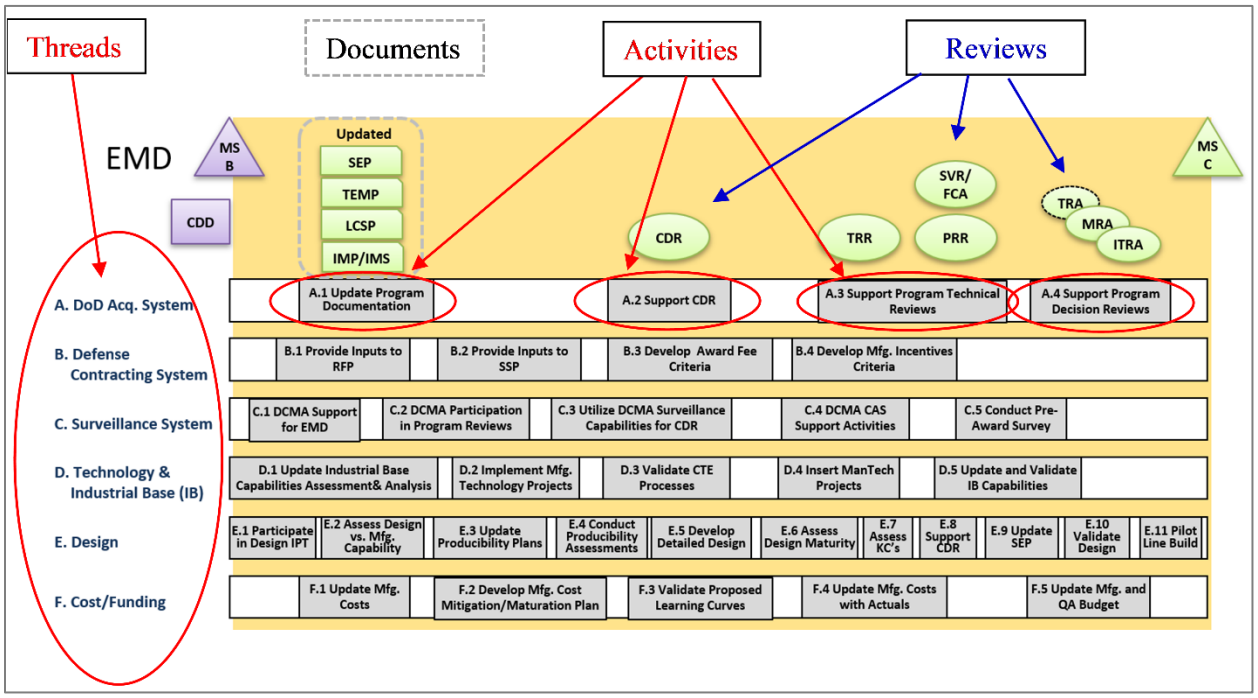
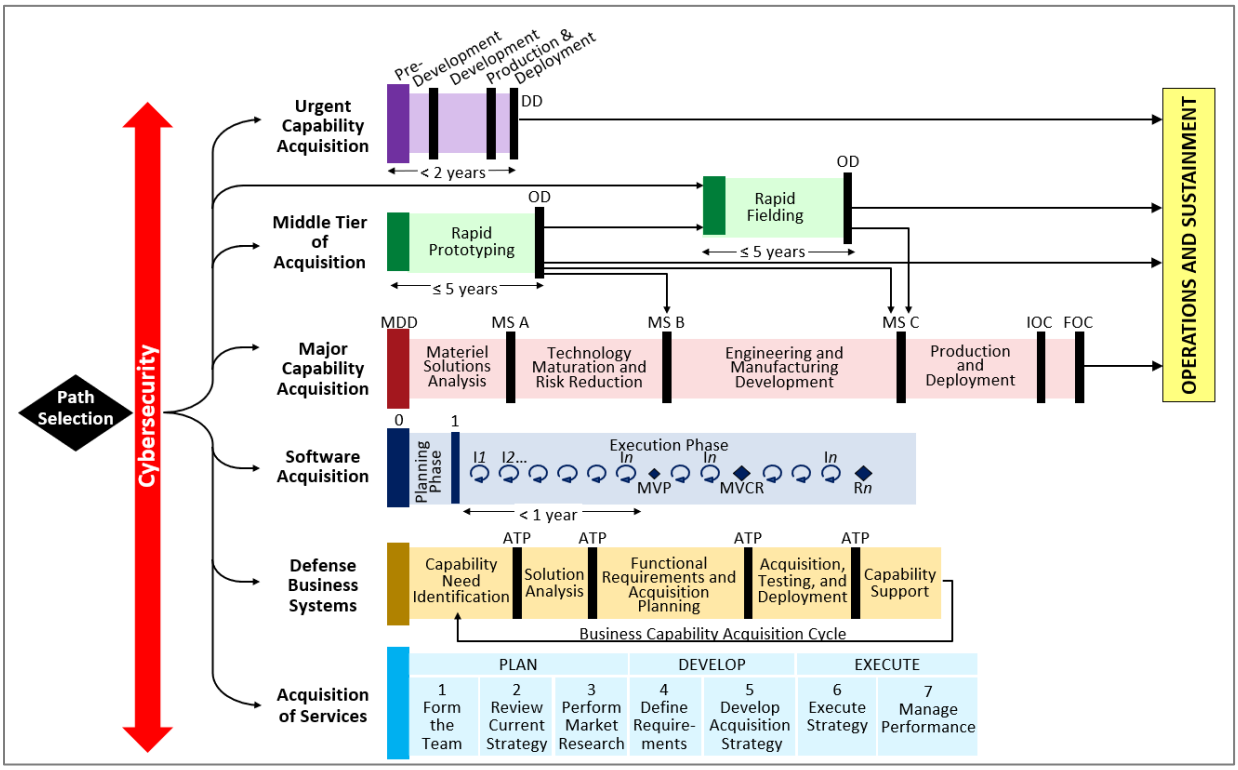


Figure 1. Sample Activity Chart

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 (MCA). This path includes a comprehensive and systematic approach for applying M&Q best practices; however, the M&Q BoK best practices are applicable to the alternative AAF pathways as well. AAF pathways are depicted in Figure 2.



Source: DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework, January 23, 2020

Figure 2. Adaptive Acquisition Framework Paths

For example, under the AAF, a program may have an Urgent Capability Acquisition (UCA) and may have less than 2 years to provide a solution to the Warfighter, or the program may be involved in a Middle Tier of Acquisition (MTA) approach focused on rapid prototyping or rapid fielding. If so, users can see how these efforts are aligned with the MCA process in Figure 2 and 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
- DoD Instruction 5000.81, Urgent Capability Acquisition
- DoD Instruction 5000.85, Major Capability Acquisition

- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation

With any acquisition model, the program office should include M&Q personnel on the technical Integrated Product Team (IPT) and to support M&Q activities and tasks, many of which are support tasks for activities that control specific acquisition areas. For example, M&Q personnel do not have authority to sign contracts, but they should be involved in submitting M&Q input for consideration. This BoK serves as a framework for identifying and accomplishing the tasks and activities. It is up to the individual program office or acquisition organization to tailor this BoK for their application.

Manufacturing and Quality Planning

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

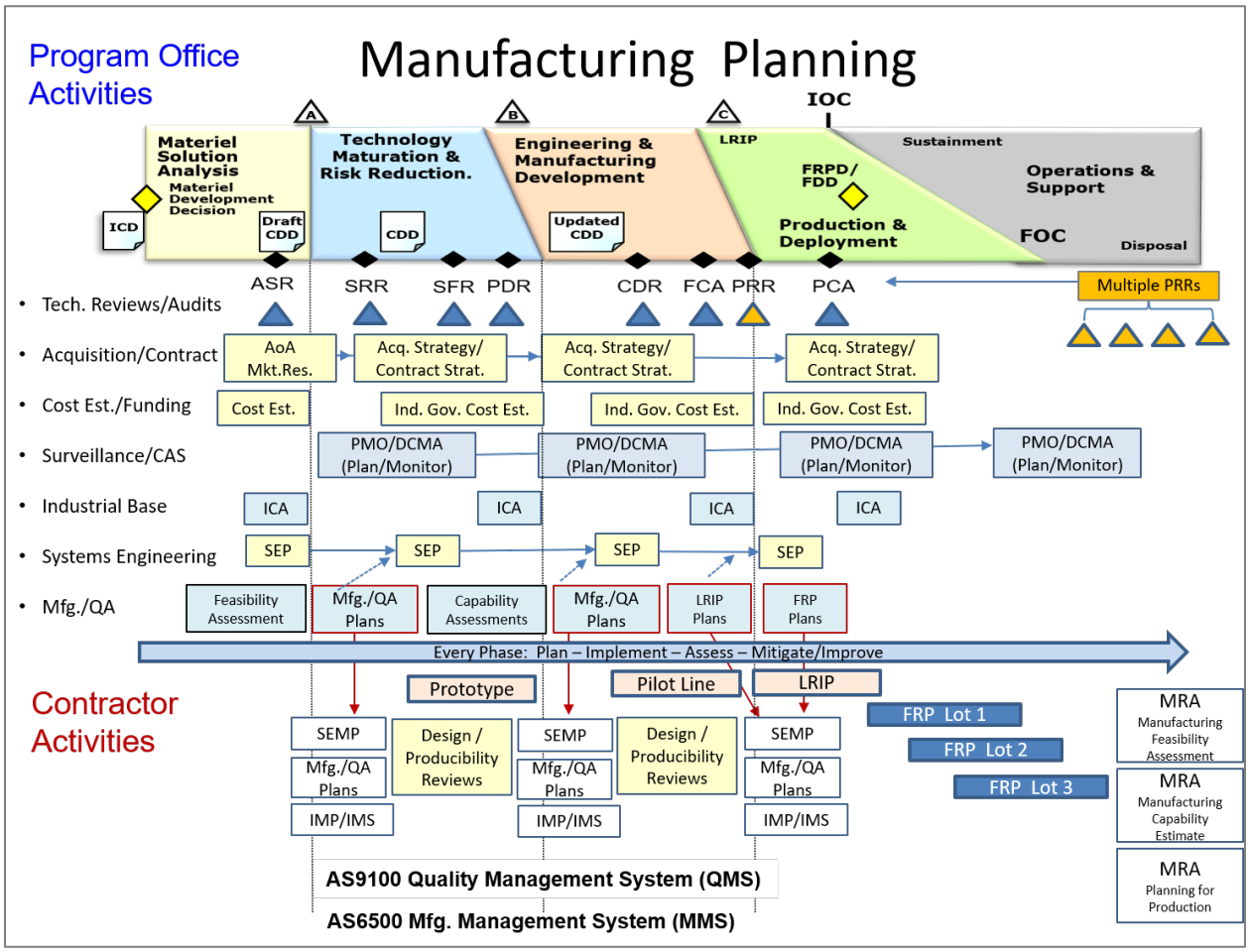


Figure 3. Typical Manufacturing and Quality Planning Activities

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

Once the plans have been developed and the requirements handed off to the contractor in the form of a contract, then the detailed planning and execution occur. The contractor is responsible for the execution of the program and in planning for success. The government Program Management Office (PMO), along with the Defense Contract Management Agency (DCMA) or other contract surveillance organizations and engineering support activities, is responsible for oversight and management of the acquisition. Risk assessment and mitigation is an ongoing effort that should be conducted throughout the system life cycle. Key references for DoD M&Q planning and management approaches include: MIL-HDBK-896, Manufacturing Management Program Guide; SAE Standard AS6500, Manufacturing Management Program; and Quality Management Systems standards ISO 9100 and/or AS9100. In addition, MRL criteria and assessments are a best practice for identifying and mitigating M&Q risks across the system life cycle. As a best practice, DoD ETM practitioners and managers should become familiar with these fundamental planning and management approaches.

Tools and Resources

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

Key Manufacturing and Quality Body of Knowledge References and Resources

Department of Defense (DoD) Issuances, Directives Division https://esd.whs.mil/DD/

- DoD Directive 5000.01, The Defense Acquisition System
- DoD Instruction 5000.02, Operation of the Adaptive Acquisition Framework
- DoD Instruction 5000.80, Operation of the Middle Tier of Acquisition (MTA)
- DoD Instruction 5000.81, Urgent Capability Acquisition

- DoD Instruction 5000.84, Analysis of Alternatives
- DoD Instruction 5000.85, Major Capability Acquisition
- DoD Instruction 5000.88, Engineering of Defense Systems
- DoD Instruction 5000.89, Test and Evaluation
- DoD Instruction 5000.93, Use of Additive Manufacturing in the DoD
- DoD Instruction 5000.94, Use of Robotic Systems for Manufacturing and Sustainment in the DoD
- DoD Instruction 5000.60, Defense Industrial Capabilities Assessments
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Instruction 5000.73, Cost Analysis Guidance and Procedures
- DoD Directive 5105.84, Director of Cost Assessment and Program Evaluation
- DoD Directive 4200.15, Manufacturing Technology (ManTech) Program
- DoD Directive 4400.01E, Defense Production Act Programs
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures

Defense Acquisition University (DAU) www.dau.edu

- DAU Guidebooks and References https://aaf.dau.edu/guidebooks/
- Acquisition Notes (AcqNotes) www.acqnotes.com
- Adaptive Acquisition Framework (AAF) https://aaf.dau.edu
- Analysis of Alternatives (AoA) www.acqnote/acquisitions/analsis-of-alternatives
- Market Research www.acqnotes/acqnote/acquisitions/market-research
- Acquisition Strategy (AS) Process/Guidance https://ac.cto.mil/wp-content/uploads/2019/06/PDUSD-Approved-TDS_AS_Outline-04-20-2011.pdf
- Systems Engineering Plan (SEP) Outline https://ac.cto.mil/erpo/ (Engineering Guidance tab)
- DoD Risk, Issue, and Opportunity (RIO) Management Guide for Defense Acquisition Programs https://ac.cto.mil/wp-content/uploads/2019/06/2017-RIO.pdf
- Logistics Assessment Guidebook www.dau.edu/tools/t/logistics-assessment-guidebook

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

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

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

- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS Subpart 242.7200, Contractor Material Management and Accounting

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

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

Federal Acquisition Regulation (FAR) https://www.acquisition.gov/

Manufacturing Readiness Levels (MRLs) www.dodmrl.org

- MRL Assessment Criteria Matrix www.dodmrl.org
- Interactive MRL Users Guide (MRL Assessment Criteria) www.dodmrl.org
- MRL Deskbook www.dodmrl.org
- MIL-HDBK-896, Manufacturing Management Program Guide www.dodmrl.org

National Institute of Standards and Technology (NIST) www.nist.gov

- NIST 800-82, Guide to Industrial Control Systems (ICS) Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST Manufacturing https://www.manufacturing.gov

Office of the Director, Cost Assessment and Program Evaluation (CAPE) www.cape.osd.mil

OSD Manufacturing Technology (ManTech) Program Office https://www.dodmantech.mil

OUSD(R&E) Systems Engineering and Architecture (SE&A) https://ac.cto.mil/engineering

Relevant Government Publications (Available via Web/Internet Search)

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

Standards, Specifications, and Standards Organizations

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

Technology Readiness Levels (TRLs)

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

3. Technology Maturation and Risk Reduction

Introduction

The purpose of the Technology Maturation and Risk Reduction (TMRR) phase is to reduce technology, engineering, integration, and life cycle cost risk to the point that a decision to contract for Engineering and Manufacturing Development (EMD) can be made with confidence in successful program execution for development, production, and sustainment.

TMRR includes a mix of activities intended to reduce the risks associated with the product to be developed. This includes design and requirements trades, maturation and validation of capability requirements, and finalization of affordability caps. The phase normally includes competing sources conducting technology maturation and risk reduction activities. The phase also includes preliminary design activities, including a Preliminary Design Review (PDR), leading to source selection for the EMD phase.

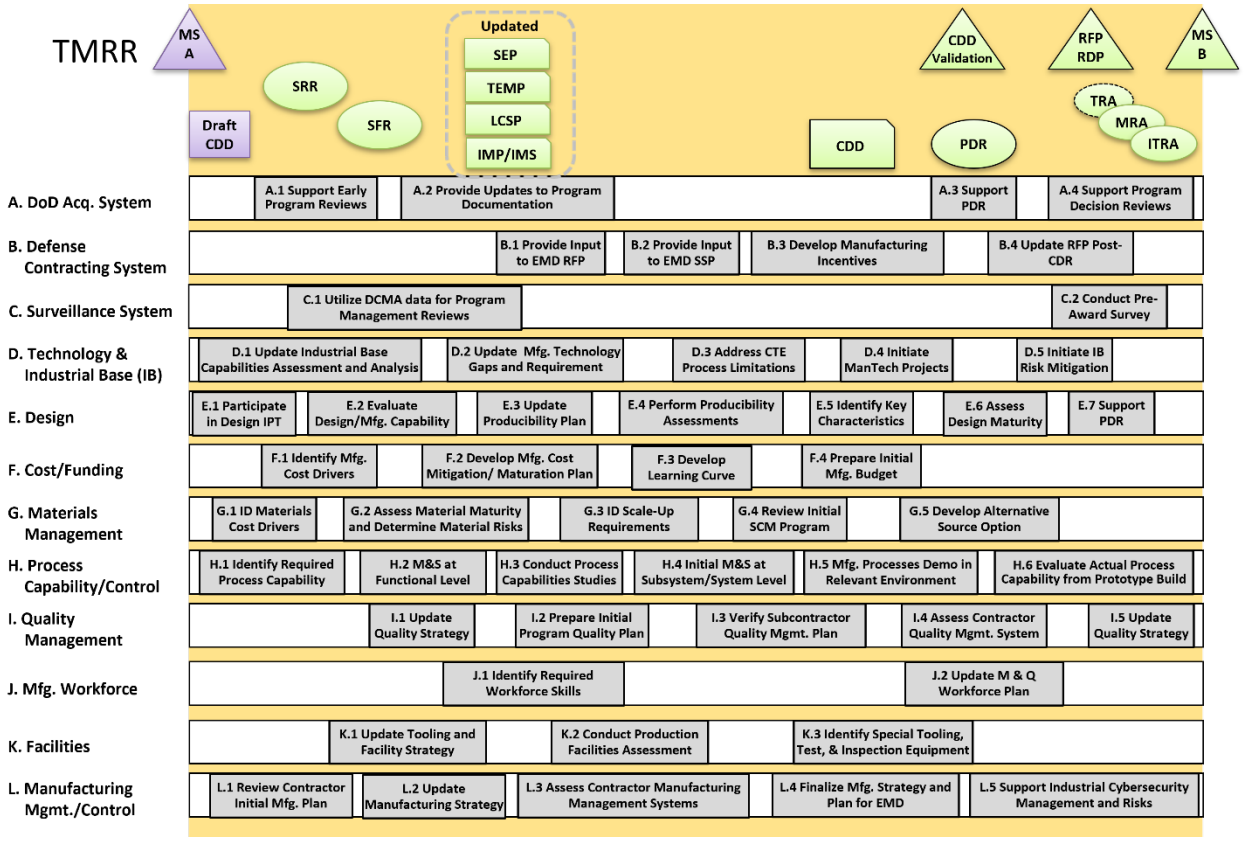


Figure 3-1. TMRR Phase Manufacturing and Quality Activities

The program can exit TMRR when an affordable program or increment of militarily useful capability has been identified, the technology and manufacturing processes for that program or increment have been assessed and demonstrated in a relevant environment and found to be sufficiently mature,

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manufacturing risks have been identified and assessed, and a system or increment can be developed for production within a short time frame.

Key program phase reviews and documentation include:

- System Requirements Review (SRR)
- System Functional Review (SFR)
- Program Documentation
    - Acquisition Strategy (AS)
    - Systems Engineering Plan (SEP)
    - Test and Evaluation Master Plan (TEMP)
    - Capability Development Document (CDD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)
- Preliminary Design Review (PDR)
- Manufacturing Readiness Assessment (MRA)
- Independent Technical Risk Assessment (ITRA)
- CDD Validation
- Milestone B (MS B) Decision

Adaptive Acquisition Framework Pathway (Rapid Prototyping)

Under DoDI 5000.02, Operation of the Adaptive Acquisition Pathway, the objective of the Middle Tier of Acquisition (MTA) Rapid Prototyping pathway is to field a prototype to meet defined requirements that can be demonstrated in an operational environment and provide for a residual operational capability within 5 years of the MTA program start date.

Rapid prototyping can be considered an advanced version of TMRR in which the prototype system must be fielded within 5 years, thus the manufacturing processes used to implement the final system configuration must be significantly mature based on acceptable program risk. As a best practice, manufacturing maturity should start at no lower than and MRL 4 and should achieve MRL 7 before demonstrating in an operational environment. Critical manufacturing processes must be matured sufficiently to support fielding.

When a Rapid Prototyping option is chosen, the usual TMRR phase requirements may be truncated and a tailored program initiated. M&Q personnel need to be able to support risk assessments with a Manufacturing Readiness Assessment (MRA) and PRR before entering production.

Manufacturing and Quality Objectives

Manufacturing and quality (M&Q) risks, issues, and opportunities are the most important factors in making the decision to proceed within all phases of development and production. The producibility of

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the design and risks are reviewed prior to the EMD phase. The TMRR phase requires assessments of the industrial base (IB) and of the contractor(s) selected.

Programs need to specifically assess the capabilities of the industrial base to understand if the base can support their program. Multiple technology development demonstrations may be required before the operational user and the contractor can substantiate that the solution is feasible, affordable, and supportable; satisfies capability requirements; and has acceptable risks.

By the end of the TMRR phase, M&Q processes will be assessed and demonstrated to the extent needed to verify that risks have been reduced to an acceptable level. Some of the mitigations may involve investments in industrial base capabilities (i.e., Title III) as well as investments in advanced manufacturing capabilities (i.e., ManTech).

Program management is responsible for implementing effective risk, issue, and opportunity management and tracking to include the identification of all known risks, key assumptions, probability of occurrence, consequences of occurrence (in terms of cost, schedule, and performance) if not managed, analysis of risk handling options, decisions about actions to mitigate risk, and execution of those actions. M&Q personnel are responsible for identification, prioritization, and mitigation of M&Q risks and issues. The identification of risks often occurs during the various technical reviews and audits conducted during this phase to include the Independent Technical Risk Assessment (ITRA).

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

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

M&Q personnel participation in and support to program design IPTs are critical to success in producing a manufacturable and affordable system with acceptable risks. In TMRR, costs need to be defined and finalized to include identified M&Q cost drivers based on contractor-proposed materials and processes, producibility costs, required investments.

M&Q personnel should analyze the contractor's processes, materials, make/buy processes (hardware and software), and supply chain for capability and completeness, and identification of single points of failure for mitigation. Process capability and control should be an integral part of any development

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program and lead to a producible system with effective and efficient manufacturing processes. Workforce skills identification and plans should provide inputs to program planning and should identify the skills required for the scope of the technical effort needed to develop, field, and sustain the system. Also, M&Q personnel should conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases.

During the TMRR phase the contractor will produce prototypes that will be used during tests to validate that the design meets requirements. These prototypes will be built in a relevant manufacturing environment, meaning that there are some elements of production realism present on the manufacturing line. To the extent practicable, M&Q personnel will assess the processes used for prototype build and evaluate the tests and demonstrations to better understand the issues that will need to be resolved during the EMD phase.

Contractors must have an effective combination of people and systems to plan for, monitor, and control M&Q resources. A well-structured manufacturing management system employs the use of industry best practices. A Quality Management System (QMS) compliant with industry best practices is the foundation for the contractor to deliver a system that meets requirements. The contractor should assess its manufacturing management and quality systems against the recognized industry best practices such as AS6500, ISO 9000, AS9100, etc.

The initial M&Q strategies should have been developed during the Materiel Solution Analysis (MSA) phase. During the TMRR phase, an effective joint government/contractor manufacturing strategy and quality strategy are required if the program is to reduce risks and mature and deliver a design for an operationally safe, suitable, and effective weapon system. In addition, the program and the contractor should develop joint government/contractor M&Q plans that execute the strategy for EMD.

A. DOD ACQUISITION SYSTEM

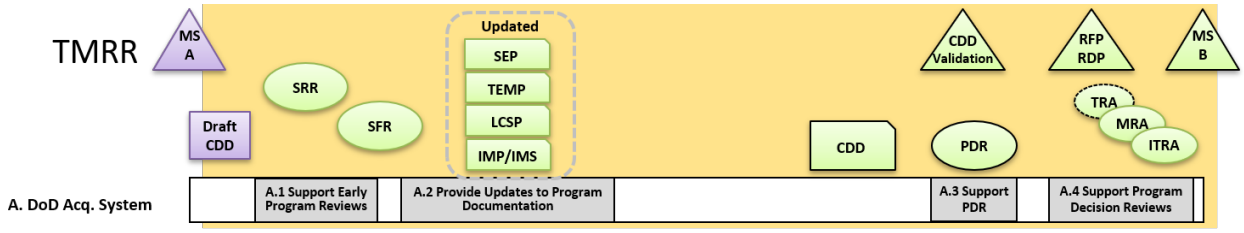

Figure 3-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

The acquisition process includes a series of processes, milestones (five phases), and reviews to determine whether a program will proceed into the next phase. Major Defense Acquisition Programs (MDAPs) and major systems with production requirements should address industrial and

manufacturing readiness in the Acquisition Strategy, during milestone reviews, and in program documentation.

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

- Analysis of Alternatives (AoA)
- User Requirements
- Acquisition Strategy
- Program Documentation
- Program Support
- Milestone Decisions

The TMRR phase objective is to develop designs, demonstrate competitive sources, and prototype designs to reduce technical risk, validate designs and cost estimates, evaluate manufacturing processes, and refine requirements. It focuses on maturing, prototyping, and demonstrating technologies in a relevant environment, resulting in a preferred system concept that achieves acceptable low-risk entry into the EMD phase.

Effective employment of systems engineering will reduce program risk. The program monitors progress with technical reviews to reduce program risk, identify potential management issues in a timely manner, and support key program decisions. M&Q managers should be making significant inputs into these activities and reviews. Early program reviews include the System Requirements Review (SRR) and the System Functional Review (SFR). The SRR helps ensure that the understanding of top-level system requirements is adequate to support further requirements analysis and design activities, and that the system can proceed into initial system design with acceptable risk. The SFR helps ensure that the system under review can proceed into preliminary design with acceptable risk and that all system requirements and functional performance requirements derived from the approved preliminary system specification are defined and are consistent with the program budget, program schedule, risk, and other program and system constraints.

The Acquisition Strategy developed for the Milestone A (MS A) decision should have addressed the following program objectives:

- The program will use industry best practices for manufacturing, quality, and systems engineering management.
- The likely outcome is worth the investment in both resources (real costs) and schedule (opportunity costs).
- The end item meets required performance objectives.
- All risks, issues, and opportunities are identified, managed, and mitigated to an acceptable level.
- The business strategy effectively executes the program.

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In the TMRR phase, the updated Acquisition Strategy describes the overall approach to acquiring the capability to include the program schedule, risks, funding, and the business strategy.

The pre-Milestone A initial M&Q strategies, as an integral part of the Acquisition Strategy, should include considerations of:

- Competition
- New manufacturing technologies
- Production rates and quantities
- Materials sourcing
- Contracting strategies

For TMRR, the updated M&Q strategies are a subset of the program Acquisition Strategy and will include these same considerations. Competition is a major contributor to reducing weapon system cost. If the program will be dual sourced, the early planning must consider the strategy required to ensure availability of capability and data and data rights for dual sourcing. New manufacturing technologies, if required by the system concept, will require specific plans for development, proofing, and transition of the technology to the eventual producer. This effort will necessitate close coordination with the Service manufacturing technology (ManTech) organization to ensure compatibility of the technology development schedule with the system development schedule. Production rates and quantities also play a major role in driving manufacturing cost as they will drive decisions on what production processes to use, types of tooling required, make-buy decisions, etc.

The Acquisition Strategy provides a master schedule for research, development, test, and production. M&Q considerations for the strategy should include establishing feasibility, assessing risks, identifying capable manufacturers and suppliers, manufacturing technology maturation, capabilities of the industrial base, availability of critical materials, and the transition from development to production. The Acquisition Strategy and the included M&Q strategies summarize how the industrial and manufacturing risk will be addressed in the TMRR phase to ensure that manufacturing maturity is appropriate to enter EMD, particularly for new or high-risk manufacturing endeavors.

The SEP implements the technical development and engineering aspects of the Acquisition Strategy. The Pre-Milestone A SEP requires updates based on contract award to reflect any changes due to the contractor's technical approach and details not available prior to contract award. Effective employment of systems engineering with competitive prototyping, as applied through the SEP, and monitored with meaningful technical reviews, will reduce program risk, identify potential management issues in a timely manner, and support key program decisions. M&Q managers should be making significant inputs into these documents and activities. In addition, M&Q personnel should provide an M&Q capability assessment update for the SEP during TMRR. They should assess M&Q risks for each competing prototype during TMRR and verify risks have been reduced to an acceptable level. Individual risks should be identified and integrated into a cumulative assessment of the production, manufacturing, and quality risks, issues, and opportunities.

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As the program matures, it is important to mature the requisite manufacturing requirements and processes needed to build prototypes and production items. The SEP ensures this by providing, updating, and planning for:

- Conducting producibility analyses with consideration of the life cycle costs of proposed manufacturing, assembly, and test processes.
- Significant activities (i.e., manufacturing assessments, long-lead or advanced procurements, prototype builds, production lots/phases, and Production Readiness Review (PRR) indicated on program schedule).
- Industrial, manufacturing, production, engineering, software, firmware, and quality risks and issues, and reduction efforts, as well as opportunities.
- M&Q organization, billets, and Production, Quality, and Manufacturing (PQM) Key Leadership Positions (KLPs).
- M&Q Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics).
- Planned activities for the next phase.

Additional considerations for the Acquisition Strategy and the SEP, based on assessments of the contractor's cybersecurity plans, are M&Q inputs for cybersecurity that include technical risks, processes, industrial control systems, M&Q resources and organizations, and design considerations. The updated program M&Q strategies also should include appropriate agreements, delegations, and contracts with other agencies (e.g., Defense Contract Management Agency (DCMA), Defense Logistics Agency (DLA), etc.).

Outputs of the SRR, SFR, and PDR will create the need for substantive updates and changes to the SEP. This phase normally includes competitive sources conducting TMRR activities and preliminary design activities up to and including a PDR in advance of source selection for the EMD phase. A final revision and re-submission will be required for approval before the Development Request for Proposal Release Decision (RFP RD) and Milestone B.

The role of M&Q in the TMRR phase is to influence the design. This is critical because of the impact of design decisions on Life Cycle Cost (LCC). Studies have shown that by the time a PDR is held approximately 80 percent of the program's LCC is determined, even though only a small percentage of the program's cumulative costs have been expended (source: DoD O&S Cost Management Guidebook, Figure 4). TMRR is also the time when a program or contractor has the most opportunity to impact life cycle cost savings.

The PDR is a technical assessment establishing the allocated baseline to ensure that the system under review has a reasonable expectation of being judged operationally effective and suitable and has a reasonable expectation of satisfying the requirements within the currently allocated budget and schedule. A successful PDR includes an assessment of the producibility of the design and an assessment of manufacturing costs and risks.

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During this phase and timed to support CDD validation (or its equivalent), M&Q will provide support to the Program Manager's conduct of systems engineering trade-off analyses showing how cost and capability vary as a function of the major design parameters. The analyses will support the assessment of refined Key Performance Parameters (KPPs) and Key System Attributes (KSAs) in the CDD. Capability requirements proposed in the CDD (or equivalent requirements document) should be consistent with program affordability goals.

In support of program decision reviews, Development RFP RD, and Milestone B, M&Q will have conducted additional requirements analyses and demonstrations including requirements decomposition and allocation, definition of internal and external interfaces, design activities, and prototypes and process demonstrations that led to a PDR. Milestone B requires final demonstration that all sources of risk have been mitigated to support a commitment to design for production. This includes technology, engineering, integration, manufacturing, sustainment, and cost risks. In addition, pursuant to the NDAA for FY 2017, Sec. 807, before any decision to grant Milestone B approval for the program (pursuant to section 2366b), M&Q personnel are required to identify manufacturing processes that have not been successfully demonstrated in a relevant environment.

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

10 USC 2448b requires that ITRAs be conducted in support of milestone and production decisions for MDAPs. ITRAs will be conducted for all MDAPs before Milestone A, Milestone B, and Milestone C approval and before a Full-Rate Production 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), 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 (TRLs), and the ITRA team's assessment.

A.1 Support Early Technical Reviews

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

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

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

Manufacturing and Quality Tasks

- Provide M&Q support to various Technical Reviews to include:
    - System Requirements Review (SRR)
    - System Functional Review (SFR)
    - Preliminary Design Review (PDR)
    - Manufacturing Readiness Assessment (MRA)
    - Independent Technical Risk Assessment (ITRA)
    - Technical Readiness Assessments (TRAs)
    - Independent Logistics Assessment (ILA)
- Support to the program's overall risk, issue, and opportunity management processes (e.g., industrial base, manufacturing technology gaps, quality, software, and engineering-related risks and issues, etc.).
- Identify program workforce requirements for program organization, billets, and PQM Key Leadership Positions.
- Identify M&Q program requirements (e.g., AS6500, ISO 9000, AS9100, IEEE 15288, etc.) to program management to be used in assessing the contractor's plans to meet program cost, schedule, and performance requirements throughout the product life cycle (*See* I.1 and L.1).
    - Ensure the program and contractor have a joint understanding of the system M&Q requirements and performance that are:
        - Consistent with the preferred materiel solution
        - Consistent with M&Q budget, schedule, risk, user, and other specific constraints
        - Feasible given available manufacturing technologies for the preferred system solution
        - Adequate and consider the maturity of interdependent system elements
        - Bidirectional with traceability to the set of source documents (e.g., Key Characteristics (KC) to KPPs)
        - Verifiable with defined and agreed-upon methods
        - Consistent with program's objectives (with manageable risk
- Technical reviews should address the following areas:
    - Provide M&Q requirements that are sufficiently detailed and understood that enable M&Q functional definitions and functional decompositions
    - Assess M&Q feasibility of the contractor(s)' proposed (traceable to the AoA results):
        - External interface requirements
        - Alternative and/or competitive architectural concepts

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- Operational and life cycle sustainment requirements

- Provide M&Q requirements in support of:
  - Human safety and health
  - Hazardous materials (HAZMAT) management and pollution prevention
  - Environmental management (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security (physical and cyber) for both hardware and software
  - KPPs and KCs
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
  - Supportability and sustainment
  - Use of commercial off-the-shelf (COTS), government off-the-shelf (GOTS), and government-furnished equipment (GFE) (including diminishing manufacturing sources)
  - Parts, materials, and processes
- Provide M&Q analyses of requirements that could impact manufacturing feasibility for:
  - System human systems integration/interface requirements
  - System safety requirements
  - System command, control, communication, computer, and intelligence (C4I) requirements
  - System security requirements (e.g., communications, cyber, program protection, anti-tamper, etc.)
  - KPPs (e.g., mandatory, and other)
  - Interoperability requirements
  - Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) requirements
  - Product assurance
  - Specialized manufacturing requirements (extreme complexity, multiple or very tight tolerances, precision assembly, handling of fragile components, etc.)
- Assess and analyze the completeness and adequacy of M&Q requirements for:
  - Contractor's plans for processes and metrics included in the System Engineering Management Plan (SEMP)
  - Contractor's budget and schedule plans including identification of cost and schedule drivers (with impacts on the critical path)
  - Contractor's software development strategy and development plans (to include functionality, adequacy, testing, etc.)
  - Technology maturation plans
  - Developmental Test and Evaluation (DT&E) approaches

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        - Development, qualification, and acceptance testing approaches including consideration for non-developmental items (NDI), COTS, and reuse items
        - Modeling and Simulation plans to include design, production, processes, costing, etc.
    - Provide M&Q strategies input to:
        - The joint program/contractor risk, issue, and opportunity management system including hazards, technologies, sources of supply, etc., and mitigating courses of action
        - The joint program/contractor configuration management system
        - The joint program/contractor Integrated Master Plan/Integrated Master Schedule
        - The Cost Analysis Requirements Description (CARD) for M&Q should-cost inputs (*See* F.1)

- Provide M&Q analyses and support to the program and systems engineering functions by:
    - Conducting manufacturing feasibility analyses including cost and schedule
    - Providing M&Q requirements mapped to the hardware and software functional baseline
    - Providing traceability of M&Q requirements to the draft Capability Development Document (CDD)
    - Providing results of Industrial Base Assessments
    - Conducting assessments of risks, issues, and opportunities and associated mitigation planning
    - M&Q inputs to the program PDR planning to include sustainment and life cycle planning
    - Providing analysis of the contractor's SEMP
    - Providing inputs to the detailed plan and schedule with inputs on sufficient resources to continue design and development (i.e., Integrated Master Plan (IMP) and Integrated Master Schedule (IMS)
    - Providing results of assessments of contractor(s) and supply chain capability to mature the proposed design(s) within the program overall cost, schedule, and performance goals (*See* E.2)
    - Providing results of M&Q design producibility analyses (*See* E.2)
    - Conducting analyses of materials availability, maturity, and characterization (*See* G.2)
    - Conducting assessments and providing estimates of process maturity and capability for manufacturing and production processes (*See* H.1)
    - Assessing contractor initial Manufacturing Plans for workforce requirements, skills, capabilities, training, and certifications (including for prototypes and system development) (*See* J.1)
    - Providing analyses of the contractor's tooling and facilities strategies (*See* K.1)
    - Assessing the contractor's Manufacturing Management System and plans (*See* L.1)

Tools

- Army Acquisition Logistician's Assessment Checklist

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- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Independent Technical Risk Assessments (ITRAs) Execution Guidance
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide Checklist
- ISO 9001 Quality Management System Checklist
- Manufacturing Maturation Plan
- MCSC Independent Logistics Assessment Checklist
- NAVSO P-3690, Acquisition Logistics: An Assessment Tool
- Preliminary Design Review (PDR) Checklist
- Risk Assessment Tool
- System Functional Review (SFR) Checklist
- System Requirements Review (SRR) Checklist
- Systems Engineering Plan (SEP) Outline
- Technical Readiness Assessments (TRAs) Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits, specifically 12.5.3 System Requirements Review (SRR), 12.5.4 and System Functional Review (SFR)
- Defense Technical Risk Assessment Methodology (DTRAM)
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoD 5000.60-H, DoD Handbook: Assessing Defense Industrial Capabilities
- DoD HCI Style Guide, Human Computer Interaction (HCI)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.84, Analysis of Alternatives
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Guide to Environment, Safety, and Occupational Health (ESOH) in the Systems Engineering Plan (SEP)
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs

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- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Independent Logistics Assessment Guidebook
- 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-896, Manufacturing Management Program Guide
- MIL-STD-1472, DoD Design Criteria Standard: Human Engineering
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- NIST 800-171, Controls for Controlled Unclassified information
- Systems Engineering Plan (SEP) Outline
- Systems Engineering Plan Preparation Guide
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

A.2 Provide Manufacturing and Quality Updates to Program Documentation

M&Q personnel need to 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 Evaluation Master Plan (TEMP)
- Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
- Life Cycle Sustainment Plan (LCSP)
- Capability Development Document (CDD)
- Requests for Proposals (RFP)
- Source Selection Plans (SSP)

Per DoDI 5000.88, programs are required to develop a Systems Engineering Plan (SEP) for Milestone Decision Authority (MDA) approval in conjunction with each milestone review and integrated with the Acquisition Strategy. The SEP must describe the program's overall technical approach, including processes, resources, metrics, and applicable performance incentives. It must detail the timing, conduct, and success criteria of technical reviews.

Manufacturing and Quality Tasks

- Update the Manufacturing Strategy and Quality Strategies based on the results, action items, and resolutions pertaining to M&Q requirements and concerns from the SRR and the SFR, to address development and considerations of:
    - Competition and contracting strategies
    - Management (quality, manufacturing, supply chain, risks, etc.)
    - Design (feasibility, producibility, KCs, risks, etc.)
    - New manufacturing technologies
    - Modular Open Systems Approach (MOSA)
    - Intellectual Property rights (including deliverables and associated license rights over the entire product life cycle)
    - Materials (characteristics, sourcing, risks, etc.)
    - Cyber threat protection measures (*See* L.2)
    - Integrated Product Support Plan
    - Process, rates, and quantities (capabilities, control, risks, etc.) (*See* H.1)
    - Facilities, Tooling, and Workforce (including GFE/GFI, STE/SIE, special requirements, etc.)
- Provide M&Q support for the development of Quality Strategies with detailed M&Q requirements for:
    - Rates, quantities, and schedule (including reference to Economic Order Quantity and the affordability targets)
    - Manufacturing maturity and progress against M&Q goals required for each technical review (SRRs, PDRs, Critical Design Reviews (CDRs), and at other appropriate reviews)
    - 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 parameters (physical and cyber) for both hardware and software
    - KPPs (i.e., KCs)
    - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
    - Supportability and sustainment
    - Use of priorities, allocations, and allotments, and justification
    - Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
    - Parts, materials, and processes (PM&P)
- Update the Manufacturing Strategy and Quality Strategy to address the sustainment of industrial capabilities (including manufacturing technologies and capabilities) and the maturation required during the EMD and subsequent phases.

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  - Provide M&Q inputs on product or component obsolescence (known and/or projected), use and replacement of limited-life items, options for unique manufacturing processes and products (avoidance or regeneration), and the capability to convert off-the-shelf items to required specifications at the subsystem, item, and component levels.
  - Provide M&Q inputs on products or components (known and/or projected) from sole, single, fragile, or foreign sources including options for:
    - Domestic alternatives through regeneration of prior capability
    - Creation of new capability for manufacturing products and processes
    - Lifetime buy of items at the subsystems, and component levels

- Incorporate planning for new or high-risk manufacturing capabilities and processes Manufacturing Technology (ManTech) in the Manufacturing Strategy that addresses risks, issues, and opportunities in the EMD phase. (*See* D.2)
  - If this new manufacturing capability can be demonstrated in TMRR phase in a relevant manufacturing environment, specify this demonstration in the plans
  - Include insertion of the new manufacturing capability in planning for EMD
- Initiate the M&Q Industrial Base (IB) capability analyses updates for inclusion in the Acquisition Strategy and the RFP to include inputs on:
  - IB capabilities, fragility, gaps, and risks for the Acquisition Strategy (e.g., key technologies and key and critical processes, parts, components, etc.)
  - Capability of the IB to design, develop, produce, support, and restart the acquisition program, if appropriate
  - Impacts and interdependencies of this acquisition on the National Technology Industrial Base (NTIB) and the analyses used to make this determination
    - Include how they will be managed
    - Include plans for future assessments, including frequency
  - Government strategy and actions necessary to preserve the IB capabilities (e.g., incentives for the contractor to support IB capability preservation, ManTech/Title III initiatives, etc.)
- Provide M&Q inputs to Acquisition Strategy for a contracting strategy that supports selection of the best course of action through either a competitive award, a sole source award, or multiple source development to include:
  - M&Q metrics to differentiate the value of each contract type to include performance, capability, capacity, affordability, etc.
  - Impacts and risks, issues, and opportunities that may result from different contract types (Firm Fixed Price (FFP), Fixed Price Incentive Fee (FPIF), Cost Plus Fixed Fee (CPFF), etc.)

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  - Prototyping approach for EMD, either competitive, single, or prototyping of critical subsystems (statutory requirement for MDAP AS, regulatory requirement for all other programs)
  - Potential production approach for EMD and subsequent phases

- Update M&Q inputs to the Acquisition Strategy for EMD with a source selection approach that establishes and maintains access to competitive suppliers at the system, subsystem, and component level (e.g., requiring a modular open systems approach, alternative sources of supplies or services, etc.).
- Provide updated M&Q requirements as inputs for required technical reviews, production decisions, events, prototypes, and deliveries, including sub-tier subsystem, item, and components, to be included in the Acquisition Strategy based on:
  - Reports and data from DCMA
  - Analyses materials availability (lead-time and scale-up) and maturity (characterization)
  - Contractor data on rates and yields for M&Q
  - Analyses of M&Q maturity and projections
  - Reports on facilities, tooling, and workforce utilization
  - Updated capital equipment requirements
- Provide updated M&Q inputs and plans to the IMP/IMS including:
  - Schedule for any planned use of government-furnished special test equipment (STE), government facilities/ranges, unique tooling, or other similar requirements (specific M&S, communications, restricted environment, etc.).
  - Schedule impacts from the requirements for special materials and allotments, and the reasons for them if applicable
  - M&Q internal and external interdependencies and integration with existing programs, systems, and other programs in development that potentially impact the critical path
  - Inputs on reviews down to the sub-tier level (including PDR, CDR, PRR, etc.), documentation inputs (e.g., draft CDD, TEMP, AS, SEP, PDR, etc.), production events, and deliveries
- Update the government Manufacturing Management and Quality Management approach for EMD to include: (*See* I.1 and L.2)
  - Changes in M&Q requirements
  - M&Q resource management (minimizing cost, schedule, and performance risks for the product life cycle)
  - Potential changes to M&Q organization and staffing with Key Leadership Positions (KLP) and necessary skilled manpower
  - Changes to M&Q support organization required to meet program projected needs for EMD and subsequent phases including:
    - Earned Value Management requirements

    - Cost control requirements
    - Data collection, reporting, and management

- Update the M&Q requirements for the EMD contractor's Manufacturing Management System (MMS) and Quality Management System (QMS).
    - Specify the standards to be used to promote industry best practices (e.g., AS6500, ISO 9000, AS9100, IEEE 15288.0, -.1, -.2, etc.)
    - If M&Q standards are not specified, develop requirements for program specific manufacturing management plan and quality management plan.
    - Identify M&Q opportunities, initiatives, and systems that will contribute to minimizing cost, schedule, and performance risks throughout the product life cycle
- Update requirements for identification, analysis, mitigation, tracking, and control of M&Q risks, issues, and opportunities that impact performance, technical, cost, schedule, sustainment, and programmatic areas throughout the life of the program.
    - Ensure a joint M&Q comprehensive Risk, Issue, and Opportunity Management Process that can identify, and tracking risks and associated mitigation plans is in place
- Analyze identified M&Q risks, issues, and opportunities, and associated mitigation plans for adequacy and completeness, and potential impacts on EMD and subsequent phases to include:
    - Risk of industry being unable to provide program design or manufacturing capabilities at planned cost and schedule
    - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software and engineering related risks, issues etc.
    - Required maturation of critical technologies and manufacturing processes to the appropriate level
    - M&Q cost and schedule impacts
- Update M&Q exit criteria metrics for TMRR and subsequent phase decision points.
    - Metrics should include current and projected M&Q maturity of identified critical technologies and manufacturing processes
    - Metrics should also include the planned Manufacturing Readiness Level (MRL) targets for system, subsystems, components, and items
- Update the M&Q support plan for an assessment of manufacturing readiness and the mandated independent assessment.
- Ensure other agencies are providing inputs on strategies (e.g., DCMA, Defense Logistics Agency (DLA), etc.) for quality, manufacturing, production, engineering, software development, configuration management, testing, and quality.
- Ensure M&Q updated inputs to the SEP and TEMP include the following:

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- M&Q updates and impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
- Planned significant activities indicated on the updated EMD program schedule
  - Manufacturing assessments
  - Long-lead or advanced procurements
  - Prototype builds
  - Projected lots or phases
  - Production Readiness Review
- Updated inputs to the program Risk, Issue, and Opportunity Management process and plans that include:
  - Industrial risks
  - Manufacturing risks
  - Quality risks
  - Engineering risks
  - Software risks
  - Production risks
  - Risk reduction and mitigation efforts
- Updated Program Manufacturing Management Plan addressing software development and reuse.
- Updated M&Q inputs from assessment of the contractor's management of and processes for Safeguarding Covered Defense Information and Cyber Incident Reporting including:
  - Compliance with Defense Federal Acquisition Regulation Supplement (DFARS), Program Protection Plan (PPP), International Trafficking in Arms Regulation (ITAR), etc.
  - Management of Controlled Unclassified Information
  - Technical approaches to cybersecurity and related M&Q security, including suppliers, risks, processes, industrial control systems, resources, metrics, and design considerations
- Updated Program Manufacturing Management Plan addressing each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
  - Manufacturing Risk Identification (including mitigation)
  - Manufacturing Planning
  - Manufacturing Operations Management
- Updated inputs on the M&Q organization, billets and key assignments including

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        - Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
    - Updated M&Q planning for assessments to be conducted; metrics to be tracked; progress against goals, thresholds, and objectives; entry and exit criteria for technical reviews; design considerations; etc.
    - Updated M&Q inputs to the configuration managed IMP/IMS including critical path

Tools

- Acquisition Strategy Outline
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- CDD Template
- ISO 9001, Quality Management System Checklist
- Interactive MRL Users Guide Checklist
- Life Cycle Sustainment Plan
- Manufacturing Maturation Plan
- Technology Readiness Level (TRL) Assessment Checklist
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Integrated Master Plan/Integrated Master Schedule use MS Project
- Risk Management Plan Template
- Systems Engineering Plan Outline
    - Manufacturing Management Plan
    - Quality Assurance Management Plan
- TEMP Outline

Resources

- Acquisition Strategy Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- CDD Writing Guide
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting

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- DoD 5000.60-H DoD Handbook: Assessing Defense Industrial Capabilities subpart 207.106 (S-70) of the Defense Federal Acquisition Regulation Supplement
- DoDD 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89 Test and Evaluation
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- ISO 9001:2015, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- NIST 800-171, June 2015, Controls for Controlled Unclassified Information
- RFP Proposal Evaluation Guide
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide

A.3 Support Preliminary Design Review

M&Q personnel should be actively engaged in the organization and execution of the Preliminary Design Review (PDR) during this phase. The PDR is an assessment that establishes the Allocated Baseline of the system and is used to ensure that the system has a reasonable expectation of meeting the current requirements within the given cost and schedule. The completion of the PDR should provide:

- An established system allocated baseline
- An updated risk assessment for the EMD phase
- An updated CARD based on the allocated baseline
- An updated program schedule including system and software critical path drivers
- An approved Life Cycle Sustainment Plan

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Manufacturing and Quality Tasks

- Ensure all M&Q system-level requirements, base-lined at the SRR and the SFR have been correctly decomposed or directly allocated to the appropriate subsystem, item, or component.
- Provide M&Q system, subsystem, item, and component requirements and inputs for the verification and validation entry/exit criteria required for the PDR process.
- Provide M&Q support to system (product), subsystem, item, and component design trades to finalize system requirements and configuration.
- Provide an M&Q assessment of the preliminary system-level design and margins for producibility and costs within the production budget.
- Assess all system (product), subsystem, item, and component physical and functional interfaces and architecture for M&Q feasibility and producibility (e.g., inspectability, manufacturability, etc.)
    - Include analyses of prototypes
- Assess the design for M&Q constraints and ensure they have been captured and incorporated into the allocated requirements.
- Provide M&Q support for the analyses to identify all preliminary key and critical M&Q processes and characteristics to show traceability to system-level requirements and technical performance measures (e.g., KPPs, KSAs, TPMs) using Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA) and similar analyses for design (DFMEA) and process (PFMEA).
    - Ensure all the preliminary key and critical M&Q processes are defined and traceable to Critical Safety Items (CSI)and/or Critical Application Items (CAIs)
    - Identify initial process capability indexes for key and critical manufacturing processes
    - Analyze the contractor's identified major/critical sub-tier suppliers for their impact on or responsibility for KCs (and therefore KPPs/KSAs)
- Assess the preliminary system design for impacts on requirements to M&Q design, processes, and procedures, including:
    - Incomplete specifications of subsystem, items, and components (i.e., TBDs)
    - Change to subsystem, items, and components from re-design based on testing deficiencies or failures
    - Results and data from building and testing prototypes
    - Incorporation of Parts, Materials, and Processes allocated requirements
    - Requirements for computer system Hardware Configuration Items (HWCIs)
    - Analyses of mass properties including growth
    - MOSA requirements
    - Tooling design, testing, and schedule (including special tooling and test equipment)
    - Security physical and cyber (e.g., processes, industrial control systems, anti-tamper requirements, manufacturing resources and organization, etc.)

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  - Requirements for processes and procedures to control and mitigate EMI
  - Human Machine Interface requirements
  - ESOH requirements
  - System safety requirements
  - HAZMAT and environmental controls (e.g., handling, contamination, pollution control, disposal, etc.)
  - Supportability and maintainability requirements

- Provide an assessment of requirements for M&Q data and data storage including:
  - Analyses and post processing
  - Availability, integrity, and maintainability
  - Communications and processing capacity
  - User integrity
- Provide M&Q analyses of the Software Development Plan for physical architectures, firmware integration, and physical interfaces that impact M&Q processes, procedures, and schedule.
- Provide an assessment of long-lead materials and production requirements (e.g., components, facilities, equipment, etc.).
- Provide an updated analysis of M&Q inputs to the TEMP include the following:
  - M&Q updates and impacts on all KPPs including the mandatory KPPs (Force Protection, System Survivability, Sustainment, and Energy)
  - Planned significant activities indicated on the updated EMD program schedule (e.g., manufacturing assessments, long-lead or advanced procurements, prototype builds, projected lots, or phases, PRRs, etc.)
  - Updated inputs to the program Risk, Issue, and Opportunity Management System and plans including industrial, manufacturing and production, quality, engineering, software (firmware), and risk reduction and/or mitigation efforts
  - Results of prototype builds, demonstrations, and tests and associated data
  - Updated M&Q inputs from the contractor's management of defense information and Cyber Incident Reporting, compliance with DFARS, PPP, ITAR, etc.
  - Updated planning for M&Q tests and assessments to be conducted, facilities and test equipment to be used, metrics to be tracked, progress against goals, thresholds, and objectives, etc.
- Provide an updated assessment and analysis of the M&Q processes and metrics included in the contractor's SEMP for completeness, adequacy, and alignment with those processes and metrics included in the program SEP, including:
  - Integration of any lower-level technical reviews and audits such as SFRs, PDRs, CDRs, Physical Configuration Audits (PCAs), Functional Configuration Audits (FCAs), and/or PRRs

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  - Identified risks and issues to be incorporated into mitigation and/or action plans
  - Contractor's plan to CDR

- Provide an updated assessment of program and contractor M&Q workforce plans and requirements for adequacy and completeness including:
  - Skills, capabilities, training, and certifications
  - M&Q human resources (staffing and staffing plans)
  - Potential changes to organization and KLPs

- Update the M&Q strategies to include plans for: (*See* A.1, I.5, and L.4)
  - Manufacturing maturity and progress against M&Q goals required for each technical review (SRRs, PDRs, CDRs, and at other appropriate reviews)
    - Definition and characterization of all M&Q processes
    - Manufacturing technology ongoing and future projects (ManTech)
    - Rates, yields, quantities, and schedule (including reference to Economic Order Quantity and the affordability targets)
  - KPPs (i.e., KCs)
  - Data management and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
  - Continued M&Q IB analyses on:
    - IB capabilities, fragility, gaps, and risks (e.g., key technologies and key and critical processes, parts, components, etc.)
    - IB capabilities to design, develop, produce, support, and restart the acquisition program, if appropriate
    - Impacts and interdependencies of this acquisition program to the NTIB
    - Government strategy and actions necessary to preserve the IB
  - Use of priorities, allocations, and allotments, and justification
  - Meeting IMP/IMS with acceptable risk for schedule and budget
  - Impacts and changes, requiring updates to the program's Configuration Items (i.e., GFE, GOTS, etc.) and contractor's supply chain (including COTS)
  - Impacts and changes, requiring updates to program critical items and Critical Safety Items
  - Support of the failure reporting and corrective action system (FRACAS)
  - Updates and changes to the program Variability Reduction Plans
  - Support and inputs to the Life Cycle Sustainment Plans (LCSP)including Diminishing Manufacturing Sources Materials Sources (DMSMS), PM&P, and counterfeit parts
  - Human safety and health
  - Hazardous materials management and pollution prevention

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  - Environmental parameters (e.g., shock, vibration, thermal, humidity, electromagnetic interference/impact, electrostatic discharge, transport, etc.)
  - Security parameters (physical and cyber) for both hardware and software
  - Use of COTS, GOTS, and GFE (including diminishing manufacturing sources)
  - 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

- Update the plans for a comprehensive joint M&Q Risk, Issue, and Opportunity Management Process for EMD that has the capacity to identify, monitor, and track risks and associated mitigation plans, including plans for:
  - Materials, facilities, workforce, interdependencies with other programs, manufacturing technology gaps, quality, software, and engineering related risks and issues
  - Required maturation of critical technologies and manufacturing processes to the appropriate level
  - M&Q cost and schedule impacts
- Provide M&Q support for the analyses of demonstrations conducted in a production relevant environment to include verification of:
  - Prototypes (e.g., subsystems, items, and components)
  - Manufacturing processes with yield and rate data collected
  - Special Handling procedures
  - Workforce skills
  - Prototype tooling
  - Special test equipment/special inspection equipment (STE/SIE)
  - Acceptance test procedures
  - Modeling and Simulations (M&S)
  - Material maturity
  - Cost models
  - KCs
  - Producibility efforts
  - Manufacturing technology solutions
- Conduct an assessment and an analysis of program manufacturing maturity against the MRL criteria.

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist

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- Manufacturing Maturation Plan
- Preliminary Design Review Checklist

Resources

- AS6500, Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- Defense Manufacturing Management Guide for Program Managers, Chapter 12 – Technical Reviews and Audits
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- 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 for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Preliminary Design Review (PDR) Procedure
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)

A.4 Support Program Decision Reviews

M&Q assurance managers should support the Milestone B decision by providing insight into various M&Q considerations. The goal of Milestone B is to determine if a program has met all its Exit Criteria and is mature enough to move into EMD. Often it is the maturity of the emerging technologies and manufacturing processes that determines the path forward. Manufacturing and quality assurance (QA) managers need to assess and demonstrate manufacturing processes to the extent needed to verify that risk have been reduced to an acceptable level. Risk reduction prototypes will be developed if those prototypes will materially reduce EMD development risks to an acceptable cost.

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Manufacturing and Quality Tasks

- Provide M&Q inputs and updates, for both the Development RFP RD and Milestone B Decision following post-PDR assessment results, the following statutory and regulatory program required updates to:
  - The Acquisition Strategy
    - Acquisition Approach
    - Business Strategy
    - Contracting Strategy (type and termination liability)
    - Cooperative Opportunities (if necessary)
    - General Equipment Valuation
    - Industrial Base Considerations
    - Intellectual Property Considerations
    - Market Research (for Development RFP RD)
    - Modular Open Systems Approach
    - Multiyear Procurement
    - Risk, Issue, and Opportunity Management Process
    - Small Business Innovation Research/Small Business Technology Transfer (for RFP DP)
  - Acquisition Program Baseline
  - Affordability Analysis
  - Analysis of Alternatives
  - Bandwidth Requirements Review
  - Capability Development Document
  - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
  - Exit Criteria
  - Item Unique Identification Implementation Plan
  - Life Cycle Sustainment Plan (LCSP)
  - Low-Rate Initial Production (LRIP) Quantity
  - PESHE and NEPA Compliance Schedule
  - 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)
- Provide PDR documentation of conducted demonstrations in a production relevant environment of M&Q maturity (including risks and mitigation) with status of:

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  - Prototypes (e.g., subsystems, items, and components)
  - Manufacturing processes with yield and rate data collected
  - Special Handling procedures
  - Workforce skills
  - Prototype tooling
  - Special Test Equipment/Special Inspection Equipment (STE/SIE)
  - Acceptance test procedures
  - Modeling and Simulations (M&S)
  - Material maturity
  - Cost models
  - KCs
  - Producibility efforts
  - Manufacturing technology solutions
- Provide results of an MRL assessment and analyses that was conducted for PDR.

Tools

- Acquisition Decision Memorandum (ADM) Milestone B Template
- Independent Technical Risk Assessment Checklist
- Integrated Master Plan/Schedule
- Interactive MRL Users Guide Checklist
- Life Cycle Sustainment Plan
- Manufacturing Maturation Plan
- Market Research using Pugh Template
- Navy PEO Milestone B Review Checklist
- Technology Readiness Assessment (TRA)
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Master Plan
- Transition to Production Assessment

Resources

- Affordability Analysis Tools
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- DoD Market Research Guide
- DoDI 4245.7-M, Transition from Development to Production
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework

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- 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
- Life Cycle Sustainment Plan (*See* Product Support Manager Guide)
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Technology Readiness Assessment (TRA) Deskbook
- Test and Evaluation Management Guide

B. DEFENSE CONTRACTING SYSTEM

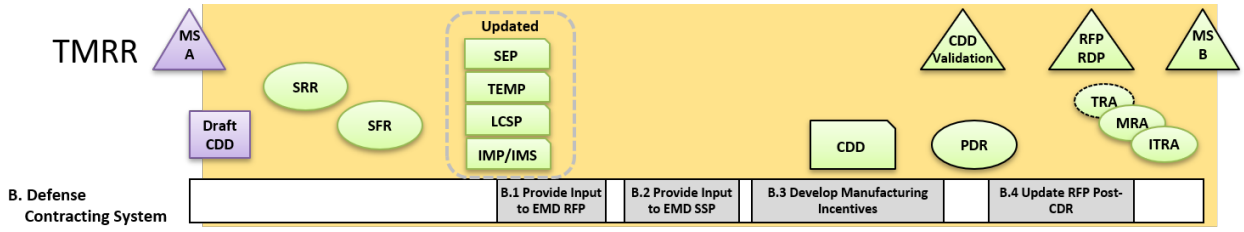

Figure 3-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

DoD contracting requirements are governed by the Federal Acquisition Regulation (FAR)/DFAR and by DoD, Service and Agency regulations, policies, and guidance documents.

The contract is the vehicle used to establish the formal relationship between the government and a prime contractor. Government business processes include the business strategy or Acquisition Strategy, contracting approach, contracting strategies, contract language, and financial strategies. M&Q personnel often are called upon to support various contracting functions and activities.

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

- Market Research
- Contract Strategy
- Source Selection Plan
- Request for Proposal
- M&Q Inputs to the Contract (Section C, E, L and M) (refer to MIL-HDBK-245E)
- Contract Evaluation and Award

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The contracting process is a partnership between the contracting office and program personnel. Contracting molds and shapes the procurement process and is responsible for contract award and administration. However, a cohesive effort between the contracts and program management including the participation of both contractual and technical subject matter experts is essential to managing and completing the steps in this phase of the contracting process.

In preparation for the RFP, Market Research is a pre-solicitation activity that involves the identification of the market or market of interest, the sources of market information, the collection of market information, and the evaluation of the market's ability to satisfy the user needs. M&Q personnel need to support market research to identify suppliers and evaluate potential sources and opportunities to assess the associated risks. Once market research has been completed, requirements may be defined in the form of Performance Work Statements, Statements of Work, or Statements of Objectives.

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

As part of implementing industry best practices and meeting regulatory requirements, certain M&Q requirements need to be incorporated into the EMD RFP. For example, when the system under development meets the definitions in FAR 46.203 (Criteria for Use of Contract Quality Requirements, for Complexity and/or Criticality), FAR 46.202-4 requires supplier compliance with higher-level quality standards that should be addressed in the RFP. This may also require on-site government quality personnel to perform source inspections.

Other program requirements, often neglected during the contracting process, for M&Q input include:

- Direction for use of COTS items, GOTS items, and NDIs.
- Determination of need to develop and maintain a FMECA
- Determination of intellectual property and data rights, maintenance, ownership, and access for later phases.
- Direction for incorporation of manufacturing safety into System Safety Analyses.
- Determination of specialized system requirements, such as Flight Operations, Space Operations, etc.
- Determination of appropriate M&Q physical and cybersecurity requirements (e.g., data, information, control systems and networks, supply chain, etc.)
- Direction for inclusion of DCMA in an appropriate role to support the program

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M&Q personnel should be making early and significant inputs into EMD RFP documents and activities to ensure M&Q risks, issues, and opportunities will be considered. Having determined and provided the early and significant requirements for EMD, the M&Q objective for the source selection plan is to develop criteria that ensure selection of the proposal that represents the best value to the government. The criteria for source selection should be realistic and address all the above areas, especially industry best practices.

Award 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 reward 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 Manufacturing Readiness Level
- 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

Incentives in the contract should be consistent with the Acquisition Strategy and tied to goals for exceeding contract requirements and program expectations. M&Q incentives in contracts are 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

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The success of an enterprise's M&Q system is related to the commitment of the enterprise to the quality and producibility elements presented in the contract and the ability of the successful contractor to implement them effectively.

The learning curve (cost improvement curve, or experience curve) is a well-known approach to modeling many effects, such as the effect of quantity on cost. Generally, people and organizations learn to do things more efficiently when performing repetitive tasks. Learning curves are used as a measurement of progress in processes and procedures. Learning curves show that as the number of units produced doubles, the unit cost decreases in a predictable pattern. This technique continues as an industry standard today both in commercial and government applications. M&Q should be developing the appropriate learning curves for the system and the plans for data collection to support further development.

Before the RFP RD, but after M&Q analyses of the PDR, the M&Q inputs provided to the RFP should be reviewed, including:

- Overall affordability
- Competition strategy and incentive structure
- Provisions for small business utilization
- Source selection criteria
- M&Q trades
- Capability requirements
- Security requirements
- Should Cost goals
- Risk, issue, and opportunity management
- M&Q schedule

B.1 Provide Input to EMD 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. Manufacturing and QA managers typically support the development of the RFP by identifying M&Q considerations and criteria for inclusion in the RFP and subsequent contract. These considerations need to ensure that there is linkage between the M&Q consideration and the warfighter requirements and evaluation factors and sub-factors. Evaluation factors often include cost or price, and quality of product or service, which includes technical, past performance and others.

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Manufacturing and Quality Tasks

- Ensure M&Q personnel are included in the EMD Request for Proposals (RFP) writing and review teams.
- Support the development of performance specifications:
    - Support the requirements process and the identification and flow down of requirements into performance, detail, process, or material specifications
    - Ensure traceability between requirement or capability and production/quality verification
    - Ensure identification or development of rigorous verification methods for incorporation for all requirements.
    - Ensure incorporation of rigorous, statistically based acceptance requirements including for Qualification (including Design Verification), First Article, and Conformance inspections.
- 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.1 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 contractors to identify and to describe their proposed specific processes, methods, and actions to address manufacturing feasibility, producibility, and M&Q risks associated with the proposed system
    - Specify a requirement for on-site government quality personnel will have access to perform management system audits
    - Specify a requirement for on-site government quality personnel to have access to perform source inspections and data monitoring
- 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 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 Technical Data Package (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 FMEA on critical manufacturing processes (PFMEA)

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- 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
  - Conduct Pre-award Survey
  - Conduct Post-award Orientation Conference
- Manufacturing Planning:
  - 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, 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 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

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  - 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
    - Continual Improvement

- Analyze the TMRR M&Q output as a basis for RFP EMD requirements and inputs to include the following areas:
  - Risk, Issue, and Opportunity Management System and processes
  - Design producibility, feasibility, and manufacturability studies and analyses
  - Tooling, facility, and workforce analyses
  - Prototype demonstrations and development tests
  - Materials analyses
  - Make/buy processes and analyses
  - Costs and budget analyses
  - Market research and analyses
  - Modeling and simulations analyses
  - Process Capability Studies
  - Environmental studies and risks (PESHE)
  - M&Q processes and data
  - Work measurement/learning curve analyses
  - Industrial Base studies

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- Specify appropriate requirements for 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 QA personnel will have access to perform source inspection of the plan (include on-site government Quality personnel in contractual distribution of the program Quality Plan (ref. I.1))
- Specify industry M&Q best practices for Systems Engineering to be used (e.g., IEEE 15288, -1, -2, etc.) in the EMD 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
- Specify contractual M&Q requirements for:
    - Content for SOW, SOO, and contract sections C, L, M, and H
    - Conducting M&Q reviews of engineering and software (with frequency of reviews)
    - Intellectual property and government technical/manufacturing data rights, maintenance, ownership, and access
    - Identification and description of producibility efforts including cost sharing and incentive plans relevant to the solution
    - Plans for facilities, tooling, test equipment, workforce (e.g., training, certifications, etc.), and supply chain management
    - Plans for material availability including make/buy, long-lead, sources, and risks (sole, single, foreign, fragile, and critical)
    - Utilizing analyses of failure mode effects and criticality (e.g., FTA, FMECA, DFMEA, PFMEA) from the system level down to the component level (i.e., throughout the supply chain)
    - Definition and traceability of CSI and/or CAIs to all preliminary key and critical M&Q processes
    - Conducting analyses of manufacturing system safety (in support of System Safety Assessments in accordance with MIL-STD-882)
    - Providing M&Q information for costs, cost models, and cost estimates that include rate, alternate materials, quantity, etc. (including Cost of Quality data)
    - Plans for establishing and meeting EMD required process capability (Cpk) goals
    - Identification and description of manufacturing technology capability improvements
    - Encouraging investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
    - Implementing (or continuing) a joint risk, issue, and opportunity management and mitigation program that includes M&Q (including industrial base risks)

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  - Implementing (or continuing) an M&Q variability reduction program
  - Appropriate cyber threat protection measures including
    - Safeguarding M&Q information, designed-in system 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
    - 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 Security
  - Managing 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
  - Utilizing COTS, GOTS, GFE, and NDIs
  - Metrics to be met as exit criteria for EMD phase
- Provide M&Q inputs and support to specialized system requirements, such as Flight Operations, Space Operations, etc.
- Specify the requirement that the contractor support and/or conduct as required M&Q:
  - Technical reviews and audits including CDR, TRR, PRR, PCA, FCA, etc.
  - MRL assessments with trained personnel utilizing the MRL criteria
  - Independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment
  - 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 meetings to manage mitigation activities

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- IG5315.204-5(b), Section L Guide and Template
- IG5315.204-5(c), Section M Guide and Template

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- ISO 9001, Quality Management System Checklist
- DOORS or other Requirements Management Tool
- DCMA Pre-award Survey System (PASS)
- SF 1403 DCMA Pre-award Survey General
- SF 1404 DCMA Pre-award Survey Technical
- SF 1405 DCMA Pre-award Survey Production
- SF 1406 DCMA Pre-award Survey Quality Assurance
- SF1407 DCMA Pre-award Survey Financial Capability
- DCMA Post-award Orientation Conference (FAR 42.502)
- DCMA Post-award Orientation Conference Record (DD1484)

Resources

- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- AS6500, Manufacturing Management Program
- AS9100, Quality Management 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
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- IG5315.204-5(b) Section L Guide
- IG5315.204-5(c) Section M Guide
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- SD-15 Performance Specification Guide

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- DI-IPSC-81431A/T System Performance Specification Data Item Description
- MIL-STD-961 Defense and Program-Unique Specifications Format and Content
- MIL-HDBK-245E, Preparation of Statement of Work
- MIL-STD-882, Rev. E, System Safety
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- AFMC Inst 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-award Survey Guide
- Pre-award Survey User's Manual
- DCMA Post-award Orientation Conference Record (DD1484)

B.2 Provide Input to EMD Source Selection Plan

The Source Selection Plan (SSP) is a key document that specifies how the source selection activities will be organized, initiated, and conducted. 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. Manufacturing and QA managers, as members of the technical IPT, should be involved in the development of the SSP and in the identification of evaluation factors for their respective functions.

Manufacturing and Quality Tasks

- Ensure that M&Q personnel are included in the EMD Source Selection Plan (SSP) writing and review team.
- Specify in the SSP metrics and scoring for application of M&Q industry best practices for the contractor's Manufacturing Management System and Quality Management System (e.g., AS6500, ISO 9000, AS9100, etc.).
    - Plan should include metrics and scoring for preferred specific processes, methods, and actions to address manufacturing feasibility, producibility, and M&Q risks associated with the proposed system
    - Plan should include metrics and scoring for accommodation of on-site government quality personnel to complete required management and quality audits and data collection
- If manufacturing management industry best practice requirements (i.e., AS6500) are not invoked in the contract(s), the requirements cited in AS6500 should be the basis for specific SSP metrics and scoring. Specify metrics that, at a minimum, include the contractor plans, processes, and procedures for:
    - Documenting how, when, and by whom each requirement of their manufacturing management system is to be accomplished and defining the authority and responsibility for each.

  - Conducting producibility design analyses
  - Identification and management of 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 Process FMEA 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 any 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, and tooling, test equipment, and facilities
  - 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 quality management industry best practices are not invoked in the contract(s), the requirements cited in the standards should be the basis for specific SSP metrics and scoring. Specify metrics that, at a minimum, include the contractor 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

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  - Quality performance including monitoring, measurement, analyses, evaluation, and internal audits
  - Quality improvement including nonconformities and corrective actions, and continual improvement

- Specify metrics and scoring that at a minimum address the contractor(s) plans, processes, and procedures utilizing analyses of TMRR M&Q outputs for the following:
  - Risk, issue, and opportunity management
  - Design producibility, feasibility, and manufacturability
  - Tooling, facility, and workforce
  - Prototype demonstrations and development tests
  - Materials management
  - Make/buy management
  - Costs and budgets
  - Modeling and simulations
  - Process capability management
  - Hazardous materials, environmental and safety management
  - M&Q process and data management
  - Work measurement/learning curve management
  - Industrial security
  - Supply chain management
- Specify metrics and scoring that ranks 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.
- Specify in the SSP metrics and scoring for application of M&Q industry best practices for the contractor's 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 on timeliness, completeness, accuracy, and alignment (corrective actions, if required) for:
  - Meeting each SOW, SOO requirements, and requirements for contract sections C, L, M, and H
  - Planning of M&Q reviews of engineering and software (with frequency of reviews)
  - Planning and processes for Intellectual Property management and government Technical/Manufacturing Data Rights, maintenance, ownership, and access
  - Planning and processes for producibility (including cost sharing and incentive plans relevant to the solution)

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- Plans for facilities, tooling, test equipment, workforce (e.g., training, certifications, etc.), and supply chain management
- Planning and processes for materials including make/buy, long-lead, sources, and risks (sole, single, foreign, fragile, and critical)
- Plans for utilizing failure mode effects and criticality analyses (e.g., FMECA, DFMEA, PFMEA) from the system level down to the component level (i.e., throughout the supply chain)
- Planning and processes for management of CSIs and/or CAIs, and all preliminary key and critical M&Q processes
- Planning and processes for manufacturing system safety analyses
- Planning and processes for providing M&Q information for costs, cost models, and cost estimates that include rate, alternate materials, quantity, etc. (including Cost of Quality data)
- Plans for establishing and processes for meeting EMD required process capability (Cpk) goals
- Planning for manufacturing technology capability improvements
- Plans for investments in advanced manufacturing technology production equipment and processes from U.S. domestic sources that increase the productivity and reduce life cycle costs
- Plans for implementing (or continuing) a joint risk, issue, and opportunity management and mitigation program that includes M&Q (including industrial base risks)
- Plans for implementing (or continuing) an M&Q variability reduction program
- Planning and processes for cyber-threat protection measures including:
  - Safeguarding M&Q information including supply chain risks
  - Designed-in system protection, hardware, and software manufacturing network assurance (including suppliers), anti-tamper, and security-related activities such as physical security and industrial security
  - Anti-counterfeit practices
  - 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.
- Planning and processes for utilization of COTS, GOTS, GFE, NDI items

- Specify metrics and scoring that ranks 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.

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- Specify M&Q metrics and scoring on timeliness, completeness, accuracy, and alignment (corrective actions, if required) for contractor planning and processes to support and/or conduct as required M&Q:
    - Technical reviews and audits including CDR, TRR, PRR, PCA, FCA, etc.
    - MRL assessments with trained personnel utilizing the MRL criteria
    - Independent risk assessments to include the identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment
    - 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 meetings to manage mitigation activities

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System Checklist
- Source Selection Plan Template, USMC

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems – Requirements for Aviation, Space, and Defense Organizations
- DoD Systems Engineering Guidebook
- DAU AcqNotes
- 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 Source Selection Procedures Memo
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs

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- ISO 9001, Quality Management System
- ISO 9001:2015, Quality Management System
- MIL-HDBK 245E, Preparation of Statement of Work
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-882, Rev. E, System Safety
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- Source Selection Plan Guide, IG5315.303

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

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

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/#)

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

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

Tools

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

Resources

- Air Force Award Fee Guide
- Army Award Fee Guide
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations,
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Mission Engineering Guide
- Early Manufacturing and Quality Engineering Guide
- DAU AcqNotes
- 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, Mar 2016
- 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)

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B.4 Update Request for Proposal Post-PDR

The RFP should be updated to identify the information required in the contractor's proposal for the next acquisition phase and the criteria that will be used to evaluate the proposal and the relative importance of those criteria. Manufacturing and QA managers typically support the development of the RFP by identifying M&Q considerations and criteria for inclusion in the RFP and subsequent contract. These considerations need to ensure that there is linkage between the M&Q consideration and the warfighter requirements and evaluation factors and sub-factors. Evaluation factors often include cost or price, and quality of product or service, which includes technical, past performance and others.

Manufacturing and Quality Tasks

- Update M&Q inputs to the RFP based on post-PDR assessment results (*See* A.3) and updates made to the following (*see* A.4):
    - The Acquisition Strategy
        - Acquisition Approach
        - Business Strategy
        - Contracting Strategy (type and termination liability)
        - Cooperative Opportunities (if necessary)
        - General Equipment Valuation
        - Industrial Base Considerations
        - Intellectual Property Considerations
        - Market Research (for RFP RD)
        - Modular Open Systems Approach
        - Multiyear Procurement
        - Risk, Issue, and Opportunity Management Process
        - Small Business Innovation Research/Small Business Technology Transfer (for RFP RD)
    - Acquisition Program Baseline
    - Affordability Analysis
    - Analysis of Alternatives
    - Bandwidth Requirements Review
    - Capability Development Document
    - Cost Analysis Requirements Description (CARD), RFP Release Cost Assessment, etc.
    - Exit Criteria
    - Item Unique Identification Implementation Plan
    - Life Cycle Sustainment Plan (LCSP)
    - Low-Rate Initial Production (LRIP) Quantity
    - PESHE and NEPA Compliance Schedule
    - Program Protection Plan (PPP)

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- Should Cost Targets
- Spectrum Supportability Risk Assessment
- Systems Engineering Plan (SEP)
- Technology Readiness Assessment (TRA)
- Test and Evaluation Master Plan (TEMP)

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System Checklist
- Section L Guide and Template, IG5315.204-5(b)
- Section M Guide and Template, IG5315.204-5(c)

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001, Quality Management System
- ISO 9001:2015, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)

C. SURVEILLANCE SYSTEM

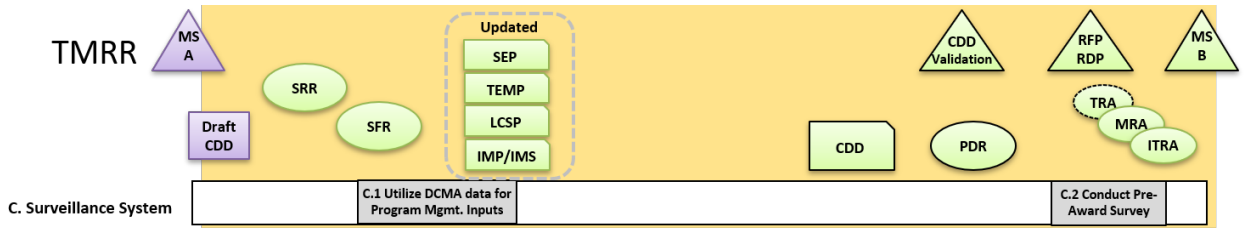

Figure 3-4. Surveillance System Manufacturing and Quality Activities

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Introduction

The purpose of contract administration is to ensure that the contractor performs in accordance with the terms and conditions of the contractual agreement (surveillance). DoD contractor surveillance requirements and activities are required by the FAR/DFAR and by many DoD, Service, and Agency regulations, policies, and guidance documents. DFAR Part 242.2 Contract Administration Services and DFAR Part 242.3, Contract Administration Office Functions, and PGI 242.3 Contract Administration Functions outline the 70 Contract Administration Service (CAS) functions and the many that may require M&Q support. M&Q personnel often are called upon to support CAS functions and activities.

Often these activities may be performed under mutual agreement by the program office and DCMA. In many cases these contractor surveillance activities may be performed by on-site engineering support activity, program office contract administrators, delegated Service contract surveillance offices or a variety of engineering support activities (i.e. supervisor of shipbuilding (SUPSHIP), development command field activities). This thread (Surveillance System) will focus on the following sub-threads, tasks, activities, tools, and resources:

- Contract Administration Service (CAS) Functions
- Engineering Support Activity (ESA)
- DCMA Support
- DCMA Documentation
- Monitor and Track Risks
- Participate in Program Reviews

Contractors often depend on their own policies, procedures, processes, plans, controls, and schedules to meet government requirements. Their processes often 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 defining the total scope of contract administration.

Program offices may 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 an MOA or a Quality Assurance Letter of Delegation (QALI) with DCMA. DCMA may then, based on manpower availability and funding, utilize a systematic approach

deploying surveillance through the supply chain to evaluate the supply chain and supplier improvement initiatives. At resident and non-resident facilities DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes. Most contractors will have implemented a higher-level quality management process in accordance with AS9100 or ISO 9001 as a best practice. Some contractors, but not all, may have implemented a manufacturing management process in accordance with AS6500. Regardless of what management processes the contractor has implemented, DCMA personnel should have access to that data and should be reviewing it on a continuous basis.

Effective M&Q management is required if the contractor is to deliver an operationally safe, suitable, and effective system. The Quality Management System (QMS) assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The QMS serves as the control function within the systems engineering process, requiring control over requirements reviews, design inputs, verification and validation of design outputs, and control of design changes. The QMS also requires monitoring and measuring of processes and products to ensure they conform to requirements.

DCMA provides access to reliable and accurate QMS data and process information on costs, schedule, and technical performance and can assist with objective assessment of supplier plans and the verification of initial and continuing compliance with requirements. The ability to continually analyze risks and identify risk-adjusted solutions to sustain a reliable, technologically superior, efficient, cost-effective, and resilient defense industrial base mitigates overall program risk.

M&Q should provide information, data, plans for the requirement to obtain DCMA analyses, supporting information, and recommendations as inputs to the program management and technical reviews.

A pre-award survey is one tool DCMA personnel can use to focus on virtually every facet of the contractor's business operation from technical capability to financial stability, from QA to plant safety. DCMA conducts nearly all pre-award surveys required by government buying activities. M&Q should provide recommendations and inputs to program management for the pre-award survey requirements to be addressed by DCMA.

The process begins with a program request for a survey and concludes with a program decision based on a recommendation by a DCMA Contract Management Office (CMO) survey team. A pre-award survey can focus on virtually every facet of the contractor's business operation from technical capability to financial stability, from QA to plant safety. 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.

A Post-award Orientation Conference is one tool DCMA or the DoD engineering support activity personnel can use to achieve a clear and mutual understanding of all contractual requirements and identify and resolve potential problems.

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C.1 Utilize DCMA data for Program Management Reviews

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

- System Requirements Review (SRR)
- System Functional Review (SFR)
- Preliminary Design Review (PDR)
- Manufacturing Readiness Assessments (MRAs)
- Technical Readiness Assessments (TRAs)
- Independent Technical Risk Assessments (ITRAs)

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

- M&Q 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:
    - System Requirements Review (SRR)
    - System Functional Review (SFR)
    - Preliminary Design Review (PDR)
    - Manufacturing Readiness Assessments (MRAs)
    - Technical Readiness Assessments (TRAs)
    - Independent Technical Risk Assessments (ITRAs)
- Request and utilize the DCMA information and data in the following areas:
    - Assessments of M&Q feasibility
    - Contractor(s) capability to meet M&Q requirements for:
        - Manufacturing Management System best practices (i.e., AS6500)
        - Quality Management System best practices (e.g., AS9100, ISO 9000, etc.)
        - Risk, Issues, and Opportunities Management System capabilities
        - Human safety and health
        - Environmental and HAZMAT management (pollution prevention)

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  - Security (physical and cyber) for both hardware and software (e.g., communications, cyber, program protection, anti-tamper, etc.)
  - Management of KCs
  - Management of data and software (including collection, analysis, testing, and methods of analysis, storage, retrieval of M&Q data)
  - Supportability and sustainment
  - Use of COTS, GOTS, NDIs, and GFE (including diminishing manufacturing sources)
  - Management of parts, materials, and processes (PMP)
  - Configuration Management System capabilities
  - Specialized manufacturing requirements (extreme complexity, multiple or very tight tolerances, EMI protection, precision assembly, handling of fragile components and Electrostatic Discharge protection, etc.)
  - Process capabilities and manufacturing operations
  - Modeling and Simulation tools and capabilities
  - Testing processes, equipment, and facilities capabilities
  - Earned Value Management System capabilities
  - Cost, Scheduling, and Control System capabilities
  - Systems Engineering Management capabilities (i.e., IEEE 15288)
  - Performance to plans and schedules (IMP/IMS)

- Request and utilize the DCMA information and data in the following areas:
  - Analyses and results of contractor(s) and supply chain capabilities
  - Analyses and results of industrial base capability studies
  - Recommendations from assessments of contractor(s) supply chain capability, if available
  - Analyses of contractor(s)' capability to procure, mature, and characterize materials
  - Analyses and recommendations for contractor(s)' producibility and continuous improvement processes
  - Recommendations for the contractor(s) tooling and equipment strategies
  - Recommendations for the M&Q Plans, the TEMP, and the IMP/IMS
  - Analyses and recommendations for the contractor's SEMP
  - Recommendations for the contractor(s) workforce requirements, skills, capabilities, training, and certifications
  - Analyses of contractor(s) manufacturing and production process verifications and Process Capabilities (Cpks)
  - Analyses and recommendations for the contractor(s) Quality Management System and processes

- Develop recommendations for manufacturing investment programs that mature emerging manufacturing technologies and industrial capabilities based in part on DCMA data inputs.

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Tools

- DCMA provides inputs to the following documents, go/no-go (either is or is not included)
- Independent Technical Risk Assessments (ITRAs) Execution Guidance
- Integrated Master Plan/Schedule (IMP/IMS)
- Interactive MRL Users Guide (Checklist), 2018
- Manufacturing Maturation Plan
- Manufacturing Readiness Assessment (MRA) Checklist
- Preliminary Design Review (PDR) Checklist
- System Functional Review (SFR) Checklist
- System Requirements Review (SRR) Checklist
- Systems Engineering Plan (SEP)
- Technology Readiness Assessment (TRA) Checklist
- Test and Evaluation Master Plan (TEMP)

Resources

- DCMA-209, Pre-award Surveys
- DCMA-INST-1201, Corrective Action
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-323, Data Collection and Analysis
- DCMA-INST-325, Technical Reviews
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Assessment (MRA) Deskbook
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

C.2 Conduct Pre-Award Survey and Post-Award Orientation Conference

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. Manufacturing and QA managers need to support assessments at the contractors'

facilities and should involve the support by DCMA personnel stationed at the facility. DMCA personnel can conduct the following pre-award surveys:

- 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
- SF 1408 Pre-award Survey – Technical Contractor Accounting System

Manufacturing and Quality Tasks

- Develop M&Q requirements for DCMA pre-award surveys requests.
- Provide M&Q recommendations and inputs to program management for the pre-award type survey requirements (e.g., formal general purpose, formal on-site with solicitation requirements, or short form).
    - Identify M&Q management systems (MMS/QMS) specific contract clauses and work statements within the acquisition planning documents
    - Identify MMS/QMS risk areas during pre-award and post-award conferences, and follow-on assessments
- Ensure the following factors are included in the pre-award surveys of the contractor and key and critical suppliers:
    - Technical capability
    - Production capability
    - Quality assurance
    - Financial capability
    - Risk identification
    - Supply chain management
    - Finance and accounting
    - Government property control
    - Transportation and packaging
    - Security, physical and cyber
    - Plant safety
    - HAZMAT/environmental/energy/regulatory compliance
    - Flight, space, and/or operations, and safety
    - Software capability
    - Technical documentation
    - Configuration management
- Review DCMA audit results for M&Q impacts and make recommendations to the source selection personnel, the Procurement Contracting Officer (PCO), the program Systems Engineer, and the Program Manager.

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Tools

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

Resources

- DCMA Pre-Award Survey Guide
- DCMA-209, Pre-Award Surveys
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- Manufacturing Readiness Level (MRL) Deskbook

Post-Award Orientation Conference

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

- Ensure M&Q personnel provide inputs for the request to DCMA to conduct a Post-Award Orientation Conference. All aspects of the contract are subject to discussion with emphasis in the areas of:
    - Compliance 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.

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- 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 Post-Award Orientation Conference Checklist

Resources

- FAR Part 42.5, and DFARS, 242.5
- Multiple DCMA standards, documents, and procedures
- DCMA Post-Award Orientation Conference Checklist

D. TECHNOLOGY AND INDUSTRIAL BASE

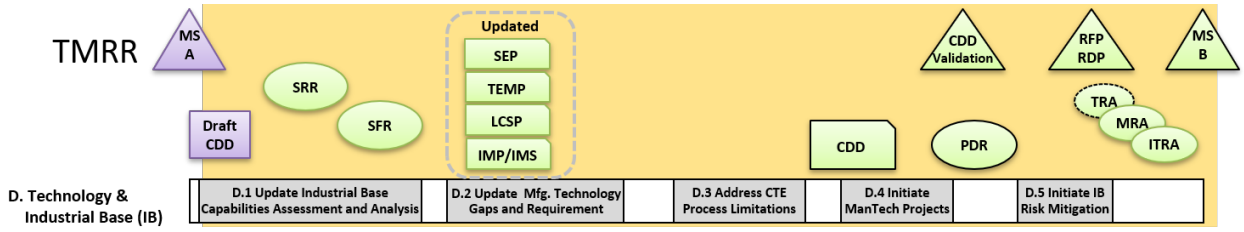

Figure 3-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

10 USC 2440 requires the Secretary of Defense to consider the National Technology Industrial Base (NTIB) in the development and implementation of acquisition plans for each MDAP. The NTIB consists of the people and organizations engaged in national security and dual-use research and development (R&D), production, maintenance, and related activities within the United States, Canada, the United Kingdom, and Australia. Acquisition planning and plans shall include considerations of the NTIB for all MDAPs. These considerations should include:

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

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

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

TMRR phase IB considerations should include a thorough evaluation of the IB to understand how the IB capability and availability will impact the program. DoD Directives (DoDD) and Public Law requires each major program to conduct assessments of the IB throughout the acquisition cycle. The phase assessments help determine the capabilities of the IB to develop, produce, maintain, and support all defense acquisition programs. The program will document the source availability, producibility, supportability, and maintainability risks and technology needs associated with the materials and components needed.

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

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

IB analysis is a continuing process that gathers program specific information and provides feedback throughout the program life cycle. Earlier IB analyses require updating for the following:

- Development requirements and planned production rates
- Industrial capabilities risks, issues, and opportunities (e.g., single points of failure, fragile suppliers, sole and single sources, etc.)
- Resilience of critical defense industrial base capabilities
- Procurement surges and contractions

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

While all new or innovative technologies need to be monitored, certain technologies will be critical to the success of the program these critical technologies deserve special considerations. If a system depends on specific technologies to meet operational thresholds in development, production, operation, and sustainment, and if the technology or its application is either new or novel, then that technology is considered a critical or enabling technology. These Critical Technology Elements should have been identified and evaluated in the MSA phase for maturity of the technology, in preparation for a formal Technology Readiness Assessment (TRA).

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

Technology risks that are critical to the success of the program are candidates for new Manufacturing Technology (ManTech) projects. However, these types of projects will have their own risks, costs, and schedule impacts that must be factored into the program. The objective of the ManTech program is to improve performance while reducing acquisition cost by developing, maturing, and transitioning advanced manufacturing technologies. The ManTech program impacts all phases of acquisition. It aids in achieving reduced acquisition and total ownership costs by developing, maturing, and transitioning key manufacturing technologies in support of new system technologies. Plans from the previous provide the basis for investments and should be initiated in this phase to find and implement affordable, low-risk solutions.

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

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

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

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

D.1 Update Industrial Base Assessment and Analyses

M&Q personnel as members 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

- Update the analyses of Industrial Base Considerations (from previous phase or conduct if not previously accomplished) of the national technology and industrial base to develop, produce, maintain, and support the program, including foreign dependency. The updated analyses will consider the following:
    - Identification of 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

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- Vulnerabilities of and effect on the supply chain including sole, single, fragile, or foreign sources, cyber exploitation, and foreign acquisition
- Capability of the materiel solution to be produced using existing manufacturing capabilities and capacities while meeting quality, production rate and cost requirements.
- Capability of the IB to protect digitized program and system information including system definition, design, and test, contracting, and competitive prototyping.
- Capability to cost effectively design, develop, produce, maintain, and support the program, including:
  - Tooling
  - Production test equipment
  - Operation of systems
  - Maintenance and sustainment of systems
- Capability to make production 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
- Assessed requirements and capabilities, which include:
  - Identified sources for key technologies, components, and processes, including known gaps and risks
  - Identified needs including design, development, production, operation, and sustainment, and eventual disposal
  - All technological developments, market trends, processes, environmental factors, and policies, etc. that could potentially impact the program
- Updated DCMA industrial analysis data and reports to include:
  - Industrial Capability Assessments
  - Appropriate Analytical Products
  - Defense Business and Economic Analysis
  - Acquisition Planning Support

- Prepare the updated Industrial Base Considerations summary report for inclusion in the Acquisition Strategy and appropriate updates to the 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

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- 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.

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide Checklist, 2018 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
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

D.2 Update Manufacturing Technology Gaps and Requirements

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

Manufacturing and Quality Tasks

- Update assessments and analyses of emerging technologies to determine capability of current manufacturing technology, processes, and infrastructure to support system development.

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  - Analyze the need (determine gaps) for new manufacturing technologies, processes, and infrastructure
  - Identify required risk mitigation efforts with cost and schedule impacts
- Perform manufacturing technology trade studies that includes an assessment of how new and emerging technology might impact product design requirements, affordability, and manufacturing capabilities.
- Update the assessment of identified high risk manufacturing process areas necessary for the program that require investments in ManTech programs.
  - Estimate cost, schedule, and performance impacts
- Update current ManTech project plans with survey data from ongoing ManTech projects and DCMA reports and analyses for solutions to manufacturing technology gaps.
  - Request DCMA provide up-to-date data
  - Update the comprehensive plan for each required ManTech investment
    - Ensure DoD/Service ManTech membership in appropriate IPT
    - Request information from other government agencies, industry, and academia responses to needs

Tools

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

Resources

- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687 Producibility Systems Guidelines,
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Technology Transition Managers Guide

D.3 Address Critical Technology Element Process Limitations

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

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Manufacturing and Quality Tasks

- Update and assess the identified CTEs for feasibility, affordability, and supportability and for M&Q maturity.
    - Identify mature alternative components or subsystems for each immature CTE
    - Develop plans for increasing CTE M&Q maturity and mitigating associated risks:
        - Update plans to improve and/or maintain maturity from the draft CDD, AS, and SEP (if available)
        - If manufacturing processes need to be updated or developed, plan and budget for the effort to mitigate manufacturing risk
        - Include integration risks associated with the updated CTEs from trade studies
        - Include updates for CTE interdependencies and associated risks
- Update the identified M&Q process areas and process limitations requiring risk mitigation
    - Include necessary hardware and the associated embedded software maturity
    - Include cybersecurity risks and vulnerabilities (software and firmware)
- Support the Technology Readiness Assessments that benchmark technology risks.
    - Determine the degree of M&Q risks in development
    - Conduct in depth analyses of the M&Q risks associated with the design as needed
    - Develop plans for recommended M&Q risk mitigations to be conducted
    - Implement plans to improve CTE M&Q maturity
- Support the identification of the required Technology Readiness Levels (TRLs) to be achieved for each CTE at each systems engineering milestone (e.g., Systems Requirements Review (SRR), Test Readiness Review (TRR), etc.).

Tools

- Independent Technical Risk Assessment Checklist/DTRAM
- Interactive MRL Users Guide Checklist, for Technology and Industrial Base thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Technology Readiness Assessment
- TRL Calculator

Resources

- Defense Acquisition Program Support Methodology
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)

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- 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
- NAVSO P-3687, Producibility Systems Guidelines
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.4 Initiate ManTech 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. Manufacturing and QA managers as members of the Technical IPT need to support the analysis of maturity and the insertion of technologies into production programs.

Manufacturing and Quality Tasks

- Review Service ManTech portfolios for projects with potential application to program gaps to:
    - Determine if the program/contractor should participate in the project
    - Determine if the program/contractor should support bridging of the project to the next phase
    - Determine how the results of the project can be implemented in the program
- Review current Title III, IBAS, and other government investment program portfolios for projects with potential application to program gaps.
- Update program ManTech plan and submit proposals for funding based on Service portfolio reviews, which should include:
    - Identified high-risk manufacturing process areas that require investments in state-of-the-art manufacturing technology
    - Identification of manufacturing technology development efforts to be funded by the program or other alternative sources
    - Justification of benefit to industry, industry sector, or other DoD systems
    - Determination if required manufacture technology efforts will be completed in time to support program needs
    - Relevant data from DCMA and other sources to support plan

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Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, Technology and Industrial Base thread
- Manufacturing Maturation Plan
- TRL Assessment Checklist

Resources

- Defense Manufacturing Management Guide for PMs, Chapter 8, Technology Development, and Investments
- Defense Production Act, Title III
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDD 4200.15, ManTech Program
- 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
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Service ManTech guidance, e.g., Air Force Technology and Transition Strategy Guidebook,
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.5 Initiate Industrial Base Risk Mitigation

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

Manufacturing and Quality Tasks

- Initiate mitigation plans that address current and future M&Q Industrial Base risks. Plans should:
    - Address all M&Q capabilities required that should be maintained throughout the life of the program
    - Mitigate product or technology obsolescence, lifetime replacement, or regeneration of items projected to go out of production
    - Mitigate business fragility of any facilities or corporations that provide unique services or products or unique M&Q capabilities
    - Address the approach to making production rate and quantity changes that support a response to contingency and support requirements including surges

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- Mitigate the vulnerability of the supply chain (to include sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources)
- Address the availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment (required to include the availability of alternatives for obtaining such items from within the NTIB)
- Address the impacts of external dependencies and integration
- Address the risks introduced by new and unique capabilities and processes

Tools

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

Resources

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions, Apr 1996
- Manufacturing Readiness Level (MRL) Deskbook, Chapter 5.2 Development of a Manufacturing Maturation Plan
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

E. DESIGN

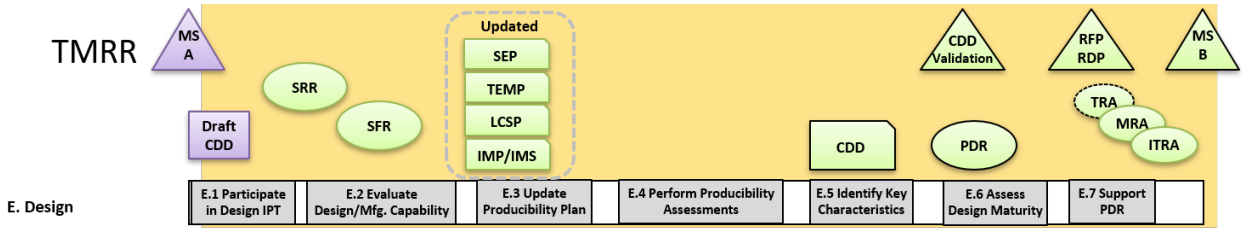

Figure 3-6. Design Manufacturing and Quality Activities

Introduction

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

to support these SE activities. For a detailed description of SE processes refer to the DoD Systems Engineering Guidebook at www.ac.cto/erpo.

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

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

M&Q personnel participation in and support to Program Design IPTs are critical to success in developing a producible and affordable system with acceptable risks. M&Q industry best practices are integral to design and development efforts in both Manufacturing Management System (MMS) and Quality Management System (QMS) requirements (e.g., AS6500, ISO 9001, AS9100, etc.). The program should integrate M&Q into the product design and development process and engage M&Q expertise as early as possible. Analyses of design alternatives through trade studies, producibility analyses, and manufacturing feasibility based on program requirements need to be conducted with results incorporated into the design. To accomplish program objectives, these need to be performed throughout the supply chain (e.g., failure mode analyses, Key Characteristics (KC), quality capabilities, test processes, etc.), enabling appropriate visibility and accountability through collection, recording, and communication of technical and programmatic data to all levels.

During the TMRR phase, the M&Q capabilities should be assessed for each competing design under consideration. The assessments should baseline needed industrial, manufacturing, and quality capabilities and identify required investments. While it is not expected that contractors have a complete factory and supply chain established at this point, program understanding of key and critical M&Q processes, scale-up efforts, and supply chain risks and issues is critical. This understanding for TMRR phase should include:

- Manufacturing processes and techniques not currently available
- Design producibility risks, issues, and opportunities
- Probability of meeting milestones
- Potential impacts of critical, strategic, and long-lead materials including disruptions
- M&Q equipment and tooling availability
- Cost models and goals realism
- Estimates for support of management reviews

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- Analyses and rationale for M&Q feasibility, cost, and schedule trade-offs of alternative approaches
- Anticipated M&Q processes testing and demonstration efforts

Producibility criteria should reflect a blending of general criteria and specific criteria applicable to the system being developed. Producibility analyses will be effective if the design engineers understand and apply the producibility design criteria. Producibility is more than a design engineering function requiring M&Q engineer participation to generate a design that is compatible with the M&Q capabilities of the contractors. Producibility is the most important determinant of product cost, due to the impacts on EMD, Production and Deployment (P&D), and Operations and Support (O&S) costs. Ignoring producibility may lock the acquisition program into design solutions that can only be accomplished at unnecessarily high costs and/or designs that can entail substantial technical, cost and schedule risk. The TMRR contract should have required that the contractor develop, execute, and maintain a Producibility Plan and criteria to guide the design and development efforts. The plan should describe specifically what activities will be accomplished in each phase, the responsible organization, and the management controls that will be established to ensure successful accomplishment. M&Q should review the plan with a focus on the completeness, clarity, adequacy, and realism of the planning accomplished by the contractor. Results of these analyses will support the development of specific contractual provisions for the EMD phase.

DoD policy on major system acquisitions makes producibility risk considerations a requirement in the Acquisition Program Baseline (APB) prior to the start of technology development. Producibility assessments should be an integral part of the on-going systems engineering process. Design processes should have included producibility assessments as part of the design decisions, however producibility is not limited to design.

Effective measurement is critical to accuracy producibility assessments. Measurement is a tool for evaluating the effectiveness of producibility performance and for determining the degree to which improvements need to be made to ensure that future products are producible. Producibility assessments are conducted on system, subsystem, item, and component levels. M&Q processes must be monitored and controlled with measurements, to ensure repeatable and consistent production of accurate, high-quality products. Process variability results in product variability, and product variability, when outside of design limits, means unacceptable quality. As a rule, reducing process variability improves product quality and, therefore, producibility.

In general, to assess program producibility, the organization must evaluate producibility on a product-by-product basis. Analysis of producibility on a per product basis allows the organization to better understand the strengths and weaknesses of the system, so that enhancements can be identified.

Other producibility considerations include:

- Minimizing costs and schedule while maximizing performance
- Infrastructure – cyber-security, software tools, design guides, training, and policies

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- Trade studies for design principles, reducing part counts, using of common parts, ease of assembly, simplicity of fabrication, safety, etc.

Key and critical product characteristics and features are the output of key and critical M&Q processes. Consequently, to achieve program goals it is important for the contractor to identify and control these characteristics early in the system design and development effort.

According to AS9100D, KCs (Key Characteristics) are defined as an attribute or feature whose variation have a significant effect on product fit, form, function, performance, service life or producibility, that require specific actions for the purpose of controlling variation. A critical characteristic is defined by AS6500 as a characteristic that is likely, if defective, to create or increase a hazard to human safety, or to result in failure of a system to perform a required function. Additionally, AS6500 defines a critical manufacturing process as a process that creates or affects a key or critical characteristic. KCs and critical characteristics and the associated manufacturing processes may be produced or accomplished at a sub-tier supplier. By the end of the TMRR phase, the contractor and the program office should have a top-level understanding of KCs. Products perform better when there is less variation on the key and critical characteristics.

Based on design and manufacturing feasibility and capability analyses, producibility assessments, and KC identification process, M&Q will assess design maturity in accordance with industry best practices. It must be economically feasible to manufacture a quality product at a specified rate and to deliver end items capable of achieving the performance and reliability inherent in the design. A strong emphasis early in the design phase on:

- Configuration control
- Key and critical characteristics processes
- Risk, issue, and opportunity management
- M&Q capabilities, feasibility, and producibility, contribute to reduce the time and cost required for successful transition to production

Design maturity occurs when a product design meets the requirements, as well as cost, schedule, and performance targets. It is a best practice to achieve design completion at the system-level CDR in the EMD phase. Consequently, design completion should include a ramp-up during TMRR to meet Preliminary Design Review exit criteria.

The PDR is a technical assessment establishing the physically allocated baseline and the functional baseline to ensure that the system under review has a reasonable expectation of being judged operationally effective and suitable and has a reasonable expectation of satisfying the requirements within the currently allocated budget and schedule. A successful PDR should include an assessment of the producibility of the design and an assessment of manufacturing costs and risks.

M&Q is responsible for inputs, per industry best practices, to many aspects of a PDR. M&Q inputs include:

- Entry/exit criteria for the preliminary PDR process
- Results of MRL assessments
- Reviews, analyses, assessments, and contractor deliverables that support sufficient maturity of the allocated baseline
- Results of the assessments establishing the system functional baseline
- Inputs and documentation to the technical planning process
- Manufacturing Plans and Quality Plans
- Inputs to the program risk, issue, and opportunity assessment process for identification and mitigation of M&Q cost, schedule, and technical risks
- Inputs to the program life cycle cost estimates

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. Manufacturing and quality personnel must participate with the Design IPT in the development and review of the design and design documentation.

Manufacturing and Quality Tasks

- Ensure adherence to M&Q design best practices (e.g., AS6500, AS9100, ISO 9001, etc.).
- Provide M&Q requirements based on analyses of system requirements and design concepts.
    - Identify capabilities and constraints based on the system specifications
    - Establish the required M&Q capabilities baseline
    - Identify M&Q affordability cost drivers and impact on schedule and performance
- Provide input to design trade studies (i.e., functional and performance requirements) that include criteria concerning:
    - KPPs, KSAs, APAs, and evolving KCs
    - Manufacturing process capabilities, limitations, and concerns
    - Software and firmware development and re-use
    - Safety, handling, storage, and disposal considerations and restrictions

  - Quality constraints and costs (measurements, destructive/non-destructive tests, process capabilities, limitations, etc.)
  - Manufacturing costs, materials, special tooling, and test equipment
  - Cost-effective and affordable designs to achieve performance and schedule while minimizing cost
  - Manufacturing capacity, workforce, and schedule impacts
- Participate in the design producibility process provides:
  - Identification products and processes that would benefit from producibility analyses (i.e., Design for Manufacturing (DFM)/Design for Assembly (DFA)
  - Monitoring and reporting on producibility process activities with respect to risks, issues, and opportunities
  - Integration of producibility with other design activities including software and firmware development and re-use
  - Participation in producibility design trade studies to include process capabilities, manufacturing costs, tooling, test equipment, materials, manufacturing capacity, workforce training, schedule impacts, etc.
  - Identification of innovative manufacturing technology opportunities
- Provide monitoring, reviewing, analyses, and reporting on multiple analyses as part of the FMECA process (e.g., DFMEA, PFMEA).
- Provide inputs into the Design and Development planning process to include:
  - Planning inputs that establish, implement, and maintain appropriate processes to manage key and critical subsystems, components, and items including process controls for KCs
  - Requirements for design, production process verification, test, inspection, verification, and product acceptance (statistical techniques)
  - Inputs for monitoring and managing the development process through frequency, data, and metrics for design reviews
  - Criteria for M&Q evaluation of design outputs (product)
  - Requirements for M&Q verification, validation, and change control
- Provide M&Q impacts and interdependencies of design activities to other functional areas or activities (e.g., engineering, producibility, costs, safety, manpower, schedule, etc.).
- Perform assessments and identification of M&Q risks, issues, and opportunities (e.g., technology, manufacturing, cybersecurity, software development, and sustainment) including mitigation.
- Provide M&Q support to program reviews (e.g., PMRs, SRR, SFR, and PDR).
- Provide M&Q support to the program level TRA and MRL assessment (as required).
- Provide M&Q support to the specified program configuration control process for the design.
- Evaluate the design for the impacts on M&Q requirements with respect to GFE (e.g., subsystems, components, test ranges, facilities, etc.).

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- Provide M&Q inputs to program documentation (e.g., SEP, TEMP, AS, CDD, etc.)
    - Include inputs and support for CDD validation efforts
    - Include inputs for manufacturing plan updates (including design changes, investments, etc.)
- Provide support to other IPTs as required (e.g., Systems Engineering, Costs, Proposal Team, etc.)
- Provide M&Q input in support of congressionally mandated assessments and reports.
    - Inputs on M&Q risks associated with the program
    - Inputs on M&Q processes that need to be matured.

Tools

- Acquisition Plan Preparation Guide template
- Capability Development Document (CDD) template
- Design for Manufacturing and Assembly (DFMA)
- Interactive MRL Users Guide Checklist for the Design thread
- Life Cycle Sustainment Plan template
- Manufacturing Maturation Plan
- Preliminary Design Review (PDR) Checklist
- Systems Engineering Plan (SEP) Outline
- System Functional Review (SFR) Checklist
- System Requirements Review (SRR) Checklist
- Test and Evaluation Master Plan (TEMP) template
- Technology Readiness Assessment (TRA) Checklist

Resources

- 10 USC 144B, Sec 2366 and 2448
- Acquisition Strategy Guide, DSMC
- AS 9103, Variation Management of Key Characteristics
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- CDD-CPD Writing Guide, Feb 2015
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Early Manufacturing and Quality Engineering Guide
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs

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- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- ISO 9001:2015, Quality Management Program
- LCSP memo, Sep 2011, and DAG Chapter 4-3.1
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment (TRA) Deskbook
- TEMP Guide, and DAG Chapter 8-4.1

E.2 Evaluate Design and 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 the 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.

Current "Design Best Practices" include the use of Computer-aided Design (CAD) and Computer-aided Manufacturing (CAM).

CAD (Computer Aided Design) is the use of computer software to design and document a product's design process. CAD is used to accomplish preliminary design and layouts, design details, and calculations, creating 3-D models, creating and releasing drawings, and interfacing with analysis, marketing, manufacturing, and end-user personnel.

Computer-aided manufacturing (CAM) is the use of software and computer-controlled machinery to automate a manufacturing process. Based on that definition, you need three components for a CAM system to function:

- Software that tells a machine how to make a product by generating toolpaths.
- Machinery that can turn raw material into a finished product.
- Post Processing converts toolpaths into a language machines can understand.

Manufacturing and Quality Tasks

- Assess the organization's approach to systems engineering and use of best practices to solve design and manufacturing problems
- Perform an M&Q Design IPT participants assessments of the contractor(s) and supply chain capability to mature the proposed design(s) within the program overall cost, schedule, and performance goals.
    - Identify risks, issues, opportunities, and mitigation plans

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  - Include competing technologies, prototypes, etc.
  - Include capabilities with respect to environmental and hazardous processes
- Conduct analyses to:
  - Determine shortfalls (risks) to the required baseline M&Q capability and mitigation required
  - Identify M&Q processes and techniques that require development (including for special and hazardous)
  - Identify materials, producibility, equipment, and schedule risks, issues, and opportunities (including availability, hazardous, and long-lead)
  - Develop M&Q inputs to production unit cost and schedule (realism) estimates
  - Provide M&Q comparisons of competing and/or alternative approaches
  - Provide M&Q recommendations for anticipated M&Q process testing and demonstration efforts for each competing and alternative approach
  - Identify required M&Q capability investments (e.g., ManTech, GFE, facilities, capital equipment, tooling, test equipment, and processes, Modeling and Simulation (M&S), etc.)

Tools

- Independent Technical Risk Assessment (ITRA) Checklist
- Interactive MRL Users Guide Checklist, Design thread
- Manufacturing Maturation Plan
- Quality System Audit

Resources

- AS6500, Manufacturing Management Program, Nov 2014
- AS9100, Quality Systems – Requirements for Aviation, Space, and Defense Organizations
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

E.3 Update Producibility Plan

Producibility Engineering and Planning should be directed toward generating a design that 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

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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) plans for specific processes, methods, and actions to address manufacturing feasibility, producibility, and M&Q risks associated with the proposed solutions.
    - Include schedule, responsibilities, and management controls
    - Review the plan for purpose, realism, completeness, and clarity
    - Identify interdependencies and integration factors
    - Identify risks, issues, and opportunities
    - Identify manufacturing technology requirements
    - Include technology insertion opportunities
- Ensure plan describes how the design engineers apply the producibility design criteria.
    - If a competitive approach is used, describe how each competing design will be evaluated from a producibility standpoint
- Update identified and potential M&Q process risks, issues, and capabilities to include:
    - Validated and updated producibility goals and metrics
    - Updated Modeling and Simulation (software) approaches (manufacturing and production)
    - Critical M&Q processes (yield, rates, and variability, if available)
    - Impacts to cost, schedule, and performance
    - Facilities, tooling, testing, and qualification
- Merge the identified contractor and government M&Q risks, issues, and opportunities into a consolidated government/contractor program plan and process.
- Ensure producibility planning for design includes M&Q considerations for and/or address the following:
    - Security (physical and cyber)
    - System safety and HAZMAT management criteria
    - Interdependencies and integration
    - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
    - Benchmarking
    - Costing
    - Data management systems
    - Design for Manufacture/Assembly
    - Design of Experiments (DOE)
    - Failure Modes and Effects Analysis (FMEA)

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        - Design Failure Modes and Effects Analysis (DFMEA)
        - System Failure Modes and Effects Analysis (SFMEA)
        - Process Failure Modes and Effects Analysis (PFMEA)
    - Prototyping approaches
    - Design for Six Sigma
    - Tools (Quality Functions Deployment (QFD), Root Cause Analyses, Statistical Process Control (SPC), Tolerance Analyses, etc.)

Tools

- Interactive MRL Users Guide Checklist, Design thread
- Manufacturing Maturation Plan
- Producibility Engineering and Planning (PEP) Data Item Description

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- MIL-STD-882E, DoD Standard Practice: System Safety
- NAVSO P-3687, Producibility System Guidelines
- Producibility System Guidelines, Missile Defense Agency

E.4 Perform Producibility Assessments

DoD policy on makes producibility considerations a requirement for MDAPs. DODD 5000.01 states that the PM shall "reduce manufacturing 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 cost. Therefore, producibility programs are necessary as a management means for ensuring 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. Manufacturing and QA managers are key to the successful implementation of a producibility program.

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Manufacturing and Quality Tasks

- Perform and/or support producibility assessments as a member of the Design IPT utilizing approved contractual documentation (CDRLs, DIDs, etc.) and other programmatic information and data including the following factors in the assessments:
    - Planned producibility goals and metrics
    - Management responsibilities and controls
    - Design analyses (between and among competitive designs)
    - Cost and schedule
    - Key Characteristics
    - Interdependencies and integration
    - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
    - Risks, issues, and opportunities
    - Manufacturing technology requirements (including innovative and advanced)
    - Technology insertion opportunities
    - Review of goals, realism, completeness, and clarity
    - Implementation of industry best practices, tools, and techniques
    - System safety design and HAZMAT management criteria
    - Security (physical and cyber)
    - Facilities, tooling, testing, and qualification
    - Government-furnished equipment (GFE), etc.
- Utilize producibility tools, techniques, procedures, and associated metrics that include:
    - State-of-the-art Modeling and Simulation software
    - Failure Modes and Effects Analyses (FMEA)
        - Fault Tree Analysis (FTA)
        - DFMEA
        - SFMEA
        - PFMEA
    - Design for Manufacture and Assembly (DFMA)
    - Design of Experiments (DOE)
    - Design for Six Sigma
    - Quality Function Deployment (QFD)
    - Benchmarking
    - Design guides
    - Interdependencies and integration analyses
    - Tolerance analyses
    - Requirements validation analyses
    - Trade studies on alternative product and process designs
    - Product complexity analyses

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  - Safety analyses
  - Manufacturing process analyses
  - 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 and process measurements utilizing Statistical Process Control (SPC)
  - Data and database management
  - Testing
- Provide M&Q support to design producibility analyses including:
  - Process capabilities
  - Manufacturing costs
  - Tooling and test equipment
  - Materials availability and characterization
  - Manufacturing capacity and capability
  - Workforce availability and training
  - Schedule impacts
  - M&Q cybersecurity (including all digital communications and connectivity for design, facilities, equipment, etc.)
  - System safety and vulnerability

Tools

- Design of Experiments (DOE)
- CAD/CAM software
- Interactive MRL Users Guide Checklist, for the Design thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Quality Function Deployment (QFD) method
- Taguchi Loss Function Sheet
- Trade Studies

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide

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- MIL-STD-882E, DoD Standard Practice: System Safety
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering Standard Practice Manual, U.S. Army Belvoir R&D Center
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)

E.5 Identify Key Characteristics

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

Manufacturing and Quality Tasks

- Provide monitoring, evaluation, and analyses from multiple FMEA activities (e.g., FMECA DFMEA, PFMEA, etc.) for the derivation of KCs, critical characteristics, and Critical Safety Items (CSIs), where possible.
    - Provide M&Q support to the System Safety Assessment (SAR) to assist in CSI identification with supporting rationale
- Guide and ensure identification, derivation, and justification of KCs and critical characteristics from identified KPPs, KSAs, and APAs (including all mandatory KPPs).
    - Update initial M&Q draft KPPs, KSAs, and APAs, and associated CTEs
    - Provide M&Q inputs on development and management processes to establish, implement, and maintain management of key and critical subsystems, components, items, and software including process controls for KCs
        - Provide inputs on development and management processes to be evaluated
        - Include identification of M&Q processes to be matured
        - Specify, as applicable, specific actions to be taken (e.g., mitigation, investments, etc.)
    - Develop a preliminary list, which includes where produced or accomplished and a rationale for inclusion (*see* G.6), of:
        - Key Characteristics

    - Critical characteristics
    - Critical Application Items (CAIs) (e.g., systems, subsystems, software, materials, components, etc.)
    - Key M&Q processes
    - Critical Safety Items (CSIs)
- Provide outputs of and updates to key and critical characteristic identification, derivation, justification, and management processes to the SEP, AS, CDD validation process, RFP development process, TRA, MRL assessment, and PDR entry/exit criteria development process.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide Checklist, for the Design thread
- Manufacturing Maturation Plan
- MRL Matrix
    - Critical to Quality Tree
    - Failure Mode and Effects Analysis
    - Process Capability Analysis Worksheet
    - Producibility Assessment Checklist
    - Technology Readiness Level (TRL) Assessment Checklist

Resources

- AS9100, Quality Management System
- AS6500, Manufacturing Management Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI5000.02, Operation of the Adaptive Acquisition Framework
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- JCIDS Manual
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-882E, DoD Standard Practice: System Safety
- NAVSO P-3687, Producibility System Guidelines
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

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- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

E.6 Assess Design Maturity

The Preliminary Design Review (PDR) is conducted at the end of the TMRR phase to assess prototype(s) technical progress, adequacy, and risks to cost, schedule and performance for moving that configuration forward into Engineering and Manufacturing Development.

After PDR, the design should be maturing to the point that the review can assess the allocated design documentation in subsystem product specifications for each configuration item in the system and that all functions have been allocated thus providing the Milestone Decision Authority enough evidence to move the program forward. M&Q managers as a part of the technical IPT should support assessments of design maturity.

Manufacturing and Quality Tasks

- Assess design maturity for the following in accordance with industry best practices (e.g., AS6500, AS9100, etc.) and readiness for the PDR (per IEEE 15288) based on design and manufacturing feasibility and capability analyses, producibility assessments, and KC identification process:
    - Update prior or conduct M&Q assessments of capability and feasibility based on contracted system concept(s).
        - Assess lower-level performance requirements to determine sufficiency to proceed to preliminary design
        - Assess completeness of product data required for component manufacturing
    - Update the producibility and manufacturability assessments for gaps and risks including:
        - Critical and unique manufacturing process requirements including software
        - Alternate design approaches within the concepts
        - Material requirements
        - Supply chain requirements
        - Production rate and yield requirements
        - Facility requirements
        - Special tooling development requirements
        - Test and demonstration requirements for new materials
        - System safety and HAZMAT management
        - Economic feasibility

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    - Manufacturing capability obsolescence
    - Manufacturing capability sustainment
  - Assess adequacy and robustness of the contractor configuration control processes with respect to design, engineering, software changes
  - Assess updates and status of key and critical characteristic processes
    - Assess M&Q engineering and management activities for adequacy and completeness (e.g., documentation, drawings, data collection and management, etc.)
    - Assess for adequacy and completeness of M&Q inputs on mandatory KPPs
  - Provide inputs and plans for M&Q risks, issues, and opportunities to the government/contractor Risk, Issue, and Opportunity Management Process:
    - Update and status known
    - Identify and develop plans for new
    - Evaluate adequacy and completeness of mitigation activities
  - Provide M&Q inputs for product level engineering/design requirements definition and support the validation activities.
  - Assess and validate product requirements and features as well enough defined to support PDR
  - Identify M&Q components of Technical Performance Measures (TPMs) to support tracking of design maturity
  - Assess and validate if product data essential for system/subsystem prototyping is ready for release
  - Assess completion status of physical and functional interface definitions for the product (system)
  - Assess and validate prototype demonstrations in a relevant environment for all enabling/critical items, parts and components including relevant software
  - Assess percentage completion of subsystem design (with schedule for completion) and component and item maturity (percentage in current production) for PDR

Tools

- Design for Six Sigma
- Independent Technical Risk Assessment Checklist
- Manufacturing Maturation Plan
- MRL Assessment Checklist, Design thread

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- Defense Technical Risk Assessment Methodology (DTRAM)

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- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- JCIDS Manual
- MIL-STD-882E DoD Standard Practice: System Safety
- NDAA for FY 2017, Public Law 114-328
- Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs

E.7 Support Preliminary Design Review

M&Q personnel should be actively engaged in the organization and execution of the Preliminary Design Review (DR) during this phase. The PDR is an assessment that establishes the Allocated Baseline of the system and is used to ensure that the system has a reasonable expectation of meeting the current requirements within the given cost and schedule. The completion of the PDR should provide:

- An established system allocated baseline
- An updated risk assessment for the EMD phase
- An updated CARD based on the allocated baseline
- An updated program schedule including system and software critical path drivers
- An approved Life Cycle Sustainment Plan

Manufacturing and Quality Tasks

- Provide M&Q inputs to the entry criteria for the preliminary PDR process per industry best practices (i.e., IEEE 15288) including:
    - Acceptability criteria for technical review outputs
    - Preparatory actions for the specific program
    - Inputs to allocated baseline and budget
    - Review of lower-level subsystem PDRs
- Provide M&Q inputs to the exit criteria for the PDR process per industry best practices (i.e., IEEE 15288) that include addressing:
    - Adequacy, accuracy, and completeness of required M&Q PDR criteria
    - Closure of M&Q action items with appropriate corrective action plans
    - Risk and issue mitigation and opportunity planning
    - Adequacy of the allocated and functional baselines
- Support the PDR to ensure, by inputs provided from results of an MRL assessment(s), that the manufacturing system will meet expectations for effectiveness and suitability (quality) within the allocated budget and schedule includes:
    - Manufacturing equipment, tooling, and software (including ManTech)

  - Processes, process control, and process capabilities (C_{pk}s)
    - Include initial data analyses
  - Interfaces and interface requirements
  - Materials management (including hazardous)
  - Workforce (personnel, skill sets, training, etc.)
  - Supply chain (includes industrial base alternatives)
  - Facilities (including GFE)
- Provide M&Q design inputs for reviews, analyses, assessments, and contractor deliverables that support sufficient maturity of the allocated baseline per contractual requirements to conduct a PDR including:
  - Analyses of system-level performance, producibility, growth allocations, and traceability
  - Design trade studies to the lowest level
  - Software development and re-use
  - Allocation of interoperability performance requirements
  - Preliminary long-lead production requirements
  - Requirements for parts, materials, and processes incorporated in the preliminary design including risks, issues, and opportunities (e.g., obsolescence; fragile, sole, single, foreign sources, hazardous, etc.)
  - M&Q control processes and procedures (e.g., Electromagnetic Interference, hazardous, environmental, etc.)
  - Meeting the Mandatory KPPs and system performance/functional KPPs and KSAs (including supply chain)
  - Key Characteristics and key processes management
    - Include critical characteristics and critical processes (including Critical Technologies List of CTEs with CSIs and CAIs included) analyses (*See* E.5 and G.6)
  - DT&E requirements
  - System safety requirements
  - Environmental Safety, Occupational Health (ESOH) requirements and preliminary hazards list
  - Manufacturing security and access (physical and cyber)
  - Quality assurance requirements (including tolerances/design margin analyses for a robust design)
  - Modular Open Systems Approach (MOSA) (includes interfaces and subsystems)
- Provide the M&Q inputs to the assessment establishing the system functional baseline, including inputs for:

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  - Preliminary designs of hardware, software, and procedures including interfaces is complete, satisfies all requirements in the system functional baseline and is under Configuration Management without any major To Be Determined (TBD) or open items
  - System, segment, subsystem, and component-level interfaces
  - M&Q aspects of C4I equipment, interfaces, processes, and procedures across segments, subsystems, and components
  - Implication of the threat scenario to M&Q processes and environments (traceable to all segments, subsystems, and components)
  - M&Q data collected to date, including test data, on the subsystems, items, and components for the preliminary design
    - Data should be traceable to requirements via specifications and verification cross-reference matrix (from SFR)
    - Data should support bidirectional traceability between functional and allocated baselines

- Provide the M&Q inputs and documentation to the technical planning process to include:
  - M&Q analyses of the Supplier(s) SEMP to determine adequacy and alignment with the M&Q provisions in the SEP
  - M&Q analyses of lower-level PDRs to identify risks and issues and determination of actions required
  - A review of the Manufacturing Management and Quality Management plans in the SEMP and the SEP for adequacy to meet proposed EMD requirements
    - Include requirements for sub-tier SE reviews and audits such as PDR, CDR, PRR, etc.
  - The assessment of design maturity for the M&Q components of TPMs for the technical planning process
  - Manufacturing Management Plan and Quality Management Plan approaches to support program Validation and Verification (V&V) processes as part of design, development, test, data acquisition, etc.
  - M&Q inputs to the HAZMAT management and pollution prevention processes and procedures
  - Inputs on adequacy of facilities chosen to perform design verification (includes facilities, equipment, GFE, etc.)
  - Status of ongoing system producibility and trade studies
  - Identification of long-lead materials and supply chain elements (including multi-sourcing of items, parts, and components)
  - Inputs to the requirements for software development plans
    - Coordination, scheduling, and availability of assets (e.g., facilities, labs, equipment, etc.) for test and integration

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    - Hardware/software interfaces and integration
    - Data storage, handling, and security (physical and cyber)
    - Built-in test and performance

- Review M&Q plans for completeness and adequacy to include
    - Analyses, demonstrations, and prototypes to confirm the design/development approach in a relevant environment
    - Trade studies that address COTS, re-use, and other related issues
    - A draft Bill of Materials for the system
    - An updated IMP and IMS that includes all major phases with acceptable risks and executable budget
    - Use of computer modeling, design tools, and test and integration labs
    - Identification, definition, and characterization of critical manufacturing processes, metrics, and the management process
    - A failure reporting and corrective action system (FRACAS) process
    - Inputs to the TEMP components and items, facilities, equipment, fixtures, and interfaces
    - Capability to meet rate and schedule
- Provide M&Q support to the Life Cycle Sustainment Plan.
- Provide inputs to the program risk, issue, and opportunity assessment process for identification and mitigation of M&Q cost, schedule, and technical risks.
- Provide inputs to the program life cycle cost estimates for M&Q.

Tools

- Interactive MRL Users Guide Checklist, Design thread
- Manufacturing Maturation Plan
- Preliminary Design Review Checklist

Resources

- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-882E, DoD Standard Practice: System Safety

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F. COST/FUNDING

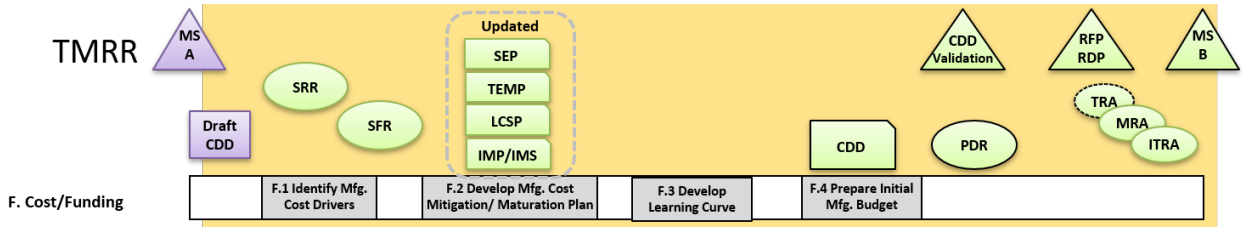

Figure 3-7. Cost and Funding Manufacturing and Quality Activities

Introduction

Services and Agencies develop Program Objective Memorandums (POMs) to identify and request resources (money) to acquire capabilities and perform operations. The POM is part of the Programming phase of the Program, Planning, Budget, and Execution (PPBE) process. The DoD combines the various Service and Agency POM inputs and Budget Estimate Submission (BES) and submits a DoD Budget Request to the Office of Management and Budget (OMB).

DoD efforts at cost estimating and analysis play a critical role in supporting DoD procurement activities to include planning, programming, budgeting, acquisition, and requirements generation. Cost estimating is both a science and an art relying on sound mathematical and analytical skills, critical thinking, communication, and the ability to understand complex functions and processes.

This thread (Cost and Funding) requires an analysis of the risk that the system development and deployment will not meet the DoD cost and funding goals. The thread will focus on the following sub-threads, tasks, activities, tools, and resources:

- Cost Modeling (Initial Estimates)
- Identification of Cost Drivers
- Assessment of M&Q Costs
- Preparation of M&Q Budgets
- Development of M&Q Cost Mitigation Plans
- Development and Validation of Learning Curves

Detailed manufacturing cost estimates could not be developed during the Materiel Solution Analysis phase, but cost drivers should have been identified based on proposed materials and process selections that were inherent in the proposed materiel solutions. In addition, producibility cost could be assessed and investments in manufacturing technologies could be estimated. In TMRR, costs need to be defined and finalized.

The DoD typically requires objective cost estimates and analysis on programs. The type of cost estimate is a function of the program category, events, and type. Cost estimates include:

- Independent Cost Estimate (ICE)

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- Component Cost Estimate (CCE)
- Component Cost Position (CCP)
- Cost Capability Analysis (CCA)
- Independent Government Cost Estimate (IGCE)
- Should Cost Estimate (SCE)
- Sufficiency Review

Cost estimates should be used to evaluate affordability and establish initial program cost thresholds. In most cases, the estimates in MSA were developed using statistically based cost estimating relationships or by comparison of the proposed systems with similar systems whose costs are known. The cost estimates will be used as the initial basis for concept costs in the TMRR phase.

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

Within any program there will be certain systems, subsystems, items, and components the cost of which will dramatically impact the overall system cost; these are the cost drivers. Any analysis of M&Q risks and producibility issues will identify a cost driver. M&Q focuses on producibility planning and risk and issue mitigation for identification and reduction of cost drivers. Areas that are ripe for discovering and eliminating manufacturing cost drivers include the following areas:

- Emerging technologies
- Industrial base
- Design/producibility
- Funding for maturing the M&Q processes
- Materials availability and environmental impacts
- Supply chain management
- Process capability and control
- M&Q management/supplier quality management
- Workforce
- Facilities, capital equipment, tooling, and test equipment

A concerted effort should be initiated to reduce identified drivers and the overall costs wherever possible. There are cost tools that can be used within the program that can help identify and achieve overall cost reductions.

A should-cost review uses an integrated team to conduct coordinated, in-depth cost analyses of a contractor's plans and ongoing efforts. The purpose of the review is to identify inefficient and uneconomical contractor practices, to quantify the impact of these practices on system cost, and to use

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the findings to develop a realistic price objective. The approved cost reduction efforts or initiatives are used to incentivize contractor performance toward achievement of the new should-cost target. The should-cost analysis is intended to not only evaluate proposed contractor costs, but to then track and monitor those costs and to identify further savings opportunities that will lead to further cost reductions.

Will-cost estimates should be verified by an office that is external to and independent of the program office. Additionally, it is DOD policy that programs actively manage the budget baseline using the current will-cost estimates for all acquisition, budget, and program execution decisions (e.g., source-selection, contract negotiations, major reviews, etc.). The programs budget baseline is based on a will-cost estimate and is sometimes referred to as the Independent Cost Estimate (ICE) or verified Program Office Estimate. This estimate is historical in nature and aims to provide sufficient funds to execute the program under normal conditions (average program risks). This will-cost estimate is used to support the budget and ensures sufficient funding.

Program Managers will employ Earned Value Management (EVM). The purpose of EVM is to ensure sound planning and resourcing of all tasks required for contract performance. EVM provides a disciplined, structured, objective, and quantitative method to integrate technical work scope, cost, and schedule objectives into a single cohesive contract baseline plan called a Performance Measurement Baseline for tracking contract performance.

M&Q personnel must analyze contractor data to develop, update, and support plans for mitigation and/or maturation of cost drivers.

As the program matures the manufacturing budget will become more refined and accurate. During the TMRR phase, as the design matures, the contractor and the program should be able to create budgets based upon specific design characteristics and knowledge of the M&Q capabilities and processes that will be used to produce the system. The budget should include:

- M&Q cost reduction initiatives.
- Accurate costs based on analyses and assessments of cost data against cost targets and trends.
- M&Q funding estimates for emerging requirements including investment opportunities and investment roadmaps
- Budgeting for M&Q initiatives and manufacturing technology investment programs.

When budgeting for M&Q, interaction with the contractor will enable the program to understand the significant cost impacts experienced by the contractor. Interaction increases the program’s understanding of the contractor's M&Q operations and M&Q costs, as well as the factors that can impact M&Q operations.

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F.1 Identify Manufacturing Cost Drivers

M&Q managers need to support to development and update of government cost estimates and the assessment of contractor cost estimates. This includes the identification of manufacturing cost drivers, those costs that have the most impact on cost and affordability.

Manufacturing and Quality Tasks

- Support cost estimates as appropriate:
  - Independent Cost Estimate (ICE)
  - Component Cost Estimate (CCE)
  - Component Cost Position (CCP)
  - Cost Capability Analysis (CCA)
  - Independent Government Cost Estimate (IGCE)
  - Should Cost Estimate (SCE)
  - Sufficiency Review
- Analyze and update M&Q should-cost inputs and provide these to the Cost Analysis Requirements Document (CARD) update for consistency with the approved system specification and budget for the SRR.
  - Include updates to the will-cost model based on industry best practices
  - Include updates to M&Q cost sensitivity analyses
- Analyze and update M&Q cost drivers from manufacturing, quality, materials, and unique or specialized requirements and associated risks and issues for the SRR.
  - Include contractor descriptions and plans for processes, materials, rates, supplier quality, workforce, special handling, environmental compliance, security (physical and cyber), etc.
  - Include identified subsystems, parts, items, and components
  - Include “should-cost” analyses
  - Quantify the cost driver uncertainties
  - Update the estimate for the cost of quality
  - Update the estimate for the cost and impact of testing
- Analyze and update the contractor producibility planning for cost drivers and associated risks for the SRR to include:
  - Emerging technologies
  - Design producibility
  - Cost reduction and avoidance
  - Manufacturing processes
  - Materials availability

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  - Compliance with ESOH, NEPA, NEPA Compliance Schedule, System Safety, HAZMAT program, Pollution Prevention, and PESHE Supply chain
  - Process capability and control
  - Quality and supplier quality
  - Workforce training
  - Security, required special handling, cyber protection
  - Facilities, capital equipment, tooling, and test equipment
- Analyze the contractor initial M&Q risk assessment for mitigation plan costs and drivers within budget and schedule for the SRR.
  - Include risks from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
- Analyze the contractor M&Q cost planning for realistic and appropriate allocation of cost drivers for the SRR.
- Update M&Q cost estimates for predicted life cycle costs of the evolving design for consistency with program affordability constraints for the SRR.
- Analyze and update M&Q cost estimates and budget for prototype demos and validations contributing to cost drivers for the SRR.
- Ensure M&Q cost should-cost estimates (inputs) to the CARD are consistent with the allocated baseline for the PDR.
  - Include M&Q cost sensitivity analyses validation
- Update M&Q cost drivers from manufacturing, quality, materials, and unique or specialized requirements and associated risks, issues, and opportunities for the MRL assessment and the PDR including:
  - Contractor processes, materials, rates, supplier quality, workforce, special handling, environmental compliance, security (physical and cyber), etc.
  - Subsystems, parts, items, and components
  - Quantified cost drivers
  - Cost of quality estimates
  - Estimates for the cost of testing
- Validate the contractor producibility cost drivers and associated risks, issues, and mitigation plans for the MRL assessment and the PDR including SRR producibility planning areas above.
- Update status of contractor M&Q risks and issues mitigation costs and drivers (budget and schedule) for the MRL assessment and the PDR.
  - Include risks and issues from sole, single, fragile, foreign sources, cyber exploitation, and foreign acquisition of domestic sources
  - Cost, schedule, and technical risks are identified, and mitigation plans are in place

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- Validate the contractor M&Q costs and cost planning for realism and allocation of cost drivers for the MRL assessment and the PDR.
- Update M&Q cost estimates for predicted life cycle costs for the MRL assessment and the PDR.
- Validate M&Q cost estimates and budget for prototype actual costs and validation costs for cost drivers for the MRL assessment and the PDR.
- Update M&Q hardware estimates for quantity, effort (costs), and schedule for the MRL assessment and the PDR.
- Update M&Q inputs to the system cost model and budget including allocations to lower system element levels, tracking against targets, and the production cost model for the MRL assessment and the PDR.

Tools

- Cost Analysis Requirements Description (CARD) template
- Cost, Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Design to Cost Estimates
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide (Checklist) for the Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- *See* CAPE website for tools

Resources

- CARD website and process
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Should-Cost and Affordability Memo

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F.2 Develop Manufacturing Cost Mitigation/Maturation 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. Since the program is in TMRR, costs are still evolving as the design evolves and as testing proves out the design. Manufacturing processes are also evolving and thus need a strong focus on maturing proposed manufacturing processes.

Manufacturing and Quality Tasks

- Develop cost reduction (i.e., mitigation) plans utilizing the outputs (SRR/SFR) from the should-cost and will-cost analyses:
    - Conduct a coordinated, in-depth should-cost review on the contractor(s) planning and ongoing efforts against best practices
    - Incorporate identified cost drivers
    - Conduct will-cost analyses on the results
    - Plans include tracking and monitoring costs to identify further savings opportunities and reductions
    - Plans address M&Q cost risks and issues mitigation plans
    - Plans include completion of major cost and performance trades, and risk and issue reduction efforts to support the CDD Validation Decision prior to PDR
- Provide M&Q inputs and support to the Independent Cost Estimate (ICE) or verified Program Office Estimate:
    - 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
- Analyze the contractor M&Q Earned Value Management (EVM) plan to include the critical path documentation.
- Update the cost model to include cost targets and include:
    - Design/Producibility analyses considerations and results
    - M&Q costs
        - New M&Q processes implementation
        - Materials availability and maturity
        - Environmental management and disposal impacts
        - Process capability and throughput (setup, yield, scrap, rework, Work in Progress)
        - Quality (including supplier quality) issues
        - Workforce issues
        - Facilities costs
        - Security, required special handling, cyber protection

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        - Special Tooling and Test Equipment
        - Equipment availability, capacity, and constraints
        - New Technologies analyses and impacts
    - Support of Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs.)
- Update the M&Q cost models to support mitigation/maturation planning to include the capability for the models to support:
    - Design trades to assess the cost impacts of specific design changes
    - Alternative production processes or process improvements
- Incorporation of the current estimates and actual (if available) manufacturing costs into the cost estimates
- Plan for EMD, production, developmental and operational test, and life cycle sustainment of proposed products.
    - The CDD Validation Decision process
- Develop cost maturation and mitigation plans to support independent evaluations (MRL assessments)
    - Manufacturing Maturation Plan incorporates and document the costs associated for maturing manufacturing capability that does not meet required maturity levels

Tools

- Cost Analysis Requirements Description (CARD) (*See* CAPE website for tools)
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Interactive MRL Users Guide Checklist, for the Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan
- Parametric, Engineering and Actual estimating

Resources

- 10 USC Sec. 2334 Independent Cost Estimation and Cost Analysis
- Cost Analysis Requirements Description (CARD) Template (*See* CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition

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

F.3 Develop Learning Curve

Manufacturing cost estimates may include learning curves. During the TMRR phase the initial manufacturing cost estimate will be based on the prototype design-build activities. These estimates may be based upon a limited number of unite and there may not yet be detailed manufacturing standards for the proposed operations to be performed. At this time, the contractor should be developing learning curves for manufacturing processes that will be carried forward into EMD. Then these learning curves can be assessed and adjusted, as the design matures and as manufacturing processes are realized.

Manufacturing and Quality Tasks

- Define appropriate learning curves for the system and subsystems to include initiation and reporting requirements.
    - Include the basis for the slope (quantity and schedule) for the learning curves
- Define requirements for the baseline data and data collection to include:
    - Costs for quality, processes, personnel, out-sourcing, re-work, scrap, etc.
    - Timing for processes, kitting, idle, takt, cycle, re-work, etc.
    - Labor efficiency
    - Improvements in methods, equipment, tools, automation
    - Standardization and common processes
    - Design changes (producibility/manufacturability)
- Plan for collection of data to support learning curves development that includes the following factors and improvements, at a minimum:
    - Workforce learning, worker, and supervisor
    - Process, line, and workstation
    - Machinery, equipment, and tooling
    - Design producibility changes
    - Work methods and processes
    - Planning and scheduling processes
    - Lot and batch sizing and optimization (just-in-time)
    - Engineering and test activities and changes
    - Quality inspections/tests sampling requirements
    - Inventory, storage, re-work, and scrap levels
    - Operation sequencing and synchronization

- Pre-Planned Product Improvement program and processes

Tools

- Interactive MRL Users Guide Checklist, Cost thread
- Learning Curve Worksheet
- Manufacturing Maturation Plan

Resources

- Application of Learning Curve Theory to Systems Acquisition, Defense Acquisition University (DAU) Teaching Note, Feb 2011
- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8 Learning Curve

F.4 Prepare Initial Manufacturing 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 manufacturing related issues. The budget estimate made near the end of the TMRR phase needs to be accurate enough to support the program through EMD. Manufacturing and QA managers need to support the review and update of M&Q budgets required to support daily manufacturing and quality activities and to support maturing technologies and processes.

Manufacturing and Quality Tasks

- Update the M&Q cost estimates from MSA to validate and update the TMRR budget to include fact-of-life changes.
  - Verify that cost estimates include all M&Q cost drivers and risk estimates from the updated cost model
  - Verify M&Q quantification of cost driver uncertainties and associated budget impact estimates as inputs to the budget process
  - Verify the producibility costs (cost drivers and risks) are included in budget process
  - Update investment estimates in M&Q technologies, processes, equipment, etc. (including ManTech) as inputs to the budget process to include:
    - Capital equipment (tooling, machines, structures, etc.)
    - Test equipment (specialized, environmental, etc.)
    - Facilities and modifications/expansion (handling, storage, transportation, disposal, etc.)
    - GFE
    - Environmental compliance (processes, facilities, equipment, etc.)
    - Manufacturing systems security (physical, cyber, etc.)

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  - Update cost estimating (should-cost and will-cost) with contractor data on M&Q aspects of the proposed system (include similar systems whose costs are known)
  - Validate established M&Q targets (from initial thresholds) affordability cost estimates (should-cost and will-cost) for TMRR based on contractor data
  - Update identified ManTech investments to mitigate M&Q technology gaps in TMRR for implementation
    - Contact and coordinate with potential funding sources for ManTech projects (program office, Service, and/or DoD-wide funding)
  - Provide analyses of the adequacy, reasonableness, and necessity of contractor-proposed manufacturing labor hours and material costs and determine the adequacy of the manufacturing budget for TMRR

- Identify and manage M&Q risks and issues identified in the SRR and the SFR with approved TMRR budget for mitigation plans to achieve PDR entrance criteria including:
  - Technology
  - Industrial Base
  - Design
  - Cost and Funding
  - Materials
  - Process and Capability Control
  - Quality Management
  - Manufacturing Workforce
  - Facilities
  - Manufacturing Management
- Analyze the M&Q TMRR budget sufficiency for the capability to produce a prototype system or subsystem in a production relevant environment prior to Milestone B.
  - Assess each TMRR prototype requirements (system or subsystem) for M&Q process needs, risks and issues, and affordability analyses with budget impacts.
- Evaluate the ongoing manufacturing technology investments (ManTech programs) for sufficiency to meet program objectives (e.g., EMD, P&D, and O&S).
  - Include sponsored initiatives in the program budget and from other sources
- Monitor the execution of the TMRR program and evaluate for impacts to recommend appropriate changes to the M&Q budget.
  - Assess the affordability and executability of the manufacturing processes
  - Recommend quality and manufacturing cost reduction initiatives
  - Analyze the quality, manufacturing, and production cost data (if available) down to the component level against cost targets, and identify trends
  - Identify quality and manufacturing emerging issues

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  - Identify manufacturing investment opportunities and develop investment roadmaps to further the manufacturing development efforts

- Identify budget resources to support an MRL assessment and a TRA prior to PDR.
- Develop M&Q budget inputs for EMD.
  - Ensure program management includes required support by M&Q to program processes and technical and programmatic reviews for:
    - Producibility
    - Key Characteristics
    - Manufacturing Risks
    - Material and supply chain management
    - Manufacturing Technology
    - Manufacturing Surveillance and Audits
    - Manufacturing Security (physical and cyber)
    - GFE
    - Continuous improvement
    - Process control and capability
    - First article inspection and test
  - Provide an assessment of requirements for manufacturing processes, risks and issues, and affordability analyses with budget impacts
  - Perform analyses of proposed manufacturing labor hours and material costs for adequacy, reasonableness, and necessity for a budget estimate
    - Utilize data from contractor reported manufacturing labor hours and material costs, if available
  - Perform analyses of proposed M&Q cost reduction initiatives and incentives for a budget estimate
  - Analyze M&Q EMD cost estimates and supporting TMRR performance data to develop appropriate budget requests that include:
    - Monitoring and managing Key Characteristics (includes critical characteristics, and all KPPs)
    - Assessment of identified trends
    - Emerging quality and manufacturing initiatives
    - Cost/funding estimates and recommendations on emerging requirements
    - Investment opportunities with associated roadmaps
  - Provide M&Q EMD phase budget inputs that include comprehensive M&Q planning for EMD, production, developmental and operational test, life cycle sustainment, and disposal of proposed products including:

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  - Investments for quality and test (e.g., training, equipment, personnel, process improvement, etc.)
  - Quantities and rates through Low-Rate Initial Production (LRIP), Production, and Sustainment
  - Materials (e.g., obsolescence, long-lead purchase, storage and handling, transportation, etc.)
  - Capital equipment requirements (e.g., production equipment, facilities, etc.)
  - Facilities (e.g., production, storage, handling, waste disposal, etc.)
  - Risk and issue identification and mitigation
  - Technology investment programs including emerging quality and manufacturing initiatives
  - Manufacturing workforce (e.g., availability, training, etc.)
  - Manufacturing processes (e.g., existing, and new, scale-up, modifications, process capability and control, corrective actions, etc.)
  - Manufacturing management and control
  - Manufacturing Security (physical and cyber)
  - Resources to support contractor, sub-tier, and supplier MRL assessments prior to CDR and PRR.
  - Resources to support an MRL assessment and a TRA prior to Milestone C
  - Demonstration of pilot line capability and readiness to begin LRIP
- Completed M&Q risks and issue identification, and all risks are understood for the Milestone B Decision with approved EMD budget for mitigation plans to achieve CDR and LRIP entrance criteria including:
  - Technology
  - Industrial Base
  - Design
  - Cost and Funding
  - Materials
  - Process and Capability Control
  - Quality Management
  - Manufacturing Workforce
  - Facilities
  - Manufacturing Management

Tools

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

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Resources

- AS6500, Manufacturing Management Program
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- 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
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

G. MATERIALS MANAGEMENT

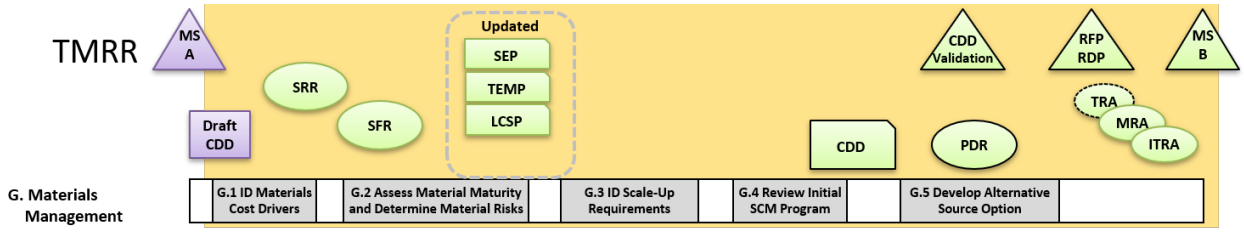

Figure 3-8. Materials Management Manufacturing and Quality Activities

Introduction

Materials Management is a core function of supply chain management including the process for planning and controlling material requirements and material flow for industrial and other organizations. Materials management will require assessment of the maturity, the materials availability, the capability and capacity of the proposed supply chain to provide the materials, and the potential need for special handling, government-furnished property (GFP), shelf life, security, storage, and environmental requirements. The process begins with the customer (demand signal), and this information flows throughout the supply chain, down several tiers, from raw materials, to fabrication, assembly, test, quality control, distribution and to the customer.

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

Material cost like manufacturing cost is estimated early in the program and turns to actual cost when production begins. As the program matures and the design becomes stable the estimates become more actual costs. Material cost drivers can vary from the cost of the material itself to the cost of the material and processing it into an end item. Selecting the most producible materials for their capability, maturity, availability, and handling characteristics during the TMRR phase will reduce costs and benefit program on cost and schedule.

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Based on contractor data, M&Q personnel must assess all materials for all M&Q risks, issues, and opportunities. This begins with an update of the evaluation of material maturity and availability from the previous phase including an assessment of the validity and maturity of emerging materials. Material availability should consider lead times with associated impacts to schedule, budget, and critical path, etc. The assessment should also include analyses for fluctuations, rarity, availability, capacity, regulatory issues, ITAR, anti-tamper, and military vulnerability. The contractor may have proposed alternate materials that will require the same rigorous assessment for properties, characteristics, and quality requirements applicable to this system. There may be other opportunities for alternate materials that address known risks and issues that should be included. Finally, M&Q risks, issues, and opportunities based on potential materials obsolescence and lack of availability based on the business climate (e.g., business failures, market changes, political, etc.) should be incorporated for the SRR and the SFR, and updates for the PDR.

During the TMRR phase, while it is not expected that contractors would have a complete factory and supply chain established, key knowledge must be obtained to determine requirements for EMD scale-up efforts, and the resulting supply chain issues. Scale up for EMD considerations should include:

- Manufacturing processes and techniques not currently available
- Probability of meeting delivery dates
- Potential impacts from critical and long-lead time materials
- Facility, equipment, tooling availability (acquisition and/or scheduling)
- Trade-offs among M&Q materials alternatives
- Anticipated in-process testing and demonstration
- Methods for conserving critical and strategic materials and mitigating supply disruption risks and associated impacts
- Transportation and security including ITAR considerations

TMRR presents the first opportunity to assess the contractor's Supply Chain Management (SCM) program. Ideally, the contractor chosen adheres to industry M&Q best practices for manufacturing management, quality management, systems engineering, sourcing, and configuration management (CM) with strong contracts and supplier interactions including processes, plans, scheduling, variability reduction, and lead times with associated impact on the critical path. If not, it can be extremely difficult to effectively manage a program's supply chain.

Alternate source options are a technique for risk mitigation due to material availability risks. If availability of materials or components, subsystems or systems is at risk, qualifying an alternative source may be a viable solution. Having an alternate source will mitigate issues with diminishing manufacturing sources and material shortages (DMSMS).

There are ways the DoD can address material needs and shortages. One is through the Defense Production Act of 1950 and the implementation of the Defense Priorities and Allocation System (DPAS) in which the government can designate programs as "high priority" and put them at the front

of the contractor's production queue. Another is the Defense Industrial Capabilities Handbook, DOD 5000.60H, which identifies alternative actions the government can take when facing material shortages to include:

- 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

M&Q should analyze the contractor Critical Supplier's List (hardware and software) for completeness and identification of single points of failure for potential mitigation in EMD phase.

G.1 Identify 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. Manufacturing and quality managers need to pay special attention to materials that are cost drivers and manage those as these cost drivers make themselves known during the development of prototypes in the TMRR phase.

Manufacturing and Quality Tasks

- Based on manufacturing, quality, and unique or specialized requirements, specifications, and tolerances, and associated risks and issues; analyze and update M&Q materials cost drivers for the SRR.
    - Include contractor descriptions and plans for materials, materials processes, rates, and quantities (including lot buys), supplier quality, special handling and training, environmental compliance and training, materials security (physical and cyber), etc.
    - Include as materials identified subsystems, parts, items, and components (supply chain commodities)
    - Include materials "should-cost" analyses
    - Quantify the materials cost driver uncertainties
    - Include cost drivers from methods used to conserve critical and strategic materials
    - Include cost drivers for mitigation of supply disruptions
    - Cost for implementing ESOH, NEPA, NEPA Compliance Schedule, System Safety, HAZMAT program, pollution prevention, and PESHE
    - Update the estimate for the cost of quality
    - Update the estimate for the cost and impact of materials testing

- Analyze and update the contractor planning (producibility) with respect to materials cost drivers and associated risks (*See* G.2) for the SRR to include:
    - Emerging materials
    - Materials design requirements
    - Price stability, cost reduction and avoidance
    - Materials processes
    - Materials availability
    - Environmental factors and compliance
    - Supply chain
    - Processes and quality
    - Security, required special handling, cyber protection
    - Facilities, capital equipment, tooling, and test equipment
- Update materials cost drivers based on manufacturing, quality, and unique or specialized requirements, specifications, and tolerances, and associated risks and issues for the MRL assessment and the PDR including:
    - Contractor materials and materials processes used
    - Materials rates and quantities obtained
    - Supplier quality levels, special handling, environmental compliance reported
    - Materials security (physical and cyber) required, etc.
    - Utilized supply chain commodities (subsystems, parts, items, and components)
    - Quantified cost drivers with continuing uncertainties
    - Cost of quality reported
    - cost of completed and projected materials testing
- Validate the contractor materials cost drivers and associated materials risks, issues, and mitigation plans for the MRL assessment and the PDR including SRR materials planning areas above.

Tools

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

Resources

- Cost/Schedule Control System Criteria
- Defense Technical Risk Assessment Methodology (DTRAM)

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- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Cost Estimating (*See* the Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Producibility Systems Guidelines, NAVSO P-3687

G.2 Assess Materials Maturity and Determine Materials Risk

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

Manufacturing and Quality Tasks

- Analyze and update the contractor planning (producibility) with respect to M&Q maturity of materials (risks, issues, and the associated cost drivers in G.1) for the SRR and the SFR to include:
    - Emerging materials
    - Materials design requirements
    - Cost reduction and avoidance
    - Materials processes
    - Materials availability and lead times
    - Environmental factors and compliance
    - Supply chain
    - Processes and quality
    - Security, required special handling, physical and cyber protection
    - Facilities, capital equipment, tooling, and test equipment
- Based on contractor data, assess all materials for M&Q risks and issues:
    - Update evaluation of material maturity and availability from the AoA process:
        - Assess validity and maturity of emerging (from Research and development and experiments in MSA) for manufacturability

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  - Update the M&Q evaluation of lead times including:
    - Impacts to schedule, budget, and critical path, etc.
    - Analyses for fluctuations, rarity, availability, capacity, regulatory issues, ITAR, Anti-Tamper, etc.
  - Evaluate maturity of other materials (contractor proposed) for properties, characteristics, and quality requirements for application in this system
  - Evaluate military vulnerability or gaps that could result from the lack of reasonable materials alternatives
  - Identify opportunities for alternative materials (to mitigate known risks and issues)
- Assess and identify M&Q risks, issues, and opportunities based on potential materials obsolescence and lack of availability based on the business climate (e.g., business failures, market changes, political, etc.) for the SRR and the SFR, and update for the PDR.
  - Include availability from single or sole sources (domestic or foreign), within the NTIB, only from sources that are outside the NTIB, vulnerable to foreign acquisition
  - Assess business climate for disruptive conditions (e.g., natural disasters, strikes, etc.)
  - Develop mitigation for known risks to critical and strategic materials
  - Assess availability issues to be addressed for prototype builds
  - Initiate government mitigation plans as appropriate as specified in the program SEP
  - Monitor contractor mitigation processes and plans as specified in the contractor SEMP in alignment with the program SEP
- Analyze and Assess the contractor's make/buy process for adequacy and completeness to include:
  - Contractor's make/buy processes for key and/or critical subsystems, items, parts, and components to include volatility
  - Contractor's supply chain (including other divisions) make/buy processes for vendors to meet quality requirements, schedule, and cost targets
  - Identification of and mitigation of counterfeit parts and materials (e.g., end items, components, parts, or assemblies)
  - Identify hazardous and special handling/storage/environmental compliance procedures, risks, and issues to include:
    - Potential regulatory requirements
    - HAZMAT and handling procedures
    - Security requirements (physical, cyber, etc.)
    - Transportation, storage, and shelf life
    - GFP, GFE (tooling, test equipment, ranges, chambers, etc.)
    - Disposal

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  - Assess the characterization of materials (maturity) and degree of M&Q risks applicable to the system under development.
  - Determine if materials have been manufactured or produced in a relevant environment (e.g., a factory, a similar application/program, as part of a prototype, etc.)
  - Assess and characterize all GFE, GFF, GFM, GFP
    - Methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials
  - Analyze government and contractor maturation efforts to mitigate material (existing and new) production risks

- Complete M&Q materials planning for EMD including preliminary specifications and material properties characterization. This should address:
  - Verification of materials maturity through technology demonstration subsystems, items, and components (articles)
  - Availability risks, issues, and opportunities
  - Long-lead items
  - Future DMSMS/Obsolescence risks, issues, and opportunities
  - Future Counterfeit Parts

Tools

- DMSMS Product Life Cycle Assessment (Consult DLA)
- Independent Technical Risk Assessment Checklist
- Industrial Base Assessment Survey Form DCMA Industrial Analysis Center
- Interactive MRL Users Guide Checklist, Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Supply Chain Management Risk Assessment Checklist
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- TRL Assessment Questionnaire

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- Defense Technical Risk Assessment Methodology (DTRAM)
- DMSMS Guidebook, SD-22
- DoD 4140.1-R, Supply Chain Management Regulation
- DoD 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoDI 5000.84, Analysis of Alternatives

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- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems 4140.01, DoD Supply Chain Materiel Management Regulation
- IEEE 15288.2, Standard for Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

G.3 Identify Scale-Up Requirements

As a program moves through the TMRR phase and develops prototype(s), M&Q managers are forced to deal with issues and concerns relating to producing the prototype and to scaling up. The back shop that is often used to develop a prototype and is not a Pilot Line and does not have the same manufacturing concerns that one has when preparing to go into limited production. The entire factory floor including the 5Ms (manpower, machines, materials, methods, and measurement) must be capable of responding to the requirements imposed by scaling up and manufacturing and quality managers need to be able to help identify scale-up requirements and risks.

Manufacturing and Quality Tasks

- Conduct assessments of materials producibility (manufacturing processes and techniques), and availability to meet future program requirements (scale-up for prototypes, pilot line, LRIP, and FRP) and determine materials risks, issues, and opportunities.
    - Consider new materials (to the industry, to the program, to the suppliers)
    - Consider source criticality and fragility (e.g., sole, or single sources, foreign sources, domestic foreign owned, etc.)
    - Consider lead times from suppliers where availability is not proven
    - Consider volume rates that are higher or lower than typical
    - Consider obsolescence due to product improvements and market/technology changes
    - Consider regulatory requirements and impacts (e.g., US law, ITAR, environmental, REACH concerns, etc.)
- Develop M&Q plans to address scale-up risks, issues, and opportunities. Plans may include:
    - Manufacturing processes and techniques not currently available
    - Probability of meeting delivery dates
    - Addressing potential impacts from critical and long-lead time materials
    - Addressing production equipment availability (acquisition and/or scheduling)

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- Impact analyses to support trade-offs among M&Q materials alternatives
- Recommendations for anticipated in-process testing and demonstration
- Methods for conserving critical and strategic materials and mitigating supply disruption risks and associated impacts
- Issues associated with materials transportation and security including ITAR considerations

Tools

- Interactive MRL Users Guide Checklist, Materials thread
- ManTech Strategic Plan
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet

Resources

- Air Force Technology Development and Transition Strategy Guidebook
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Readiness Level (MRL) Users Guide
- Producibility Systems Guidelines, NAVSO P-3687
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

G.4 Review Initial 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. Manufacturing and QA managers need to routinely review and assess contractors supply chain and procurement activities and efforts.

Manufacturing and Quality Tasks

- Assess the contractor's Supply Chain Management (SCM) program for veracity and adherence to industry M&Q best practices to include:
  - Quality management standards (e.g., ISO 9000, AS9100, etc.)

  - Manufacturing management standards (e.g., AS6500, MIL-HDBK-896, IEEE 15288, etc.)
  - Configuration management,
  - Sourcing processes
  - Development of strategic partnerships with vendors and suppliers
  - Sub-contract management
    - Monitoring sub-tier compliance to contract M&Q requirements
    - Sub-tier supplier processes (e.g., configuration management, parts management, counterfeit parts management, electro-static discharge program, etc.)
    - Collaboration of information (especially quality and forecasting data)
  - Procurement processes (schedule, quantity, packaging, kitting, identification, quality)
  - Variability reduction
  - Logistics and inventory management
    - Order Fulfillment (schedule, kitting, identification)
    - Warehouse Management (storage, schedule, kitting, packaging, environmental, security)
    - Transportation Management (methods, special handling, packaging, environment, identification)
    - Vendor Managed Inventory (schedule, quantity, packaging, kitting, identification, quality)
  - A robust risk, issue, and opportunity management process for integration of risks, criticality, obsolescence, sourcing

- Assess the contractor M&Q processes for compliance with or adherence to Company policy, process, and contracts, utilizing DCMA support (if available).
  - Contract Management with evidence of strong contracts and supplier interaction process with plans and schedule to reduce variability and lead times and associated impact on the critical path
  - Assess supply chain interdependencies with regards to other programs
  - Strategic Sourcing to minimize risks, criticality, and obsolescence
  - Supplier qualification, approval, and monitoring processes to include
    - Suppliers with known risks
    - Supplier parts usage and sources (i.e., GIDEP prohibited)
  - Requirements and data flow processes (two-way)
    - Program milestones and metrics (consistent with the IMS)
    - Demand Planning consistent with the IMS
    - Quality, safety, technical, and inspection requirements
    - Key and critical characteristics

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  - Management of suppliers and sub-tier materials manufacturing processes and procedures, especially suppliers performing key and/or critical materials manufacturing processes impacting Key Characteristics (KCs)
  - Make or buy decision analysis processes
  - DMSMS management processes
  - Material waiver process (should only be utilized in limited circumstances)
  - Requirements for use of industry best practices (e.g., AS6500, ISO 9000, AS9100, etc.)
  - Requirements for first article/qualification unit(s) (i.e., AS 9103)
  - Vendor survey requirements
  - Identification of Sub-tier supplier processes for embedded software and firmware risks, issues, and opportunities management including requirements:
    - For conducting Software Acceptance Test (SAT)/ Software Formal Qualification Testing (SFQT)
    - For performing surveillance of this activity
- Initiate SCM planning for EMD, production, developmental and operational test, and life cycle sustainment.

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Materials thread
- Manufacturing Maturation Plan
- Supply Chain Assessment

Resources

- AS 9133, Qualification Procedure for Aerospace Standard Parts
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- DoD Systems Engineering Guidebook
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Readiness Level (MRL) Users Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

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G.5 Develop Alternate Source Options

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole source, single source and foreign sources of supply come with risks. In addition, suppliers come and go in the marketplace. One day there might 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 aging. One way to mitigate those risks and to increase competition (reduce cost) is to identify critical sources and develop alternative sources of supply. But this is not a quick or a cheap fix as the new supplier will need to go through a qualification program and prove that they have the capability to produce one, the capacity to produce all that is needed and the financial stability to be able to perform for the entire contract period of performance.

Manufacturing and Quality Tasks

- Provide analyses of the program materials (system, subsystem, items, and components) for M&Q sourcing strategies to address:
    - Qualification planning
    - Contingencies for capacity, economic/political impacts, disaster impacts, etc.)
    - Dual source competition (include GFE)
    - Readily available materials that have environmental or health concerns
    - Single, sole, foreign, foreign-owned domestic, etc. vulnerability mitigation
    - Materials only available outside the NTIB
    - Quality, schedule, transportation, fulfillment, etc. requirements
    - Hazardous, difficult to obtain, or process materials
- Analyze and validate material maturity through demonstration of subsystems, items, and components in a relevant environment
    - Validate material properties have been characterized
    - Verify material specifications in place
- Based on M&Q analyses of program materials and assessments of materials maturity, availability, risks, issues, and opportunities, develop recommendations for alternate sources and options.
- Initiate planning to address DMSMS including:
    - Development of recommended options or mitigation plans
    - Analyses of materials, sources, and issues from the GIDEP database relevant to the program
- Perform analyses (e.g., FTA, FMECA, DFMEA, PFMEA, etc.) to identify KCs, critical characteristics, and key M&Q processes (*See* E.5 and E.7)
    - Include Critical Technologies list of CTEs with CSIs and CAIs

  - Include sub-tier supplier subsystems, items, and components
  - Include software and firmware configuration items
  - Develop a preliminary list, which includes where produced or accomplished and associated rationale for inclusion, of:
    - Key Characteristics
    - Critical characteristics
    - Critical Application Items (CAIs) (e.g., systems, subsystems, software, materials, components, etc.)
    - Key M&Q processes
    - Critical Safety Items (CSIs)
- Analyze and validate that the contractor Critical Supplier's List (hardware and software) is up to date.
  - Include contractor materials planning and management process (*See* L.3)
  - Include risks and issues management process (*See* G.2)

Tools

- FMECA, DFMEA, PFMEA templates
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet (PAW)
- Supply Chain Assessment
- Technology Readiness Assessment Checklist
- TRL Calculator

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations
- AS9133, Qualification Procedure for Aerospace Standard Parts
- Defense Acquisition Guide, Chapter 4
- Defense Acquisition Program Support Methodology
- Defense Manufacturing Management Guide for Program Managers, Chapter 7.4.5.5 Failure Mode and Effects Analysis (FMEA)
- Defense Technical Risk Assessment Methodology (DTRAM)
- FAR Part 46, Quality Assurance
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Integrated Product Support (IPS) Element Guide, Chapter 2.1.1.3 FMECA, Apr 2017

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- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NAVSO P-3687, Producibility Systems Guidelines
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- SAE J1739, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)
- Technology Readiness Assessment (TRA) Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

H. PROCESS CAPABILITY/CONTROL

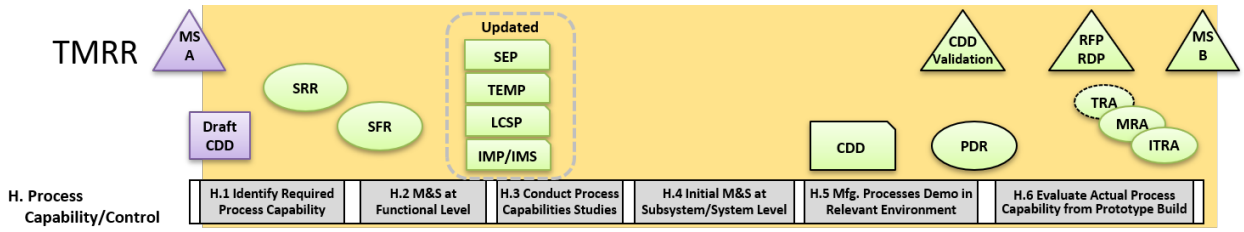

Figure 3-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

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

Process capability and control is a requirement of the AS6500 Manufacturing Management Program standard, and both ISO 9001 and AS9100 quality standards. These standards require a process control plan to describe activities to demonstrate process capabilities. Process capability clarifies the inherent variability of a given process. Typical measures include process capability and process capability index (Cp/Cpk) and process performance (Pp/Ppk); X bar and R charts; control charts; and other statistical analysis tools. A capability study generally assesses the ability of a process to meet drawing and specification requirements. These Statistical Process Control (SPC) tools measure whether a process is stable (predictable). This assessment of manufacturing feasibility will include the investigation of process maturity for similar manufacturing processes. Cp/Cpk and Pp/Ppk are typical process control measures to determine the manufacturing process capability of each concept being considered. Critical and key manufacturing processes to be placed under SPC can also be identified through M&S or experimentation. Advances in digital engineering to include modeling and simulation (M&S) along with continual improvements in computer performance have made it possible to perform

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comprehensive analysis of virtual parts and to assess the capability of processes before actual manufacturing begins. The use of solid modeling, finite element analysis, multi-paradigm numerical computing environments, and simulation software analysis tools allows users to simulate different conditions that are likely to occur during manufacturing processes and to model the behavior of systems under real-world conditions. An understanding of the capabilities to model products and processes for each of the concepts under consideration can be a valuable discriminator.

This thread (Process Capability and Control) requires an analysis of the risk that the manufacturing processes may not be able to reflect the design intent (repeatability and affordability) of key characteristics. The thread will focus on the following sub-threads, tasks, activities, tools, and resources:

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

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

M&Q engineering efforts should lead to a producible and testable system with the objective of achieving effective and efficient manufacturing processes with the necessary process controls to satisfy requirements with consistent, repeatable products while minimizing manufacturing costs. During the MSA phase, required process capabilities were identified for critical M&Q processes with the associated risks. In TMRR, process capability data collection begins and continues into EMD.

In preparation for SRR and SFR, prior 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.

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Program M&Q personnel should understand the state-of-the-art and industry best practices in manufacturing and production Modeling and Simulation (M&S) tools and or products. In TMRR, the contractor will have proposed use of certain M&S M&Q tools that must be verified for adequacy, applicability, and consistency with other system models. Additionally, M&Q must understand the contractor's plans and processes for maturing and validating their M&Ss as high-fidelity representations of the M&Q systems and systems performance and capability based on actual program data.

During the TMRR phase the contractor will produce prototypes that will be used during tests to ensure they will meet the customers' requirements. These prototypes will be built in a relevant manufacturing environment, meaning that there are elements of production realism present on the manufacturing line. To the extent practicable, the processes used for prototype build should be evaluated to better understand the difficulties and risks that will need to be overcome during the EMD phase. In preparation for PDR and EMD transition, manufacturing processes, products, and prototypes demonstrated and assessed in a relevant environment results are incorporated into the appropriate M&Ss. These assessments and demonstrations should provide an understanding of the contractor's M&S tools and provide the basis for program manufacturing planning, resource loading, and facilities management, etc. for future phases.

H.1 Identify Required Process Capability

One of the goals of manufacturing is to have a uniform, defect-free product. 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 and other tools can be used to identify upfront and early what the design requirements are and where processes must be made to be capable and in control, and what that capability metrics, goals, or targets should be established.

Manufacturing and Quality Tasks

- Update the analyses of the current state and gaps in process capability within industry for M&Q processes appropriate to the system, subsystems, items, and components.
- Update or identify M&Q process capability risks, issues, and opportunities for the SRR and the SFR from the manufacturing feasibility and other prior assessments including risks to:
    - Key Characteristics
    - M&Q processes (new equipment and technology)
    - Potential cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - Testing and qualification

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  - Environmental, transportation, storage, etc.
  - Data management (collection, storage, cybersecurity, etc.)
- Assess, estimate, and manage process maturity and capability for processes with insufficient data utilizing information from similar subsystems, items, and components that are currently or have been previously manufactured.
- Develop targeted process capability (Cp/Cpk) and process performance (Pp/Ppk) metrics.
- Analyze if planned manufacturing and production processes can produce units (subsystems, items, and components) in quantities to the contract specifications and schedule.
  - Determine if the contract requires the contractor provide estimated and actual yield rates by source and/or facility for materials, components, items, and subsystems.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guide
- DoD Systems Engineering Guidebook
- Capability-Based Assessment (CBA) Handbook
- Defense Technical Risk Assessment Methodology (DTRAM)
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.2 Modeling and Simulation at Functional Level

The DoD uses modeling and simulation (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 at the functional level can reduce the risks associated with prototype development. Manufacturing and QA managers need to support M&S for manufacturing systems and processes throughout the TMRR phase.

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Manufacturing and Quality Tasks

- Update analyses of the state of the art and industry best practices in manufacturing and production modeling and simulation tools and or products (i.e., software) that support the functional analyses of the system.
- Assess and analyze the contractor-proposed modeling and simulation tools and plan for adequacy and sufficiency for system M&Q, process capability, control, and maturation.
    - Include analyses of capability to provide inputs to manufacturing planning, resource loading, and facilities management
    - Include analyses of contractor usage of tools against industry standards for potential improvements and to determine functional constraints

Tools

- AS9100 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Plant Modeling and Simulation 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

- Defense Technical Risk Assessment Methodology (DTRAM)
- 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-HDBK-896, Manufacturing Management Program Guide
- Modeling and Simulation Guidance for the Acquisition Workforce, Oct 2008
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.3 Conduct Process Capabilities Studies

A process capability study is a measure of the inherent process variability of a given characteristic. Process capability studies are conducted to assess the ability of a process to meet the contractual specification. Typically, a process capability study follows these steps:

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

Manufacturing and Quality Tasks

- Utilizing results of the SRR/SFR, update M&Q process capability risks, issues, and opportunities for the Acquisition Strategy, the SEP, the TEMP, and the CDD including:
    - Key Characteristics
    - M&Q processes (new equipment and technology)
    - Potential cost and schedule impacts
    - Producibility
    - Tooling and facilities
    - Testing and qualification
    - Environmental, transportation, storage, etc.
    - Data management (collection, storage, cybersecurity, etc.)
- Conduct process capability and variability studies and analyses on:
    - Similar subsystems, items, and components that are currently or have been previously manufactured utilizing previous estimates
    - Current subsystems, items, and components manufacturing and production processes and equipment
    - Incorporate data collected from contractor yield rates for subsystem, item, component, and prototype builds
- Identify required process capability and variability studies and analyses for planned subsystems, items, and components manufacturing and production processes and equipment for the Acquisition Strategy, the SEP, and the PDR.
- Determine process capability requirements for pilot line and production.
    - Identify C_{pk} goals for each key manufacturing process

Tools

- AS9100 Checklist
- AS6500 Checklist
- Cause and Effect Diagram
- Cost of Quality Estimates

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- First Pass Yield Estimates Worksheet
- Histograms
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Pareto Analysis
- Process Capability Studies (C_p and C_{pk} assessment)
- Producibility Assessment Worksheet (PAWs)
- Six Sigma Worksheet

Resources

- AS9100 Quality Management System
- ISO 9001 Quality Management System
- AS6500 Manufacturing Management Program
- AS9103 Variation Management of Key Characteristics
- DoD Systems Engineering Guide
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI/Lean and Six Sigma) Program
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.4 Modeling and Simulation (M&S) at Subsystem/System Level

During the TMRR phase, programs often build prototypes and Modeling and Simulation (M&S) can help to reduce risks associated with prototype development. M&S needs to move beyond the functional level to the sub-system and system level. As each level of design matures and is build, the integration and testing becomes more complex and complete. M&S of manufacturing and QA processes needs to enable Manufacturing and QA managers need to analyze manufacturing systems and processes early and develop maturation plans to get these processes into a steady state.

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Manufacturing and Quality Tasks

- Assess contractor Modeling and Simulation (M&S) tools prior to product and/or process implementation for the capability to model the proposed design concept(s) for the PDR process. Tools should include:
    - Capability to evaluate the proposed design and manufacturing concepts to meet M&Q objectives
    - Capability to estimate outputs of design performance
    - Outputs for updating cost models (*See* F.2)
    - Identification of potential M&Q bottlenecks or constraints
    - Confirmation of planned M&Q cycle times achievability
    - Impacts of M&Q process variability
    - Capability to model the factory floor, process flows, assembly lines, yields/ throughput, cycle times, etc.
    - Capability to estimate required quantities of tooling, personnel, and inventory
    - Sufficient complexity to represent and support the complexity of the product being manufactured
- Assess the M&Q aspects of the contractor and/or government prototype environment (i.e., system simulation/integration lab) to validate M&S emulation of subsystems, components, and items, including:
    - A mix of mature hardware, prototypes, and models and simulations
    - Integration and interdependencies
    - Identification of constraints
    - Performance
    - Status of contractor M&S of the "to be" system or subsystem
- Provide M&Q recommendations to the contractor for innovative M&S capabilities (factory simulations) that go beyond basic capabilities and will allow the manufacturing engineer to address:
    - Sustainable manufacturing goals (energy, water, and other resource usage)
    - Monitor and optimize maintenance and calibration requirements
    - Supply chain collaboration for product design, quality, and scheduling
    - Manufacturing execution and execution systems networked to machines, test, and measurement devices, robotics, and process planning

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, Process Capability and Control thread
- Manufacturing Maturation Plan
- Plant Modeling and Simulation tools (FlexSim, SimFactory, etc.)

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- Process Modeling Tools (Siemens PLM, Delmia, etc.)
- Solid modeling and analysis software programs (e.g., NX, CATIA, Pro-Engineer, Nastran add-ins, etc.)

Resources

- AS6500, Manufacturing Management Program
- Defense Technical Risk Assessment Methodology (DTRAM)
- 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
- Modeling and Simulation Guidance for the Acquisition Workforce
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

H.5 Manufacturing Processes Demonstration in Relevant Environment

A relevant environment is an environment that moves beyond the lab and onto a shop floor with some production realism present. That is, manpower, materials, machines, methods, measurement systems, facilities and tooling should be identified and utilized in at least a limited fashion. This environment requires the contractor to demonstrate their ability to meet cost, schedule, and performance objectives. The demonstration must provide the program with confidence that program targets are achievable.

Manufacturing and Quality Tasks

- Based on government/contractor IPT interactions, define, and document the appropriate M&Q production relevant environment(s) to be used for process demonstrations and prototypes.
- Assess demonstrations of manufacturing processes in an environment with shop floor production realism present (e.g., actual production facilities, manufacturing personnel, using production tooling, processes, materials) incorporating factors such as:
    - Minimum reliance on laboratory resources
    - Environmental conditions (i.e., temperature, humidity, air quality)
    - Equipment (i.e., accuracy, calibration, age and condition, suitability, capacity, reliability)
    - Workforce (i.e., training, skills, and certifications)
    - Human factors (i.e., noise, vibrations, ergonomics)
    - Ability to meet the cost, schedule, and performance requirements of the EMD phase
- Evaluate demonstrations to determine environmental factors impacting the manufacturing of subsystems, items, and components.
    - Include ambient temperature, humidity, noise, vibrations, personnel skills levels, materials specifications, etc.

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- Evaluate process demonstrations and production of prototypes for mitigation of M&Q risks.
- Evaluate and analyze yields and rates from process demonstrations and production of components and items for prototype builds.
    - Utilize results as inputs to improvement plans
- Collect data from process demonstrations and production of components and items for prototype builds to support verification, validation, and authentication of M&S processes.
- Develop a comprehensive plan for EMD to demonstrate M&Q processes in a production representative environment by CDR and on a pilot line to support the Milestone C decision process.
    - Include all M&Q risks
- Assess manufacturing readiness by conducting an MRL assessment to support PDR and the Milestone B decision process (See A.3)
    - Support the Technology Readiness Assessment, if conducted
    - Support identification of any critical technologies or manufacturing processes that have not been successfully demonstrated in a relevant environment

Tools

- AS9100 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan

Resources

- AS9100, Quality Management System
- ISO 9001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

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H.6 Evaluate Actual Process Capability from Prototype Builds

Prototype builds offer an opportunity to evaluate process capability on the preliminary design and preliminary production environment. At this point there is still design work to accomplish, but some of the design and some of the manufacturing processes are stable enough to assess against future work.

Manufacturing and Quality Tasks

- Based on analyses and evaluations of M&S models, process demonstrations, production of components and items, and prototype builds, summarize, define, and finalize M&Q processes, process capabilities, and limitations for EMD Acquisition Strategy and SEP planning.
    - Refine process capability requirements for the EMD phase.
    - Develop plans to transition from production relevant environment with some shop floor realism present to the production representative environment with as much production realism as possible prior to CDR
    - Update models and simulations for use in EMD with actual data to increase fidelity and confidence that the model and prototypes realistically represent the final product

Tools

- AS9100 Checklist
- AS6500 Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Process Capability and Control thread
- Manufacturing Maturation Plan
- Process Capability Studies (C_p and C_{pk} assessments)
- Producibility Assessment Worksheet (PAW)

Resources

- AS9100, Quality Management System
- ISO 9001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9103, Variation Management of Key Characteristics
- DoD Systems Engineering Guidebook
- Defense Technical Risk Assessment Methodology (DTRAM)
- 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
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy

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- Process Capability Control and Improvement Requirements – Process Control Plan Reference Guide, Picatinny Arsenal
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

I. QUALITY MANAGEMENT

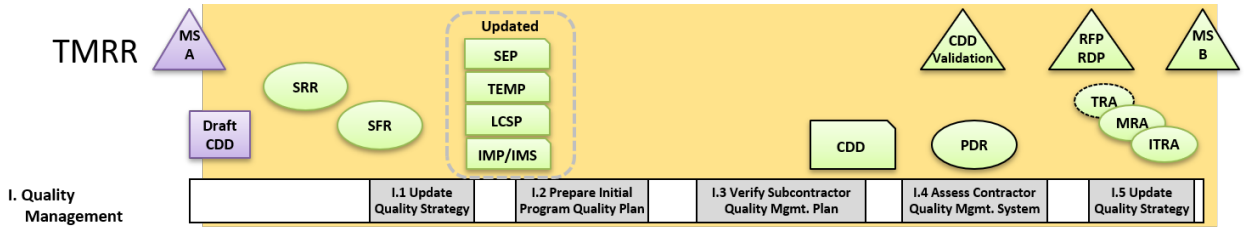

Figure 3-10. Quality Management Manufacturing and Quality Activities

Introduction

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

Quality management is an integral part of design and development efforts. QMS standards include industry best practices such as ISO 9001, Quality Management Systems–Requirements. AS9100, Quality Management Systems–Requirements for Aviation, Space and Defense Organizations, Product Realization (clause 7) includes typical systems engineering tasks under sub-clause 7.3, Design and Development. The typical systems engineering processes included in the QMS are:

- Design and Development Planning – SE Management, Failure Modes, Effects, and Criticality Analysis (FMECA), System Safety, etc.
- Design and Development Inputs/Outputs – T&E, Reviews, and Audits.
- Design and Development Review, Verification and Validation.
- Control of Design and Development Changes – hardware and software Configuration Management.
- Hardware and Software Configuration Management.
- Risk, Issue, and Opportunity Management.
- Corrective Action System.

The requirements for Quality Assurance and Control come from the FAR/DFAR and general industry guidance comes from ISO 9001 and AS9100 quality standards. These standards requires that organizations establish a formal quality policy and must submit documentation on its internal processes, procedures, and standards. The following are mandatory requirements of ISO 9001:

- Monitoring and measuring equipment calibration records

- Records of training, skills, experience and qualifications
- Product/service requirements review records
- Record about design and development outputs review
- Record about design and development inputs
- Records of design and development controls
- Records of design and development outputs
- Design and development changes records
- Characteristics of product to be produced and service to be provided
- Records about customer property
- Production/service provision change control records
- Record of conformity of product/service with acceptance criteria
- Record of nonconforming outputs
- Monitoring measurement results
- Internal audit program
- Results of internal audits
- Results of the management review
- Results of corrective actions

Note: AS9100 standards includes all of the above, and more.

An effective quality strategy and contractor Quality Management System (QMS) are required if the program is to deliver operationally safe, suitable, and effective weapon systems. The initial quality strategy should have been developed during the MSA phase. The QMS assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The quality strategy serves as the basis for the management and control function within the program systems engineering process and should be continuously updated in each phase. The strategy requires basic 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 (including embedded software and firmware) to ensure they conform to requirements. Quality strategy development must begin during the earliest stages of system development and must continue throughout the program life cycle.

A QMS compliant with industry best practices, ISO 9000 or AS9100, is the foundation for the contractor to deliver a system that meets requirements. The program must evaluate the contractor's QMS to ensure implementation of industry best practices. The program and the contractor should develop a joint government/contractor M&Q plan that specifies:

- Roles, responsibilities, and quality processes
- Tasks, schedules, and outcomes
- Standards, requirements, and metrics
- Joint risk, issue, and opportunity processes and procedures

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- Quality tools such as Continuous Process Improvement (CPI)

Everything a contractor does will be related to the quality of its products or services, a contractor's QMS should be the basis for integrating all other management systems within an enterprise. The program must assess the contractor QMS to ensure that the contractor has an effective QMS and an effective subcontractor quality management system and plan. M&Q personnel must ensure that all M&Q systems are working toward the same goals and are not creating conflicting or dysfunctional results. It is important for the program to convey to the contractor the requirement and importance of quality throughout supply chain and effective supply chain management, as quality deficiencies often occur in the lower tiers. The contractor, in addition to having list of qualified vendors, should have visibility into their subcontractors' planned suppliers with the same requirements.

Effective quality management activities are important for identifying and reducing process-related risks. If not managed and mitigated, these risks may start a chain of events leading to undesirable outcomes such as defects discovered later in production or testing, not meeting requirements, degraded mission effectiveness, overruns, shortages, etc. The later these risks are identified, the greater the cost of corrective action and the greater the delays in schedule.

Quality will permeate all levels of a company only if certain important factors are present in the contractor’s QMS:

- Corporate strategic vision, objectives, policies, and procedures with a commitment to quality in-house and in the supply chain
- Communication of organizational direction and values regarding quality
- Structures and resources for full implementation of the QMS
- Commitment to continuous processes improvement
- Goals, objectives, and metrics throughout the organization for customer satisfaction
- Management accountability

This thread (Quality Management) requires an analysis of the risk and management efforts to control quality, and foster continuous quality improvement.

At the conclusion of TMRR phase, post PDR evaluation, the program quality strategy should be updated for entry into EMD based on TMRR results, assessment of the contractor and subcontractor QMSs, and the revised program quality plans for EMD.

I.1 Update Quality Strategy

M&Q managers support the development and updates to the Acquisition Strategy by providing their inputs into the Systems Engineering Plan (SEP). quality managers can look to the FAR Part 46 and 52 to understand potential contractual QA requirements and to industry best practices such as ISO 9001 and AS9100 for implementation requirements. Manufacturing managers can look to industry best

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practices such as AS6500 to help them identify manufacturing requirements. Planning is the foundation for implementation activities and to the success of a program.

Manufacturing and Quality Tasks

- Update and revise the draft Program Quality Strategy in the Acquisition Strategy and the SEP based on the contractor's QMS and strategies to include:
    - The contractor's quality strategy should address compliance to established standards (e.g., AS9100, ISO 9000, etc.)
    - Alternatively, the contractor's quality strategy requirements should address:
        - 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
- Verify that the Program Quality Strategy:
    - Incorporates new quality technologies and processes (state of the art), unique product quality requirements, metrics, and the review frequency.
    - Includes compliance with FAR 52.2456-11, Higher-Level Contract Quality Requirements.
    - M&Q personnel may also consider related clauses to include:
        - Inspection of supplies and services clauses, 52.246-2 thru 52.246-9 to ensure appropriate government access, oversight, and protection.
        - Warranty for supplies and/or services: 52.246-17 thru 52.246-21 though mainly -18, -19, & -20 depending on what work is being done and what product is being delivered.
    - Encompasses 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 COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
    - Encompasses supply chain quality management requirements that include:
        - Need for focused supplier quality management requirements
        - Contractor supplier quality management plan
        - Supply chain best practices and standards (e.g., AS9100, ISO 9000, etc.)

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        - Metrics and review frequency
        - Solutions, tools, techniques, and procedures
        - Use of government furnished quality and testing equipment and assets
    - Establishes appropriate agreements, delegations, and contracts with other agencies, e.g., DCMA, throughout the supply chain
    - Addresses software and firmware development quality assurance and configuration management.

Tools

- Acquisition Strategy Template
- AS9100 Audit Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the 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
- DAG Chapter 14.3.1.3.6 Quality Plans
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- FAR 52.246-11
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

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I.2 Prepare Initial Program Quality Plan

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

M&Q personnel need to be actively engaged in the development and update of the SEP to include the Initial Quality Plan.

Manufacturing and Quality Tasks

- Evaluate the contractor's QMS for processes and procedures that are in alignment with industry best practices (e.g., AS9100, ISO 9000, etc.) to include elements such as:
    - Effective policies and procedures that encourage adherence to the quality system
    - Organizations with defined authorities and responsibilities
    - Objectives to drive people, processes, and the system
    - Methods to analyze and resolve quality problems
    - Product and process metrics that reflect desired outcomes
    - Interacting processes to transform inputs into outputs
    - Records as evidence of what happened
- Based on MSA documentation, evaluate Contractor's proposed quality plan for previously determined product quality requirements, metrics, frequency of metrics reviews, and M&Q risks, issues, and opportunities, and update accordingly.
    - Include software development quality requirements
    - Include impacts of safety processes and procedures
    - Include Contactor's planned supply chain
    - Include DCMA inputs on Contractor and supply chain quality performance against quality requirements for similar products or processes
- Evaluate Contractor-proposed or planned solutions, capabilities, equipment, and processes that address product quality requirements in the form of:
- Quality technologies (i.e., metrology technologies) that could improve product quality (e.g., new quality technologies, state of the art, etc.)
    - Proposed or planned solutions or processes to improve low-yield processes and components product quality
- Develop a joint government/contractor M&Q plan based upon the evaluations of contractor's and supplier's QMSs and proposed plans that specifies:

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  - Roles, responsibilities, and quality processes for government and contractor quality management including:
    - Role and participation of DCMA (contractor and supply chain)
    - Key Characteristics management
    - Acceptance test procedures including software
    - In-process and final inspections
    - Statistical process controls and management
    - Quality improvement plans
    - Certification requirements (e.g., flight safety, man-ratings, etc.)
    - Issues and dispositions (i.e., material review boards and processes)
    - Continuous process improvement
    - Software quality assurance
    - Data storage, management, and security (physical and cyber)
    - Use of COTS items, GOTS items, and NDIs
    - GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
    - Audits and verifications
  - Tasks, schedules, and outcomes
  - Standards and requirements to be followed (e.g., industry product standards, MIL-STDs, etc.)
  - Joint risk, issue, and opportunity processes including supply chain quality capabilities and risk, issue, and opportunity identification processes
  - Quality processes, roles, and responsibilities identified for:
    - Key Characteristics management
    - Acceptance test procedures including software
    - In-process and final inspections
    - Statistical process controls and management
    - Quality improvement plans
  - Quality workforce qualifications and training requirements
  - Quality tooling and equipment requirements
  - Quality targets, metrics, incentives, and process capabilities (C_{pk}s)
  - Quality failures identification and analyses processes
  - Software requirements
  - Requirements for tracking quality costs
  - New quality technology identification and introduction processes to include transformative processes

- Update the joint government/contractor risk, issue, and opportunity process to ensure inclusion of updated M&Q process capability risks, issues, and opportunities from the SRR and the SFR (*see* H.1) including:

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- Key Characteristics
- M&Q processes (new equipment and technology)
- Potential cost and schedule impacts
- Producibility
- Tooling and facilities
- Testing and qualification
- Environmental, transportation, storage, etc.
- Data management (collection, storage, cybersecurity, etc.)
- Process maturity and capabilities
- Yields, rates, and quantities

Tools

- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Quality thread
- Manufacturing Maturation Plan
- Quality Management Plan Template
- Systems Engineering Plan (SEP) Outline

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 Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Specified Industry and Military Standards
- Systems Engineering Plan (SEP) Outline

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I.3 Verify Subcontractor Quality Management

Major programs require the engagement of the entire supply chain to be successful. Thus, program planning, to include the Quality Management Plan, must be delegated down through the supply chain, and evaluated on a regular basis for compliance and adequacy.

Manufacturing and Quality Tasks

- Verify that the contractor supplier management system requires subcontractor QMS processes and procedures that are in alignment with industry best practices (e.g., AS9100, ISO 9000, 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.)
    - First Article Inspection if required
    - Risks, issues, and opportunities
    - Measurement, analysis, and improvement requirements
- Establish supply chain quality management metrics for each of the concepts being considered for incoming quality inspection to include the identification of acceptable quality levels (AQLs)
    - Determine the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Analyze the contractor's supplier management system capability to perform the anticipated design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including:
    - Effectiveness of prime and subcontractor communication and interaction processes to include:
        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Quality data exchange processes
        - Integration of risk, issue, and opportunity management
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions, communication, and end user feedback
        - Specification and production of prototypes
    - Key Characteristics management
    - Supplier risk, issue, and opportunity management processes for quality, technical, schedule, material, facility, scale-up, financial impacts, etc.

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  - Make/buy processes for supplier quality performance and impacts
  - Approval/removal and qualification processes for suppliers, which includes period re-assessment
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials (*See* AS5553 and AS6174)
  - Identification of major and critical suppliers, and suppliers performing Critical Manufacturing Processes
  - Supplier development program that focuses on and measures continuous improvement
  - Effective metrics to monitor, evaluate, verify, improve processes, and prevent defects
- Analyze the contractor's supplier management system and quality management plan for:
  - Management of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
    - Request DMCA assistance in analyses and verifications
  - Roles, responsibilities, and quality processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Software and firmware quality and integration into the program Software Quality Assurance Plan (SQAP), Software Development Plan (SDP), and Software Configuration Management Plan (SCMP)
  - Acceptance tests (prototypes, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP
- 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.

Tools

- AS9100, Audit Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Supplier QA Questionnaire

Resources

- AS5553, 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

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  - 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 Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

I.4 Assess Contractor Quality Management System

Quality managers use FAR Part 46 to identify the appropriate contractual quality requirements based on complexity and criticality of the item being procured. Most DoD programs will require a higher-level quality clause. Both ISO 9001 and AS9100 satisfy the requirements for a higher-level quality management system (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. A typical QMS will address leadership and policy, planning, organizational support, operations, performance measurement and evaluation, and continuous improvement.

Organizations need to identify the process of measuring, examining, testing, or otherwise comparing the product to the requirements for acceptance. FAR 46.291 Production Lot Testing identifies the purpose of production lot testing is to validate quality conformance of products prior to lot acceptance, which usually occurs after acceptance testing.

Manufacturing and Quality Tasks

- Evaluate the QMSs in use for the following:
  - Management responsibility
  - Resource management
  - Quality System
  - Contract Review
  - Product Realization
  - Design Control
  - Document Control
  - Purchasing
  - Purchaser-Supplied Product

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  - Product Identification and Traceability
  - Process Control
  - Measurement, Analysis, and Improvement (metrology and calibration)

- Assess the contractor's corporate strategic vision, objectives, policies, 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, customer satisfaction, and continuous improvement
  - Procedures independent reporting channels for quality functions and audits
  - Management accountability with emphasis on quality results and customer satisfaction
- M&Q personnel need to identify and manage product quality requirements:
  - Identify product acceptance methods and determine sampling plans as appropriate.
  - Incorporate and mature new quality technologies and process state of the art into product quality requirements.
  - Identify and manage product quality requirements on prototype items (i.e., specific product characteristics).
  - Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks.
- Conduct a functional audit of the contractor's QMS including assessment of:
  - Quality processes, product quality, and supply chain quality including:
    - Role and participation of DCMA (contractor and supply chain)
    - Key Characteristics management
    - Acceptance testing including software
    - In-process and final inspection functionality
    - Statistical process controls, rates, and yields (and management of same)
    - Quality improvement plan execution
    - Certification process (e.g., flight safety, man-ratings, etc.)
    - Continuous process improvement results

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        - 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.)
        - Audits and verifications results
    - Incorporate results and reports from contractor's developmental testing for CTEs, KPPs, KSAs, and Key Characteristics and integration into the QMS.
    - Results and reports from the contractor's QMS Failure Reporting, Analysis and Corrective Action System 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.)
    - Integration with the Risk, Issue, and Opportunity Management processes
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements.
- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards.
- Request DCMA support to assess veracity of contractor QMS for inclusion and integration of subsystems, items, and components and inclusion in the initial TEMP including:
    - Assessment of the contractor's progress in generating or updating the TEMP
    - Verification of the TEMP addressing requirements to conduct a Physical Configuration Audits (PCAs) and Functional Configuration Audits (FCAs) on designated subsystems, items, components, and software/firmware
    - Verification of Software testing, to include Software Acceptance Test (SAT)/Software Formal Qualification Testing (SFQT) is addressed in the TEMP

Tools

- AS9100, Audit Checklist
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Quality thread
- ISO 9001, QMS Audit Checklist
- Manufacturing Maturation Plan
- Lot Acceptance Testing Calculator

Resources

- AS9100, Quality Management System – Aerospace

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  - 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 Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-1916 DoD Test Method Standard, Apr 1996,
- ANSI Z1.4 Sampling Procedures and Tables for Inspection by Attributes
- ANSI Z1.9 Sampling Procedure and Tables for Inspection by Variables for Percent Nonconforming
- DCMA-INST 302 First Article and Production Lot Testing
- DoD Systems Engineering Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

I.5 Update Quality Strategy

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

Manufacturing and Quality Tasks

- Update and revise the initial Program Quality Management Strategy from the Acquisition Strategy and the SEP:
  - Incorporate changes based the results of the assessment of the contractor's QMS
  - Update all quality factors from tasks accomplished in I.1 through I.4
- Initiate quality planning for EMD, production, developmental and operational test, and life cycle sustainment.

Tools

- Acquisition Strategy Template

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- Interactive MRL Users Guide Checklist, for the Quality thread
- Manufacturing Maturation Plan
- MRL Assessment Checklist, Quality thread

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
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

J. MANUFACTURING WORKFORCE

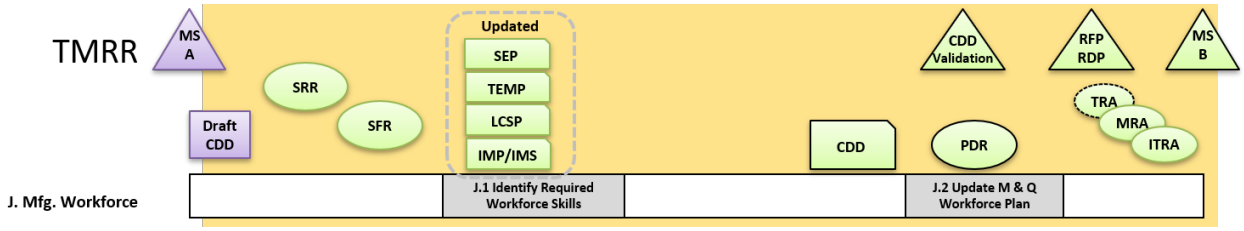

Figure 3-11. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

Manufacturing feasibility and industrial base analysis of concepts considered by the TMRR program team should address the existing skills of the appropriate workforce. This thread (Manufacturing Workforce) outlines activities and tasks to assess required skills (capability) and availability (workforce capacity) to support the manufacturing effort.

A comprehensive assessment of contractor manufacturing plans for prototype and system development is necessary to understand the requirements workforce skills, capabilities, training, and certifications.

Workforce skills identification and plans provide quantitative inputs to program planning. Workforce planning should align the skills required to the scope of the technical effort required to develop, field, and sustain the system.

To determine the scope of the M&Q workforce plan to develop, field, and sustain the system, the following should be included:

- Work Breakdown Structure for the technical activities and tasks (including the Bill of Materials)
- Contractor's make/buy plans
- Contractor's M&Q plans, process, and procedures
- Identified risks, issues, and opportunities
- Integrated Master Plan for all technical activities and tasks
- Time-phased sequence of the technical efforts (Integrated Master Schedule)
- Other resources (support equipment, tools, facilities, training, etc.

Based on contractor M&Q planning, execution, and results of the system development and prototypes efforts, update the program M&Q workforce plans for required skills, capabilities, training, and certifications for EMD.

J.1 Identify Required Workforce Skills

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on a regular and on-going basis, especially early in the development of the prototypes as new manufacturing processes and workforce skills are emerging. Two major focus areas are:

- Workforce Skills availability (are there enough people)
- Workforce Skills capability (do they have the right skills)

Manufacturing and Quality Tasks

- Assess contractor initial Manufacturing Plans for prototypes and system development to identify workforce requirements for skills, capabilities, training, and certifications, including:
    - Contractor's make/buy processes for factors that determine the outsourcing of workforce skills
    - Scale-up of materials, subsystems, items, and components for TMRR
    - Contractor's labor market (availability, stability, capabilities, training, etc.)
    - Potential ManTech changes, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
    - Potential facilities changes (e.g., location, improvements and expansion, lay-out changes, etc.)

  - Materials handling (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
  - Environmental, safety, and health
  - Manufacturing machinery and equipment (e.g., programming and operation, maintenance, calibration, and repair, etc.)
  - Facilities and tooling (e.g., operation and maintenance, safety, security, cleanliness, acoustics, Heating, Ventilation, Air Conditioning (HVAC), and environmental controls, etc.)
  - Quality (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- Review contractor's processes for impacts on the workforce:
  - Identify impacts on personnel, training, etc.
  - Identify risk, issues, and opportunities concerning the workforce
  - Include M&Q requirements on workforce environmental, safety, and health

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Workforce thread
- Learning Curve Calculator
- 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 System
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II) software

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

J.2 Update Manufacturing and Quality Workforce Plan

As the prototype is being developed and built, Manufacturing and QA managers need to review and update workforce plans. If there are new skills, then the plan should include training and certification if required.

Manufacturing and Quality Tasks

- Based on contractor M&Q planning, execution, and results of the system development and prototypes efforts, update M&Q plans for required workforce skills, capabilities, training, and certifications for EMD planning, update the Acquisition Strategy and as input for PDR and other decision reviews. Updates include:
    - Workforce skills requirements based on contractor's make/buy decisions for internal and/or outsourcing of workforce skills
    - Contractor's labor market impacts on availability, stability, capabilities, and training to meet M&Q workforce requirements
    - Scale-up of materials, subsystems, items, and components
    - Materials handling requirements changes (e.g., safety processes, storage and disposal processes, environmental processes, etc.)
    - Environmental, safety, and health requirements changes
    - Manufacturing machinery and equipment improvements and changes (e.g., programming and operation, maintenance, calibration, and repair, etc.)
    - ManTech demonstrations, additions, and new manufacturing methods (e.g., automation, upgrades, additive manufacturing, etc.)
    - Facility's re-locations, and changes (e.g., location, improvements and expansion, lay-out changes, etc.)
    - Tooling improvements and changes (e.g., operation and maintenance, safety, security, cleanliness, acoustics, HVAC, and environmental controls, etc.)
    - Quality requirements changes and additions (e.g., inspections, equipment operation, maintenance, calibration, etc.)
- Assess contractor M&Q workforce management and plans for EMD to include:
    - Synchronization with the SEP, the IMP/IMS, and the Subcontractor Management Plan
    - Consistency with the contractor's Manufacturing Plan
    - Staffing rate requirements for pilot line and initial production
    - Workforce skills availability (i.e., number of trained capable workers)
    - Workforce stability (e.g., labor force age, turn-over rate, labor force sustainability, etc.)

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  - Special skills certification and training requirements
- Analyze TMRR planned versus actual staffing rates, training, turn-over, etc.
- Assess M&Q workforce and environmental, safety, and health requirements in current guidance, regulations, and laws for impact.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Forecasting and Regression Analysis
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Workforce thread
- Learning Curve Calculator
- 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 Program
- AS9100, Quality Management System
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001:2015, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

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K. FACILITIES

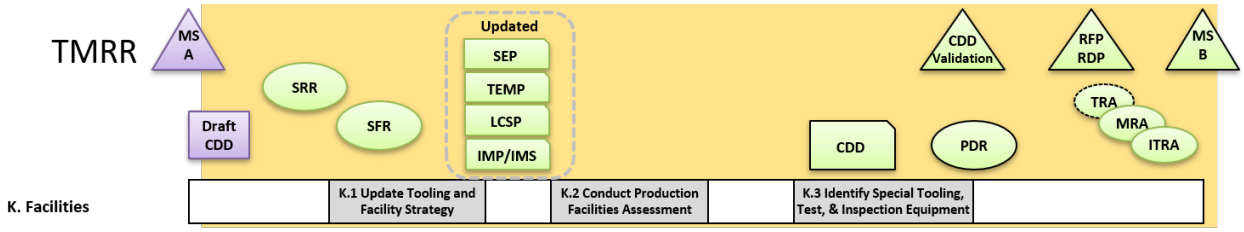

Figure 3-12. Facilities Manufacturing and Quality Activities

Introduction

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

The facility includes the plant, production equipment, and waste handling and storage equipment to be made available to accomplish the production task. In developing the facility plan, both the quantitative and qualitative demands of the product must be considered. The quantitative analysis will determine the size of the processing departments within the facility. This analysis should consider the number of units to be delivered, and the rate of delivery. For example, the information collected in the analysis will provide a measure of the workstations, plant layout, and the floor space required. The qualitative analysis determines the types of processes that will be required. The contractor then has the option of utilizing currently existing facilities, acquiring new facilities, requesting government-furnished facilities (must be requested in the proposal), or subcontracting a portion of the effort.

This thread (Facilities) requires an analysis of the capabilities and capacity (Prime, Subcontractor, Supplier, Vendor, and Maintenance Repair) that are key risks in manufacturing and will focus on the following sub-threads, tasks, activities, tools, and resources:

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

During the TMRR phase, M&Q personnel should update the facility and tooling strategies and plans developed for the concept during MSA, and conduct assessments of proposed production facilities, and update and finalize the tooling plan for EMD and future phases.

Based on the concept, new facilities and tools may be required for new materials, new technologies, and new processes. Programs and the contractor(s) need to address and plan for the capability and capacity to develop, produce, maintain, and support the program. Included in this are considerations

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of the availability of essential tooling, facilities, and production and test equipment for the sustained production of systems capable of meeting the performance objectives, as well as sustained operations, maintenance, and repair. Capacity is normally constrained by physical facilities, available equipment, tooling and/or test equipment. The portion of this capacity utilized is determined by the demand on the plant for current and known future workload. Final validation of M&Q plans must be accomplished prior to PDR and prior to entry into EMD.

M&Q personnel should conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases. These assessments should include subcontractors and key suppliers identified in the contractor's manufacturing management plan. Assessments of the contractor's manufacturing management plans 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. 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 PDR and entry into EMD, the program tooling plan, which includes specialized tooling and test equipment is finalized. This requires that all facilities, tooling, and test equipment has been appropriately identified from assessments conducted as required by the FAR Section 2.101.

The lack of attention to facilities, tooling, and test equipment will increase risk and can be a major factor in cost overruns and schedule delays. Facilities, tooling, and test equipment is a common production risk that can affect cost, schedule, and performance if the program is not proactive in managing it.

K.1 Update Tooling and Facility Strategy

Facilities and Tooling (special tooling, special test equipment and special inspection equipment) is often a significant cost and schedule driver. The B1 program for example had over $1B in tooling, and the lead times for facility and tooling development can be years. Often one risk reduction strategy is to begin development of facilities and long-lead tooling well in advance of the contract for the next phase. During TMRR Manufacturing and QA managers need to be considering what their strategy is for reducing risk in the implementation of a facility and tooling program.

Manufacturing and Quality Tasks

- Update the Manufacturing Strategy (tooling and facilities plans from the MSA Acquisition Strategy and SEP) for tooling and facilities to include:
    - Design, fabrication, and control of tooling and test equipment
    - Mix of "soft" and "hard" tooling
    - Availability
    - Surge capability to meet rates and/or fluctuating demand

  - Procurement of commercial or existing tooling,
  - Identification of any unique tooling required to support production
  - Planning for M&Q ManTech initiatives for new tools
  - Specific material specifications that require peculiar production facilities or special handling
  - M&Q environmental and safety factors
  - Security requirements for M&Q facilities (physical and cyber)
- Initiate planning for construction, fabrication, test, and demonstration of required new or modified facilities or tools.
- Update the planning for Special Test Equipment (STE) and Special Inspection Equipment (SIE) based on prototyping results (e.g., acquisition of specialized fixtures, construction of test chambers, upgrading laboratories and clean rooms, upgrading waste storage and disposal equipment, etc.).
- Update planning for new manufacturing tooling and facilities required for new technologies.
- Update M&Q tooling and facilities plans based on the availability, storage, and handling requirements of essential raw materials, special alloys, composite materials, components, tooling, and production test.
- Update plans for mitigation of identified tooling and facility shortfalls and risk areas associated with the proposed facility.
- Initiate M&Q planning for EMD tooling and facilities.

Tools

- Acquisition Strategy Template
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Facilities thread
- Manufacturing Maturation Plan
- Manufacturing Strategy (no template available)

Resources

- AS6500, Manufacturing Management Program
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

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K.2 Conduct Production Facilities Assessments

Manufacturing facilities assessment includes an analysis if the capabilities and capacity of the production facilities to develop and build the prototype(s) and prepare for EMD. Facilities assessments should include facilities at the prime, subcontractor, supplier, vendor, lab, maintenance, or repair activities. Anywhere where production may occur.

Manufacturing and Quality Tasks

- Conduct assessments of contractor-proposed facilities and tooling for TMRR and subsequent phases, including prime/subcontractors and key suppliers identified in the contractor's manufacturing management plan for the program.
- Assess the contractor's manufacturing management plans for tooling and facilities including plans, utilization, and any relocation/consolidation, program schedules, and manufacturing maturity requirements for adequacy, compliance, and impact to the contract to include:
    - Identification new to the contractor materials, technologies, manufacturing methods that require new M&Q processes requiring additional facilities, equipment, and tools
    - Review of the technical data package to identify specific material specifications that require unique production facilities
    - Assessment of current utilization for proposed manufacturing facilities
        - Assess adequacy of contractor identified facility, manufacturing equipment, test, and quality assurance equipment
        - Review contractor capabilities required for special handling, material storage, ultra-clean work environments, material, and part handling, storage, and transportation, etc.
    - Planned relocation and/or consolidation of production facilities, tooling, and production lines impacts to schedule and costs
    - Impacts to schedule and costs from planned changes to increase manufacturing maturity (i.e., manufacturing technology)
    - M&Q environmental and safety factors
    - Security requirements for M&Q facilities (physical and cyber)
    - Request DCMA data and assistance for these efforts
- Conduct on-site capability assessments of contractor's current and proposed manufacturing facilities (including critical and prototype suppliers) for:
    - Adequacy of contractor-identified facility and layout, tooling, manufacturing equipment, test, and quality assurance equipment
    - Contractor capabilities required for special handling, material storage, ultra-clean work environments, material, and part handling, storage, and transportation, etc.
    - Adequacy for prototype builds
    - Program unique production facility and tooling requirements
    - M&Q environmental and safety factors

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  - Security requirements for M&Q facilities (physical and cyber)
  - Request DCMA data and assistance for these efforts
- Identify production facility and tooling shortfalls and risks, issues, and opportunities associated with the proposed facility (include current and subsequent phases).
  - Include data from the prototype builds into overall facility risks, issues, and opportunities process
  - Identify capacity constraints
  - Request DCMA data and assistance for these efforts

Tools

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

Resources

- AS6500, Manufacturing Management Program
- DCMA-INST-204 Manufacturing and Production
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide

K.3 Identify Special Tooling, Test, and Inspection Equipment

The Department of Defense often permits contractors to acquire Special Tooling, Special Test Equipment, and Special Inspection Equipment (ST/STE/SIE) as government-furnished property to be used in the development or manufacturing of a product. Special tooling can include jigs, dies, fixtures, molds, patterns, taps, and gauges that are of a specialized nature intended for the development or production of specific DoD products. Special test equipment can be single or multi-purpose test units based to accomplish special purpose testing in the performance of a DoD contract. Special inspection equipment can be single or multi-purpose equipment used in the inspection and acceptance of DoD products.

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Manufacturing and Quality Tasks

- For EMD and subsequent phases, finalize the Tooling Plan (developed in MSA) for specialized tooling whose use is limited to the development or production of supplies or parts or to the performance of functions for the program including jigs, dies, fixtures, molds, patterns, taps, gauges, and all components of these items including foundations and similar improvements necessary.
- For EMD and subsequent phases, finalize the Tooling Plan for single or multipurpose integrated specialized test equipment (STE/SIE) that is engineered, designed, fabricated, or modified to accomplish special purpose testing for the program including items or assemblies of equipment including inter-connected or interdependent, and foundations and similar improvements necessary.
- Assess contractor demonstrations of Prototype tooling and STE/SIE in production relevant environment for functionality and sufficiency.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- DCMA Manufacturing Systems Risk Assessment Checklist
- DCMA Production Planning and Control Risk Assessment Checklist
- Independent Technical 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 System
- DCMA-INST-204 Manufacturing and Production
- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 4275.5, Acquisition and Management of Industrial Resources
- DoDI 5000.88, Engineering of Defense Systems
- FAR Part 2, §2.101 Definitions
- Manufacturing Readiness Level (MRL) Deskbook
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide

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- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

L. MANUFACTURING MANAGEMENT/CONTROL

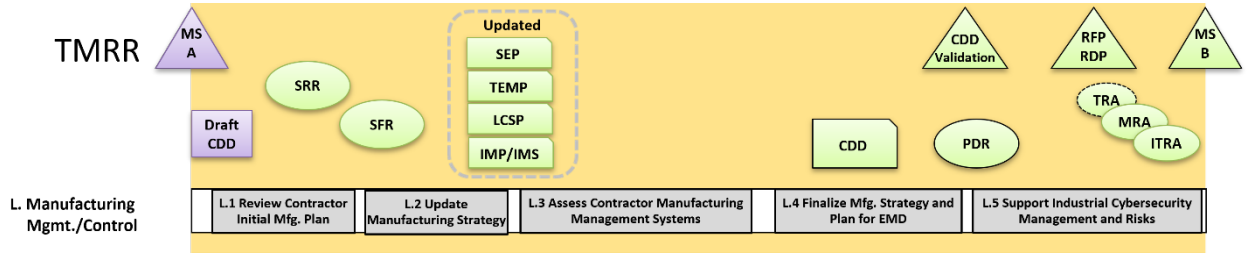

Figure 3-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

DoD Manufacturing Management is concerned with the conversion of raw materials into products based upon a detailed design. This conversion is accomplished through a series of manufacturing procedures and processes. It includes such major functions as manufacturing planning, cost estimating and scheduling; engineering; fabrication and assembly; installation and checkout; demonstration and testing; and product assurance. Manufacturing considerations begin as early as during the Analysis of Alternatives (AoA) in which the manufacturing manager and the PM must be able to understand the "manufacturing feasibility (risks)" are that are associated with each materiel solution.

Programs with any manufacturing aspects will require a manufacturing management system. The timely development, production, modification, fielding, and sustainment of affordable products by managing manufacturing risks and issues throughout the program life cycle will only be met by a comprehensive system. Meeting this objective is best accomplished by including best practices and standards (i.e., AS6500, Manufacturing Management Program) in the contracts with industry.

Beginning in this phase, the activities managing the concept (or program office) should begin the planning for manufacturing management and control of the concepts under consideration. This planning will be evolving and should be updated during the subsequent acquisition phases. The purpose of manufacturing planning is the identification of resources and integration into a structure that provides the capability to achieve production objectives. Manufacturing planning should include:

- Manufacturing requirements in contracts and in appropriate agreements with other agencies (e.g., DCMA)
- Manufacturing assessments to support program Milestone decision points and major design reviews
- Manufacturing metrics and reviews at a frequency commensurate with manufacturing risks

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This thread (Acquisition) requires an analysis of the orchestration of all elements needed to translate the design into an integrated and fielded system (meeting Program goals for affordability and availability) and will focus on the following sub-threads, tasks, activities, tools, and resources:

- Manufacturing Strategy and Planning
- Manufacturing Management System Program
- Material Management System
- Manufacturing Resource Planning
- Assess Production Lines

The initial program M&Q strategy should have been developed as part of the program's Acquisition Strategy in MSA phase. The M&Q strategy is a major aspect of the master schedule for development, test, production, fielding, modification, postproduction management, and other activities essential for program success. Now that there is a contractor responsible for technology maturation and risk reduction, the M&Q strategy will require updating. This requires an assessment of the contractor's manufacturing plans for adequacy and alignment with the Acquisition Strategy.

Manufacturing resources consist of facilities, materials, machines, manpower, methods, measurement systems, and capital that are used to convert or transform raw materials and component parts into end products. Contractors must have an effective combination of people and systems to plan for, monitor, and control these manufacturing resources. A well-structured manufacturing management system employs the use of industry best practices. A program technical team to include manufacturing and quality practitioners should assess the contractor's manufacturing management and quality systems against recognized industry best practices such as AS6500, ISO 9000, AS9100, etc.

In addition, the government requires contractors to implement cyber threat protection measures and manufacturing control systems that include safeguarding M&Q information, designed-in system 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 to comply with the following:

- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- NIST 800-82 Guide to Industrial Control Systems Security
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST, Cybersecurity Framework

In preparation for PDR, the Request for Proposal Release Decision Point (RFP DP), and Milestone B, the program's M&Q Management Strategies and Plans should be updated. The knowledge gained from the results of TMRR assessments, prototypes, demonstrations, and accomplishments, risk, issue, and opportunity plans and on-going mitigations, etc., should be utilized for the updates. These

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comprehensive strategies and plans will provide the basis for program M&Q management in the EMD phase.

L.1 Review Contractor Initial Manufacturing Plan

Manufacturing planning is about understanding everything it takes to produce the items required by the contract, on time, on budget, and with the right performance features. It includes considerations of all the 5Ms (manpower, machines, materials, methods, and measurements), at the prime contractor and throughout the supply chain. During the TMRR phase, there may be many new manufacturing requirements (5Ms) that will require development and maturing.

Manufacturing and Quality Tasks

- Compare, contrast, and assess the contractor's Manufacturing Plan for agreement with the program's overall Acquisition Strategy and the program's Manufacturing Strategy for TMRR and future phases, to include:
    - Consistency with program IB risk and issue mitigation plans
    - Development and incorporation of enabling/critical technologies (and constraints)
    - Requirements and schedules for incorporating manufacturing development projects (ManTech)
    - Design feasibility, methodology, and producibility
    - Planned rates and schedules (includes processes, tooling, make/buy, etc.)
    - Management of key and critical characteristics
    - Costs, schedule, budgets, and affordability requirements
    - Management of materials, including lead-times, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
    - Management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
    - Processes for managing the schedule, including contingencies, variances, and risks
    - Development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
    - Processes and process capability control requirements
    - Workforce capabilities, training, certifications, availability, etc.
    - Facilities, tooling, and test equipment (including GFE and assets) requirements
    - Environmental, security, and safety requirements
- Assess the contractor's Manufacturing Plan for appropriate cyber threat protection measures including safeguarding M&Q information, designed-in system protection, supply chain risks, software assurance, hardware assurance, anti-counterfeit practices, anti-tamper, and security-related activities such as physical security and industrial security.

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  - Verify that the contractor and subcontractors can comply with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
  - Verify periodic assessments are conducted to understand the risk 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
  - Verify contractor's Industrial Control Systems (ICS) are included in plans for cyber threat protection measures to be applied to M&Q systems

- Assess the contractor's Manufacturing Plan for proposed processes, methods, actions, and metrics that address M&Q capability improvement, feasibility, producibility, and risks, issues, and opportunities.
  - Review plan for a scheduled review cycle of the above commensurate with the risks and issues
- Assess the contractor's Risk, Issue, and Opportunity Management System and planning for this contractual TMRR phase (may be part of the SEP).
  - Verify the contractor has included in their plan a requirement for a joint government/contractor program risk and issue registers
- Assess the contractor's Configuration Management Plan for control and management of M&Q data for the program's TMRR phase contract.
- Assess the contractor's M&Q safety analyses processes and procedures for compliance to required program standards (i.e., MIL-STD-882) and integration into the Manufacturing Management System.
- Evaluate the contractor's proposed processes and methods for submission, review, revision, and process for obtaining approval of CDRLs, DIDs, etc. to support M&Q processes for consistency with program plans and procedures.
- Evaluate the contractor's proposed processes and methods for providing M&Q data and support to:
  - Milestone and technical reviews
  - M&Q reviews (with frequency of reviews)
  - Cost models and data (including Cost of Quality)
  - Key characteristic management process
  - Risk, issue, and opportunity identification, management, and mitigation system
  - Variability reduction processes
  - Materials management processes
  - Supply chain management system
  - Facilities, tooling, and test equipment planning
  - Workforce planning

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- Assess the contractor's Manufacturing Plan for M&Q TMRR phase goals/exit criteria.
- Assess the contractor's strategy and plans for acquisition of modern technology, production equipment, and production systems that increase the productivity and reduce life cycle costs including methods to encourage investment in U.S. domestic sources.
- Assess contractor's capability to comply with DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting.

Tools

- Assembly Chart Analysis
- Bottleneck Analysis (Theory of Constraints)
- Capacity Planning Worksheet
- Critical Chain Project Management
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Manufacturing Management/Control thread
- Learning Curve Calculator
- Line of Balance Template
- Manufacturing Maturation Plan
- Manufacturing Resource Planning (MRPII)
- Material Management and Accounting System (MMAS) audit
- Material Requirements Planning (MRP)
- Risk, Issues and Opportunities assessment
- 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 Program
- DAG, Chapter 3-4 3.18, Producibility, Quality and Manufacturing Readiness
- Defense Technical Risk Assessment Methodology (DTRAM)
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.72 Contractor Material Management and Accounting System
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.1-2014, Application of Systems Engineering on Defense Programs
- IEEE 15288.2-2014, Technical Reviews and Audits on Defense Programs

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- Manufacturing Readiness Level (MRL) Deskbook
- MIL-STD-882E DoD Standard Practice: System Safety
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Risk, Issue, and Opportunity Management Guide
- Systems Engineering Preparation Guide

L.2 Update Manufacturing Strategy

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 also be addressed. The producibility of each system design concept shall be evaluated to determine if the proposed system can be manufactured in compliance with the production cost and industrial base goals and thresholds.

Manufacturing and Quality Tasks

- From the assessment of the contractor's Manufacturing Strategy and plans, update the program Manufacturing Strategy (and the Acquisition Strategy) and plans (and the SEP) for TMRR and future phases to include:
    - Incorporation of industry and government M&Q best practices (e.g., AS6500, AS9100, ISO 9000, MIL-HDBK-896, etc.)
    - Compliance with policy directives and regulations
    - Requirements for the EMD Acquisition Strategy and RFP
    - Program plans for IB risk and issue mitigation (government plans) complementary to contractor plans
    - The joint 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 (ManTech)
    - Management of Intellectual Property
    - Design feasibility, methodology, and 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 Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path

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  - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)
  - Management of the supply chain, including supplier performance, characteristics, and constraints (e.g., sole, single, foreign, etc.)
  - Processes for managing the schedule, including contingencies, variances, and risks
  - 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 (including incorporation in the IMP/IMS)
  - Environmental, security, and safety requirements
- Based on assessments of the contractor's Manufacturing System and plans for cyber threat protection measures, update the SEP technical approaches for cybersecurity and related program security
  - Include technical risk, processes, industrial control systems, resources, organization, metrics, and design considerations
  - Provide M&Q input to the Program Protection Plan (PPP) for considerations of contractor level of compliance, risks, and issues
    - Validate that the updated Program Manufacturing Strategy (and Acquisition Strategy) includes appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA), Defense Logistics Agency (DLA), etc.)
    - For the SEP, update the Program Manufacturing Management Plan to address each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
      - Manufacturing Management System
      - Design Analysis for Manufacturing
      - Manufacturing Risk Identification (including mitigation)
      - Manufacturing Planning
      - Manufacturing Operations Management
- Identify requirements for Integrated Product Support for the program and update the Program Manufacturing Strategy accordingly (if required).

Tools

- Acquisition Strategy Template
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Manufacturing Management/Control thread
- Manufacturing Maturation Plan

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Resources

- Acquisition Plan Preparation Guide
- AS6500, Manufacturing Management System
- Defense Technical Risk Assessment Methodology (DTRAM)
- DFARS 252.204-7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- 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-HDBK-896, Manufacturing Management Program Guide
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82 Guide to Industrial Control Systems Security
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs
- Service-specific policies and regulations (i.e., AFI 63-145)

L.3 Assess Contractor Manufacturing Management System

The Department of Defense was instrumental in the development of AS6500 Manufacturing Management Program. This document is a replacement for the old MIL-STD-1528A Manufacturing Management Program. AS6500 outlines the requirements for a Manufacturing Management System (MMS) to include design and producibility analysis, the identification of key characteristics and use of process controls, manufacturing feasibility and other manufacturing risks assessments, supply chain management, technology development manufacturing cost, modeling, and simulation, etc. Manufacturing and QA managers need to be well versed in AS6500 to be able to assess a contractor's MMS.

Manufacturing and Quality Tasks

- Assess the contractor's Manufacturing Management system capability to perform the design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including (*see* I.3) for:
    - 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 incorporating producibility and manufacturing feasibility
    - Failure mode analyses processes
    - Key Characteristics management processes
    - Risk, issue, and opportunity management processes (to include quality, technical, schedule, material, facility, scale-up, financial impacts, etc.)
    - Make/buy processes (to include performance and impacts)
    - Processes and procedures for prevention and/or detection of counterfeit parts and materials
    - Development program that focuses on and measures continuous improvement
    - Effective metrics management processes to identify, monitor, evaluate, and verify to improve processes, and prevent defects
    - Supplier management system that tracks and reports supplier performance, which includes a supplier quality assessment process
    - Manufacturing verification system that verifies the proposed production processes, tooling, and test equipment meet program requirements (including Special Tooling and Special Test Equipment)
    - Manufacturing assessment and self-assessment processes to measure progress in manufacturing maturation and risk reduction including suppliers
    - Management processes for COTS items, GOTS items, and NDIs
    - Management processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.) including roles and responsibilities
    - Production Process Verifications (PPVs) that verify manufacturing processes, tooling, and equipment are statistically capable of producing required parts and assemblies
    - Process control planning incorporating process capability studies
    - Variability Reduction (VR) processes and techniques
    - Manufacturing software and firmware management processes and integration (including the SDP, and SCMP
    - Development processes for in-process and acceptance tests (including prototypes, first articles, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP

- Assess the contractor's materials and inventory control systems for sufficiency and capability to effectively meet program requirements consistent with industry best practices including:
    - An appropriate materials, manufacturing, or enterprise resources planning system (MRP/MRP II/Enterprise Resource Plan (ERP)) including cost control, capacity and

facility planning, economic order quantities, inventory control, shop floor control, bills of material, scheduling, purchasing, etc.
    - Appropriate organization/expertise to effectively operate, analyze, and maintain the system

- Assess the contractor's Manufacturing Management System processes for incorporation of M&Q in the development, management, execution, and maintenance of the IMP/IMS including processes to:
    - Identify and assess actual progress versus planned progress
    - Monitor and manage the Critical Path
    - Monitor the status of risk, issue, and opportunity management
    - Manage Key Performance Parameters, Key System Attributes, Technical Performance Measures, and Key Characteristics
- Assess the contractor's Manufacturing Management System for capability to develop an Integrated Product Support Plan (if required) including planning for EMD, production, developmental and operational test, and life cycle sustainment
- Assess the contractor's Manufacturing Management System make or buy decision process for compliance with program M&Q objectives including:
    - Rationale for specific make/buy decisions
    - Identification of items that could become obsolete or are from a diminishing or fragile manufacturing source and contingency plans
    - Identification sole source, single source, or foreign sourced items and contingency plans
    - Availability and lead-times (including long lead)
    - ITAR and anti-tamper considerations
    - Security implications
    - COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
- Analyze the contractor's Supplier Management System capability to perform the anticipated design and manufacturing work scope in accordance with industry best practices (i.e., AS6500) including:
    - Effectiveness of prime and subcontractor communication and interaction processes to include:
        - Flow down of cost, schedule, and performance requirements to suppliers and timely notification of changes
        - Quality data exchange processes
        - Integration of risk, issue, and opportunity management
        - Responses, status, and reports for cost, schedule, and performance actuals
        - Corrective and preventative actions, communication, and end user feedback
        - Specification and production of prototypes

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  - Key Characteristics management
  - Supplier risk, issue, and opportunity management processes for quality, technical, schedule, material, facility, scale-up, financial impacts, etc.
  - Make/buy processes for supplier quality performance and impacts
  - Approval/removal and qualification processes for suppliers, which includes period re-assessment
  - Processes and procedures for prevention and/or detection of counterfeit parts and materials (*See* AS5553 and AS6174)
  - Identification of major and critical suppliers, and suppliers performing Critical Manufacturing Processes
  - Supplier development program that focuses on and measures continuous improvement
  - Effective metrics to monitor, evaluate, verify, improve processes, and prevent defects
- Analyze the contractor's Supplier Management System and Quality Management Plan for:
  - Management of COTS items, GOTS items, and NDIs and their incorporation into the contractor's QMS.
  - Roles, responsibilities, and quality processes for GFE/GFP (e.g., controlled products, test ranges, specialized equipment, radiation test facilities, etc.)
  - Software and firmware quality and integration into the program software quality Assurance Plan, Software Development Plan, and Software Configuration Management Plan
  - Acceptance tests (prototypes, hardware, software, and firmware), test procedures including test equipment, and incorporation into the TEMP
- 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 DMCA assistance in data collection, assessment, analyses, and verification of the contractor Manufacturing Management System including the supply chain.

Tools

- AS6500 Assessment
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Manufacturing Management/Control thread
- Manufacturing Maturation Plan
- Material Management and Accounting System Audit

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Requirements for Aviation, Space, And Defense Organizations

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- Defense Technical Risk Assessment Methodology (DTRAM)
- DFAR 242.72, Contractor Material Management and Accounting System
- DoDI 5000.88, Engineering of Defense Systems
- 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-HDBK-896, Manufacturing Management Program Guide
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

L.4 Finalize Manufacturing Strategy and Plan for EMD

A manufacturing strategy should be updated prior to EMD 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 EMD 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. It includes considerations of all the 5Ms, at the prime contractor and throughout the supply chain.

Manufacturing and Quality Tasks

- Update the Program Manufacturing Strategy for EMD to include:
    - Incorporation of direction and results from a completed PDR (e.g., date, open items, issues, etc.)
    - Incorporation of requirements for EMD that were included in the EMD RFP
    - Incorporation of all Risks, Issues, and Opportunities
    - Maturity and plans for manufacturing development and enabling manufacturing technologies
    - Manufacturing maturity and plans for system required technologies
    - Results of design feasibility, methodology, and producibility initiatives
    - Management of Intellectual Property and data rights
    - Revised rates and schedules (includes processes, surges, tooling, make/buy, etc.)
    - Key and critical characteristics
    - Costs, schedule, budgets, and affordability requirements including Integrated Master Plan and Integrated Master Schedule (IMP/IMS) with critical path
    - Management of materials, including critical and controlled, lead-times, long-lead, sourcing, risks, and issues (e.g., sole, single, foreign, counterfeit, obsolescence, etc.)

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  - Revisions and updates to development plans and methodologies (e.g., prototypes, competitive, dual source, co-production, etc.)
  - Revisions and updates for use of COTS items, GOTS items, NDIs, and GFE/GFP (e.g., controlled products, test ranges, specialized equipment, test facilities, etc.)
  - Revised process capability requirements
  - Revised requirements for in-process and acceptance tests (including prototypes, first articles, hardware, software, and firmware), test procedures including test equipment
  - Revised workforce needs, capabilities, training, certifications, availability, etc.
  - Revised facilities, tooling, and test equipment (including GFE and assets) requirements
  - Revised processes and procedures for prevention and/or detection of counterfeit parts and materials
  - Revised acceptance testing (including incorporation in the IMP/IMS)
  - Revised environmental, security, and safety requirements
  - ITAR and anti-tamper
  - Revised plans for manufacturing cyber threat protection measures, including risks, processes, industrial control systems, resources, metrics, and design considerations

- Update the Program Manufacturing Management Plan, based on assessments, analyses, and incremental updates (including issues, open items, etc.) conducted to address each key area of the Manufacturing Strategy (in accordance with AS6500) to include:
  - Manufacturing Management System
  - Design Analysis for Manufacturing
    - Design analysis
    - Producibility analysis
    - Key Characteristics
    - Failure Mode Effects Analyses
  - Manufacturing Risk Identification (including mitigation)
    - Manufacturing feasibility assessments
    - MRL assessments
    - Production readiness reviews
  - Manufacturing Planning
    - Supply chain and material management
    - Manufacturing technology development
    - Manufacturing cost
    - Modeling and simulations
    - Manufacturing system verification
    - Manufacturing workforce
    - Tooling, test equipment and facilities

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  - Manufacturing Operations Management
    - Production Scheduling and Control
    - Manufacturing Surveillance
    - Continuous Improvement
    - Process Control Plans
    - Process Capabilities
    - Production Process Verification
    - First Article Inspection and test
    - Supplier Management
    - Supplier Quality

- Update the Program Manufacturing Management Plan for manufacturing software and firmware management processes and integration (including the program Software Development Plan, and Software Configuration Management Plan.
- Provide revised M&Q inputs to the Program Protection Plan (PPP) for considerations of contractor compliance, risks, and issues for EMD.
- Update the Program Manufacturing Strategy (and AS) for EMD to include development of appropriate agreements, delegations, and contracts with other agencies (e.g., DCMA), DLA, National Test Facilities, etc.).
- Update M&Q planning for EMD, production, developmental and operational test, and life cycle sustainment of proposed products.
  - Initial manufacturing approach developed
  - All system related manufacturing events included in Integrated Master Plan and Schedule
  - Manufacturing risk mitigation approach for pilot line or technology insertion programs defined
  - Most material decisions complete (make/buy)
  - Material risks identified and mitigation plans developed

Tools

- Acquisition Strategy Template
- Independent Technical Risk Assessment Checklist
- Interactive MRL Users Guide Checklist, for the Manufacturing Management/Control thread
- Manufacturing Maturation Plan
- Manufacturing Plan (DID-MGMG-81889)

Resources

- Acquisition Strategy Plan Preparation Guide
- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- AS6500, Manufacturing Management Program

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- Defense Technical Risk Assessment Methodology (DTRAM)
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- MIL-HDBK-896, Manufacturing Management Program Guide
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NDAA for FY 2017, Public Law 114-328, §807, Cost, Schedule, and Performance of Major Defense Acquisition Programs

L.5 Support Industrial Cybersecurity Management and Risk Assessment

Industrial cybersecurity is concerned with the ability of organizations to share information digitally (government to industry, prime contractor to subcontractors, labs to program offices, etc.). While the sharing of information is critical, it is equally important to do so in a safe and secure environment. Industrial cybersecurity is concerned with the transfer of digital data via operational technology (OT) inside a facility and through the cloud to other organizations and facilities.

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

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

There are three main types of operational technologies of concern:

- Product lifecycle management (PLM) systems for creating and managing the design process.
- Manufacturing execution system (MES) to support the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers.
- Enterprise resource planning (ERP) system to support functional management resources within an enterprise, and control process performance.

These data systems are often digital and shared across multiple functions and organizations.

DFARS 252.204-7012 requires contractors to follow NIST SP 800-171 and to:

- Provide adequate security to safeguard covered defense information that resides on or is transiting through a contractor's internal information system or network.
- Report cyber incidents that affect a covered contractor information system or the covered defense information residing therein.

- Submit malicious software discovered and isolated in connection with a reported cyber incident to the DoD Cyber Crime Center.
- Submit media/information as requested to support damage assessment activities.
- Flow down the contract clause in subcontracts for operationally critical support, or for which subcontract performance will involve covered defense information.

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

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

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

M&Q personnel need to identify and manage industrial cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the AAF.

M&Q personnel need to develop and execute industrial cybersecurity planning for system concepts identified and execute the management of those plans. Programs will employ system security engineering methods and practices, including cybersecurity, cyber resilience, and cyber survivability in design, test, manufacture, and sustainment. Such methods and practices will ensure that systems function as intended, mitigating risks associated with known and exploitable vulnerabilities to provide a level of assurance commensurate with technology, program, system, and mission objectives.

Manufacturing and Quality Tasks

- Assess supply chain OT cybersecurity and vulnerability risks, and develop risk management plans
- Implement supply chain OT cybersecurity and vulnerability risk mitigation plans
- Demonstrate OT cybersecurity solutions in a production relevant environment
- Assess OT systems for facilities and equipment (i.e., in-house factory systems, production equipment, STE/SIE, and tooling) to ensure they include cybersecurity and physical/digital controls and access requirements
- Identify and assess OT cyber incidents throughout the supply chain
- Ensure that OT Cyber Incident Reporting procedures are in-place, including reporting, tracking, and corrective actions
- Train the workforce in current cybersecurity procedures for production environment

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Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (DAU)
- Cybersecurity Strategy ADDM Template
- Interactive MRL Users Guide (Checklist), Cybersecurity thread
- USMC Cybersecurity Management Checklist

Resources

- FAR 52.202.21 Basic Safeguarding of Covered Contractor Information Systems
- DFAR 252.7012 Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoDI 5000.83 Technology and Program Protection
- DoDI 8500.01 Cybersecurity
- DoDI 5000.90 Cybersecurity for Acquisition Decision Authorities and Program Managers
- DoD 5220.22-M National Industrial Security Program
- DoD Program Managers Guidebook for Integrating Cybersecurity Risk Management Framework into Acquisition Life Cycle
- NIST SP 800-171 Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations
- NIST Special Publication 800-82 Guide to Industrial Control Systems (ICS) Security

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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
AQAP	Advanced Product Quality Planning
AQL	Acceptable Quality Level
ARL	Army Research Laboratory
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
BES	Budget Estimate Submission
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
CAD	Computer-Aided Design
CAE	Component Acquisition Executive
CAI	Critical Application Item
CAIG	Cost Analysis Improvement Group
CAIV	Cost as an Independent Variable

CAM	Computer-Aided Manufacturing
CAPE	Cost Assessment and Program Evaluation
CARD	Cost Analysis Requirements Description
CAS	Contract Administration Services
CBA	Capabilities-Based Assessment
CCA	Cost Capability Analysis
CCB	Configuration Control Board
CCE	Component Cost Estimate
CDD	Capability Development Document
CDRL	Contract Data Requirements List
CI	Configuration Item
CI	Critical Item
CJCS	Chairman of the Joint Chiefs of Staff
CLIN	Contract Line Item Number
CM	Configuration Management
CMO	Contract Management Office
CMP	Configuration Management Plan
CMP	Critical Manufacturing Process
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
CPI	Continuous Process Improvement
Cp/Cpk	Process Capability/Process Capability Index
CRI	Cost Reduction Initiative
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
DPM	Defective Parts Per Million
DFA	Design for Assembly
DFARS	Defense Federal Acquisition Regulation Supplement
DFM	Design for Manufacturability
DFMA	Design for Manufacture and Assembly
DFMEA	Design Failure Modes and Effects Analysis
DFSS	Design for Six Sigma
DIB	Defense Industrial Base
DID	Data Item Description
DLA	Defense Logistics Agency
DMS	Diminishing Manufacturing Sources
DMMG	Defense Manufacturing Management Guide
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
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
ED, SE&A	Executive Director, Systems Engineering and Architecture
EMC	Electromagnetic Compatibility
EMD	Engineering and Manufacturing Development
EMI	Electromagnetic Interference

EOQ	Economic Order Quantity
ERP	Enterprise Resource Plan
ESA	Engineering Support Activity
ESOH	Environment, Safety, and Occupational Health
ESS	Environmental Stress Screening
EVMS	Earned Value Management System
FA	First Article
FAI	First Article Inspection
FAR	Federal Acquisition Regulation
FAT	First Article Test
FCA	Functional Configuration Audit
FDD	Full Deployment Decision
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOD	Foreign Object Damage
FOT&E	Follow-on Test and Evaluation
FPAF	Fixed Price Award Fee
FRACAS	Failure Reporting, Analysis, and Corrective Action System
FRP	Full-Rate Production
FRPDR	Full-Rate Production Decision Review
FTA	Fault Tree Analysis
FYDP	Future Years Defense Program
GAO	Government Accountability Office
GCQA	Government Contract Quality Assurance
GFE	Government-Furnished Equipment
GFM	Government-Furnished Material
GFP	Government-Furnished Property
GIDEP	Government and Industry Data Exchange Program
GOTS	Government Off-the-Shelf
HAZMAT	Hazardous Material
HSI	Human Systems Integration
HVAC	Heating, Ventilation, and Air Conditioning
HWCIs	Hardware Configuration Items
IB	Industrial Base

ICA	Industrial Capabilities Assessments
ICD	Initial Capabilities Document
ICE	Independent Cost Estimate
ICS	Industrial Control Systems
IEEE	Institute of Electrical and Electronics Engineers
IG	Inspector General
IGCE	Independent Government Cost Estimate
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
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
M&S	Modeling and Simulation
ManTech	Manufacturing Technology

MATE	Multi-Attribute Trade Space Exploration
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDD	Milestone Development Decision
MEP	Manufacturing Extension Program
MES	Manufacturing Execution System
MIL-STD	Military Standard
MMAS	Material Management and Accounting System
MMP	Manufacturing Maturation Plan
MMS	Manufacturing Management System
MOA	Memorandum of Agreement
MOE	Measure of Effectiveness
MOSA	Modular Open Systems Approach
MP	Mission Profile
MRO	Maintenance, Repair, and Overhaul
MMP	Manufacturing Maturation Plan
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
MRP II	Manufacturing Resource Planning
MS A	Milestone A
MS B	Milestone B
MS C	Milestone C
MSA	Materiel Solution Analysis
MSRA	Manufacturing Systems Risk Assessment
MTA	Middle Tier Acquisition
MTTR	Mean Time to Repair
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
NAVSO-P	Navy Standard Operating Procedure
NDAA	National Defense Authorization Act

NDI	Non-Developmental Item
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NRL	Naval Research Laboratory
NSPAR	Non-Standard Parts Approval Request
NTIB	National Technology Industrial Base
O&A	Over and Above
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
OIPT	Overarching Integrated Product Team
O&M	Operations and Maintenance
OMB	Office of Management and Budget
OMS/MP	Operational Mode Summary/Mission Profile
O&S	Operations and Support
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
OT	Operational Technology
OTRR	Operational Test Readiness Review
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
P3I/P^3I	Preplanned Product Improvement
PAOC	Post-Award Orientation Conference
PAW	Producibility Assessment Worksheet
PBL	Performance-Based Logistics
PCA	Physical Configuration Audit
PCO	Procurement Contracting Officer
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
PLM	Product Lifecycle Management
PM	Program Manager

PMP	Parts, Materials, and Processes
PMR	Program Management Review
PMO	Program Management Office
POE	Program Office Estimate
POM	Program Objective Memorandum
Pp / Ppk	Process Performance/Process Performance Index
PPAP	Production Part Approval Process
PPBE	Program, Planning, Budget, and Execution
PPC	Production Planning and Control
PPP	Program Protection Plan
PPV	Production Part Verification
PQM	Production, Quality, and Manufacturing
Pre-MDD	Pre-Materiel Development Decision
PRR	Production Readiness Review
PSA	Program Support Assessment
PSM	Product Support Manager
PSS	Product Support Strategy
PTAC	Procurement Technical Assistance Center
PWBS	Program Work Breakdown Structure
QA	Quality Assurance
QALI	Quality Assurance Letter of Instruction
QDR	Quality Deficiency Report
QFD	Quality Function Deployment
QMS	Quality Management System
QSP	Quality Surveillance Plan
R&D	Research and Development
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RIO	Risk, Issues and Opportunities
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
RMBoK	Reliability and Maintainability Body of Knowledge

SAE	Society of Automotive Engineers
SAR	Safety Assessment Report
SAT	Software Acceptance Test
SCE	Should Cost Estimate
SCM	Supply Chain Management
SCMP	Software Configuration Management Plan
SCOR	Supply Chain Operations Reference
SCRM	Supply Chain Risk Management
SDP	Software Development Plan
SE	Systems Engineering
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
SUPSHIP	Supervisor of Shipbuilding
SVR	System Verification Review

SWOT	Strengths, Weaknesses, Opportunities, and Threats
TAPP	Technology Area Protection Plan
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
TRL	Technology Readiness Level
TRR	Test Readiness Review
USD(R&E)	Under Secretary of Defense for Research and Engineering
USC	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 Manufacturing and Quality Body of Knowledge (M&Q BoK) are listed below alphabetically and contain links to the referenced document or website. As many of these resources are revised frequently, readers are advised the documents may change or be updated, replaced, or cancelled between editions of this BoK. Readers may need to conduct an Internet search to find the most recent version.

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

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

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

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

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

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

10 USC 2431a. Acquisition Strategy
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Material Requirements Planning (MRP)
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Materiel Solution Analysis (MSA) Guide, DAG Chapter 3-3.2.2 Materiel Solution Analysis Phase
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The Memory Jogger, Goal/QPC
https://goalqpc.com/product/memory-jogger/

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https://goalqpc.com/product/design-for-six-sigma-mem-jogger/

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MIL-HDBK-727, Design Guidance for Producibility
https://quicksearch.dla.mil/

MIL-HDBK-766, Design to Cost
https://quicksearch.dla.mil/

MIL-HDBK-896, Manufacturing Management Program Guide
https://quicksearch.dla.mil/

MIL-HDBK-29612-1A, Guidance for Acquisition of Training Data Products and Services
https://quicksearch.dla.mil/

MIL-STD-882E, System Safety
https://quicksearch.dla.mil/

MIL-STD-1472H, Human Engineering
https://quicksearch.dla.mil/

MIL-STD-11991A, General Standard for Parts, Materials, and Processes
https://quicksearch.dla.mil/

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https://ac.cto.mil/engineering/

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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

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Supply Chain Operations Reference (SCOR) Model, Association for Supply Chain Management
https://www.apics.org/apics-for-business/frameworks/scor

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https://www.denix.osd.mil/esohacq/home/dod-guidance/dod-sustainability-analysis-guidance/OSD-ATL%20SA%20Guidance%20v5%20508%20Additions.pdf

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Technology Transition Managers Guide, Real title is Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment, DAU Press, 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)

Appendix C: Manufacturing and Quality Tools

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

AS6500 Manufacturing Management Program Checklist
Internet Search

AS9100 Quality Management System Checklist
Internet Search

AS9100 Quality Audit Checklist
Internet Search

AS9103 Variation Management of Key Characteristics Assessment
Internet Search

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

AS9134 Supply Chain Risk Management Guidelines
Internet Search

AS9137 Advanced Quality Assurance Procedure (AQAP) Checklist
Internet Search

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

Assembly Chart
Internet Search

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

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

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

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

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

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

Benchmarking
Internet Search

Bill of Material Assessment
Internet Search

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

Bottleneck Analysis (Theory of Constraints)
Internet Search

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

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

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

Capacity Assessment Worksheet
Internet Search

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

Cause and Effect Diagram
Internet Search

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

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

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

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

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

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

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

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

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

Cost of Quality (CoQ) Estimates
Internet Search

Critical Chain Project Management
Internet Search

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

Critical Path Template
Internet Search

Critical to Customer Template
Internet Search

Critical to Quality Tree Template
Internet Search

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Design Failure Modes and Effects Analysis (DFMEA)
Internet Search

Design for Affordability
Internet Search

Design for Manufacture and Assembly (DFMA)
Internet Search

Design for Performance
Internet Search

Design for Producibility
Internet Search

Design for Six Sigma (DFSS)
Internet Search

Design of Experiments (DoE)
Internet Search

Design of Experiments (DoE) Analysis
Internet Search

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

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

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

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

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

Failure Mode and Effects Analysis (FMEA)
Internet Search

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

First Pass Yield Estimates Worksheet
Internet Search

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

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

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

Gantt Charts
Internet Search

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

Histograms
Internet Search

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

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

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

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

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

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

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

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

Industrial Base Sector Plans (no specific tool)
Internet Search

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

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

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

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

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

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

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

ITAR Compliance Checklist
Internet Search

Lead Time Estimator
Internet Search

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

Learning Curve Estimation (M&S Software)
Internet Search

Learning Curve Worksheet (in Excel)
Internet Search

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

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

Line of Balance Template
Internet Search

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

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

Make/Buy Plans/Decision
Internet Search

ManTech Roadmap
Internet Search

ManTech Strategic Plan
Internet Search

Manufacturing Capability Assessment Worksheet
Internet Search

Manufacturing Cost Estimating Worksheet (commercial)
Internet Search

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

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

Manufacturing Resource Planning (MRP II)
Internet Search

Manufacturing Resource Planning (MRPII) Assessment
Internet Search

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

Manufacturing Strategy (no template available)
Internet Search

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

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

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

Material Requirements Planning (MRP I)
Internet Search

Materials Requirements Planning (MRP) Assessment
Internet Search

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

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

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

Milestone Charts (Program)
Internet Search

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

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

Operations Process Chart
Internet Search

Pareto Analysis
Internet Search

Parts List
Internet Search

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

PERT/Network Charts
Internet Search

Pilot Line Demonstration and Assessment
Internet Search

Plant Design and Facility Layout Software Evaluation Tools
Internet Search

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

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

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

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

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

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

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

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

Process Capability Studies (Cp and Cpk assessment)
Internet Search

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

Process Control Document (PCD)
Internet Search

Process Control Plan Worksheet
Internet Search

Process Failure Modes and Effects Analysis (PFMEA)
Internet Search

Process Modeling Tools (Siemens PLM, Delmia)
Internet Search

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

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

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

Production Part Approval Process (PPAP) Checklist
Internet Search

Production Plan (schedule)
Internet Search

Production Readiness Review (PRR) Checklist
Internet Search

Production Verification Test
Internet Search

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

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

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

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

Pugh Matrix Template
Internet Search

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

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

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

Quality Function Deployment (QFD) Excel Spreadsheet
Internet Search

Quality Management Plan (Sample)
Internet Search

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

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

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

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

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

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

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

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

Robust Design (Taguchi)
Internet Search

Rough Cut Capacity Planning Spreadsheet
Internet Search

Route Sheet
Internet Search

Route Sheet Analysis
Internet Search

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

Shop Floor Manufacturing Plan Analysis
Internet Search

Six Sigma Worksheet
Internet Search

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

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

Supplier Quality Questionnaire
Internet Search

Supply Chain Management Risk Assessment Checklist
Internet Search

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

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

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

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

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

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

Taguchi Loss Function Analysis
Internet Search

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

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

Technology Readiness Level (TRL) Assessment Checklist
Internet Search

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

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

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

Theory of Inventive Problem Solving (TRIZ) Matrix
Internet Search

Tolerance Design
Internet Search

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

TRIZ Matrix Template
Internet Search

Work Breakdown Structure (Template)
Internet Search

Work Measurement Analysis
Internet Search

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

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

Yield Rate Assessment
Internet Search

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

Sample Manufacturing and Quality Assurance Request for Proposal Input

Office of the Under Secretary of Defense for Research and Engineering

2021

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

Contents

Introduction

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

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

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

Data Item Descriptions (DIDs):

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

Manufacturing and Quality RFP Guide Summary Applicability Matrix

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

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

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

Manufacturing and Quality Input to RFP

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

1. Core SOW Inputs

1.1. Manufacturing Management Program

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

Suggested Data Item Description (DID):

- DI-MGMT-81889B, Manufacturing Plan

Guidance:

1. Major and critical suppliers are defined in AS6500A:

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

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

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

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

1.2. Quality Management System Requirements

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

Suggested DID:

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

Guidance:

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

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

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

1.3. Manufacturing Readiness Levels and Assessments (MRLs)

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

Suggested DIDs:

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

Guidance:

1. Ensure DIDs are current and appropriate.

1.4. Quality and Manufacturing Metrics

In accordance with AS6500A, the contractor shall maintain a manufacturing surveillance process. The contractor shall submit quality and manufacturing metrics at the agreed upon frequency that report the contractor's and major/critical suppliers' performance and progress. Metrics shall include cost, schedule, and quality metrics to monitor the effectiveness of the contractor's manufacturing, quality, and supplier management programs. Metrics shall be

presented at design, technical, and program management reviews. The contractor shall provide on-line access of these metrics to the government.

Suggested DIDs:

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

Guidance:

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

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

1.5. Counterfeit Parts Prevention

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

Suggested DID:

- DI-MISC-81832, Counterfeit Prevention Plan

Guidance:

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

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

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

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

Suggested DIDs:

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

Guidance:

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

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

1.7. Government Industry Data Exchange Program (GIDEP) Participation

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

Suggested DID:

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

1.8. Production Readiness Review (PRR)

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

Suggested DIDs:

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

Guidance:

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

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

2. Other SOW Requirements to Consider

2.1. Aviation Critical Safety Items (CSIs)

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

Suggested DIDs:

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

Guidance:

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

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

2.2. Manufacturing Modeling and Simulation

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

Suggested DID:

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

Guidance:

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

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

2.3. Calibration

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

2.4. Configuration Management

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

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

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

Guidance:

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

2.5. Risk Management

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

2.6. Parts, Materials, and Processes Control Program

The contractor shall establish, document, and maintain a Parts, Materials, and Processes Control Program (PMPCP) to ensure selection and use of parts, devices, and materials, including commercial and non-developmental items, meet specified performance, quality, reliability, safety, supportability, and configuration management requirements throughout the life cycle of

the system. The program shall include provisions for mitigating the impact of counterfeit parts and parts obsolescence on product integrity.

The contractor shall flow down applicable PMPCP requirements to applicable lower-tier suppliers.

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

Suggested DID:

- DI-MGMT-81949, DMSMS Implementation Plan

2.7. Environmental Stress Screening

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

Guidance:

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

2.8. Key Characteristics and Variation Reduction

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

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

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

3. Suggested Section L and M inputs

3.1. Instructions to Offerors Guidance (Section L):

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

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

2. Manufacturing Plan. The offeror shall describe:

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

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

4. Supplier Management. The offeror shall describe their:

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

3.2. Evaluation Criteria Guidance (Section M):

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

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

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

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

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

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

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

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

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

4. FAR/DFARS Clauses

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

4.1. Higher Level Quality Requirements

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

4.2. Counterfeit Parts Prevention

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

4.3. First Article Approvals

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

4.4. Contract Administration Functions

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

4.5. Labor Relationships

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

4.6. Government Property

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

4.7. Records Retention

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

4.8. Contractor Debarment, Suspension, and Ineligibility

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

Acronyms

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

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

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

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

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