### LESSON ASSIGNMENT SHEET

<table>
<thead>
<tr>
<th>Lesson Number</th>
<th>09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson Title</td>
<td>Production and Deployment</td>
</tr>
<tr>
<td>Lesson Time</td>
<td>3.5 hours</td>
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<tr>
<td>Learning Objective</td>
<td>Apply system requirements, configuration management, and urgent capability acquisition processes in a Production and Deployment (PD) phase exercise with a given set of Defense Acquisition Guide (DAG) SE processes and tools to improve lifecycle efficiency.</td>
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| Assignments   | Review the following ENG 202 course material:  
  • Lesson 09 Production and Deployment |
| Estimated Student Preparation Time | N/A |
| Assessment | Class participation; oral presentation |
| Related Lessons | Lesson 04, Systems Engineering Plan  
  Lesson 05, Materiel Solution Analysis  
  Lesson 06, TMRR  
  Lesson 07, Risk Management and Technical Problem Solving |
| Self-Study References | Defense Acquisition Guidebook Chapter 3 ([http://www.dau.mil](http://www.dau.mil))  
  MIL-HDBK-61A  
  Manufacturing Readiness Level Desk Book |
Lesson 09
Production and Deployment (P&D)

Learning Objectives

Apply system requirements, configuration management, and urgent capability acquisition processes in a Production and Deployment (PD) phase exercise with a given set of Defense Acquisition Guide (DAG) SE processes and tools to improve lifecycle efficiency.

- Given an acquisition scenario, relate how the SE processes affect the technical execution and planning involved in the P&D phase.
- Given an acquisition scenario, relate how the DoD SE Technical Review(s) and Audits discussed in the DAG Chapter 3 for the P&D phase are used to reduce technical risk.
- Identify the Technical Inputs and Outputs of the P&D phase as per DAG Chapter 3.
- Given a JUON requirement, develop an integration strategy that meets User's needs and is in accordance with the appropriate DoDI 5000.02 Program Model.
- Given a Configuration Management exercise, identify how risk planning could have been used to mitigate the issues and/or risks highlighted in the program office scenario.
- Recognize the uses and cautions of using Manufacturing Readiness Levels (MRLs) to indicate progress.
- Identify basic principles of Lean, Six Sigma, and Theory of Constraints Manufacturing concepts.
- Given a production scenario, conduct SE analysis to determine potential root causes for manufacturing issues.
- Use systems engineering processes to analyze critical technical information and apply the findings in an impactful briefing format.
Lesson 09 Recommended Reading

- Production and Deployment Phase
  - DAG Chapter 3
  - DoDI 5000.02
- Continuous Process Improvement (CPI)
  - CPI/LSS Guidebook Revision 1
- Physical Configuration Audit
  - DAG Chapter 3
- Configuration Management:
  - MIL-HDBK-61A
- Manufacturing Readiness Levels
  - Manufacturing Readiness Level Desk Book (www.dodmrl.com)
- Acquisition Encyclopedia

Production and Deployment

PURPOSE: To produce and deliver requirements-compliant products to receiving military organizations

- INPUTS: Acceptable performance in DT; mature software; no significant manufacturing risks; updated CDD as required; acceptable interoperability and operational supportability; demonstration of affordability; fully funded.

- ACTIVITIES: Low Rate Initial Production (LRIP), Initial Operational Test and Evaluation (IOT&E), Live Fire Test and Evaluation (LFT&E) (if required) and interoperability testing of production-representative articles; Full-Rate Production (FRP) Decision; fielding and support of fielded systems; IOC/FOC.

- GUIDED BY: Updated CDD if required, TEMP, SEP, Life Cycle Sustainment Plan (LCSP).

- OUTPUTS: Full operational capability; deployment complete.
DoD Continuous Process Improvement (CPI) Policy

- **Continuous Process Improvement (CPI)** - Provides organizations a structured approach for analyzing how they are currently doing work and how they can improve their processes to do the job more efficiently and effectively on an ongoing basis.

- CPI/Lean Six Sigma (LSS) concepts and tools should be applied to benefit the full range of DoD organizations. These include combat, industrial, service, and office environments of headquarters, field, and operational organizations. Each DoD Component should use CPI/LSS concepts and tools to improve the full range of processes and activities that comprise their operations, including decision-making processes and appropriate engagement with industrial base suppliers.

Sources: Continuous Process Improvement/Lean Six Sigma Guidebook, Revision 1 and DoD Directive 5010.42, “DoD-Wide Continuous Process Improvement/Lean Six Sigma Program”.

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**Introduction to Continuous Process Improvement (CPI) Tools**

(Lean – TOC – Six Sigma)

<table>
<thead>
<tr>
<th>Program</th>
<th>Lean Thinking</th>
<th>Theory of Constraints (TOC)</th>
<th>Six Sigma (6σ)</th>
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<tr>
<td>Theory</td>
<td>Remove Waste</td>
<td>Manage Constraints</td>
<td>Reduce Variation</td>
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<tr>
<td>Application Guidelines</td>
<td>Identify value value stream</td>
<td>Identify constraint constraint</td>
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<tr>
<td></td>
<td>1. Identify value</td>
<td>2. Identify constraint</td>
<td>1. Define</td>
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<td></td>
<td>2. Identify value stream</td>
<td>3. Exploit constraint</td>
<td>2. Measure</td>
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<td></td>
<td>3. Flow</td>
<td>4. Subordinate the process</td>
<td>3. Analyze</td>
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<td></td>
<td>5. Perfection</td>
<td>5. Repeat cycle</td>
<td>5. Control</td>
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<tr>
<td>Focus</td>
<td>Flow focused</td>
<td>System constraints</td>
<td>Problem focused</td>
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<tr>
<td>Assumptions</td>
<td>Waste removal will</td>
<td>Emphasis on speed and</td>
<td>A problem exists</td>
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<tr>
<td></td>
<td>improve business</td>
<td>volume</td>
<td></td>
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<tr>
<td></td>
<td>performance</td>
<td>Uses existing systems</td>
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<tr>
<td></td>
<td>Many small improvements</td>
<td>Process interdependence</td>
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<tr>
<td></td>
<td>are better than system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>analysis</td>
<td></td>
<td></td>
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<tr>
<td>Primary Effect</td>
<td>Reduced flow time</td>
<td>Fast throughput</td>
<td>Uniform process output</td>
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</table>
Lean Manufacturing

• Lean Definition:
  − "Lean" is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, "value" is defined as any action or process that a customer would be willing to pay for.

• Types of Waste (7 plus 1):
  − Transport (moving products that are not actually required to perform the processing)
  − Inventory (all components, work in process and finished product not being processed)
  − Motion (people or equipment moving or walking more than is required to perform the processing)
  − Waiting (waiting for the next production step)
  − Overproduction (production ahead of demand)
  − Over Processing (resulting from poor tool or product design creating activity)
  − Defects (the effort involved in inspecting for and fixing defects)
  − Creativity (unused employee ideas)

What is Waste?

• Anything that does not add value for the customer or …

• Anything your customer is not willing to pay for…

• Anything that consumes resources without transforming the product.

• 2 types of Non-Value Added (NVA) Waste
  • Type I Waste: Obvious things like Defects and Inventory
  • Type II Waste: Must do it, but nothing is transformed (A.K.A “Business NVA”)
The Value Stream

All actions required to bring a product or service through the main flows essential to every product.

- Used to capture key flows of work, information and materials within a process
- Idea to raw materials to final disposal
- Data rich
- Used to ID waste, non value added time, and develop the “Ideal State”

The Value of Time

Within the 8 sources of waste, time is a significant factor

Value-Added Time is only a very small percentage of the total time
Theory of Constraints (TOC)

- Understanding the organization’s true goal (e.g., “make money”)
- Anything which prevents the organization from achieving the goal is a constraint
- Align metrics with the goal
- Avoid suboptimal solutions

Theory of Constraints

- Theory of Constraints Definition:
  - Theory of Constraints (TOC) is a management paradigm that views any manageable system as being limited in achieving more of its goals by a very small number of constraints. There is always at least one constraint, and TOC uses a focusing process to identify the constraint and restructure the rest of the organization around it.

- Types of (internal) Constraints:
  - Equipment: The way equipment is currently used limits the ability of the system to produce more salable goods/services (bottlenecks).
  - People: Lack of skilled people limits the system. Mental models held by people can cause behavior that becomes a constraint.
  - Policy: A written or unwritten policy prevents the system from making more.
Making Product ≠ Making Money
People Working ≠ Making Money

Businesses don’t make money unless they can sell the product they are working on!

**Manufacturing Goals**
- Throughput (sales)
- Inventory
- Operational expenses

Results in higher cash flow, increased net profit and higher ROI

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**Examining the Whole Process**

“Sum of the local optimums ≠ Global Optimum”

- Bottlenecks govern both throughput and inventories
- An hour lost at a bottleneck is an hour lost for the entire system
- An hour saved at a non-bottleneck is a mirage
- It is alright to let non-bottlenecks sit idle
- Never let bottlenecks sit idle
- Balance flow, not capacity
Six Sigma

- Six Sigma Definition:
  - Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes.

- Variation:
  - **Common Variation:** If only common causes of variation are present, the output of the process forms a distribution that is stable over time and is predictable.

  - **Special Variation:** If special causes of variation are present, the process output is not stable over time and is not predictable.
Six Sigma Quality

Six standard deviations between the process mean and the nearest product specification limit
3.4 Defects per Million Opportunities

6σ Process

-6σ-5σ-4σ-3σ-2σ-1σ 1σ 2σ 3σ 4σ 5σ 6σ

LSL Mean USL

-6σ-5σ-4σ-3σ-2σ-1σ 1σ 2σ 3σ 4σ 5σ 6σ

LSL Mean USL

Manufacturing Readiness Levels (MRLs) and Assessments (MRAs)

• As per DoDI 5000.02 - “The Program Manager will ensure manufacturing and producibility risks are identified and managed throughout the program’s lifecycle.”

• “Assessments of manufacturing readiness using the Manufacturing Readiness Level (MRL) criteria have been designed to manage manufacturing risk in acquisition while increasing the ability of the technology development projects to transition new technology to weapon system applications. MRL criteria create a measurement scale and vocabulary for assessing and discussing manufacturing maturity and risk.” (Source: MRL Deskbook at www.dodmrl.com).

• Caution: MRLs are a management tool and may not always provide a completely accurate assessment of current and/or predicted manufacturing readiness. As with TRLs, they should be employed in concert with other management tools to best understand/manage risk.
Manufacturing Readiness Level (MRL) Scale

<table>
<thead>
<tr>
<th>MRL</th>
<th>Short Definition from MRL Deskbook at <a href="http://www.dodmrl.com">www.dodmrl.com</a></th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td>Full Rate Production Demonstrated and Lean Production Practices in Place</td>
</tr>
<tr>
<td>9</td>
<td>Low Rate Production Demonstrated; Capability in Place to Begin Full Rate Production (FRP)</td>
</tr>
<tr>
<td>8</td>
<td>Pilot Line Capability Demonstrated; Ready to Begin Low Rate Initial Production (LRIP)</td>
</tr>
<tr>
<td>7</td>
<td>Capability to Produce Systems, Subsystems, or Components in a Production Representative Environment</td>
</tr>
<tr>
<td>6</td>
<td>Capability to Produce a Prototype System or Subsystem in a Production Relevant Environment</td>
</tr>
<tr>
<td>5</td>
<td>Capability to Produce Prototype Components in a Production Relevant Environment</td>
</tr>
<tr>
<td>4</td>
<td>Capability to Produce the Technology in a Laboratory Environment</td>
</tr>
<tr>
<td>3</td>
<td>Manufacturing Proof of Concept Developed</td>
</tr>
<tr>
<td>2</td>
<td>Manufacturing Concepts Identified</td>
</tr>
<tr>
<td>1</td>
<td>Basic Manufacturing Implications Identified</td>
</tr>
</tbody>
</table>

Initial Operational Test and Evaluation (IOT&E)

**Initial Operational Test and Evaluation (IOT&E):** Dedicated operational test and evaluation conducted on production, or production representative, articles (such as LRIP articles), to determine a system’s operational effectiveness and suitability prior to Full-Rate Production (FRP) or Full Deployment (FD).

- IOT&E is required for all programs on Director, OT&E (DOT&E), oversight in accordance 10 U.S.C. 2399. The Lead Operational Test Agency (OTA) will conduct an independent, dedicated phase of IOT&E before full-rate production or full deployment that provides objective test results free from potential conflicts of interest or bias (DoDI 5000.02 Enclosure 5).
- Independent OTAs:
  - Air Force Operational Test and Evaluation Center (AFOTEC)
  - Army Test and Evaluation Command (ATEC)
  - Commander Operational Test and Evaluation Force (COMOPTEVFOR), U.S. Navy
  - Marine Corps Operational T&E Agency (MCOTEA)
  - Joint Interoperability Test Command (JITC)
Operational Effectiveness

• The overall degree of mission accomplishment of a system when used by operational personnel in a realistic scenario with the appropriate:
  - Organization......Doctrine
  - Supportability
  - Survivability......Vulnerability
  - Threat environment (including countermeasures, and nuclear, biological, chemical, and radiological (NBCR) effects)
  - Tactics and techniques

  Can the system accomplish its assigned mission?

Operational Suitability

• The degree to which a system can be placed in operational field use; specific evaluations of:
  - Availability
  - Compatibility, Transportability, Interoperability
  - Reliability, Wartime Usage Rates, Maintainability
  - Safety, Human Factors
  - Manpower Supportability
  - Natural Environmental Effects and Impacts
  - Logistics Supportability
  - Documentation & Training Requirements

  Is it ready when we need it? Is it affordable to operate and maintain? Is it safe, transportable and effective in the hands of a trained user?
Alternatives For Unsuccessful IOT&E

- If the OTA finds that a system is not operationally effective and/or not operationally suitable, the following MDA alternatives exist:
  - System can be sent back for further development (followed by additional testing).
  - The acquisition program can be terminated (unlikely, if a need exists for the program).
  - The service can field the system anyway and fix the deficiencies later.
  - The requirements (that were not met), can be relaxed – or pushed to a later increment of an incremental development program.

Configuration Management Definitions

"Configuration management is a technical and management process applying appropriate resources, processes, and tools to establish and maintain consistency between the product requirements, the product, and associated product configuration information." – SAE EIA-649B, *Configuration Management Standard*, adopted by DoD as the Industry standard intended for use when establishing, performing, or evaluating CM processes.


CM Training: LOG 204, Configuration Management
CM Benefits

Specifically, CM can provide a number of benefits, including:

• Increased capability and availability
• Improved performance, reliability and/or maintainability
• Reduced risk and liability, arising from corrected defects
• Reduced cost
• Having the right data at the right place and at the right time

What happens to the Logistics process without adequate CM?

• Items fail due to incorrect parts selection or installation
• Impacts to real-time operations (i.e. delays)
• Maintenance problems, downtime, and increased maintenance costs occur due to inconsistencies between an item and its maintenance instructions
• Operational effectiveness decreases and costs increase

Key Activities in the CM Process

CM Planning and Management. Planning and Management actions include selecting the CM tools, techniques and methods appropriate to the specific product’s environment; developing, implementing, managing and measuring effectiveness of a CM Plan.

Configuration Identification. This includes selecting items to be placed under CM and assigning unique identifiers.

Configuration Status Accounting. This involves recording CM information and status. It also provides listings of baselines.

Configuration Verification and Audit. This activity ensures that the product meets its requirements (verification) and that the documentation matches the product (audit).

Configuration Change Management. This is a systematic approach used to identify, document, justify, evaluate, approve, incorporate and verify changes to a product.

Data Management. This is the function that governs and controls the selection, generation, preparation, acquisition and use of data.
Physical Configuration Audit

- A Physical Configuration Audit (PCA) compares the actual configuration of a CI to its related design documentation. It verifies that the "as-built" product configuration matches the "as-designed" product configuration documentation.

- During a PCA, the deliverable item is compared to the product configuration documentation to confirm that the documentation matches the design. It is important to physically confirm that the design package of the product is complete and accurate.

- A PCA is also used to verify that any elements of the CI that were redesigned after the FCA meet the requirements outlined in the performance specification.

- Successful completion of the PCA provides certified product performance and configuration documentation. This is used in the Product Baseline, which will be used to operate, maintain and support that product (or CI) throughout its life cycle.

PCA Lessons Learned

The PCA is normally conducted around the time of the Full Rate Production Decision (FRPD). Additional PCAs may be conducted later. This is typically done in cases where:

- The original production line is "shut down" for several years before being restarted.

- The production contract for a CI that has a complex, difficult-to-manufacture design is awarded to a new Industry source.

- This re-auditing in these circumstances is advisable, regardless of whether Industry or the Government controls the detail production design.
Product Improvement Funding Decision Tree

Ref: DOD FMR (7000.14-R), Volume 2A, Chapter 1

P&D Exercise

See Exercise & Artifact Book Lesson 09