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

Chapter 5
Production and Deployment (P&D) Phase

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

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Contents

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Introduction: How to Use the M&Q BoK

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

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

The BoK chapters 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.

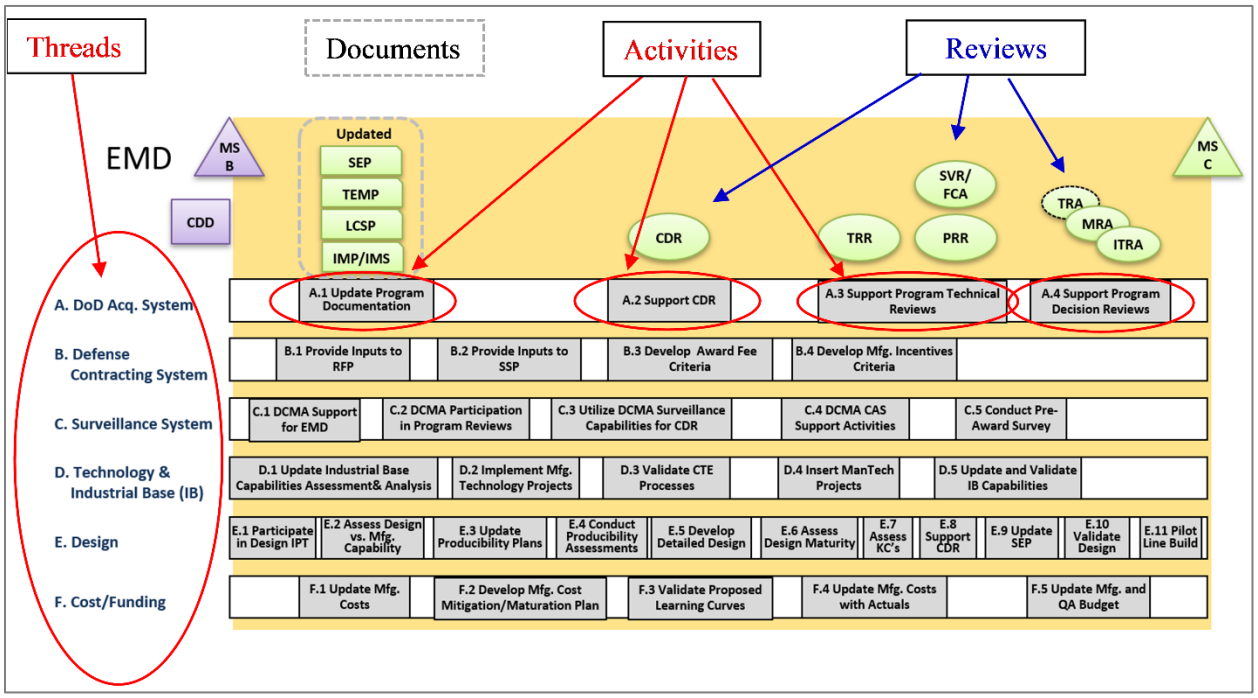
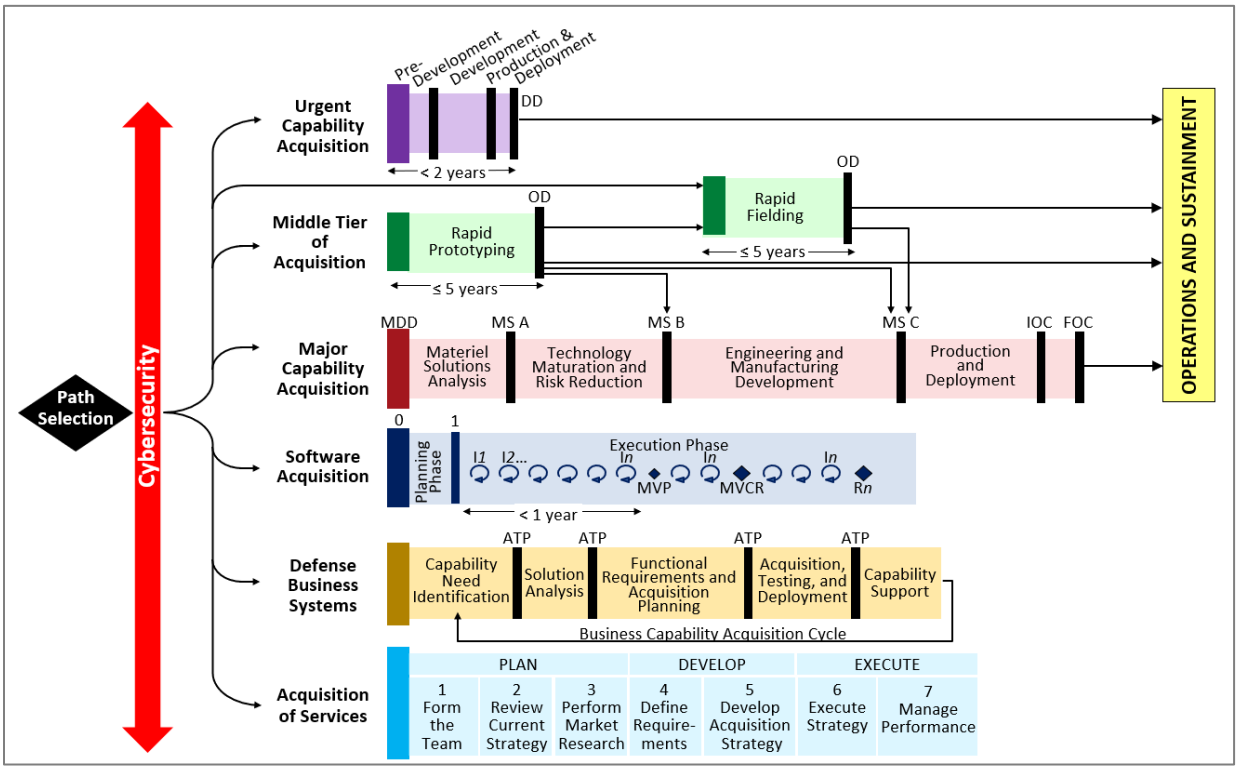


Figure 1. Sample Activity Chart

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.

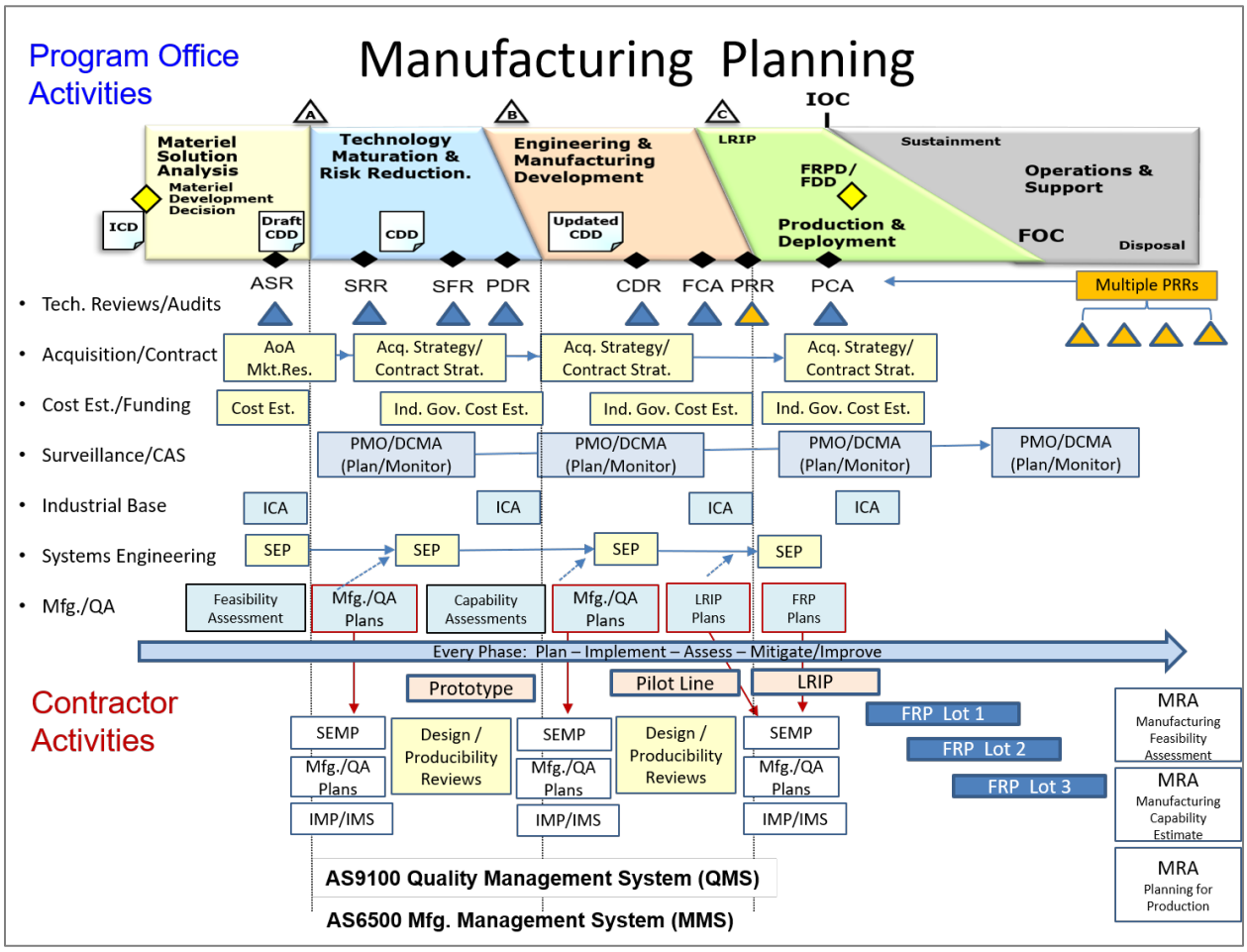


Figure 3. Typical Manufacturing and Quality Planning Activities

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

5. Production and Deployment (P&D) Phase

Introduction

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

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

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

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

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

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

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

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

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

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

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

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

Figure 5-1 shows typical M&Q activities that occur during the P&D phase.

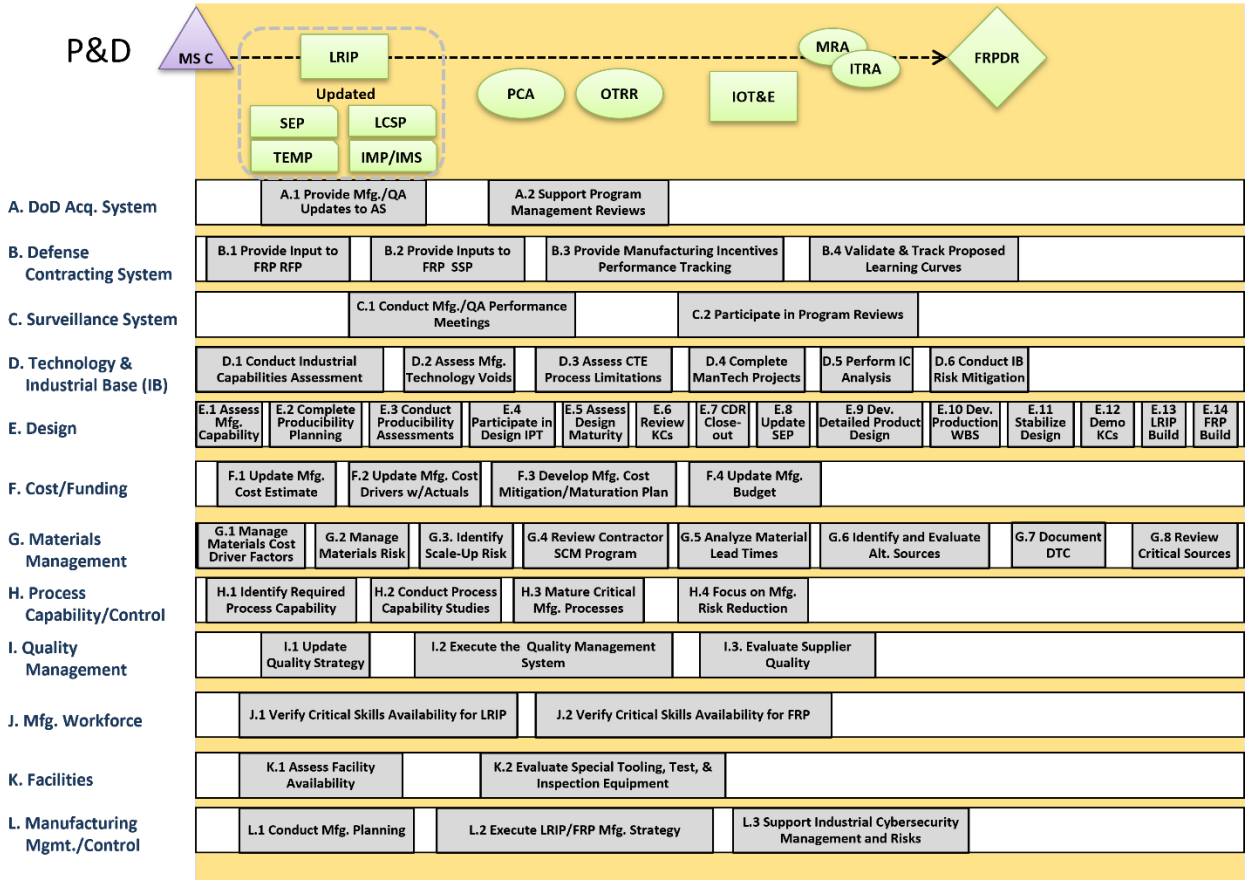


Figure 5-1. P&D Phase Manufacturing and Quality Activities

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

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

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

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

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

P&D phase objectives include the following:

- Produce authorized quantities; on time and within budget.
- Conduct technical reviews and audits:
    - Integrated Baseline Review (IBR)
    - Operational Test Readiness Review (OTTR)
    - Manufacturing Readiness Assessment (MRA)

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

A. DEPARTMENT OF DEFENSE (DOD) ACQUISITION SYSTEM

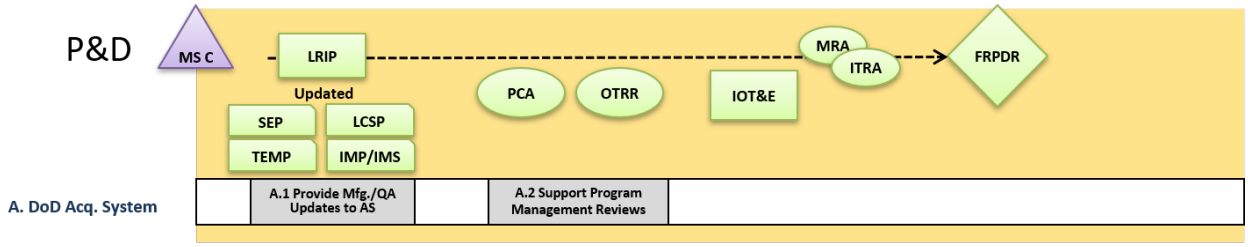


Figure 5-2. DoD Acquisition System Manufacturing and Quality Activities

Introduction

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

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

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

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

Acquisition Strategy

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

manufacturing performance evaluation should be described in enough detail for the Program Management Office to determine their expected utility.

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

Program Management Reviews

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

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

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

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

A.1 Provide Manufacturing Updates to Acquisition Strategy

Manufacturing and Quality Tasks

- Update the Acquisition Strategy to describe the planning to assess and demonstrate that the manufacturing processes/capabilities required for production have been matured to a high enough level of confidence to ensure producing production configuration products in the production phase.
- Ensure the Acquisition Strategy reflects planned efforts that results in completion of manufacturing development and demonstrates:
    - No significant manufacturing risks
    - All manufacturing processes are under control
    - Adequate and efficient manufacturing capability
    - Produces the minimum quantity necessary to provide production or production-representative articles for Initial Operational Test and Evaluation (IOT&E)
    - Establishes an initial production baseline for the system
    - Provides for an orderly increase in the production rate for the system
    - Permits the collection of statistical process control data
- Ensure that the Systems Engineering Plan (SEP) is incorporated into the Acquisition Strategy:
    - Manufacturing Planning should be a part of the SEP
    - Quality Planning should be a part of the SEP
- Ensure the Acquisition Strategy addresses the approach to making production rate and quantity changes in response to contingency needs. Consider these items in developing the strategy:
    - Technology and Industrial Base, including small business
    - Design
    - Cost and Funding
    - Materials
    - Process Capability and Control
    - Quality Management
    - Manufacturing Personnel
    - Facilities
    - Manufacturing Management
- Update other documents with manufacturing and QA input as required:
    - Test and Engineering Master Plan (TEMP)
    - Integrated Master Plan/Integrated Master Schedule (IMP/IMS)
    - Life Cycle Sustainment Plan (LCSP)
    - Capabilities Development Document (updated-CDD)

  - Transitioning to Capabilities Production Document (CPD)

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

Tools

- Acquisition Strategy Outline
- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- Industrial Base Assessment Survey Form Defense Contract management Agency (DCMA) Industrial Analysis Center

- Integrated Master Plan/Integrated Master Schedule: (i.e., Microsoft Project)
- Interactive MRL Users Guide (Checklist)
- ISO 9001, Quality Management System Checklist
- Risk Management Plan Template
- Life Cycle Sustainment Plan Outline
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline
    - Manufacturing Plan
    - Quality Assurance Plan
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Technology Readiness Level (TRL) Assessment Checklist
- Test and Evaluation Master Plan Outline

Resources

- Acquisition Strategy Guide, DSMC
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Aerospace
- DoD 5000.60-H, DoD Handbook: Assessing Defense Industrial Capabilities
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 4200.15, Manufacturing Technology (ManTech) Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE15288, System and Software Engineering
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- ISO 9001, Quality Management System
- Life Cycle Sustainment Plan Content Guide
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide
- TRA Deskbook

A.2 Support Program Management Reviews

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

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

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

Manufacturing and Quality Tasks

- Support the following reviews as required:
    - Technical Readiness Assessments (TRAs)
    - Independent Technical Risk Assessments (ITRAs)
    - Independent Logistics Assessment (ILA)
    - Industrial Capabilities Assessments (ICAs)
    - Operational Test Readiness Review (OTRR)
    - Full-Rate Production Decision Review (FRPDR)
    - Manufacturing Readiness Assessments (MRAs)
- Conduct MRL assessment using MRL 9 criteria to assess LRIP maturity.
- Conduct MRL assessment using MRL 10 criteria to assess FRP maturity.
- Identify any actual or potential producibility risks associated with the proposed design and associated manufacturing processes during any review.
- Develop mitigation plans for all quality and manufacturing risks identified during any review.
- Analyze all proposed design documentation submitted in support of reviews by applying design for manufacture and design for assembly principles to identify potential producibility risks associated with the proposed design change.
- Conduct assessment of production schedule.
- Conduct assessments of production capacity and schedule:
    - Aggregate Planning

  - Master Production Scheduling
  - Rough Cut Capacity Planning
  - Capacity Requirements Planning
- Review material sources for potential DMSMS and obsolescence issues.
- During production, assess these key manufacturing readiness considerations:
  - Industrial base viability
  - Design stability
  - Change Control
  - Manufacturing process maturity
  - Supply chain management
  - Quality management
  - Facilities (including performing capacity analyses)
  - Manufacturing skills availability
- Review these sources of industrial and manufacturing readiness data to include:
  - Technical reviews and audits
  - Program Status Reviews
  - Pre-award surveys
  - Manufacturing Readiness Level (MRL) assessments
  - Production Readiness Reviews (PRRs)
  - Industrial Capabilities Assessments (ICAs)
  - Trade-off studies
  - Tooling plans
  - Make-or-buy plans
  - Manufacturing plans
  - Bills of material

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

Tools

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

- Technology Readiness Assessment (TRA) Checklist
- Technology Readiness Assessment Calculator
- DCMA Post-award Orientation Checklist

Resources

- ISO 90001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9100, Quality Systems – Aerospace
- Defense Manufacturing Management Guide for Program Managers, Chapter 3.7.4 Technical Reviews, and Chapter 12.5 Technical Reviews and Audits
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, IEEE Standard for Technical Reviews and Audits on Defense Programs
- Independent Logistics Assessment Guidebook
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)
- ISO 9001, Quality Management System
- Logistics Assessment Guidebook Tool
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)
- Test and Evaluation Management Guide
- TRA Deskbook

B. DEFENSE CONTRACTING SYSTEM

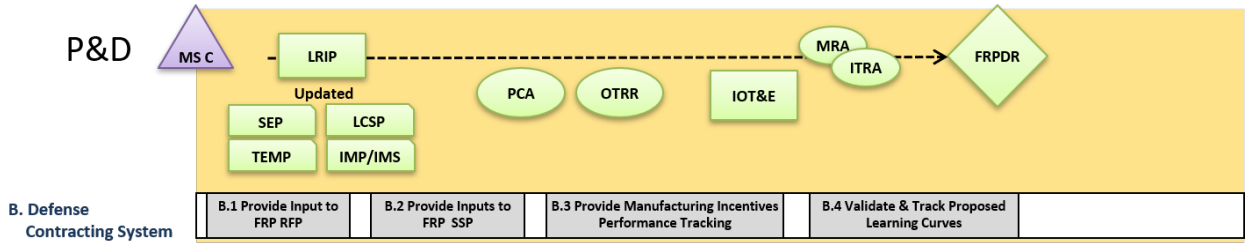


Figure 5-3. Defense Contracting System Manufacturing and Quality Activities

Introduction

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

The contract is the vehicle used to establish 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. Programs that do address manufacturing considerations in their business processes will fail. M&Q personnel often are called upon to support various contracting functions and activities.

This thread (Contracting) 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

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

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

- Section –Description/Specification/Statement of Work (SOW)
- Section E – Inspection and Acceptance
- Section L – Instructions, Conditions, and Notices to Offeror’s
- Section M – Evaluation Factors for Award (unnecessary for sole-source acquisitions)

The requirements reflect the areas that have been determined to be of importance, given the acquisition strategy of the program. Typical areas to be considered for inclusion that emphasize important M&Q considerations include:

- Manufacturing Management System (MMS)
- Quality Management System (QMS)
- Manufacturing data (including manufacturing plan updates)
- Initial production facilities
- Production and material control systems

- Production schedule assessment and control
- Manufacturing reporting systems (especially line of balance)
- Work measurement
- Control of subcontractors and vendor
- Make or Buy program
- Government Furnished Property
- System audit
- Manufacturing Readiness Assessments (MRAs)
- Technical data
- Competition

The government should provide specific areas of interest and request for data, that the contractor should include in their proposals.

When we estimate the cost or price of an item, whether it is based on a detailed cost build-up, an analogy, catalog price, or a cost estimating relationship, the cost or price may not address the effect of quantity or of learning. The learning curve (cost improvement curve, or experience curve) is a well-known approach to modeling the effect of quantity on cost.

The learning curve was adapted from the historical observation that individuals performing repetitive tasks exhibit an improvement in performance as the task is repeated several times. The current theory and practice is based:

- The time required to perform a task decreases as the task is repeated.
- The amount of improvement decreases as more units are produced.
- The rate of improvement has enough consistency to allow its use as a prediction tool.

B.1. Provide Input to Full-Rate Production Request for Proposal

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

Manufacturing and Quality Tasks

- Provide significant inputs into RFP documents on topics including the following:
    - Manufacturing Management Plan
    - Quality Assurance Management Plan
    - Quality Management System (QMS)

- Production schedule assessment and control
- Producibility Engineering Plan
- Manufacturing and Producibility Trade Studies
- Manufacturing Technology Investments
- Award Fee/Incentive Fee Criteria
- Make/Buy Plan
- Technical Reviews (i.e., PRR)
- Manufacturing Readiness Assessments
- Pre-award survey
- Perform or support a DCMA hosted Post-Award Orientation Conference
- Material Availability/Long-Lead Procurement Analysis
- Technical Data/Manufacturing Data
- Process Capability Study
- Capacity analysis
- Work Measurement/Learning Curve Analysis
- Manufacturing Reporting and Control Systems
- Contractor maintained cost data/libraries associated with manufacturing processes and technologies
- Contractor maintained Cost of Quality data available

Tools

- AS6500, Manufacturing Management System Checklist
- AS9100, Quality Management System Checklist
- IG5315.204-5(b), Section L Guide and Template
- IG5315.204-5(c), Section M Guide and Template
- ISO 9001, Quality Management System Checklist
- DCMA Pre-award Survey System (PASS)
- DCMA Post-award Orientation Conference
- SF 1403 DCMA Pre-Award Survey General
- SF 1404 DCMA Pre-Award Survey Technical
- SF 1405 DCMA Pre-Award Survey Production
- SF 1406 DCMA Pre-Award Survey Quality Assurance
- SF1407 DCMA Pre-Award Survey Financial Capability

Resources

- Federal Acquisition Regulation (FAR) https://www.acquisition.gov/
- Defense Federal Acquisition Regulation Supplement (DFARS) https://www.acquisition.gov/dfars
- MIL-HDBK-245E, Preparation of Statement of Work

- ISO9000, Quality Management System
- ACC Systems Engineering RFP Guide
- AS6500, Manufacturing Management System
- AS9100, Quality Management System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288, System and Software Engineering
- IG5315.204-5(b), Section L Guide
- IG5315.204-5(c), Section M Guide
- ISO9000, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- MRL Deskbook
- AFMC Inst 23-113 Pre-Award Qualification of New or Additional Parts Sources
- DCMA Pre-award Survey Guide
- Pre-Award Survey User's Manual

B.2. Provide Inputs to Full-Rate Production Source Selection Plan

FAR 15.101, "Best Value" section, states that an agency can obtain best value in negotiated acquisitions by using any one or a combination of source selection approaches. The SSP is a key document which specifies how the source selection activities will be organized, initiated, and conducted. 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

- Provide significant manufacturing/industrial base/quality inputs into the SSP, which could include the following topics:
    - Manufacturing Readiness
    - Investments in advanced manufacturing technology production equipment, processes, and organization of work systems that build on workers' skill and experience, and work force skill development
    - Tooling, special tooling, special test equipment
    - Material handling, management, availability
    - Production capability and efficiency

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

Tools

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

Resources

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

B.3. Provide Manufacturing Incentives Performance Tracking

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

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

Manufacturing and QA 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

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

Tools

- Award Fee Template, (see applicable service templates)

Resources

- Air Force Award Fee Guide (Army and Navy guides available)
- AS6500, Manufacturing Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD/NASA Incentive Contracting Guide
- Federal Acquisition Regulation (FAR) Subpart 16.4, Incentive Contracts
- ISO 9001, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Section L Guide, IG5315.204-5(b)
- Section M Guide, IG5315.204-5(c)

B.4. Validate and Track Proposed Learning Curves

During the Production and Deployment phase manufacturing cost estimate should be based upon application of detailed manufacturing standards and learning curves to the operations being performed and adjusted, as necessary, by realization factors or actual costs. Since the program is moving into production from a pilot line, the learning curve may need to be adjusted for LRIP and FRP. By the time, the program is in FRP, learning should be relatively flat.

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

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

Manufacturing and Quality Tasks

- Provide significant inputs into the development and management of an appropriate learning curve for the program.
- Establish the learning curve based on appropriate factors such as:
    - Worker learning
    - Supervisor learning
    - Reductions in crowded workstation
    - Tooling improvements
    - Design producibility improvements
    - Improved work methods
    - Improved planning and scheduling
    - Increased lot sizes
    - Reduced engineering change activity
    - Reduction in scrap and rework
    - Better operation sequencing and synchronizations
- Establish the expected cost of the first items using previous cost models and actuals.

- Establish how much cost reduction is possible using expected schedule, production amounts, and process times using the learning curve formula.
- Apply the curve against the program schedule and determine the expected cost reductions.
- Manage cost reductions from the learning curve.

Tools

- Learning Curve Calculator (Estimator)
- Manufacturing Cost Estimating Worksheet
- Modeling and Simulation Software for Learning Curve Estimation
- Statistical Software for Learning Curve Estimation

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 9.8, Learning Curve
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, System and Software Engineering
- Learning Curve Methodology for Cost Analysis
- MIL-HDBK-896, Manufacturing Management Program

C. SURVEILLANCE SYSTEM

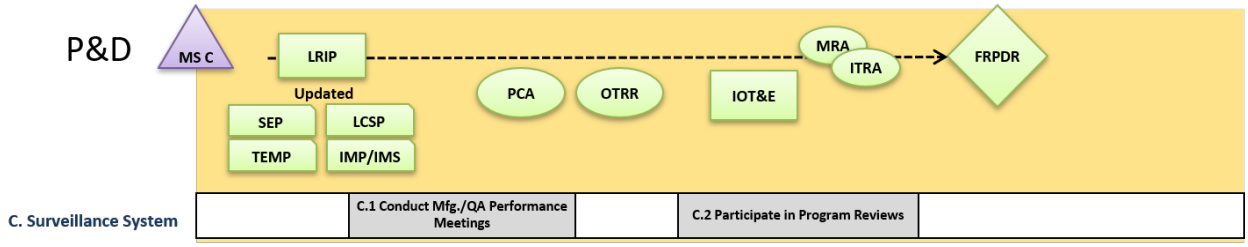


Figure 5-4. Surveillance System Manufacturing and Quality Activities

Introduction

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

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

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

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

The Program Manager should maximize the use of DCMA information, data, and analyses from contractor facilities where there is delegation of authority and expertise available. This may require the program office to establish a Memorandum of Agreement (MOA) or a Quality Assurance Letter of Delegation (QALI) with DCMA. DCMA may then, based on manpower availability and funding, utilize a systematic approach deploying surveillance through the supply chain to evaluate the supply chain and supplier improvement initiatives. At resident and non-resident facilities DCMA personnel can tap into contractor databases to assess manufacturing, quality, engineering, and business processes. Most contractors will have implemented a higher-level quality management process IAW AS9100 or ISO 9001 as a best practice. Some contractors, but not all, may have implemented a manufacturing

management process IAW AS6500. No matter what management processes the contractor has implemented, DCMA personnel should have access to that data and should be reviewing it on a continuous basis.

C.1. Conduct Manufacturing/Quality Assurance Performance Meetings

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

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

Manufacturing and Quality Tasks

- Ensure that manufacturing and QA personnel meet to discuss contractor performance in their respective areas. Meeting discussions should focus on and document the following elements of a Manufacturing Management System or Quality Management System:
    - Effective policies and procedures that encourage the use of the industry M&Q management systems
    - Organizations with defined authorities and responsibilities
    - Objectives to drive people, processes, and the system
    - Method to analyze and resolve M&Q problems
    - Metrics that reflect desired outcomes
    - Interacting processes to transform inputs into outputs
    - Records as evidence of what happened
- Evaluate M&Q impacts of factors such as:
    - Technical Performance
    - Production Performance

- Quality Assurance
- *Finance
- *Accounting
- Government Property Control
- Transportation and Packaging
- *Security
- Environmental/Energy Compliance
- Plant Safety
- *Flight Operations/Safety

*Other functional areas should be included in reviews. It is important to understand how these non-manufacturing areas can and will impact the manufacturing function.

Tools

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

Resources

- ISO9001, Quality Management System
- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DCMA-INST-204, Manufacturing and Production
- DCMA-INST-205, Major Program Support
- DCMA-INST-207, Engineering Surveillance
- DCMA-INST-219, SCM Risk Management
- DCMA-INST-309, Government QA Surveillance Planning
- DCMA-INST-401, Industrial Analysis
- DD 1423, Contract Data Requirements List
- DFAR subpart 242.3, CAS Functions
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, Systems and Software Engineering
- ISO9001, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide

C.2. Participate in Program Reviews

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

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

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

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

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

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

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

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

Manufacturing and Quality Tasks

- Conduct Production Program Assessments by reviewing the following:
  - Technical Performance
  - Production Performance
  - Quality Management System Assessment
  - Quality Assurance
  - *Finance
  - *Accounting
  - Government Property Control
  - Transportation and Packaging
  - *Security
  - Plant Safety
  - Environmental/Energy Compliance
  - *Flight Operations/Safety

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

Tools

- DCMA Program Assessment Report
- Independent Technical Risk Assessment (ITRA) Execution Guidance
- Interactive MRL Users Guide (Checklist)
- Manufacturing Maturation Plan

Resources

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

- DCMA-INST-401, Industrial Analysis
- DFAR subpart 242.3, CAS Functions
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoDI 5000.89, Test and Evaluation
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Independent Technical Risk Assessment (ITRA) Resources
- Defense Technical Risk Assessment Methodology (DTRAM)

D. TECHNOLOGY AND INDUSTRIAL BASE

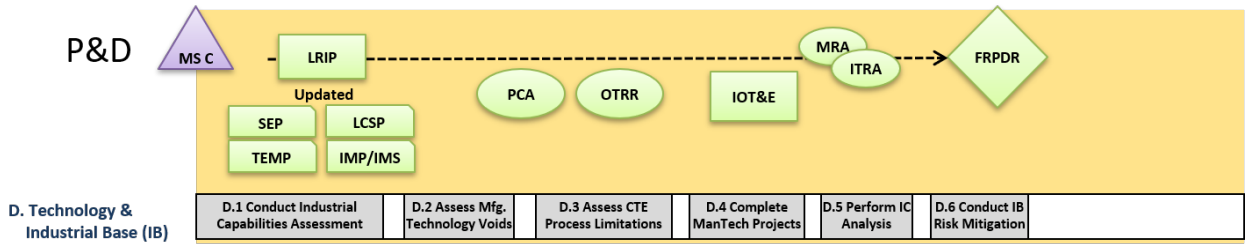


Figure 5-5. Technology and Industrial Base Manufacturing and Quality Activities

Introduction

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

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

This thread (NTIB) requires an analysis of the capabilities of the national technology and industrial base to support the design, development, production, operation, uninterrupted maintenance support of

the system, and eventual disposal (including environmentally conscious manufacturing). This thread will focus on the following sub-threads, tasks, activities, tools, and resources:

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

When acquiring material for the warfighter the DoD develops and employs strategies to effectively use the capabilities of the National Technology and Industrial Base (NTIB). Today, the U.S. Industrial Base consists of "all persons and organizations that are engaged in the Research, Development, Production, or Maintenance activities conducted with the United States, United Kingdom of Great Britain and Northern Ireland, Australia and Canada." Notice how the industrial base capabilities include research activities (technology) as well as organic capabilities.

The EMD phase activities should have highlighted the strategy for assessing the capability of emerging technologies and the industrial base to support pending production in a low-rate environment. Manufacturing processes should have been effectively demonstrated in an appropriate environment, a pilot line environment, prior to Milestone C. The manufacturing environment should incorporate key elements (Manpower, Material, Machines, Methods, Measurements, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in low-rate production. To the maximum extent practical, the environment should utilize rate production processes that are forecasted for use during LRIP.

Industrial base assessment is a continuing process with two primary components. The first gathers program specific industrial base information to help create an appropriate acquisition strategy for a program; the second engages throughout the life cycle of the program to provide feedback and updates. The objective of our NTIB is to ensure that the Department of Defense can:

- Create, expand, or preserve domestic industrial manufacturing capabilities to meet national defense requirements.
- Identify and support stable development and economical production rates.
- Identify and mitigate industrial base capabilities risks such as single points of failure and unreliable suppliers.
- Support resilience of critical defense industrial base capabilities.
- Support DoD's management of defense procurement surges and contractions.

Industrial base considerations should be documented in the Acquisition Strategy and include identification of industrial capability problems (e.g., access to raw materials, export controls,

production capabilities) that have the potential to impact the DoD near- and long-term, and identification of mitigation strategies that are within the scope of program management.

The Acquisition Strategy should strategically describe the planning required to assess and demonstrate that the manufacturing processes/capabilities, required for production will have been matured to a level of high confidence for building production configuration products in the P&D phase. Industrial Base considerations should have included:

- Industrial base sources relevant to the program, the contractor, and supply chain
- Manufacturing and quality 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

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

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

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

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

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

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

D.1. Conduct Industrial Capabilities Assessments

10 USC 2440 and DFAR Subpart 207.1 requires assessments of the capability of the U.S. Industrial Base to support the development, production and sustainment of weapon systems used by our defense forces." The program office as a member of the IPT should lead and support assessments of the impact of programmatic decisions on the national and international NTIB supporting U.S. weapon system programs.

Manufacturing and Quality Tasks

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

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

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

Tools

- Industrial Base Assessment Survey Form, DCMA Industrial Analysis Center
- Interactive MRL Users Guide (Checklist), 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 Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60, Defense Industrial Base Assessments
- DoDI 5000.60H, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

D.2. Assess Manufacturing Technology Voids

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 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

- Manufacturing and QA personnel should conduct "technology gap analysis."
- Identify new ManTech voids have surfaced.
- Evaluate ongoing ManTech efforts and determine if they can be applied to the program.
    - Assess if ManTech projects could impact projects from other Services and Agencies.

Tools

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

- Manufacturing Readiness Level (MRL) Deskbook
- Service ManTech guidance, e.g., Air Force Technology and Transition Strategy Guidebook
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.3. Assess CTE 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. These technologies are often immature and have process limitations that need to be assessed.

Manufacturing and Quality Tasks

- Critical technology elements (CTEs) need to be evaluated to assess process maturity.
- Ensure all CTEs have been identified.
- Ensure all CTE limitations have been identified.
- Ensure all CTE risks have associated mitigation efforts.

Tools

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

Resources

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility Systems Guidelines
- Technology Readiness Assessment Deskbook
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.4. Complete ManTech Projects

ManTech projects that have been identified and implemented must be managed and completed in a timely fashion so they can be integrated into the system. ManTech projects focuses on efforts to

enhance the manufacturability and producibility of defense essential and unique processes or components.

Manufacturing and Quality Tasks

- ManTech projects should be conducted to demonstrate production application of emerging technologies.
- Ensure primary manufacturing technology efforts are maturing, and improvement efforts are continuing.
- Ensure required manufacturing technology development solutions have been demonstrated in LRIP.
- Validate required manufacturing technology solutions before the FRP decision.

Tools

- 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
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- Manufacturing Readiness Level (MRL) Deskbook
- Service ManTech guidance, e.g., Air Force Technology and Transition Strategy Guidebook
- Technology Readiness Assessment Guidance
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

D.5. Perform Industrial Capabilities Assessment

An ICA is an assessment of an industry to evaluate the skills and knowledge, processes, facilities, and equipment needed to design, develop, manufacture, repair, and support DoD products. Capability Assessments (ICAs) can be performed in many ways. One way is using a standardized questionnaire which is sent out to companies and they complete the survey. After the survey has been completed a small team could visit the company to follow-up on the questions and tour of the facilities. The purpose of the assessment is to identify potential IB/program risks.

Manufacturing and Quality Tasks

- Conduct ICAs.
- Ensure the ICA questionnaire or other assessment tool addresses the following IB considerations:
    - Suppliers name, location, etc.
    - Company Ownership (public or private)
    - Facility Size and other facility information
    - Sales and sales backlog
    - Distribution or Sales Mix (% government vs commercial)
    - DoD Programs Supported
    - Significance of Current Program to overall sales
    - Maturity of product technology
    - Production Status
- Ensure the ICA addresses the following:
    - Industry status (consolidations, rising or falling market, etc.)
    - Unique or critical manufacturing processes
    - Technology issues (DMSMS, obsolescence, etc.)
    - Vendor or supply chain issues
    - Industrial base risks
    - Production rate and quantity
    - All industrial capabilities risks have been identified and all IC risks have associated mitigation efforts.

Tools

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

Resources

- 10 2501, National Security Objectives Concerning National Technology and Industrial Base
- 10 2503, Analysis of the Technology and Industrial Base
- 10 USC 2440, Technology, and Industrial Base
- DCMA Industrial Analysis (DCMA-INST-401)
- DoD Handbook 5000.60-H, Assessing Defense Industrial Capabilities
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.60, Defense Industrial Capabilities Assessments
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems

- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Readiness Level (MRL) Deskbook

D.6. Conduct Industrial Base Risk Handling and Mitigation

Industrial base risk handling and mitigation activities may be a result of a formal study or analysis or may be a result of routine oversight that identifies risk(s) or issue(s). Manufacturing and QA managers need to assist in the development and management of risk management strategies and implementation plans that include accepting, avoiding, transferring, or mitigating the risks and issues.

Manufacturing and Quality Tasks

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

Tools

- Interactive MRL Users Guide (Checklist), Technology and Industrial Base thread
- Manufacturing and QA Risk Mitigation Plan (no Template available)
- Manufacturing Maturation Plan

Resources

- DoD Handbook 5000.60H, Assessing Defense Industrial Capabilities, Part II, Chapter 5 Identify and evaluate Alternative Actions
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook

- Engineering of Defense Systems Guidebook
- MRL Deskbook Chapter 5.2 Development of a Manufacturing Maturation Plan

E. DESIGN

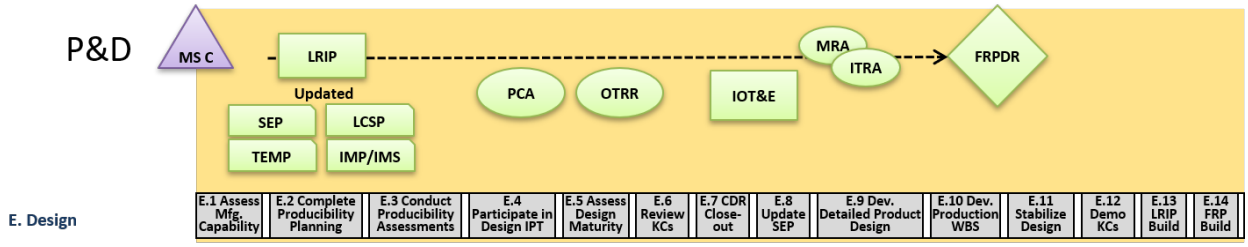


Figure 5-6. Design Manufacturing and Quality Activities

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 many disciplines to include operations, maintenance, logistics, test, production, quality, etc. SE accomplishes these activities by focusing on eight technical processes and eight technical management processes. M&Q personnel need to support these SE activities.

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

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

relatively easy to manufacture. Producible designs are lower risk, more cost-effective and repeatable, which enhances product reliability and supportability. The Program Manager (PM) should implement Producibility Engineering and Planning (PEP) efforts early and should continuously assess the integrated processes and resources needed to successfully achieve producibility.

To assess producibility on a product level, both the product and its manufacturing processes should be measured. Manufacturing processes should be monitored and controlled, through measurement, to ensure that they can repeatedly produce accurate, high-quality products, which helps the program meet objectives for limiting process variability to a tolerable range.

Producibility assessments and engineering should be a part of the ongoing systems engineering process. DoDI 5000.02 states that "design for producibility" should be a part of the Engineering and Manufacturing Development phase. DoDD 5000.01 states that the PM should "reduce manufacturing risk and demonstrate producibility" prior to FRP.

History has demonstrated that as the complexity of systems increases, so does the acquisition cost. Therefore, producibility programs are necessary as a management means for assuring that practicality is addressed and that the cost increases associated with the growing complexity of systems are minimized. Consequently, the PMO approach to organizing for producibility is of prime importance to a successful defense system.

Major programs are organized around core design team, usually composed of 20-50 of the contractor's best engineers. This core design team makes 90-95 percent of all critical decisions. If M&Q is not one of their primary concerns, then production issues will be delegated to secondary teams, will not be addressed early, and will cause major problems. Therefore, manufacturing and QA personnel need to be assigned to the programs technical IPT and participate as appropriate in the systems engineering processes.

DoD acquisition programs face a high risk of failure at the outset of the design process. Developing and maturing a new design has a high level of risk. Historically this risk has been magnified by the misunderstanding of the industrial design disciplines necessary to turn the concept into a mature product. Assessing design maturity is one of the major activities the IPT should perform.

A mature design meets operational requirements without additional government or contractor intervention - no further field modifications or additional equipment and spares are required to overcome design shortfalls. In the factory, design maturity might be indicated by a reduction in Engineering Change Proposal (ECP) traffic. During EMD the Critical Design Review (CDR) is conducted, and the design is considered stable if 80 percent of the design has been released to manufacturing. There are not specific measures for design stability during the P&D phase, but most experts would suggest that design traffic (ECPs) should be minimal and minor in nature unless there is a major design modification going on.

A strong producibility emphasis early in design will minimize the time and cost required for successful transition to production and will ensure that production items are more reliable and dependable.

A Key Characteristic (KC) is a feature of a material, process, or part (includes assemblies) whose variation within the specified tolerance has a significant influence on product fit, performance, service life, or manufacturability. In other words, if the product deviates from the specified design (mid-tolerance dimension) then the product will experience early field failure rates and impact life cycle costs. The contractor needs to identify and manage key characteristics and demonstrate the capability to achieve these KCs.

A Critical Characteristic is any feature throughout the life cycle of a Critical Safety Item (CSI), such as dimension, tolerance, finish, material or assembly, manufacturing or inspection process, operation, field maintenance, or depot overhaul requirement that if nonconforming, missing or degraded may cause the failure or malfunction of a CSI. CSIs are parts whose failure could have catastrophic consequences. In general terms, a CSI's failure could cause loss of life, serious injury or permanent disability, loss of a weapon system, or substantial equipment damage.

DoDI 5000.02 requires that PMs and their technical staff to, “Develop an affordable and executable manufacturing process during the Engineering and Manufacturing Development (EMD) phase.” The Post-CDR assessment will include a demonstration that the “maturity of critical manufacturing processes has been accomplished. EMD should end when “manufacturing processes have been effectively demonstrated in a pilot line environment” prior to Milestone C. CDR identified risks should have been mitigated by Milestone C, but any risks that are still open and active in the Production and Deployment Phase should be managed and closed out using risk reduction techniques.

One of the most important elements of any production design is the definition of the manufacturing resources. No matter how good a design may be, it is useless if system or product cannot be built. It is therefore essential that availability and capability of manufacturing resources be a consideration during the design review process. Manufacturing engineers should be a part of each design team to assure adequate consideration of availability and capability of required manufacturing resources.

Manufacturing resources should not be limited to manufacturing methods, but should include materials, capital, manufacturing technology, facilities, qualified labor, and the management structure to effectively integrate them. The successful competitor, of the production phase will depend upon the efficient application of the full spectrum of these resources to the task of fabricating and delivering the defense system design.

The planning, execution and control of the production phase activities require that the work be divided into manageable tasks that are compatible with the existing manufacturing and performance measurement systems. Often, the work breakdown structure (WBS) used during the development phases will need to be updated for the production phase. A well-defined and documented WBS will

support the development of accurate cost and schedule models. This is critical for those programs which have utilized a design-to-unit production cost management approach during development.

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

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

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

E.1. Assess Manufacturing Capability

As members of the technical IPT, M&Q managers should develop and integrate the M&Q Plans and Strategies into the SEP. These plans and strategies should include results of an assessment of the capability to design, develop, produce, support an acquisition program. This includes assessing manufacturing readiness and effective integration of industrial capability considerations into the design process. The first consideration is a need to understand current manufacturing capabilities to see if they match up against the design requirements so that the program can plan for the enhancements of capabilities where there is a gap between the design and factory floor capabilities. Consider these items during the capability assessment:

- Technology and Industrial Base, including small business
- Design
- Cost and Funding
- Materials
- Process Capability and Control
- Quality Management

- Manufacturing Personnel
- Facilities
- Manufacturing Management

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, as well as 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 contractors' use of best practices to manage design and manufacturing considerations
- Assess the contractors' manufacturing capability and capacity to produce an item and ensure that the assessment covers:
    - All required manufacturing processes and techniques
    - All design producibility risks
    - Manufacturing capability and capacity has a high probability of meeting delivery dates including spares and in-line repair work
    - Manufacturing capability and capacity provides for minimal impact of critical and long-lead time material
    - Manufacturing capability and capacity ensures all production equipment will be available
    - Manufacturing capability and capacity provides accurate production unit cost goals
    - Capability and capacity includes cost and production schedule estimates updated with actuals to support management reviews
    - All alternatives have adequate manufacturing feasibility and cost and schedule impact analyses that support trade-offs
    - Capability and capacity includes recommendations for anticipated production testing and demonstration efforts
    - Prior producibility improvements analyzed for effectiveness during LRIP

Tools

- Design Failure Modes and Effects Analysis (DFMEA)
- Design for Manufacturing and Assembly (DFMA) Assessment
- Design for Six Sigma
- Design of Experiments
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Fault Tree Analysis (FTA)
- Design Failure Modes and Effects Analysis (DFMEA)
- Process Failure Modes and Effects Analysis (PFMEA)
- Robust Design
- Systems Engineering Plan (SEP) Outline
- Tolerance Design

Resources

- DCMA Industrial Analysis (DCMA-INST 401)
- Design for Six Sigma Memory Jogger
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis
- Manufacturing Readiness Level (MRL) Deskbook
- Principles and Guidelines for Design for Manufacturing and Assembly
- Systems Engineering Plan (SEP) Outline
- Taguchi Robust Design/Six Sigma Guide

E.2. Complete Producibility Planning

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

Producibility criteria should reflect a blending of general criteria (such as minimum parts count) and specific criteria applicable to the type of equipment being developed. The producibility program will be effective if the design engineers understand and apply the producibility design criteria. Each competing design needs to be evaluated from a producibility standpoint. Producibility evaluations will serve as a basis for estimating the likely manufacturing cost and assessing the level of manufacturing risk of the system.

Manufacturing and Quality Tasks

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

Tools

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

Resources

- Defense Manufacturing Management Guide for Program Managers, Chapter 7.6 Producibility Engineering and Planning (PEP)
- DoD Integrated Product and Process Development Handbook
- DoD Integrated Product and Process Development Handbook

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE15288.2, System and Software Engineering
- MIL-HDBK-727, Design Guidance for Producibility
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center
- Systems Engineering Plan (SEP) Outline

E.3. Conduct Producibility Assessments

During this Phase, the PM should conduct producibility assessments to 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 assuring that the cost increases associated with the growing complexity of systems are minimized. Producibility analysis accomplished by the PMO must be performed by a team of specialists assembled from the program office: and supporting organizations. Manufacturing and QA managers are key to the successful implementation of a producibility program.

Manufacturing and Quality Tasks

- Ongoing Producibility Assessments conducted on current efforts including additional efforts if necessary:
    - At the enterprise level (including infrastructure – software tools, design guides, training, and policies).
    - On a product-by-product level (including trade studies, and design principles – reduce part count, use of common parts, ease of assembly, and simplicity of fabrication).
    - Producibility issues/risks discovered in LRIP have been mitigated and pose no significant risk for FRP.

Tools

- CAD/CAM software
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Producibility Assessment Worksheet
- Systems Engineering Plan (SEP) Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- IEEE 15288.2, System and Software Engineering
- ISO 9001, Quality Management System
- MIL-HDBK-727, Design Guidance for Producibility
- MIL-HDBK-896, Manufacturing Management Program Guide
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Producibility Engineering Standard Practice Manual, US Army Belvoir R&D Center
- Systems Engineering Plan (SEP) Outline

E.4. Participate in Design Integrated Product Teams

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 percent 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 QA personnel must participate with the Design IPT in the development and review of the design and design documentation.

Manufacturing and Quality Tasks

- Support and participate in ongoing Design IPT activities that demonstrates:
    - Producibility has been assessed and integrated with other design activities.
    - Key and critical manufacturing assembly and test processes have been identified, evaluated, and matured.
    - All risks (technology, manufacturing, software development, and sustainment) have been assessed.
    - Metrics and data to assess, monitor, manage and control the transition process have been developed.

  - Manufacturing and quality engineers participate on engineering IPTs.
- Ensure the product design is stable.
  - Design change process is stable and under control and includes adequate process for identifying and approving Class 1 changes, and the classification of changes is periodically reviewed.
  - Design changes are few and generally limited to those required for continuous improvement or in reaction to obsolescence.
  - Design change process includes sign-off by contractor manufacturing or production engineer, and quality engineer.
- Ensure the production environment is robust and can be used to validate LRIP manufacturing needs.

Tools

- Design for Manufacturing and Assembly (DFMA)
- Integrated Master Plan/Integrated Master Schedule template
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- Design for Six Sigma Memory Jogger
- DoD Integrated Product and Process Development Handbook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.5. Assess Design Maturity

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

Manufacturing and Quality Tasks

- Continue design maturity assessments. Ensure that all:
  - Product data required for pilot-line component manufacturing completed.
  - Pilot-line product requirements and features have been defined.
  - Product data essential for subsystem/system pilot line has been released.
  - All enabling/critical components have been demonstrated on the pilot line.
  - Design maturity metrics have been applied to the planned Production Line.

Tools

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

Resources

- DoD Integrated Product and Process Development Handbook
- DoD MIL-STD 882E, System Safety
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-727, Design Guidance for Producibility
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Systems Engineering Plan (SEP) Outline

E.6. Review Key Characteristics

AS9103 is the industry best practice of the identification and control of Key Characteristics and requires the producer to maintain documentation of Key Characteristics and control those manufacturing processes that directly influence variation of those Key Characteristics. Key Characteristics should be capable and have a Cpk of 1.33 or greater or as specified by the customer. The concept of identifying key characteristics is linked to the Pareto principle, which asserts that a relatively small number of features will have the most significant impact on performance.

Manufacturing and Quality Tasks

- Design KCs have been identified, are being tracked and managed, and mitigation plans developed.
- All KCs are controlled in LRIP to appropriate quality levels.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Critical to Quality Tree
- Failure Mode and Effects Analysis
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Process Capability Analysis Worksheet
- Process Control Document (PCD)
- Producibility Assessment Checklist
- Systems Engineering Plan (SEP) Outline
- Technology Readiness Level Assessment Checklist

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Assurance Management
- AS9103, Variation Management of Key Characteristics
- DoD Integrated Product and Process Development Handbook
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines
- Systems Engineering Plan (SEP) Outline
- Technology Level Assessment Guidance
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

E.7 Critical Design Review Close-Out

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

Manufacturing and Quality Tasks

- Manufacturing and QA personnel should support the conduct of the CDR, and concerns include:
    - That the system product baseline has been established and documented to enable hardware fabrication to proceed with proper configuration management.
    - Adequate processes and metrics are in place for the program to succeed.
    - All the known risks are understood and manageable for testing in support of developmental and operational evaluation objectives.
    - The program schedule is executable (technical/cost risks).
    - The program is executable with the existing budget and the approved product baseline.
    - The detailed design is producible within the production budget.
    - The updated Cost Analysis Requirements Description (CARD) is consistent with the approved product baseline.
    - The updated cost estimate fits within the existing budget.
    - Key product characteristics that have the most impact on system performance, assembly, cost, and sustainment or safety are identified.
    - The critical manufacturing processes that affect the key characteristics have been identified and their capability to meet design tolerances determined.
    - Process control plans have been developed for critical manufacturing processes.
    - Manufacturing processes have been demonstrated in a production representative environment.
    - Detailed trade studies and system producibility assessments are complete.
    - Materials and tooling are available to meet LRIP/FRP schedule.
    - System production cost models have been updated, allocated to subsystem level, and tracked against targets.
    - Long-lead procurement plans are in place and the supply chain has been validated.
    - All product data essential for component manufacturing has been released.
    - Design change traffic does not impact LRIP.
- Ensure that major product design features and configuration are stable.
- Manufacturing and QA personnel need to support the conduct of the PCA or equivalent completed.
- Ensure that production equipment is maintained, and this translates to high overall equipment effectiveness (OEE) rate and is accounted for in determining the availability of the equipment and contingency plans.

Tools

- Critical Design Review Checklist and Assessment
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan

- Systems Engineering Plan (SEP) Outline

Resources

- DoD Integrated Product and Process Development Handbook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Systems Engineering Plan (SEP) Outline

E.8. Update to Systems Engineering Plan

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

Manufacturing and Quality Tasks

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

- Manufacturing and quality personnel should ensure that the SEP contains the following manufacturing considerations:
    - Program Schedule (PRR/Production Lot/Phases)
    - Technical Risks and Mitigation Planning (Production/Manufacturing/Quality)
    - Manufacturing Readiness Assessment (MRA)
    - Manufacturing and Quality Roles and Responsibilities of IPTs (Team Details – Name, Chair, Membership, Roles, Responsibility, and Authority, Products and Metrics)
    - Planned Activities for the Next Phase (including manufacturing maturity)

- All modifications, upgrades, Diminishing Manufacturing Sources and Material Shortages (DMSMS) and other changes assessed for producibility
- Technical Review Process (Manufacturing Purposes/Criteria)
- Manufacturing and Quality TPMs/Metrics to be used to identify and manage risks
- Manufacturing Design Considerations (Include Trade Study Criteria)
- Engineering Tools (such as Producibility/Throughput Analysis, Line of Balance, factory and process modeling and simulation tools, and quality tools) are available and in use

Tools

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

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System
- DoD Integrated Product and Process Development Handbook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoDI 5000.89, Test and Evaluation
- ISO 9001, Quality Management System
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines, Dept. of the Navy
- Systems Engineering Plan (SEP) Outline

E.9 Develop Detailed Product Design

Detailed product design includes the realization (build) effort down to the lowest level system elements and includes the fabrication/production processes required to complete the build effort. As a best practice, the Systems Engineer should develop an implementation plan that includes implementation procedures, fabrication processes, tools and equipment, implementation tolerances and verification

uncertainties. Manufacturing and quality managers/engineers need to be a part of the development and assessment of detailed design efforts.

Manufacturing and Quality Tasks

- Support the development of the detailed product design.
- Ensure detailed design drawings, bills of material and product and process specifications are completed by release of design to manufacturing.
- Participate in design reviews to assure that the contractor is complying with the design requirements and meeting the cost/design goals.
- Ensure the final design definition is the result of the performance requirements, the outcomes of the testing accomplished, producibility studies and other design influences.
- Ensure that the design is specified to a low level of detail so that the required production phase processes and resources can be identified and obtained.
- Demonstrate design producibility improvements in LRIP and in FRP.

Tools

- Design for Manufacturing and Assembly (DFMA)
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Systems Engineering Plan (SEP) Outline

Resources

- DoD Integrated Product and Process Development Handbook
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.10 Develop Work Breakdown Structure

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

Manufacturing and Quality Tasks

- Support the development the Program and Contract WBS to ensure planning, execution and control of the production phase activities are compatible with the existing manufacturing and performance measurement systems.
    - Ensure that the Program WBS is accurate down to at least three levels and includes manufacturing and quality considerations.
    - Ensure the contractor identifies the Contract WBS down to at least three levels and that production phase costs and schedule can be related to the development WBS, tracked and managed.

Tools

- Manufacturing Maturation Plan
- Manufacturing Readiness Assessment Checklist, Design thread
- Systems Engineering Plan Outline
- Work Breakdown Standard review

Resources

- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-STD-881 Work Breakdown Standard
- Systems Engineering Plan (SEP) Outline

E.11 Stabilize the Design

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

Manufacturing and Quality Tasks

- Product design and features should be assessed during the CDR to support a production decision.
    - Verify that design change traffic should be minimal
    - Verify that 80% of the drawing packages have been released to production

- Verify the detailed design of all product features and interfaces is completed.
    - All product data essential for product manufacturing has been released
- Evaluate the final material selection for completeness and for producibility.
- Evaluate the product specifications/build-to packages to ensure that they are matured to the same level as the design.
- Verify that the LRIP Build-to Packages are complete.
- Verify that the FRP Build-to Packages are complete
- Verify that the system design has been validated through operational testing of LRIP items.
- Verify that the design change traffic is now limited to Class II ECPs.
- Verify that the design efforts achieved effective and efficient manufacturing processes with the necessary process controls to satisfy requirements and minimize manufacturing costs.
- Verify that the design of the system facilitates the timely and affordable manufacture, assembly, and delivery of a quality product to the customer.

Tools

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

Resources

- DoD Integrated Product and Process Development Handbook
- DoD MIL-STD 882E, System Safety
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoD 4245.7-M, Transition from Development to Production, Chapter 3 – Design
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.12 Key Characteristics Demonstrated

Once a Key Characteristic has been identified, the team must determine which manufacturing processes create or significantly contribute to each KC. These processes are then termed critical processes. The contractor should maintain documentation depicting this relationship between each KC and their associated critical manufacturing processes. Then those manufacturing processes must be controlled to demonstrate that the process is stable, capable and in control. For each critical

manufacturing process, a Process Failure Modes and Effects Analysis (FMEA) should be performed, and process control plans should be developed and implemented.

Manufacturing and Quality Tasks

- Support the identification and management of Key Characteristics to ensure that they are under control.
- Manufacturing process should be identified, documented, and put under statistical control.
- Process capability (i.e., Cpk) studies should be accomplished to demonstrate process maturity.
- Key Characteristics (KC) risk issues should be identified, and mitigation plans developed and put into place.
- Key Characteristics should be assessed to ensure that they are attainable based upon production demonstrations.
- Process producibility improvements should be ongoing.
- All KCs should be controlled in FRP to appropriate quality levels.
- Manufacturing Readiness Assessment should be conducted to assess KCs.
- Manufacturing processes should be re-assessed as needed for capability to test and verify potential influence on Operations and Support.

Tools

- AS9100 Checklist
- AS6500 Checklist
- Critical to Quality Tree
- Failure Mode and Effects Analysis
- Interactive MRL Users Guide (Checklist), Design thread
- Manufacturing Maturation Plan
- Process Capability Analysis Worksheet
- Producibility Assessment Checklist
- Systems Engineering Plan Outline

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Assurance Management
- AS9103, Variation Management of Key Characteristics
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- MIL-STD-1629, Procedures for Performing a Failure Mode, Effects and Criticality Analysis

- Manufacturing Readiness Level (MRL) Deskbook
- NAVSO P-3687, Producibility System Guidelines
- Systems Engineering Plan (SEP) Outline

E.13 Low-Rate Initial Production Build

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

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

Manufacturing and Quality Tasks

- Assess LRIP to ensure that:
    - New technologies are mature and ready to transition into the production units
    - The detailed system design is complete with few engineering changes, and none that impact form, fit or function
    - All manufacturing processes are capable and under statistical control, and there are no producibility risks
    - A complete definition of the fabrication and assembly tasks and they are transferred to the general factory work force
    - Detailed work instructions exist and a controlled system for changes to the documents used in the factory, such as drawings and process specifications
    - Required production planning documentation are based on a stable design, quantity requirements and delivery schedule
    - Engineering changes are controlled to minimize disruption to production documentation and planned manufacturing schedules
    - QMS is operating effectively to produce quality systems
    - Participate in the PCA and examine the actual configuration of an item being produced and confirms that the manufacturing processes, QMS, measurement and test equipment, and training are adequately planned, tracked, and controlled and that the related design documentation matches the item as specified in the contract
- Ensure affordable and executable manufacturing process have been developed and demonstrated/proven.

- Demonstrate that the maturity of critical manufacturing processes has been accomplished.
- Ensure all manufacturing processes have been effectively demonstrated during LRIP.

Tools

- Integrated Master Plan/Integrated Master Schedule assessment
- Interactive MRL Users Guide (Checklist), Design thread
- Production Part Approval Process (PPAP) Checklist
- Production Readiness Review (PRR) checklist
- Production Verification Test
- Systems Engineering Plan Outline

Resources

- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- AS6500, Manufacturing Management System
- DCMA Instruction 302, First Article and Production Lot Testing
- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoDI 5000.89, Test and Evaluation
- IEEE 15288.2, System and Software Engineering
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

E.14 Full-Rate Production Build

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

Manufacturing and Quality Tasks

- Manufacturing personnel must ensure that:

  - Engineering/design changes are few and generally limited to quality and cost improvements
  - System, components, or items are in FRP and meet all engineering, performance, and quality requirements
  - Manufacturing process capability is at the appropriate quality level
  - All materials, tooling, inspection and test equipment, facilities and manpower are in place and have met FRP requirements
  - Rate production unit costs meet goals, and funding is enough for production at required rates
  - Lean practices are well established, and continuous process improvements are ongoing
  - There are no significant manufacturing risks
  - Manufacturing processes should be under statistical control if quantities warrant
- Identify remaining risks prior to FRP production go-ahead decision. Key considerations should include:
  - Industrial base viability
  - Design stability
  - Process maturity
  - Supply chain management
  - Quality management
  - Facilities and manufacturing skills availability
  - Mitigation plans from the FRP MRA
- Review and assess the following sources of data to include:
  - Technical reviews and audits
  - Program Status Reviews
  - Pre-award surveys
  - Production Readiness Reviews
  - Industrial Capabilities Assessments
  - Trade-off studies
  - Tooling plans
  - Make-or-buy plans
  - Manufacturing plans
  - Bills of material
- Assess if a follow-on, tailored, PRR may be appropriate in the Production and Deployment phase for the prime contractor and major subcontractors if:
  - Changes from the EMD phase and during the production stage of the design, in either materials or manufacturing processes, occur
  - Production start-up or re-start occurs after a significant shutdown period
  - Production start-up with a new contractor, or

- Relocation of a manufacturing site

Tools

- Integrated Master Plan/Integrated Master Schedule assessment
- Interactive MRL Users Guide (Checklist), Design thread
- Production Part Approval Process (PPAP) Checklist
- Production Readiness Review Checklist
- Production Verification Test
- Systems Engineering Plan (SEP) Outline

Resources

- AS/EN/SJAC9102, Aerospace First Article Inspection Requirement
- AS6500, Manufacturing Management System
- DCMA Instruction 302, First Article and Production Lot Testing
- DoD Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, System and Software Engineering
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook
- Systems Engineering Plan (SEP) Outline

F. COST/FUNDING

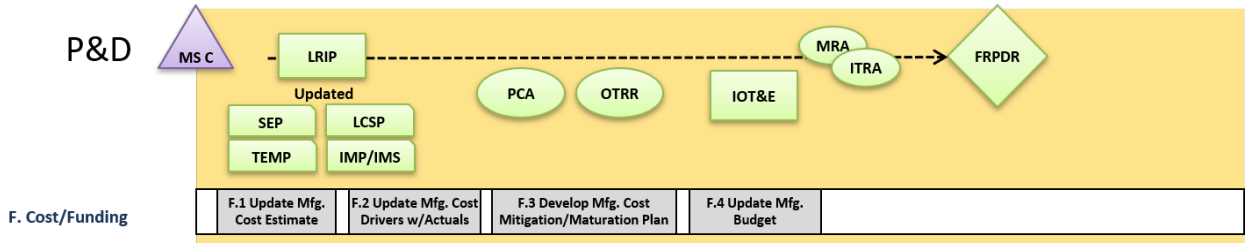


Figure 5-7. Cost and Funding Manufacturing and Quality Activities

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 submit a DoD Budget Request to the Office of Management and Budget (OMB).

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

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

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

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

The problems with all cost models is that they are not perfectly accurate, and often we find programs overrunning costs for various reasons. An actual cost are calculated based on costs actually incurred

and recorded in accomplishing the work performed within a given time period, as distinguished from forecasted or estimated costs, and when costs are overrun the program may need to develop cost mitigation and maturation plans.

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

F.1 Update Manufacturing Cost Estimates

DoDI 5000.73, "Cost Analysis Guidance and Procedures" identifies Cost Estimating and Reporting requirements. Manufacturing and quality managers need to support to development and update of government cost estimates and the assessment of contractor cost estimates.

Manufacturing and Quality Tasks

- Support the development of various cost models and estimates:
  - Affordability Analysis
  - Cost Analysis Requirements Description (CARD)
  - DoD Component Cost Estimate
  - Component Cost Estimate (CCE)
  - Component Cost Position (CCP)
  - Cost Capability Analysis (CCA)
  - Should Cost Estimate
  - Sufficiency Review
  - Independent Cost Estimate (ICE)
- Update the initial manufacturing cost estimate to reflect the final definition of the system design and the completed manufacturing approach.
- Support fact finding and negotiations by collecting and analyzing cost and efficiency data from LRIP and earlier Production lots, development and application of learning curves, and development and defense of negotiation positions.
- Base manufacturing cost estimates on the application of detailed manufacturing standards to the operations to be performed and adjusted, as necessary, by realization factors and/or learning curves to develop the time phased manufacturing cost.
- Consider including a contract requirement for Work Measurement in the LRIP/FRP phase contract if the contractor does not have a system for development and application of labor standards.

- Update the FRP cost model based on the results of the LRIP build.

Tools

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

Resources

- Cost Analysis Requirements Description (CARD) website and process (*See* CAPE website)
- Defense Manufacturing Management Guide for Program Managers, Chapter 9 Manufacturing Cost Estimating
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- MIL-HDBK-766 Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook
- Should-Cost and Affordability Memo

F.2 Update Manufacturing Cost Drivers with Actuals

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

Manufacturing and Quality Tasks

- Manufacturing cost drivers should be identified and updated on a regular basis based on actual cost performance.
- Manufacturing costs should be rolled up to system/subsystem level and tracked against targets.
- Detailed trade studies and engineering change requests should be supported by cost estimates.
- Cost reduction and avoidance strategies should be developed and implemented.

- LRIP costs estimates should be analyzed using pilot-line actuals and updated into manufacturing cost estimates to ensure target costs are achievable.
- Manufacturing cost analysis should be conducted when there are proposed changes to requirements or configuration.
- All cost models should be updated based on the results of pilot line build.
- All cost models should be updated based on the results of LRIP build.
- LRIP cost should be monitored to ensure they meet program goals, and the learning curve should be analyzed based on actual data.

Tools

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

Resources

- Cost Analysis Requirements Description (CARD) website and process (*See* CAPE website)
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Cost Estimating, see the Defense Manufacturing Management Guide for Program Managers, Chapter 9
- MIL-HDBK-766, Design to Cost
- Manufacturing Readiness Level (MRL) Deskbook
- Should-cost and Affordability Memo

F.3 Develop Manufacturing Cost Mitigation/Maturation Plan

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

Manufacturing and Quality Tasks

- Develop and update Manufacturing cost models regularly to include:
  - The collection of actual cost data during fact finding.
  - The analysis of contractor cost and pricing data.
  - The ability to develop and defend cost estimates for future production lots.
  - The ability to be used in design trades to assess the cost impacts of specific design changes, alternative production processes or process improvements.
  - The ability to incorporate the current, actual manufacturing costs into the production cost estimate.
  - The ability to support Finance and Contracting processes (such as independent program estimates, proposal preparation, fact-finding and negotiations, budgeting, and what-ifs.)
- Develop Manufacturing Maturation Plans for any areas assessed that do not comply with the appropriate manufacturing readiness criteria.
- Analyze touch labor efficiency to ensure the contractor can meet production rates and elements of inefficiency identified with plans in place for reduction.

Tools

- Cost Analysis Requirements Description (CARD) (*See* CAPE website)
- Cost/Schedule Control Systems Criteria (C/SCSC)
- Earned Value Management (EVM)
- Interactive MRL Users Guide (Checklist), Cost thread
- Manufacturing Cost Estimating Worksheet
- Manufacturing Maturation Plan (no template available)
- Parametric, Engineering and Actual estimating

Resources

- 10 USC 2334, Independent Cost Estimation and Cost Analysis
- CARD - Cost Analysis Requirements Description Template (See CAPE website for guidance)
- Cost/Schedule Control Systems Criteria Reference Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 5105.84, Director of Cost Assessment and Program Evaluation
- DoDI 5000.73, Cost Analysis Guidance and Procedures
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Public Law 114-328, §807, Cost, Schedule, and performance of major defense acquisition programs

F.4 Update 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 several manufacturing related issues. A budget estimate was developed to take the program from EMD pilot line to low-rate production, and this budget needs to be updated to take the program from LRIP to FRP.

Manufacturing and Quality Tasks

- Support the development of a program budget estimate for achieving FRP.
    - Program estimate should support cost for achieving MRL 9 by the FRP decision point
- Identify manufacturing costs and cost drivers associated with design alternatives considered in trade-off process.
- Update manufacturing cost drivers for "Should-Cost" and other models.
- Support “Should-cost” activities.
- Develop manufacturing mitigation plans for outstanding MRL 9 risk areas that impact budget estimates and actual costs.
- Ensure that all program budget estimates includes investment for LRIP and FRP.
- Assess the affordability and executability of the manufacturing processes.
- Determine the risks to affordably to develop, manage and execute required manufacturing processes for each identified prototype.
- Analyze the identified risks.
- Integrate the individual risks identified for each prototype into a cumulative assessment of the ability to affordably install and execute the proposed manufacturing processes.
- Document and provide the cumulative assessment of the ability/risk to affordably install and execute the proposed manufacturing processes.
- Analyze of the adequacy, reasonableness and necessity of contractor-proposed manufacturing labor hours and material costs.
- Recommend quality and manufacturing cost reduction initiatives.
- Provide accurate cost performance versus target analysis and assessment of identified trends.
- Analyze the quality, manufacturing, and production cost data against cost targets, and identify trends.
- Identify and provide quality, and manufacturing cost/funding estimates and recommendations on emerging requirements.
- Identify manufacturing investment opportunities and develop investment roadmaps for achieving the manufacturing development efforts.
- Develop funding and budgeting request for quality and manufacturing initiatives.
    - Identify emerging quality and manufacturing initiatives.
    - Develop program estimates for applicable quality and manufacturing initiatives.

- Develop and manage industrial base investment programs that create, expand, or preserve assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense.
- Assess cost models and validate them based against actual FRP cost.
- FRP cost goals should be assessed.
- Production budgets should be developed that are enough for producing at the required rates and schedule.

Tools

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

Resources

- Manufacturing Readiness Level (MRL) Deskbook
- Public Law 114-328, §807
- Technology Readiness Assessment Guidance
- Technology Readiness Assessment Guide (Best Practices) (Report GAO-20-48G)

G. MATERIALS MANAGEMENT

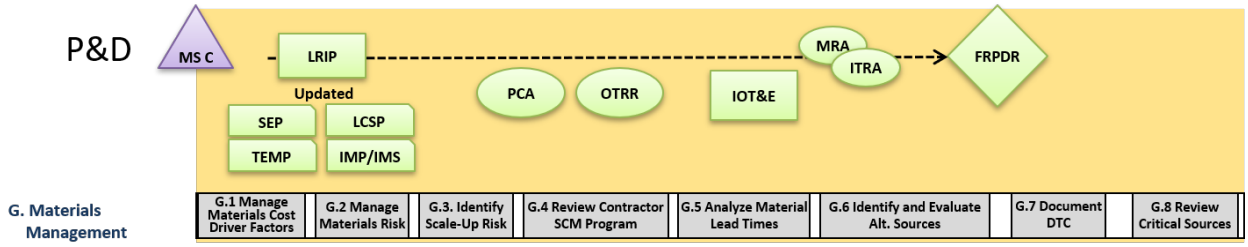


Figure 5-8. Materials Management Manufacturing and Quality Activities

Introduction

Materials is one of the 5Ms (manpower) that needs to be addressed on a regular and ongoing basis. Material Management is concerned with the ability of a program to have the right materials, at the right place, at the right time, at the right cost and quality levels. This includes raw materials, components, semi-finished parts, and subassemblies. Some major concerns that need to be assessed include:

- Material availability
- Material maturity
- Special Handling of Material
- Supply Chain Management

The DoD has many supply chains, and these chains are a multibillion- dollar business. However, many SCM best practices have not been incorporated into the DoD supply chain uniformly because the DoD supply chain is a conglomeration of different supply chains managed under different organizational structures. Some of these supply chains have a logistics view and some have an acquisition view. Because the DoD supply chain is enormous, making it even slightly more efficient could result in tremendous cost savings.

The GAO has consistently rated Supply Chain Management (SCM) as a "high-risk" area for DoD acquisition programs. This is a major concern since 60-80 percent for the material dollar value of a program exists within the supply chain, not at the prime contractors. Therefore, M&Q personnel need to be active in helping to identify and manage supply chain risks. SCM risks can include some of the following:

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

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

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

Programs with potential supply chain risks may need to identify alternative sources of supply for several reasons:

- When the program is dependent on a sole source of supply, a single source of supply or a foreign source of supply.
- When the item being procured is a critical item.
- To encourage competition to achieve and maintain affordability.
- When faced with Diminishing Manufacturing Sources and Material Shortages (DMSMS) and Obsolescence

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

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

- 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

The SEP should address the parts management strategy, including the need for a parts management plan. Parts selection should be based on trade-off and cost-benefit analyses that are conducted in accordance with the program's parts strategy and management plan, as derived from the overall acquisition and sustainment strategies. Selected parts should be documented in a parts list, which is under configuration management of the overall technical baseline.

A parts management plan typically includes the following:

- Implementation of an effective parts management program which supports acquisition strategies and systems engineering practices.
- Parts selection criteria and a parts selection baseline.
- Identification of Critical Parts/Long Lead Parts and Sole/Single/Foreign Sources of parts.
- DMSMS and Obsolescence management.
- Development of a parts list or Bill of Materials (BOM).
- Part and Supplier QA requirements and programs.
- Alternative part selection and approval procedures.

Lead times for defense materials and components can be long and volatile. There are various reasons for this situation, such as:

- Imbalances between capacity and demand.
- Imperfect forecasting of needs.
- Competition from commercial suppliers.
- Poor quality and lack of process improvement.

- Production bottlenecks.
- Long testing cycles.
- Raw materials not available.
- Long contracting process.
- Lack of funding.
- Transportation.
- Labor issues.

Supply chain management is a key driver in the ability of a program to scale up or ramp up production from a pilot line to LRIP, to FRP, and finally to slow the line down and get ready for production close out.

G.1. Manage Materials Cost Driver Factors

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 versus 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.

Manufacturing and Quality Tasks

- Update material cost drivers based on:
    - Design requirements
    - Material specifications and tolerances
    - Material specification is stable
    - Bill of Materials
    - Make/Buy decisions
    - Projected rates/quantities (lot buys)
    - Price stability
    - Supply Chain stability
    - Material maturities demonstrated on pilot-line build and LRIP
    - Materials proven and validated during EMD as adequate to support LRIP/FRP
- Assess and manage material risk:
    - Methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials

Tools

- Cost, Schedule Control Systems Criteria (C/SCSC)

- Earned Value Management (EVM)
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan
- Producibility Assessment

Resources

- DoD Cost/Schedule Control System Criteria
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Manufacturing Cost Estimating (*see* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687
- Strategic and Critical Materials Stock Piling Act, as amended by NDAA FY 2017 (Public Law (PL) 114-328)

G.2. Manage Materials Risk

Risk can be described as anything that has the potential to impact negatively on cost, schedule, or performance. Material risks have been known to be risks and issues that can slow or delay a program, add additional costs to a program, or create field failures because of poor material reliability. Material risks could include availability of the material, maturity of the material, or need for special handling and control. Material risks can occur anywhere in the supply chain all the way down to the lowest level (dirt). Manufacturing and quality managers need to support the identification and management of material risks.

Manufacturing and Quality Tasks

- Identify material availability risks and minimize through mitigations.
- Assess material availability risks to meet LRIP.
- Assess material availability risks to meet FRP.
- Identify, manage, and mitigate lead procurement risk.
- Assess and initiate long-lead procurement LRIP/FRP.
- Develop and put into place an effective supply chain management process.
- Assessment of critical first tier supply chain must be completed.
- Assessment of critical second and lower tier supply chain must be conducted.
- Assess the supply chain to ensure it is adequate to support LRIP/FRP.

- Identify and manage sole source/single source items.
- Assess make/buy decisions.
- Analyze make/buy decisions for all key or critical components.
- Analyze make/buy decisions for capability of selected manufacturers, whether in factory or at vendor facility, to meet quality requirements, schedule, and cost targets.
- Develop an obsolescence plan.
- Ensure DMSMS and parts obsolescence risks are managed and mitigated.
- Ensure that counterfeit material is not finding its way into the product.
- Manage all part shortage issues to minimize impact on production line.
- Identify all special handling/storage/environmental compliance risks/issues.
- Characterize all new materials in a factory environment.
- Account for and manage all GFE, GFP, government-furnished facilities (GFF), and government-furnished materials (GFM).
- Prove and validate materials as adequate to support FRP.

Tools

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

Resources

- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- DMSMS Guidebook, SD-22
- DoD 5000.60, Defense Industrial Capabilities Assessments
- DoD 5000.60H, Assessing Defense Industrial Capabilities
- DoD Manual 4140.01, DoD Supply Chain Materiel Management Procedures
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- ESOH in Acquisition Guide

- ISO 14001 Environmental Management Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687
- Technology Readiness Assessment Guidance

G.3. Identify Scale-Up Risk

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

Manufacturing and Quality Tasks

- Identify any manufacturing processes and techniques that are not currently available.
- Identify any design producibility risks.
- Identify probability of meeting delivery dates.
- Identify the potential impact of critical and long-lead time material.
- Identify any production equipment availability issues.
- Verify that all production unit cost goals are realistic.
- Verify that all cost and production schedule estimates support management reviews.
- Verify that all manufacturing feasibility and cost and schedule impact analyses that supports trade-offs among alternatives.
- Verify all recommendations for anticipated production testing and demonstration efforts.
- Validate all methods for conserving critical and strategic materials and mitigating supply disruption risks and program impacts associated with those materials.
- Verify that all manufacturing processes and techniques are currently available and used on pilot line.
- Verify that there are no design producibility risks.
- Verify that there are no production manpower constraints.
- Verify that there are no capacity constraints.
- Verify that there is a high probability of meeting delivery dates.
- Verify that the potential impact of critical and long-lead time material is minimal.
- Verify that there are no production equipment availability issues.
- Verify production unit cost goal realism on the pilot line.
- Verify that cost and production schedule estimates support management estimates.
- Conduct manufacturing feasibility studies and analyze cost and schedule impact to support all trade-offs among alternatives.
- Verify that the supply chain is stable and adequate to support FRP.

- Verify that recommendations for anticipated production testing and demonstration efforts have been implemented.
- Develop special handling procedures and incorporate them into the production line instructions:
    - Verify that special handling procedures have been integrated into the work instructions.
    - Verify special handling procedures have been demonstrated in the LRIP and FRP environments.
    - Verify that special handling poses no significant risk for LRIP/FRP.

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
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDD 4200.15, ManTech Program
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Cost Estimating (*See* Defense Manufacturing Management Guide for Program Managers, Chapter 9)
- Manufacturing Readiness Level (MRL) Deskbook
- MRL Users Guide
- Producibility Systems Guidelines, NAVSO P-3687

G.4. Review Contractor Supply Chain Management Program

Since much (60-80%) of the program's components and subsystems comes from the supply chain, then Supply Chain Management 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 quality managers need to routinely review and assess contractor supply chain and procurement activities and efforts. A thorough review of the entire supply chain is needed to ensure that the contractor is can ramp up production for LRIP and FRP.

Manufacturing and Quality Tasks

- Support a review of the contractors Supply Chain Management (SCM) program for:

  - Strategic partnerships with vendors and suppliers
  - Stronger collaboration of information (especially forecasting data)
  - Reducing lead times on the critical path
  - Reducing variability
  - Supply Chain Planning
  - Demand Planning
  - Vendor Managed Inventory
  - Supplier Management
  - Procurement
  - Strategic Sourcing
  - Warehouse Management
  - Transportation Management
  - Order Fulfillment
  - Contract Management
- Review contractor's procurement system to ensure procurement packages are complete and accurate.
- Review contractor's parts management program including:
  - Management of distinct part numbers
  - Reduction in the number of distinct part numbers
- Review contractor's supplier qualification process to make sure it adequately ensures supplier's processes are capable on critical parts.
- Review contractor's supplier audit process to make sure it adequately ensures quality on critical parts.
- Participate in supplier audits and encourage other relevant organizations to participate (DCMA, etc.) to determine effectiveness of supplier qualification and auditing of supplier quality.
- Assess the supply chain management process for effectiveness.
  - Assessment of critical first tier supply chain completed.
- Ensure the supply chain is adequate to support LRIP.
  - Assessment of critical second and lower tier supply chain completed.
- Assess the supply chain to verify that it is proven and supports FRP requirements.

Tools

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

Resources

- AS5553, Counterfeit Electronics Parts
- AS6500, Manufacturing Management Systems
- AS9100, Quality Management Systems
- AS9103, Variation Management of Key Characteristics
- AS9133, Qualification Procedure for Aerospace Standard Parts
- DFARS 246.870, Contractors' Counterfeit Electronic Part Detection and Avoidance
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- IEEE 15288.2, System and Software Engineering
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- ISO 9001, Quality Management Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security

G.5. Analyze Materials Lead Time

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

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

The contractor may go out to their suppliers and ask for lead times or delivery dates, but how accurate are those dates? What happens when there is a disruption in the supply chain caused by weather,

political unrest, change in suppliers, etc.? Forecasting and lead time assessment gets harder to do the further out the delivery date is. Furthermore, there is always a balance between the cost of holding an item and the cost of ordering. If too much is ordered or it comes in early, it could cause additional cost and risks. The same holds true if too little is ordered, or it comes in late.

Contractors must have a procurement system that ensures procurement packages are complete and accurate and are issued well in advance of lead times.

Manufacturing and Quality Tasks

- Identify potential long-lead items or issues.
- Analyze lead time fluctuations for schedule impacts.
- Ensure government funding is aligned with contractor long-lead requirements.
- Verify long-lead procurement has been initiated for LRIP.
- Verify long-lead procurement initiated for FRP.
- Verify procurement packages are complete and accurate.
- Perform material availability risk assessment.
- Develop long-lead material agreements, processes, and/or contracts.
- Verify that long-term agreements are in place where practical.

Tools

- Gantt Charts
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan
- Milestone Charts
- PERT/Network Charts

Resources

- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Integrated Master Plan and Integrated Master Schedule Preparation and Users Guide
- Manufacturing Readiness Level (MRL) Deskbook

G.6. Identify and Evaluate Alternative Sources

Programs often face shortages in the supply chain that can cause significant problems in meeting cost, schedule, and performance. Sole source, single source, and foreign sources of supply come with a lot of risks. In addition, suppliers come and go in the marketplace. One day there may be four sources of supply and the next day one or none. Diminishing Manufacturing Sources and Obsolescence is a real problem on DoD programs, including programs that are pushing the state of the art but have

components that are past their prime. One way to mitigate those risks and to increase competition (reduce cost) is to identify and develop alternative sources of supply. This is not a quick or a cheap fix as the new supplier will probably need to go through a qualification program and prove that it has the capability to produce one, the capacity to produce all that are needed and the financial stability to be able to perform for the entire contract period of performance.

Manufacturing and Quality Tasks

- Review contractor's Bill of Materials to identify risks and potential requirements for alternative sources of supply.
- Review contractor's Parts Management Program to assess risks of not having parts when needed for production.
- Identify supply chain supplier risks.
- Identify single/sole/foreign sources of supply.
- Identify DMSMS and Obsolescence risks and plans for mitigation.
- Review contractor's use of the Government and Industry Data Exchange Program (GIDEP) database for configuration items that are susceptible to DMSMS issues.
- Identify potential alternative sources of supply.
- Identify and develop Qualification Plans for alternative sources of supply.
- Review contractor's DMSMS recommendations for the program risk management plan.
-

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit
- DMSMS Cost of Alternative Solutions Worksheet
- DMSMS Program Self-Assessment Guide
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Interactive MRL Users Guide (Checklist), Materials thread
- Make or Buy Plans
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- Contractor Purchasing System Review (CPSR) Guidebook
- DFAR 15.407-2, Make or Buy Programs
- DFARS Subpart 242.7200, Contractor Material Management and Accounting System
- MIL-STD-3018, Parts Management
- Manufacturing Readiness Level (MRL) Deskbook

- SD-22, DMSMS Guidebook

G.7. Document Design to Cost

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

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

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

Manufacturing and Quality Tasks

- Analyze production costs using pilot-line system/subsystem actuals to ensure target costs are achievable.
- Analyze production costs using LRIP system/subsystem actuals to ensure target costs are achievable.
- Analyze production costs using FRP system/subsystem actuals to ensure target costs are achievable.
- Update cost models with design requirements, material specifications, and pilot-line results.
- Assess cost impacts from design changes due to P3I.
- Assess cost impacts from design changes due to Value Engineering Change Proposals.

Tools

- Cost Estimate (based on actuals)
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- Department of the Army Design to Cost Handbook
- DFAR 207.103(B)(i)(i), Apply design to cost principles
- DoDI 5000.85, Major Capability Acquisition
- GAO-09-3SP, GAO Cost Estimating and Assessment Guide
- MIL-HDBK-766, Design to Cost
- DoDI 5000.88, Engineering of Defense SystemsG.8. Review Critical Sources

A source is only a good source if it provides the right product, at the right time and place, at the right cost, and with the right performance. Thus, if an item is the lowest cost but is unreliable or comes in late, or comes in with quality deficiencies, then buying that item was a poor decision. Supply chain material assessments are especially needed for those items that may be considered critical sources of supply. These critical items (Pareto the vital few vs the trivial many) are often long-lead or are sole/single sources of supply. Lead times for defense materials and components can be long and volatile. There are various reasons for this situation, such as:

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

Manufacturing and Quality Tasks

- Verify LRIP/FRP material availability.
- Assess the LRIP/FRP bill of materials using pilot-line activity.
    - Identify key and/or critical components in the LRIP/FRP BOM.
    - Analyze key and/or critical components in the LRIP/FRP BOM for potential issues.
- Validate material maturity based on pilot line.
    - Validate that the properties and characteristics of the material to be used for the LRIP/FRP system meet requirements.
    - Determine that the material's properties and manufacturing characteristics are predictable.
    - Assess the properties of the material for basic manufacturability.
- Develop mitigation strategies for quality and manufacturing-related supply chain counterfeit and anti-tamper and related exportability risks.
- Assess the materials planning systems. Identify materials planning systems being employed by the contractor or facility.
- Update Critical Suppliers List.
- Assess program in FRP to ensure that there are no significant material availability issues.

Tools

- Contractor Purchasing System Review
- DCMA Material Management and Accounting System Audit
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- Interactive MRL Users Guide (Checklist), Materials thread
- Manufacturing Maturation Plan

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Material
- Contractor Purchasing System Review (CPSR) Guidebook
- DFAR 15.407-2 Make or Buy Programs
- DFARS Subpart 242.7200 Contractor Material Management and Accounting System
- DoDI 5000.85, Major Capability Acquisition
- DoDI 5000.88, Engineering of Defense Systems
- Manufacturing Readiness Level (MRL) Deskbook
- Strategic and Critical Materials Stock Piling Act, as amended by PL 114-328

H. PROCESS CAPABILITY/CONTROL

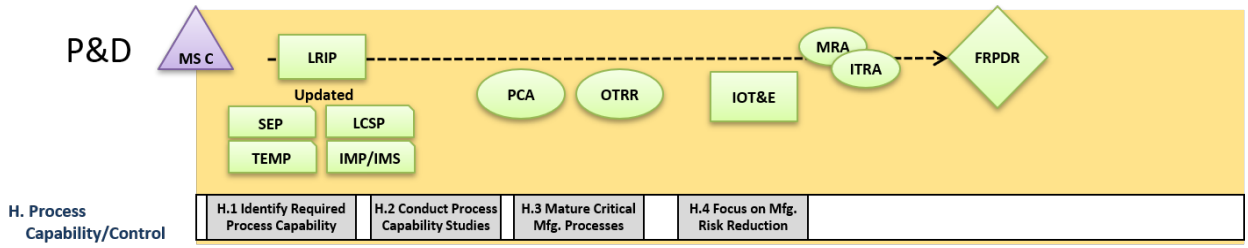


Figure 5-9. Process Capability and Control Manufacturing and Quality Activities

Introduction

One of the major goals of manufacturing is to provide the customer with "uniform, defect free product that has consistent performance and is affordable. 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 AS6500 Manufacturing Management Program standard, and ISO 9001 and AS9100 quality standards which requires a process control plan which describes the actions and activities that will demonstrate process capabilities. Process capability clarifies the inherent process variability of a given characteristic/process. Typical process capabilities measures include Cp/Cpk and Pp/Ppk A capability study is generally used to assess the ability of a

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

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

This thread (Acquisition) 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 and 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
- Statistical Process Control charts and reports

Manufacturing methods (processes) is one of the 5Ms (manpower) that needs to be addressed on a regular and ongoing basis. Three major focus areas include:

- Need for Modeling and Simulation (M&S) of the processes and production line prior to build
- Need to mature manufacturing processes so that they are ready for LRIP and FRP
- Need to measure, manage, and improve process yields and rates

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

Manufacturing process capability analysis determines the available manufacturing capacity and its capability to produce the desired end item without special controls. It is a critical activity in

producibility analysis. This normally includes analysis of the degree of process variability, the causes of variability, and the definition of methods to reduce it.

Process capability is a measure of how repeatable and consistent a manufacturing process is relative to the customer requirements in terms of specification limits of a product parameter. This measure is used to objectively measure the degree to which a process is or is not meeting the requirements.

Process capability compares the output of an in-control process to the specification limits by using capability indices. The comparison is made by forming the ratio of the spread between the process specifications (the specification "width") to the spread of the process values, as measured by six process standard deviation units (the process "width"). Process capabilities are often measured as a process capability index. Cp and Cpk are two frequently used indices and measure the short-term potential of a process. Key processes and characteristics should be controlled to a ± 3 sigma for all characteristics and ± 6 sigma for key and critical process characteristics.

Programs should be identifying all "key" and "critical" characteristics. These are the ones that really need to put under statistical process control. These are the ones that significantly impact form, fit, function, and costs. 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.

Once key characteristics have been identified the contractor needs to assess their current state. Are these characteristics stable (predictable) or not, and are they capable or not? This requires that the contractor conduct process capability studies. Once the studies have been completed (if required) then it is a matter of controlling those key and critical characteristics and implementing variability reduction programs to reduce costs and risks.

When associated with process capability and control, manufacturing risk reduction often focuses on the development and implementation of variability reduction programs. Variability reduction is the continuous and systematic reduction of variability in key product features and manufacturing processes. Variation reduction efforts should be applied only to those features and processes defined as key or critical based on human safety and/or mission essential performance.

Variation may be defined as any unwanted condition or as the difference between a current and a desired end-state. Both product performance and manufacturing processes exhibit variation. To manage and reduce variation, the variation must be traced back to its source. Variation occurs in all natural and man-made processes. If variation cannot be measured, it is only because the measurement systems are of insufficient precision and accuracy.

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 the specification. Manufacturing and quality managers need to be working continuously on production processes to reduce variation and to make the process robust to design requirements. Process control studies are often accomplished when the contractor finds that they are producing product that does not meet spec. But why wait for bad outcomes when the program can plan for success? Identify up-front and early what the design requirements are and ensure all processes can meet those requirements even before the start of production.

Manufacturing and Quality Tasks

- Verify and demonstrate models/simulation (M&S) of process capabilities developed earlier using the LRIP.
- Use M&S analysis to assist in the management of LRIP, and to determine that FRP requirements can be met.
- Develop manufacturing process documentation concurrently with the product specification to ensure the design is producible, supportable, and affordable.
- Conduct manufacturing assessments to determine system constraints and identify improvement opportunities.
- Conduct process capability studies to baseline the as-is process and further the development of improvement plans.
- Demonstrate manufacturing processes capability using production data:
    - Statistical analysis of current capability (Cp and Cpk, Pp and Ppk, or other appropriate metrics)
    - Results used to improve process and determine that LRIP/FRP requirements can be met
    - Continue collecting or estimating process capability data and using to improve
- Assess manufacturing processes and verified for LRIP/FRP:
    - Process Capability data from LRIP should be assessed against LRIP build target values
    - Process Capability data from FRP should be assessed against FRP Build target values
- Update and refine process capability requirements as the production environment moves from LRIP to FRP.
- Ensure continuous improvement of both LRIP and FRP are ongoing and generating positive results based on process capability models.

Tools

- AS9100 Checklist
- AS6500 Checklist

- Critical to Quality Tree
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan

Resources

- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- Capability-Based Assessment (CBA) Handbook
- Manufacturing Readiness Level (MRL) Deskbook

H.2. 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

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

Tools

- AS9100 Checklist
- AS6500 Checklist
- First Pass Yield Estimates Worksheet
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan
- Process Capability Studies (Cp and Cpk assessment)
- Producibility Assessment Worksheet (PAW)
- Six Sigma Worksheet

Resources

- AS9100, Quality Management System – Aerospace
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Continuous Process Improvement Transformation Guide
- DoD-Wide Continuous Process Improvement (CPI)/Lean and Six Sigma Program
- Manufacturing Readiness Level (MRL) Deskbook
- Producibility Systems Guidelines, NAVSO P-3687

H.3. Mature Critical Manufacturing Processes

Immature processes are a major source of risks on acquisition programs, especially during the Production and Deployment phase when most production takes place and as the program ramps up production to LRIP and FRP. As a program moves forward, process maturity takes on greater importance. According to DoDI 5000.02, the FRP decision requires that manufacturing risk be understood and that the manufacturing processes for the system be capable, in statistical control, and affordable. If these processes are not capable, in control, and affordable, the program office needs to continue to mature those processes.

Manufacturing and Quality Tasks

- Verify that manufacturing processes are stable, adequately controlled, and have the capability to achieve program LRIP and FRP objectives.

- Conduct manufacturing process demonstrations (LRIP and FRP) which includes the development of affordable and executable manufacturing processes, the completion of system fabrication, production of test articles so that system integration, interoperability, supportability, safety, and utility can be demonstrated.
- Ensure processes demonstrations include such items as cleaning, heat treatment, clean room controls, controlled testing, and special handling (i.e., personal grounding requirements for electronic components).
- Ensure processes are identified in the design and manufacturing documentation.
- Proof manufacturing processes that could contribute manufacturing risk to the program for LRIP and FRP:
    - Ensure that process can repeatedly produce conforming hardware within the cost and time constraints of the production phase.
    - Evaluate expected process yields for each critical process and indicate the statistical or other method used to maintain control of process performance.
    - Ensure proofing is accomplished in LRIP and FRP environments.
    - Assess and verify that factory floor conditions include the physical facilities, personnel, and manufacturing documentation.
    - Ensure that the contractor establishes training and certification programs for the shop personnel to ensure that process capabilities can be attained on a recurring basis for LRIP and FRP.
    - Ensure environmental and safety regulations and standards are a part of the production planning and are compliant with federal, state, and industry standards and laws.
    - Ensure that the impacts of environmental and safety regulations and standards on the cost of production operations is known.

- Tools
- ISO9001 Checklist
- AS9100 Checklist
- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan
- Process Capability Assessment
- Production Part Approval Process (PPAP)

Resources

- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9138, Statistical Process Acceptance

- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- Manufacturing Readiness Level (MRL) Deskbook

H.4. Focus on Manufacturing Risk Reduction

According to the DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs dated June 2015, the following approach should be considered to help identify risks in the production environment:

- Make-buy decisions, changes to suppliers, parts obsolescence, product delivery issues
- Manufacturing: manufacturing readiness, tooling, process maturity, etc.

Other considerations such as GFE availability, business consolidations, sole and single source suppliers, access to raw materials, export control, etc.

Manufacturing and Quality Tasks

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

Tools

- AS9100 Checklist

- AS6500 Checklist
- Interactive MRL Users Guide (Checklist), Process Capability and Control thread
- Manufacturing Maturity Plan

Resources

- AS6500, Manufacturing Management Program
- AS9100, Quality Management System – Aerospace
  - AS9102, First Article Inspection
  - AS9103, Variation Management of Key Characteristics
  - AS9133, Qualification Procedure for Aerospace Parts
  - AS9138, Statistical Process Acceptance
- AS6500 Manufacturing Management Program
- DoD Systems Engineering Guidebook
- Engineering of Defense Systems Guidebook
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

I. QUALITY MANAGEMENT

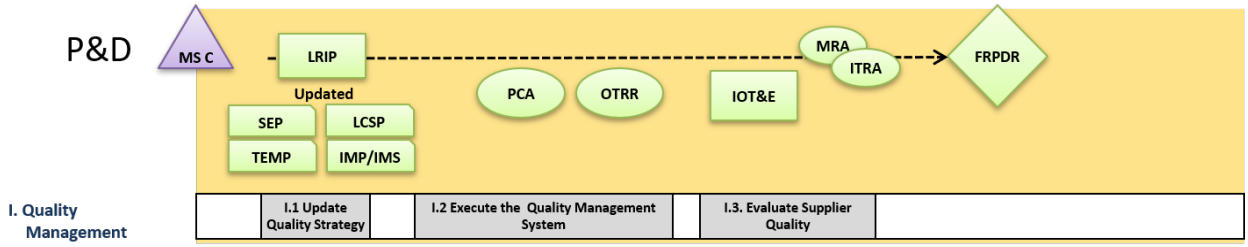


Figure 5-10. Quality Management Manufacturing and Quality Activities

Introduction

According to the Defense Manufacturing Management Guide for Program Managers, DoD Program Managers (PMs) are responsible for acquiring quality products that:

- Satisfy the needs of the warfighter.
- Provide measurable improvements in functional capabilities.
- Are affordable and arrive on schedule.

Many M&Q assurance processes, such as variability reduction, have a direct correlation to long-term performance (reliability) and to the ability to get a product back into serviceable condition after a failure (maintainability). Achieving high reliability with low maintenance costs will drive down life cycle costs and the logistics tail required by the warfighter.

An effective quality management system is required to deliver operationally safe, suitable, and effective weapon systems. The quality system assures the as-delivered configuration is the same as the as-designed and as-tested configuration. The quality system serves as the management and control function within the systems engineering process. It 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 to ensure they conform to requirements.

Compliance to a Quality Management System (QMS) standard such as ISO 9001, or AS9100, does not guarantee product or service quality. These standards are management system standards that identify requirements for processes within an organization, describe expected tasks and outcomes, and explain how the processes and tasks integrate to produce required inputs and outputs. Standards are meant to enable the organization to develop a set of processes that, if done by qualified persons using appropriate tools and methods with appropriate leadership involvement, will enable a capability for delivering high-quality products or services.

Product or service quality is achieved through the development, implementation and updating of many different plans:

- Systems Engineering Plan (SEP)
- Manufacturing Management Plan
- Quality Assurance Plan
- Supplier Quality Assurance Plan

The Program uses these plans to integrate all business and technical functions that result in the consistent application of proven, capable processes within an organization. Managers must ensure that all management systems are working toward the same goals and are not creating conflicting or dysfunctional behavior. Implementing a standard is of little use if the financial system rewards individuals for delivering non-conforming products/services. Because everything a contractor does should be related to the quality of its products or services, a contractor's quality management system should be the basis for integrating all other management systems within an enterprise.

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

Many of the program plans and risk assessments will focus on the prime contractor, but of equal importance is the health and vitality of the supply chain. Good execution of program plans requires execution throughout the supply chain. As soon as the Make/Buy decision is made and the decision is to buy, then the Supplier QA program needs to be actively engaged to ensure that the appropriate

requirements are contractually flow down thru the supply chain, that the suppliers are actively managed and have appropriate oversight, and that product delivery supports LRIP and FRP with conforming product, at the right time and place and at the right costs. Quality requirements may reach all the way down to the component level or even the raw material level.

I.1. Update Quality Strategy

Manufacturing and quality 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 ultimately to the success of a program.

Manufacturing and Quality Tasks

- Ensure the following documents have been updated to support both LRIP and FRP:
  - Acquisition Strategy
  - Systems Engineering Plan (SEP)
  - Manufacturing Strategy/Plan
  - Quality Assurance Strategy/Plan
- Ensure the following quality of design attributes are represented as Key Performance Parameters:
  - Performance
  - Conformance
  - Durability
  - Serviceability
  - Safety
- Confirm that Government-furnished information (GFI) to meet system requirements and to be available, complete, and supportable.

Tools

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

Resources

- AFMC Instruction 63-145 Manufacturing and Quality
- AS9100, Quality Management System – Aerospace
    - AS9102, First Article Inspection
    - AS9103, Variation Management of Key Characteristics
    - AS9133, Qualification Procedure for Aerospace Parts
    - AS9134, Supply Chain Management Guidelines
    - AS9136, Root Cause Analysis and Problem Solving
    - AS9138, Statistical Process Acceptance
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- FAR 52.246-11, Quality
- ISO 9001, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook

I.2. Execute the Quality Management System

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

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

Manufacturing and Quality Tasks

- Verify that an approved QMS is in place, operating, and is achieving desired outcomes.
- Evaluate the QMSs in use for each of the following areas:
    - Management responsibility
    - Resource management
    - Quality System
    - Contract Review
    - Product Realization
    - Design Control
    - Document Control

  - Purchasing
  - Purchaser-Supplied Product
  - Product Identification and Traceability
  - Process Control
  - Measurement, Analysis, and Improvement (metrology and calibration)
- Assess the QMS against an industry standard and the contract requirement:
  - ISO 9001
  - AS9100
  - Appropriate contractor QMS
- Establish quality targets.
- Verify quality targets on LRIP line.
- Identify and manage product quality requirements:
  - Mature new quality technologies and process state of the art into product quality requirements
  - Identify and manage product quality requirements (i.e., specific product characteristics)
  - Identify product acceptance methods and determine sampling plan as appropriate
  - Conduct First Article Inspection if required
- Identify and manage product quality for metrics and the frequency that the metrics should be reviewed, commensurate with M&Q risks
- Ensure the contractor/organization provides and maintains a measurement system to validate that products conform to requirements
- Ensure that measuring and testing devices are calibrated at specified intervals prior to use and are traceable to national standards
- Collect and analyze quality data from production and use results to feed improvement plans.
- Ensure that continuous quality improvement activities are ongoing.
- Verify quality targets on FRP line.
- Assess planned non-developmental item (NDI) or COTS items to determine that they meet program system performance and sustainment requirements through a defined acceptance process.

Tools

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

Resources

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

I.3. Evaluate Supplier Quality

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

Manufacturing and Quality Tasks

- Ensure acceptance testing and inspection of supplier products is adequate to begin LRIP.
- Develop acceptance criteria for supplier products based on need (e.g., AQL)
- Ensure supplier products have completed qualification testing and first article inspection.
- Ensure acceptance testing and inspection of supplier products is adequate to begin FRP.
- Ensure Key Characteristics are being managed.

- Ensure continuous quality improvement is ongoing.

Tools

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

Resources

- AS5553, Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition
- AS6174, Counterfeit Materiel; Assuring Acquisition of Authentic and Conforming Materiel
- 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
- DFARS 252.242-7004, Material Management and Accounting System (MMAS)
- DFARS 252.246-7007, Contractor Counterfeit Electronic Part Detection and Avoidance System
- DFARS 252.246-7008, Sources of Electronic Parts
- DFARS Subpart 242.7200, Contractor Material Management and Accounting
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- Manufacturing Readiness Level (MRL) Deskbook

J. MANUFACTURING WORKFORCE

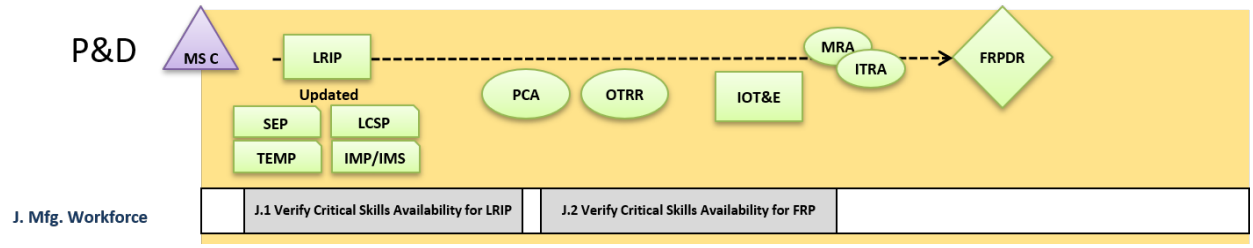


Figure 5-11. Manufacturing Workforce Manufacturing and Quality Activities

Introduction

In developing a Workforce plan, the contractor needs to consider the number of personnel needed, the specific skills of the personnel, the phasing of the requirements, and the ability of the organization to add personnel or move personnel. The ability to meet the personnel demands should be a function of the labor pool available within the contractor's organization and the ability of the local area to provide the quantity and types of people required which may include technical schools and other sources of trained personnel.

There also needs to be a clearly defined profile of the required workforce and a plan for the acquisition and training of new personnel. While on-the-job training (OJT) may be an effective mechanism for providing the required knowledge, its effectiveness is limited. Where the skills involved are relatively complex, there should be some form of formal training and/or certification requirements and a training program provided that manages the process and keeps track of these training and certification accomplishments.

The PMO should review the adequacy of the planned personnel loadings to ensure that adequate numbers of people with the required skills are made available. When a large personnel increase is planned, the sources of those personnel should be identified early, trained, and certified prior to the execution of the planned increased and then monitored after the ramp-up has occurred.

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

J.1. Verify Critical Skills Availability for LRIP

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on an ongoing basis. Two major focus areas are:

- Workforce skills availability
- Workforce skills capability (training and skills)

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

Manufacturing and Quality Tasks

- Identify LRIP/FRP manufacturing workforce resource requirements.
- Ensure required workforce availability forecast by monthly requirement against the LRIP/FRP schedule.
- Ensure workforce training requirements forecast against the LRIP/FRP schedule.
- Review any union agreements to ensure workforce/schedule compatibility.
- Update plans to achieve LRIP workforce requirements.
- Update plans to achieve FRP workforce requirements.
- Train and certify workforce to meet LRIP and FRP requirements.

Tools

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

Resources

- AS6500, Manufacturing Management Systems
- AS9100, Quality Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide

J.2. Verify Critical Skills Availability for FRP

Manufacturing workforce is one of the 5Ms (manpower) that needs to be addressed on an ongoing basis. Two major focus areas are:

- Workforce skills availability
- Workforce skills capability

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

Manufacturing and Quality Tasks

- Identify manufacturing workforce resource requirements for FRP:
    - Required workforce availability forecast by monthly requirement against the FRP schedule
    - Required workforce training requirements forecast against the FRP schedule
    - Union agreements must be reviewed to ensure workforce/schedule compatibility
- Develop workforce plans to achieve FRP requirements.
- Update workforce plans to achieve FRP workforce requirements.
- Ensure FRP personnel are trained on LRIP line.
- Ensure FRP personnel requirements are met.
- Implement a plan to achieve FRP workforce requirements.
- Ensure production workforce skill sets been maintained based on attrition of workforce.

Tools

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

- Workforce Planning Tools (SAP/Oracle/MRPII)

Resources

- AS6500, Manufacturing Management Systems
- AS9100, Quality Management System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- ISO 9001, Quality Management System
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide

K. FACILITIES

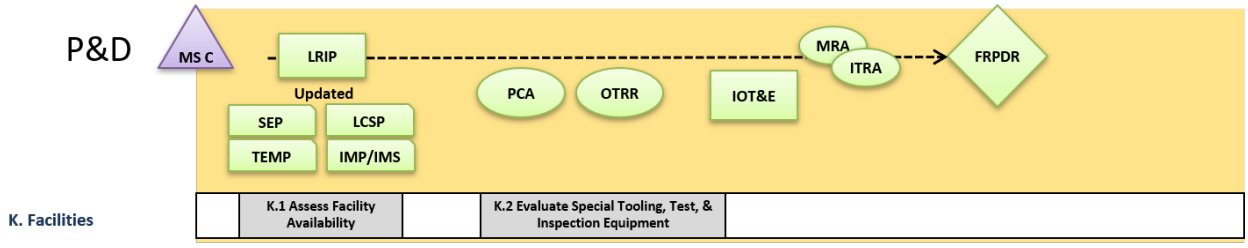


Figure 5-12. Facilities Manufacturing and Quality Activities

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 semipermanent 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.

Industrial capability refers to all the production resources that may be required to produce an end item. This includes the 5Ms (manpower, machines, material, methods, and measurement), as well as the actual buildings that support production. Capacity is normally constrained by physical facilities, available productive equipment, tooling, and/or test equipment. In addition, special tooling, special test equipment, and special inspection equipment are often found to be a restrictor on achieving rate production. Facilities and Special Tooling need additional attention as production ramps up to LRIP and then to FRP.

Manufacturing planning begins early in acquisition and is continuously updated throughout the life of the program. Among the critical considerations that must be addressed are the manufacturing processes that will be used to build the system. The sequence of manufacturing processes begins with the receipt of the raw material, where special handling and storage may be required. Additional processes requirements may include such items as cleaning, heat treatment, clean room controls, controlled

testing, and special handling (i.e., personal grounding requirements for electronic components). Identification of all processes must be a part of the design documentation.

Where the selected processes contribute manufacturing risk to the program, the processes should be proofed during EMD. The purpose of proofing is to ensure that the process can repeatedly produce conforming hardware within the cost and time constraints of the production phase. It is important that the proofing be accomplished in an environment that simulates actual production conditions (typically a pilot line environment). These conditions include the physical facilities, personnel, and manufacturing documentation. It may also be necessary for the contractor to establish training and certification programs for the shop personnel to ensure that the process capabilities can be attained on a recurring basis.

One of the most important elements of any production design is the definition of the manufacturing resources. No matter how good a design may be, it is useless if the system or product cannot be built. It is therefore essential that availability of manufacturing resources be a consideration during the design review process. Manufacturing engineers should be a part of each design team to ensure adequate consideration of availability of required manufacturing resources.

Manufacturing resources should not be limited to manufacturing methods but should include materials, capital, manufacturing technology, facilities, qualified labor, and the management structure to effectively integrate them. The successful competitor of the production phase will depend upon the efficient application of the full spectrum of these resources to the task of fabricating and delivering the defense system design.

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

K.1. Assess Facility Availability

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

Manufacturing and Quality Tasks

- Identify facility requirements for LRIP and FRP.

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

Tools

- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist

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

Resources

- AS6500, Manufacturing Management Systems
- DCMA-INST-204, Manufacturing and Production
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

K.2. Evaluate Special Tooling, Test, and Inspection Equipment

Manufacturing and Quality Tasks

- Evaluate all documentation used to manage and account for Tooling, Special Tooling (ST), and Special Test Equipment (STE), which may include the following items:
    - Limited/Soft Tooling
    - Durable/Hard Tooling
    - ST/STE needed for development and manufacture only
    - ST/STE having possible mission support utility
    - Already available government assets
- Ensure processes for qualification of special tooling is adequate and operating effectively.
- Demonstrate and prove all tooling, test, and inspection equipment can support LRIP.
- Ensure that all tooling, test, and inspection equipment is in place to support maximum FRP.
- Ensure that adequate production test infrastructure, resources, and facilities are available.
- Assess and manage planned equipment maintenance to ensure maximum overall equipment effectiveness (OEE).
- Ensure that design and development of production tooling and STE/special inspection equipment (SIE) must be underway and can support LRIP/FRP.
- Develop, demonstrate, and manage a manufacturing equipment maintenance strategy to support both LRIP and FRP.

Tools

- Bottleneck Analysis (Theory of Constraints)
- Capacity Requirements Planning Assessment Worksheet
- Critical Chain Project Management
- DCMA Manufacturing Systems Risk Assessment (MSRA) Checklist
- DCMA Production Planning and Control Risk Assessment Checklist

- Interactive MRL Users Guide (Checklist), 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
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- FAR Part 2, §2.101 Definitions
- Manufacturing Resource Planning (MRP II)
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

L. MANUFACTURING MANAGEMENT/CONTROL

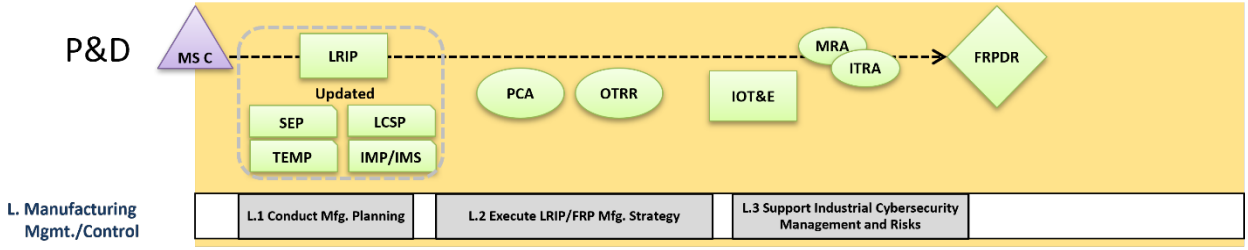


Figure 5-13. Manufacturing Management and Control Manufacturing and Quality Activities

Introduction

Manufacturing involves the process of transforming raw materials into finished products. This transformation is accomplished using contractor resources, which can include basic raw materials, to expensive facilities, human skills, machines, and capital investments. The purpose of manufacturing planning is the identification of these resources and their integration into a structure that provides the capability to achieve production objectives. This is especially true as the program ramps up production from the pilot line, to LRIP and then to FRP.

Manufacturing planning is primarily a contractor function though there are some DoD organizations that do accomplish manufacturing tasks and as such must plan for those activities. Planning is a complex task that includes long-range plans, medium-range plans, and short-range plans.

- Long-range manufacturing or production plans (2-5 years) takes into consideration Corporate Strategic Plans and long-range business forecasts to leverage core capabilities in the achievement of corporate goals.
- Medium-range manufacturing plans (6-18 months), sometimes referred to as the Master Production Scheduling (MPS), breaks down a business plan and aggregate production plan into product plans or families of products.
- Short-range manufacturing plans are the day-to-day plans and activities. This could include capacity planning and scheduling; materials requirements planning; production planning which includes detailed workflow analysis from procurement to receiving through fabrication; sub-assembly; assembly; inspection/test; and packaging and shipping.

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

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

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

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

SAE's AS6500 requires a manufacturing management system to be documented. The contractor should be able to provide examples of the analyses, work instructions, process control plans, and metrics that are required by AS6500. Government personnel can examine these products to determine if the processes and procedures are being implemented in accordance with the standard.

Work instructions are a basic manufacturing tool, developed to assist a worker in accomplishing a task. A work instruction details the sequence of steps that an employee must follow every time they perform a task. The work instruction organizes the work into logical steps so that an employee can easily follow it independently. Planning for this phase includes the planning for LRIP and the transition from LRIP to FRP, and then FRP demonstration.

L.1. Conduct Manufacturing Planning

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

Manufacturing and Quality Tasks

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

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

- During LRIP or Production obtain and evaluate processes using process control system
- A detailed allocation of production space and equipment is described, along with the factors used in developing the plan
- The status of design and acquisition of production equipment is tracked in the schedule; equipment cost, efficiency, and availability are reflected in the planning process

- Ensure that the Tooling, ST, and STE program verifies procedures for ensuring functional compliance and calibration of all tooling and test equipment
- Ensure that a Productivity Improvement program is reducing manufacturing risks and the risks are being mitigated
- Ensure that Industrial Materials Management includes:
  - Critical forms and parts
  - Strategic and critical materials
  - Diminishing Manufacturing Sources and Materials Shortages
  - Material planning systems proven in LRIP and enough for FRP.
  - Requests for Special Priorities Assistance
  - Scrap management and reclamation
  - Material planning systems validated on FRP build
- Ensure that Manufacturing Management Data includes:
  - Cost of work scheduled, cost of work performed, and the actual cost of work performed in hours
  - Cause, corrective action, and means of follow-up to attain planned performance
- Ensure that manufacturing audits including checklists and other criteria used by the prime to conduct audits of the contractor and supplier operations
  - Include audit summaries and corrective actions
- Ensure a review and assessment of Labor Relations includes:
  - Location of facilities performing program work
  - Each union representing workers at the facility locations, type, and number of workers
  - Expiration date of union’s labor management agreement.
  - History of last 3 negotiations
- Ensure that the Facility plan describes:
  - All GFP required and specific need dates.
  - Components supplied by each facility location
  - Contingency plan listing possible alternate suppliers

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

Tools

- Acquisition Strategy Template
- AS6500, Assessment
- Interactive MRL Users Guide (Checklist), Management/Control thread
- Manufacturing Maturation Plan

Resources

- Acquisition Plan Preparation Guide
- AS6500, Manufacturing Management System
- DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.02, Operation of the Adaptive Acquisition Framework
- DoDI 5000.88, Engineering of Defense Systems
- DSMC Acquisition Strategy Guide
- IEEE 15288, Systems and Software Engineering
- MIL-HDBK-896, Manufacturing Management Program Guide,
- Manufacturing Readiness Level (MRL) Deskbook
- NIST 800-171, Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations
- NIST 800-82, Guide to Industrial Control Systems Security
- Service-specific policies and regulations (i.e., AFI 63-145)

L.2. Execute LRIP/FRP Manufacturing Strategy

Developing a manufacturing plan is the first half of a great challenge. Now M&Q managers need to execute the plan. This requires constant management attention as production and deployment could

last for many years, and along the way change will happen. There may be a change in the design due to upgrade opportunities, there will probably be a change in the 5Ms as manpower changes due to retirement and personnel changes, there may be a change to material as subcontractors and vendors change. Risks and opportunities are constantly evolving, and M&Q managers need to be on top of these changes.

Manufacturing and Quality Tasks

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

Tools

- AS6500, Manufacturing Management Program Assessment
- Interactive MRL Users Guide (Checklist), Management, Control thread
- Manufacturing Maturation Plan

- Material Management and Accounting System Audit

Resources

- AS6500, Manufacturing Management Program
- DFAR 242.72, Contractor Material Management and Accounting System
- DoD Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs
- DoDI 5000.88, Engineering of Defense Systems
- MIL-HDBK-896, Manufacturing Management Program Guide
- Manufacturing Readiness Level (MRL) Deskbook

L.3 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 subs, 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 Technologies (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) support the planning, execution, and synchronization of manufacturing processes across multiple functions, distributed plants, and suppliers
- Enterprise resource planning (ERP) system supports 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 data (CUI), personal data, financial data, etc.

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

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

M&Q personnel need to identify and manage Industrial Cybersecurity risks for system concepts identified, and cybersecurity vulnerabilities at potential industrial facilities. The focus on cybersecurity must encompass platforms, weapons, and the DIB and must be regularly assessed, properly resourced, and continually mitigated. Cybersecurity crosses all pathways within the 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 an LRIP environment
- Demonstrate OT cybersecurity solutions in an FRP environment
- Assess the design of OT systems for facilities and equipment (i.e., in-house factory systems, production equipment, STE/SIE, and tooling) to ensure they include cybersecurity and physical/digital controls and access requirements
- Plan for and document that LRIP facilities and equipment OT systems include cybersecurity and physical/digital controls, and access requirements
- Identify and assess OT cyber incidents throughout the supply chain

- Ensure that OT cybersecurity Incident Reporting procedures are in-place, including reporting, tracking, and corrective actions
- Train the workforce in current cybersecurity procedures for production environment

Tools

- Cybersecurity and Acquisition Lifecycle Integration Tool (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 Organization
- NIST Special Publication 800-82 Guide to Industrial Control Systems (ICS) Security

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.

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FAR Subpart 15.1 Source Selection Processes and Techniques
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FAR Subpart 44.3 Contractors Purchasing System Reviews
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SF 1405 Preaward Survey of Prospective Contractor – Production
https://www.gsa.gov/forms-library/pre-award-survey-prospective-contractor-technical

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

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

SF 1408 Preaward Survey of Prospective Contractor – Contractor Accounting System
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Appendix C: Manufacturing and Quality Tools

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

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Alternative System Review (ASR) Checklist
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Analysis of Alternatives (AoA) Study Plan Template
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AoA Study Guidance Template
https://www.dau.edu/tools/t/Analysis-or-Alternatives-(AoA)-Study-Guidance-Template-v1-0

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AS6500 Manufacturing Management Program Checklist
Internet Search

AS9100 Quality Management System Checklist
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AS9100 Quality Audit Checklist
Internet Search

AS9103 Variation Management of Key Characteristics Assessment
Internet Search

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

AS9134 Supply Chain Risk Management Guidelines
Internet Search

AS9137 Advanced Quality Assurance Procedure (AQAP) Checklist
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AS9145 Requirements for Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP) Checklist
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https://www.acq.osd.mil/dpap/ccap/cc/jcchb/Files/Topical/1Restricted/award.fee.oct08.pdf

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Internet Search

Bill of Material Assessment
Internet Search

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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

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

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

Critical Chain Project Management
Internet Search

Critical Design Review (CDR) Checklist
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)

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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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