Lean Product Development

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Overview

- **Lean PD—is it making a difference?**

- **How Toyota does product development**

- **Current evidence of Lean in PD in aerospace**

- **Extending lean to the PD system level**

Is Lean Understanding Helping PD Performance to Improve?

- **We Have Learned a Lot About the TPDS Recently :**
  - **Morgan and Liker (2006)**
  - **Ward (2007)**
  - **Others (Kennedy, etc.), including lean manufacturing that describes PD interaction with production**
- **Most focus on Toyota practices**
  - **U Michigan research group the primary source**
  - **Focused description of a specific context and operating concept**
  - **Light on implementation/transformation insights (aside from taking decades to building the capabilities, as Toyota did)**
- **Many existing high-performance PD frameworks consistent with aspects of TPDS**
  - **e.g., Reinertson, Cooper, DFSS, body of SE knowledge, etc.**

Have these insights resulted in significant changes in the way product development is done in Aerospace?

- **Dollars of overrun per year in the military***

1970 - 1979	1980 - 1989	1990 - 1999
Development cost overrun:	Development cost overrun:	Development cost overrun:
$13 billion	**$12 billion**	**$15 billion**
(30%)	(39%)	(40%)

***** GAO 06-368**

What will development cost performance be for 2000-2010?

LAMDA: The Continuous Process for learning

(as introduced by Dr. Allen Ward)

Act » Look » Ask » Model » Discuss »

Toyota uses the Deming Cycle (PDCA):
Plan - Do - Check - Act.

But they augment with:
Genchi Genbutsu (go see for yourself),
Five-Why Analysis (ask why five times),
Nemawashi (concensus building),
Hansei (reflection events),
and Kaizen (continuous learning).

LAMDA puts it all together

Toyota PD Principles—Develop Flow in Core PD Processes

- **Define customer value, then follow the most direct path to it in the design process by**

  - **Reducing potential conflicts through tradespace exploration and planning exercises**

  - **Minimizing variance by reusing designs, using well-established routines, avoiding immature technologies**

  - **Identifying and avoiding conflicts through activist program leadership and boundary-spanning organizational structures and roles**

  - **Relying on capacity buffers to minimize disruption when activities diverge from plans**

  - **Continuous improvement and learning exercises update processes, tools, and behavioral routines**

See Morgan, James and Liker, Jeffrey, "The Toyota Product Development System", 2006

Toyota PD Principles—Develop Enterprise PD Capacity

- **Develop enterprise PD capacity (e.g., engineers and suppliers) through**

  - **Closely supervised learning-by-doing and continuous improvement along well-defined advancement paths**

  - **Experienced people filling key roles to ensure smooth and productive interactions across functions and boundaries**

  - **Using informal organization structure with entrepreneurial roles to avoid formal organizational bureaucracy from stifling innovation around satisfying customer value**

  - **A strong culture of well-defined standard work, performance transparency, and continuous improvement motivating failure identification and elimination**

See Morgan, James and Liker, Jeffrey, "The Toyota Product Development System", 2006

Toyota PD Principles—Support a Learning Enterprise

- **Structure work to allow coordination and diffusion of learning through the simplest communication modes possible by**

    - **Adopting technology when necessary and/or to automate or speed up well-understood processes**

    - **Partitioning work into independent tasks and defining simple, direct, targeted communication processes to clearly define the minimum actions required for coordination and alignment**

    - **Leveraging standard work definitions (both process and product) to capture and diffuse experience and learning through checklists and other work summaries/guidelines**

See Morgan, James and Liker, Jeffrey, "The Toyota Product Development System", 2006

Ward's Perspective on Toyota's LPDS

- **Value focus**: focus on knowledge creation for profitable operational value streams.

- **Entrepreneurial system designer (ESD)**: chief engineer who is the customer surrogate who is responsible for all aspects of success for the product (including profitability). ESD cuts across boundaries but must be supported by strong functional departments.

- **Teams of responsible experts**: create a personnel system that rewards people for creating and teaching useful knowledge (knowledge that can be turned into profitable products).

- **Set-based Concurrent engineering (SBCE)**: Aggressively explore trade space up front and eliminate weak options quickly. Use tradeoff curves (updated continuously) to capture knowledge about key design decisions.

- **Cadence, pull, and flow**: release projects into organization on a regular cadence, use integrating milestones to reduce batch size of information transfers and establish pull (also as coordination mechanism across multiple groups.)

See Ward, Allen, "Lean Product and Process Development", 2007

- ## Sort

- ## Straighten

- ## Scrub

- ## Systematize

- ## Standardize

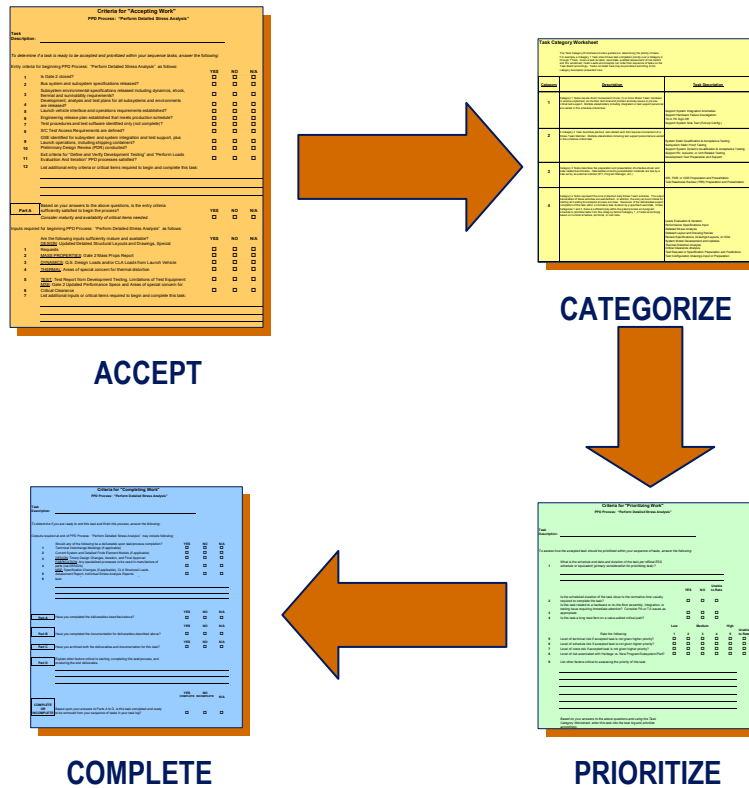**A prerequisite for establishing visibility of wastes and visual control**

Before

After

Photos from John Tile, BAE Systems, The Distributed Leadership of Lean
to the Office & Engineering Environment, LAI Plenary Conference, April 2006

Standard Work

Desktop instructions guide serial task flow

ACCEPT → CATEGORIZE → PRIORITIZE → COMPLETE

- **Best process currently known, understood, and used today**

- **Tomorrow it should be better based on continuous improvement**

- **Standard work is the key to repeatability**

Example source: Boeing S&IS, Idosor and Kozma presentation at 2006 LAI Annual conference PD session; see also HBS case N2-604-084 (2003) for a description of engineering standard work at Pratt & Whitney

Visual Control and Andon

- *Visual control* helps identify the status of the process at a glance
  - Makes the process apparent to everyone involved with or observing it
 - Only valuable if used for active process management
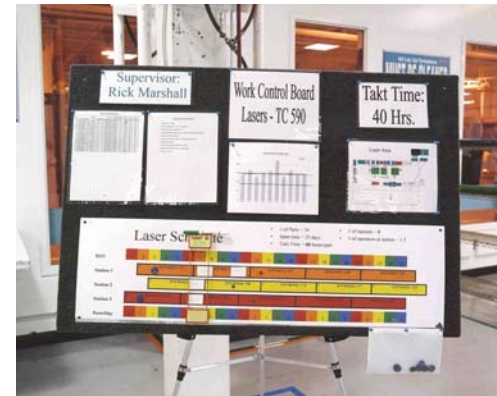
- *Andon* is a specific visual control device, typically a group of lights indicating a the current status of the process
  - Each step has a set of lights which indicates whether the step is proceeding as planned, needs monitoring, or requires immediate attention
  - In a pull system, if action is required, the entire process stops to correct the problem

- Both concepts have been successfully applied to PD processes to improve throughput and control
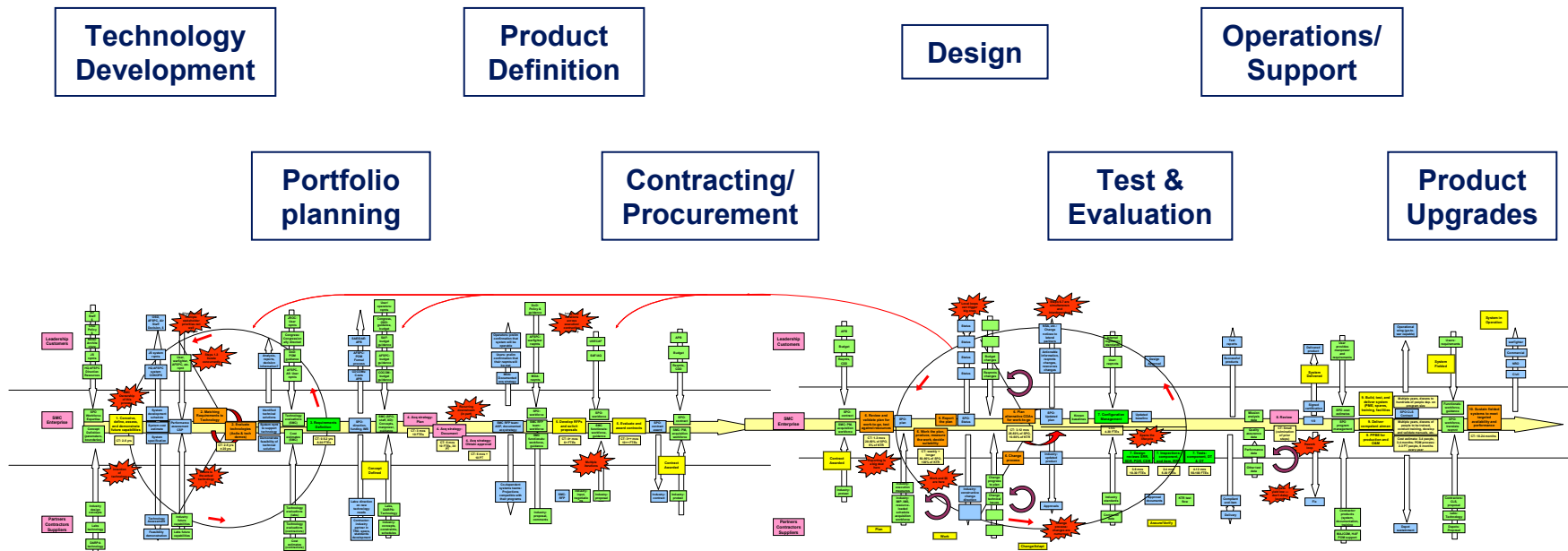
Value Stream Map (VSM)

- **Tool used to establish & document the process by developing a flow map**

- **Data Driven: Quantifies key parameters for each activity (cycle time, cost, quality defects, inventory, etc.)**

- **Uses VSM Pareto Analysis to focus improvement efforts first on areas needing the most improvement**

- **Creates " current state (as is)" and "future state (to be)" process depictions**
  - **Where you actually are, where you want to be, and how to get there?**

- **Provides systematic method to improve a process by eliminating waste and creating value**
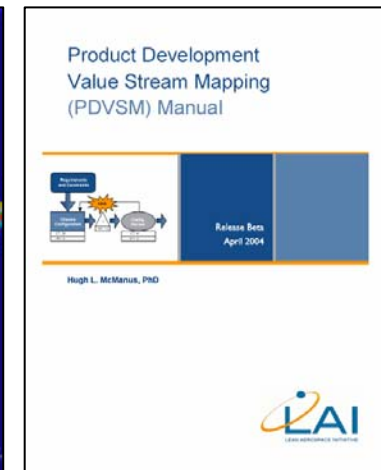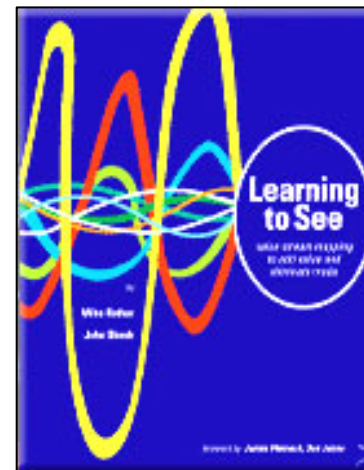
References:

M. Rother and J. Shook, *Learning to See*, **Lean Enterprise Institute, 1998**

H. McManus, *Product Development Value Stream Mapping*, **LAI 2005**

EVSM for a Large PD Enterprise

Technology Development

Portfolio planning

Product Definition

Contracting/ Procurement

Design

Test & Evaluation

Operations/ Support

Product Upgrades

Lean PD Implementation in Aerospace

- **Lean PD we've seen so far have implemented isolated aspects of these principles (or manufacturing lean techniques adapted to the PD environment)**

  - MIT/LAI research and interventions are necessarily limited to targeted elements of the enterprise

  - Consortium members' improvements efforts (with a few exceptions) often seem scoped by individual projects (e.g., 6-sigma)

  - Little evidence (so far) of system-level implementation of TPDS principles outside of high-volume environments

- **"Heal Peter (then rob) to pay Paul": impressive lean improvements in focused areas don't always translate to program-level payoff because of offsetting non-lean activities**
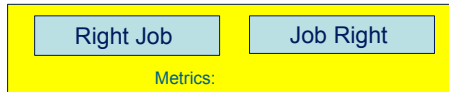
Lean Challenge: How to frame and prioritize lean PD improvement activities to enable better system-level performance?
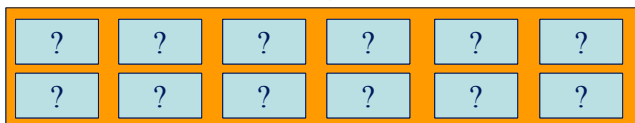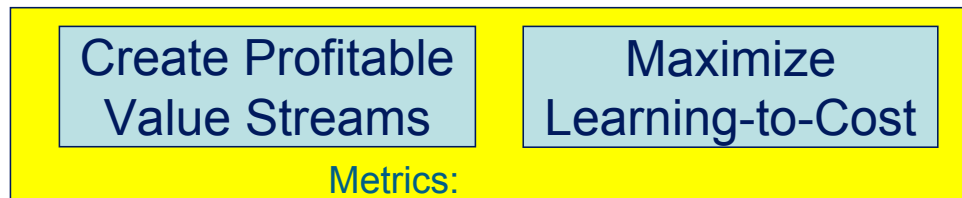
Lean SE and TPDS: Significant Overlap

Meta Principles

Right Job	Job Right

Metrics:

SE Enterprise Principles

Engineering Excellence	Leadership & Organizational Effectiveness	Programmatic Success	Efficient Process Execution

Overarching Practices

?	?	?	?	?	?
?	?	?	?	?	?

Meta Principles

Create Profitable Value Streams	Maximize Learning-to-Cost

Metrics:

LPDS Enterprise Principles

Towering Technical Competence	Chief Engineer System	Pull, Flow, Standardization, SBCE	Learning and Continuous Improvement

Overarching Practices

Adapt technology to fit your people and process	Align your organization through simple, visual communication	Use powerful tools for standardization and organizational learning	Build a culture to support excellence and relentless improvement	Build in learning and continuous improvement	Fully integrate suppliers into the PD system
Organize to balance functional expertise and cross-functional integration	Establish customer-defined value to separate value-added from waste	Front-load the PD process to explore thoroughly alternative solutions while there is maximum design space		Create leveled PD process flow	Use rigorous standardization to reduce variation, and create flexibility and predictable outcomes

Preliminary, for purposes of discussion; builds on Morgan et al (2006), and Ward (2007)

Getting Practical: Some Lean PD Things To Do

- **Standardize work at individual and team levels**
  - Standard tools, cycle times, performance expectations
  - Skills-based personnel progression system
  - Process owner responsibility for continuous improvement

- **Establish flow and pull processes**
  - Focus on creating and measuring consistent hand-offs across processes
  - Create periodic integrating events/mechanisms/roles for project-level coordination
  - Enable cadence in process execution and integration cycles

- **Manage staffing for stability, capacity, and learning**
  - Level work load, prevent overburden (static and transient) of resources
  - Keep pipeline of skilled staff, teachers, and leaders filled and flowing

- **Use product architecting process to increase PD learning cycles**
  - Increase reuse of product artifacts, standardization, system integration understanding
  - Enable knowledge capture and process refinement
  - Use tradespace exploration as an opportunity to develop deeper understanding and knowledge about elements within the architecture (e.g., refine tradeoff curves)

- **Expand tiers of the value stream participating closely in PD process**
  - Engage customers and suppliers in tradespace exploration and requirements specification