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Toolkit for DoD Manufacturing Engineers

INTRODUCTION

The Department of Defense (DoD), more often than not, requires that its products be held to elevated quality and performance standards, especially when compared to commercial products. These higher expectations lead to increased scrutiny, and subsequently, significant differences between the production cycles for DoD weapons systems and commercial products. Thus, to produce weapon systems and their components for the DoD, manufacturing engineers must have specialized and superior manufacturing knowledge.

In a commercial manufacturing setting, each manufacturer has its own set of production guidelines. These guidelines set the policies and standard operating procedures for material sourcing, supply chain management, product assembly, and quality. Likewise, the DoD has its own set of agency-wide guidelines for the manufacture of weapon systems. These guidelines coincide with the phases of the Defense Acquisition Life Cycle. However, because the Defense Acquisition Life Cycle is complex, there are numerous guidelines to follow.

This sizeable quantity of guidelines can pose challenges to manufacturing engineers as they work to remain up-to-date with the latest updates and changes. To mitigate hiccups in the transmission of this information, several resources have been developed to aid in the dissemination of the most current rules and regulations, to share lessons learned, and to foster collaboration between manufacturing groups within the DoD.

This article provides an overview of the resources available for DoD manufacturing engineers. These resources can be utilized to aid in the delivery of weapon systems that meet performance and quality requirements on schedule and without cost overruns.

DOD REGULATIONS

DoD Instruction (DoDI) 5000.02 provides a simplified, flexible management framework for translating capability needs and technology opportunities into stable, affordable, and well-managed acquisition programs. Moreover, it details the proper operation of the Defense Acquisition Life Cycle system and provides detail for program managers, explaining how they should be implementing this directive.[1]

In this instruction, the DoD Defense Acquisition Life Cycle framework is presented. Furthermore, each Service is assigned key responsibilities, the majority of which are necessary for carrying out the tasks related to DoD weapon system development and production. Most importantly, the DoDI 5000.02 framework places increased importance on developing mature manufacturing processes early in the weapon system development process. To do this, the framework requires manufacturing readiness assessments as an exit criterion for three different acquisition phases. The System Development and Demonstration (SDD) phase of the Defense Acquisition Life Cycle was renamed Engineering and Manufacturing Development (EMD) in this instruction as well.[2]

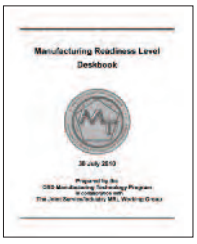
GUIDING DOCUMENTS

Several publications have been created and made available to assist manufacturing engineers in meeting the manufacturing-related requirements set forth in DoDI 5000.02. These documents cover process design, manufacturing maturity, part quality, obsolescence, and process improvements.

MIL-HDBK-896

The DoD Handbook *Manufacturing and Quality Program* (MIL-HDBK-896) is a collection of best practices for weapon system production and product quality. MIL-HDBK-896 was created by the Manufacturing and Quality Branch of the Air Force's Aeronautical Systems Center Engineering Directorate. This branch is also responsible for maintaining the handbook and ensuring that all information is up-to-date.

The 11-page MIL-HDBK-896 is intended for use across the services, in parallel with the guidance provided by the DoD's *Manufacturing Readiness Level Deskbook* and the Air Force's *Manufacturing Development Guide*. It provides detailed guidelines for the performance of manufacturing readiness assessments. In addition, this handbook defines the production and quality-related terms commonly used in the DoD.[3]



Manufacturing Readiness Level Deskbook

The DoD *Manufacturing Readiness Level Deskbook* was developed by the Joint Defense Manufacturing Technology Panel's (JDMTP's) Manufacturing Readiness Level (MRL) Working Group. This deskbook is a comprehensive resource that discusses manufacturing readiness levels (MRLs) and manufacturing readiness assessments (MRAs).

The *MRL Deskbook* provides detailed definitions for each MRL. It also presents the MRL threads and sub-threads and provides detailed instructions for incorporating MRLs and MRAs into source selection criteria as well as other facets of the government proposal process. Since the *MRL Deskbook* is updated on an annual basis, or as needed, it is continuously evolving to best support DoD manufacturing efforts.

Process maturity is critical to the success of a weapon system. To address readiness in pre-weapon system acquisitions, the *MRL Deskbook* provides guidance to ensure that manufacturing-related considerations are the focus during the Materiel Solution Analysis and Technology Development phases of the Defense Acquisition Life Cycle. In addition, best practices are provided to address manufacturing maturity during the EMD and the Production and Deployment phases of weapon system acquisition.

Table 1. The *Manufacturing Development Guide* best practice focus areas.

Best Practice Area
Manufacturing Capability Assessment and Risk Management
Production Cost Modeling
Key Suppliers
Key Characteristics and Processes
Variability Reduction
Virtual Manufacturing
Design Trade Studies
Process Failure Modes Effects and Criticality Analysis
Product and Process Validation
Manufacturing Process Control and Continuous Improvement
Factory Efficiency
Technology Obsolescence and Diminishing Manufacturing Sources

One of the main methods for evaluating process maturity is the MRA. MRAs are employed to measure the maturity of a manufacturing process, playing an important role prior to major Milestone Reviews and acquisition decisions. The *MRL Deskbook* further describes how to develop the scope of an MRA, prepare the contractor for the MRA, and carry out the MRA. The information gathered during an MRA is used to identify manufacturing risks and develop risk management and manufacturing maturation plans (MMPs).

The DoD *Manufacturing Readiness Level Deskbook* can be accessed online through the DoD Manufacturing Readiness Level resource website at http://www.dodmrl.org/ or http://www.dodmrl.com.[4]

Manufacturing Development Guide

The Air Force *Manufacturing Development Guide (MDG)* provides guidance for improving Air Force weapon system acquisition. However, much of the information can be utilized by non-Air Force organizations interested in operational improvement.[5] This guide provides tools to ensure that important design and manufacturing decisions are made early in the development process. Further, the *MDG* details the positive impacts that result from making manufacturing decisions early in the acquisition process, specifically those related to the financial and contractual considerations. The *MDG* presents the defense industry with quality-related tools and techniques that have produced positive results in the commercial manufacturing industry.

The best practices and lessons learned, that relate to these industry-adopted tools and techniques, are described in Chapter 6 of the *MDG*. Rationale for each tool and technique is provided as well to significantly reduce the potential for misinterpretation during the implementation of these practices into the Integrated Product and Process Development (IPPD) process. Table 1 lists the *MDG*'s best practice focus areas. The *MDG* also defines the roles that manufacturing engineers, for the contractor and the government, play in developing the weapon system and requisite production process. A sample of the contractor and government manufacturing engineers' responsibilities can be found in Table 2.[5]

Table 2. Example of Tasks and Responsibilities for manufacturing engineers during IPPD. [5]

Responsible for Task	Task Description
Government Manufacturing Engineer	Participate in trade studies
	Develop and refine Production Cost Model
	Initiate mapping of Key Characteristics & Processes
	Establish data collection for process capability requirements
	Initiate process development as required
	Participate in manufacturing capability and risk assessments
	Integrate suppliers into production process
	Develop and validate production plan
	Implement efforts to reduce variability
	Implement efforts to prevent defects
Contractor Manufacturing Engineer	Monitor process variation
	Develop plan for implementing process/product changes
	Implement continuous process improvement techniques (Lean Manufacturing, Six Sigma)
	Maintain Production Cost Model

DMSMS Guidebook

The DoD *Diminishing Manufacturing Sources and Material Shortages* (DMSMS): *A Guidebook of Best Practices and Tools for Implementing a DMSMS Management Program* (Report # SD-22) is a comprehensive resource that aids in the management of DMSMS. This guidebook was compiled and published by the Defense Standardization Program Office (DSPO). DMSMS relates to the loss of a source for a material or item, which in most instances surfaces when a supplier discontinues the production of a particular product or when the product becomes unavailable. Written for program managers, the DMSMS guidebook contains methods for managing and mitigating part obsolescence issues common within the DoD, specifically in the areas of electronic, electrical, and mechanical parts. These methods were derived from the best practices identified by several DoD organizations.

The DMSMS guidebook defines a proactive DMSMS man-

Table 3. DMSMS Intensity Levels.[6]

Intensity Level	Description
Level 1	Current practices for resolving identified obsolescence risks are satisfactory.
Level 2	Current practices for resolving future obsolescence risks are satisfactory.
Level 3	Current practices for mitigating obsolescence risks are adequate for situation where likelihood of opportunity to reduce total ownership costs is high.
Level 4	Current practices implemented during conceptual design phase continue through the weapon system sustainment cycle.

agement process, which can be used to build an effective DMSMS Program. It also defines the DMSMS support metrics that are used to measure the effectiveness of a proactive DMSMS Program, promotes cost-effective supply chain management integrity through DMSMS problem resolution at the lowest level, and promotes the exercise of best practices throughout the DMSMS management cycle.[6]

The four levels of DMSMS program intensity are described in Table 3. Table 4 provides the mitigation practices for each intensity level. Additional DMSMS program guidance is provided through tools in the form of DMSMS-related documents, web-based resources, and design interface assessment criteria.

The *DMSMS* guidebook can be accessed electronically through the DMSMS Sharing Portal at http://www.dmsms.org/.

DoD CPIT Guidebook

The DoD's *Continuous Process Improvement Transformation Guidebook (CPIT Guidebook)* was developed under an initiative set forth by the former Under Secretary of Defense, Gerald England. Continuous process improvement (CPI) is a process that ensures a continued improvement in an organization's performance. The key to CPI success is consistent and sustainable leadership and guidance. When considering CPI methodologies, any organization that delivers services or produces products should be viewed as a transformation mechanism.[7]

The *CPIT Guidebook* provides a method for improving DoD operational performance. In order for the continuous process improvement (CPI) method to produce lasting results, a culture of continuous improvement needs to be implemented. The *CPIT Guidebook* outlines four integral components that are needed for lasting continuous improvement efforts. These needed components are: a broad, structured CPI implementation method; focus on CPI implementation within a structure of goals that are aligned to a warfighter-driven, outcome-based metric; emphasis on the management and integration of CPI projects; and methods for determining how well projects and organizations progress with CPI initiatives, training, and certification.[8]

Upon CPI process initiation, customer requirements and organizational resources are transformed into goods, services, and business outcomes for the customer's benefit, known as process completion. The results can be tangible or knowledge-based. While

Table 4. DMSMS Mitigation Practices.[6]

Intensity Level 1	Intensity Level 2	Intensity Level 3	Intensity Level 4
DMSMS program established and funded DMT formed DMT trained in • DMSMS fundamentals and • DMSMS for executives DMSMS program plan written and approved Complete BOM developed with periodic reviews planned to keep it current Solutions to near-term obsolescence problems implemented For new acquisitions, DMSMS tasking and data byproducts inserted in the development, production, or support contracts	All level 1 practices implemented BOM processed through a predictive tool Results of predictive tool output analyzed DMSMS solution database established Budget established to fund future obsolescence solutions Website established Method established to prioritize LRUs/WRAs for DMSMS risk	All Level 2 Practices implemented DMSMS life-cycle costs and cost avoidance estimates developed DMT trained • DMSMS essentials, • DMSMS case studies, and • advanced DMSMS Funding shortfall and impact identified and communicated to decision makers For legacy systems, DMSMS tasking and data requirements included in applicable contracts Circuit design guidelines established Technology assessment and insertion under way DMSMS metrics established[a] Electronic data interchange used	All Level 3 practices implemented Technology road mapping used System upgrades planned Technology transparency attained Accessibility realized for alternate source development (VHDL, emulation, MEPs)

Notes: BOM = bill of materials, DMT = DMSMS management team, LRU = line replaceable unit, MEP = Manufacturing Extension Partnership, VHDL=VHSIC (Very High Speed Integrated Circuit) Hardware Description Language, WRA = weapons replaceable assembly.

[a]Metrics include number of cases, number of solutions implemented, life-cycle cost, and cost avoidance.

Table 5. DAU Training Course Tracks.[9]

Acquisition Management
Auditing
Business, Cost Estimating, and Financial Management
Contracting
Contracting Officer's Representative
Facilities Engineering
Grants
Industrial/Contract Property Management
Information Resource Management
Logistics
Production, Quality, and Manufacturing
Program Management
Requirements Management
Software Acquisition Management
Science and Technology Management
Systems Planning, Research, Development and Engineering
Test and Evaluation

serving a customer, organizations need to also be measuring their performance.

The successful implementation of a continuous improvement culture requires clearly defined roles and responsibilities in addition to a concise framework. The *CPIT Guidebook* identifies the roles and responsibilities of staff, members and the various DoD organizations needed to implement and execute CPI. In addition to providing roles and responsibilities, the *CPIT Guidebook* provides problem solving tools for eliminating waste and reducing variability in CPI efforts.[8]

The DoD *CPIT Guidebook* can be accessed electronically through the Defense Acquisition University's Publication website at http://www.dau.mil/pubscats/Lists/GuideBook/AllItems.aspx.

ONLINE RESOURCES

There are several online resources available for defense industry manufacturing engineers that can augment the compiled handbooks and guidebooks presented in the previous section. These resources include continuing education modules, technical forums, and Service-specific enterprise improvement websites.

Defense Acquisition University Resources

Training Courses

The Defense Acquisition University (DAU) provides continuous learning modules and training courses that cover a wide variety of technical, contractual, and management topic areas. Table 5 provides a complete list of DAU training course tracks. The tracks of greatest interest and highest importance to manufacturing engineers are the *Logistics* and *Production, Quality, and Manufacturing* (PQM) training course tracks. The Logistics Track offers courses on:

- Systems Sustainment Management,
- Reliability, Availability, and Maintainability (RAM),
- Intermediate Acquisition Logistics,
- Configuration Management,
- Intermediate Systems Sustainment Management,
- Performance-Based Logistics, and
- Enterprise Life Cycle Logistics Management.

More information on the Logistics Training Courses can be found at http://icatalog.dau.mil/onlinecatalog/tabnav.aspx?tab=LOG.

The PQM track offers courses on:

- Defense Specification Management,
- Specification Selection and Application,
- Intermediate Production, Quality, and Manufacturing,
- Preparation of Commercial Item Description for Engineering and Technical Personnel, and
- Advanced Production, Quality, and Manufacturing.[9]

For more information on the PQM Training courses, visit http://icatalog.dau.mil/onlinecatalog/tabnav.aspx?tab=PQM.

The Engineering and Technology continuous learning module provided by DAU contains several courses that are beneficial to manufacturing engineers in the defense industry as well. These courses cover modeling and simulation, ISO certifications, value engineering, Technology Readiness Assessments (TRAs), and process improvement methods such as Six Sigma and Lean Six

Figure 1. PQM Module Home Page.[10]

Table 6. PQM Topic Areas.

Hot Topics
Policy & Guidance
Product Design
Process Design & Control
Lessons Learned
Continuous Process Improvement
Supply Chain Management
e-Manufacturing
Tools
Training Center
Community Connection
Assessing Manufacturing Risk

Sigma. Detailed information on the continuous learning modules offered by the DAU can be found at http://icatalog.dau.mil/onlinecatalog/tabnavcl.aspx.

Acquisition Community Connection Production, Quality and Manufacturing (PQM) Portal

In addition to offering continuing education courses in manufacturing-related topic areas, DAU also houses an online portal where defense industry engineers, program managers, and other acquisition-related personnel can gather and share relevant information (reference material, best practices, websites, and case studies). The Production, Quality and Manufacturing (PQM) module houses several resources related to manufacturing within the defense industry. The PQM module has twelve topic areas, as presented in Table 6. Each topic area has a Question and Answer forum, a list of applicable metrics, and a brief overview of what is new to that topic area. The information contained in the PQM portal is provided by members of the PQM community and is updated regularly. Figure 1 shows a screenshot of the PQM module homepage.[10]

Continuous Process Improvement/Lean Six Sigma Program Office

A subordinate of the Office of the Deputy Chief Management Officer, the Continuous Process Improvement Lean Six Sigma Program Office (CPI/LSS) was established in 2007 to help the DoD components meet their CPI goals.[11] The CPI/LSS Office assists the individual Services in the initialization and sustainment of CPI efforts. In addition, the CPI/LSS Office collects process improvement best practices and provides training to develop performance improvement capabilities throughout the DoD. Further information on the CPI/LSS Office can be found at http://dcmo.defense.gov/index.html.

Army Continuous Process Improvement (CPI) Knowledge Center

The Continuous Process Improvement Knowledge Center (CPIKC) is a component of the Army Office of Business Transformation. This center provides the framework (Table 7) as well as the tools and techniques necessary to identify Army customers' needs and requirements (commonly known as the "Voice of the Customer") and for optimizing processes to meet the Army's needs.[7] The CPIKC also provides resources that raise awareness, provide insight into, and replicate best business practices. Tools and templates that support process improvement initiatives are provided.[7] In addition, the CPIKC provides critical success factors and industry best practices to improve the effectiveness of Army CPI efforts.

Table 7. Army CPI Framework Steps.

Step	Title
1	Define Business Drivers
2	Architect & Align Strategies
3	Develop Vision
4	Current State Understanding
5	Future State Design
6	Road Map Development
7	Execution
8	Continuing Improvement

The information, resources, and best practices available through the Army's Continuous Process Improvement Knowledge Center can be accessed at http://www.armyobt.army.mil/cpi-kc-welcome.html.

SUMMARY

The production of DoD weapon systems is extremely challenging, especially for manufacturing engineers, due to the elevated performance, quality, and lifespan standards required by the DoD. Ensuring that a weapon system is produced in the most efficient manner, while also meeting performance and quality specifications requires a focused approach for both development and production. This focused approach should be based upon the lessons learned and best practices obtained over several decades of weapon system production. The availability of this information along with program offices dedicated to the optimization of manufacturing processes are vital to manufacturing engineers responsible for producing weapon systems that meet performance and quality specifications. In the future, increased access to requirements, best practices, lessons learned, as well as increased collaboration between manufacturing colleagues (through forums and online portals) will help ensure that DoD weapon systems are produced at the highest quality for the right cost.

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