Principles and Characteristics of Lean Product Development Systems

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XXXII ENEGEP - LPD
Outline

1. Introduction: Why it matters
2. Lean Manufacturing Applied to Product Development
3. Value-focused & Risk-based Decision Making
4. Socio-technical Integration of People and Process
5. Improved Program, Pipeline & Portfolio Management
6. The Creation of a Learning Organization
We are living in a world of opportunities and challenges

- Characteristics of the global environment
  - Many potential customers with fast changing needs
  - Competitors introduce new products to meet these customer’s needs

- A focused strategic orientations seems essential
  - Product leadership
  - Operational excellence
  - Customer intimacy
Fast Product and Process Development is Key for the Success of Organizations

- Time to Market accelerates
  - 12 Month delay =
    - 50% revenue loss in slow markets
    - 90% in fast markets

- The product market life decreases
  - Which implies that both new product and process development need to accelerate

![Diagram showing product life cycle stages: Introduction, Growth, Maturity, Decline, with Units, Revenue, or Profit on the y-axis and Time on the x-axis. The diagram highlights Lost Units, Revenue, or Profit and Total Units, Revenue, or Profit.]
Companies are Not Necessarily Good at This

- Over 60% of all new product development efforts are terminated before they ever reach the marketplace.
- Of the 40% that do make it, more than half fail to become profitable or are removed from the market.

Hasty development decisions can lead to:
- Quality loss
- Additional costs
- Slow market introduction

Challenges include
- Continuously changing customer requirements
- Accelerated learning
- Knowledge retention

Traditional Product & Process Development Approaches are Under Pressure

Product Development Funnel

Stage Gate System

Source: Cooper (1994)
Traditional Product development approaches are under pressure

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**Capability Maturity Models Integrated**

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<tr>
<th>Maturity Level</th>
<th>Focus</th>
<th>Process Areas</th>
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</table>
| 5 Optimizing   | Continuous Process Improvement | Organizational Innovation and Deployment  
                             | Causal Analysis and Resolution                                                |
| 4 Quantitatively Managed | Quantitative Management | Organizational Process Performance  
                             | Quantitative Project Management                                               |
| 3 Defined      | Process Standardization    | Requirements Development  
                             | Technical Solution  
                             | Product Integration  
                             | Verification  
                             | Validation  
                             | Organizational Process Focus  
                             | Organizational Process Definition  
                             | Organizational Training  
                             | Integrated Project Management  
                             | Risk Management  
                             | Integrated Supplier Management  
                             | Integrated Teaming  
                             | Decision Analysis and Resolution  
                             | Organizational Environment for Integration                                      |
| 2 Managed      | Basic Project Management   | Requirements Management  
                             | Project Planning  
                             | Project Monitoring and Control  
                             | Supplier Agreement Management  
                             | Measurement and Analysis  
                             | Process and Product Quality Assurance  
                             | Configuration Management                                                     |
| 1 Initial       |                           |                                                                                |

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ISO 15288 – Systems Engineering Life Cycle Processes
Introduction: Why it matters

Lean Manufacturing Applied to Product Development

Value-focused & Risk-based Decision Making

Socio-technical Integration of People and Process

Improved Program, Pipeline & Portfolio Management

The Creation of a Learning Organization
**Evolution of Lean**

Taiichi Ono and Eiji Toyoda – Toyota Production System (1949)

Term “Lean Production” created by Womack, Jones and Roos at the book “The Machine that Changed the World” (1990)

Five Principles of Lean Thinking: Value, Value stream, Flow, Pull, Perfection

Value Stream Mapping: Systems Perspective that supports the identification of waste (DOWNTIME)

Various tools have been proposed to reduce waste and create flow: 5S, SMED, Kanban

Automotive  Production  Office  Service  Healthcare  Product Development
Case Study Environment

- Department of Technical Studies and Installations of the Belgian Armed Forces
  - Design and installation of Communication and Information Systems (CIS) in military vehicles
  - Radio-transmitters, satellite communication systems, GPS, etc.
  - 74 personnel, 82 ongoing projects
  - Poor performance on project lead time
  - Threat of outsourcing

- Integrated Transformation Effort
  - Initial improvement initiative focussed on a complex and critical installation project
  - Roll-out of new process to other projects after initial success.
Department Structure and Functional Groups

- TSI HOD
- Engineering
  - Study Work groups
  - Mech Prototyping Dept
- Support
  - IT, Planning, Admin
  - Installation Work Groups
    - Cabling
    - Installations
- Shelters
- CAD
- Wheeled Vehicles
- Tracked Vehicles
- Electronic Studies

- Project performance indicators
  - Leadtime of projects: 40% between 3 and 9 years
  - Workload: 80% less than 800 man hours

- Waiting: at least 78%!
## There is Plenty of Waste in Product Development

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<th>Defective products/not meeting user requirements</th>
<th>Transportation</th>
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<td>Unreliable data/information (equipment, user info)</td>
<td>Of materials from customer to development site</td>
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<td>Wrong participants/user representatives</td>
<td>Of personnel between sites and department</td>
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<td>Artificial feedback</td>
<td>External transfer of official documents</td>
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<th>Overproduction</th>
<th>Inventories</th>
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<td>Creation of redundant/unnecessary deliverables</td>
<td>Too much WIP for engineering and project manager</td>
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<td>Leading to too many parallel activities</td>
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<th>Waiting</th>
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<td>Feedback and decision</td>
<td>Inefficient layout of department</td>
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<td>User and stakeholder meetings</td>
<td>Lacking department meeting room</td>
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<td>Searching for people, materials, information</td>
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<th>Not taking advantage of employee creativity:</th>
<th>Excess Process design</th>
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<td>Lack of feedback from end-user and external and internal stakeholders</td>
<td>Inefficient meetings</td>
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<td>Supporting IE and IT tools not understood</td>
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Additional illustrations:

20-40% of PD effort “pure waste”
60-80 % of tasks idle at any given time
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Dangers of Eliminating Waste in Product Development

Thunder horse
Lean Trap in Product Development

- The problem:
  - Applying the classical lean approach ('eliminate waste') is dangerous
    - Essential development activities such as analysis and testing could be classified as 'waste' or 'non-value added'

- LPD improvements require a direct, rather than indirect (waste-focused) (Reinersten, 1999; Haque and James-Moore, 2004; Baines et al., 2006)
  - This implies adding activities that support the definition of value as a first priority

\[
Value \approx \frac{Performance \times Service}{Cost \times Time}
\]
The Identification of Value

- To support the identification and creation of Value, Browning introduced the “Atoms of Value” concept:
  - Atom of value are a set of activities that lead to valuable interim deliverables
  - These atoms of value
    • increase stakeholder value
    • by enhancing performance and reducing risks

- A Lean product development process consists of a chain of atoms of value that optimize the overall value of the development process
  - Find the right “product development recipe”

\[
\text{Value} \approx \frac{\text{Performance} \times \text{Service}}{\text{Cost} \times \text{Time}}
\]
Atoms of Value (Browning)

- Atoms of Value
  - Development activities that lead to valuable interim deliverables

Increase stakeholder value by enhancing performance and reducing risks

Mind the ISO/CMMI Trap!
Product Development Push

Pull to avoid overflow of info

- Requested information
- Interim Deliverables
- Value adding information?
- Pull Questions
- Raw Data
- Overwhelming information?
- Decision Makers
- Risk Reducing Decisions
- Risk Analysis
- Suitable Portrayal
- Suitable Portrayal
- Development input information
- Vital Actionable information
- Prototyping
- Project Analysis

Specialist or Complex Portrayal?
Pull-based Product Development

- Decision Makers
  - Risk Analysis
  - Risk Reducing Decisions

- Development input information
  - Vital Actionable Information

- Project Analysis
  - Prototyping
  - Raw Data
  - Requested information

- Interim Deliverables

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The Lean Atom of VAlue (LAVA) Model

- **Atoms of Value (Browning):**
  - Development activities that lead to valuable interim deliverables

- **Lean Atoms of VAleue:**
  - Include the decision making process that define value and reduces risk
  - Uses pull thinking to identify the appropriate interim deliverables
  - Acknowledges the need to create flow in execution and decision making

Letens, Farris, Van Aken; 2011
Increase the Level of Common Understanding

Traditional Product Development

- Pre-Construction Services
  - Architect Hired
  - Engineers Hired
  - CM/GC Hired
- Construction
  - Major Trades Hired

Source: McDonough Holland & Allen PC - Lean Construction Institute
Increase the Level of Common Understanding

Lean Product Development

Common understanding

Pre-Construction Services

Construction

Faster Knowledge Development

Source: McDonough Holland & Allen PC - Lean Construction Institute

Architect Hired
CM/GC Hired
Engineers Hired
Major Trades Hired

SD  DD  CD

Time

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The Importance of Rework

AOA-network diagram

Event
Non-critical activity
Critical activity
Dummy Activity

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Assessing Loop Criticality

- **Occurrence**: network conditional probability
- **Severity**: contribution of loop i in project lead time
- **Detection**: loop location along the project path

Knowledge Evolution
Risk-based decision making

Martínez, Farris & Hernández 2010
Knowledge development through Front-Loading

- **Front-loading definition:**
  - Frontloading is the shifting of identification and solving problems to earlier phases of the PD process (Thompke and Fujimoto, 2000).

- **Front-loading approaches:**
  - Project-to-project knowledge transfer
  - Rapid problem-solving cycles through technology leverage
  - Earlier starts of problem-solving cycles through supplier relationships
  - Optimal partitioning of iteration loops (Design Structure Matrix)

Genchi Gembutsu

- Rapid Prototype Development
- Critical to customer
- Critical to quality

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Convergent Decision Making

- Involving many stakeholders in early stages increases discussion and facilitates timely conflict identification.

- Stakeholder management is a must: Nemawashi.

- This implies the use of convergent decision making techniques:
  - Alternatives comparison
  - Set-based Concurrent Engineering
Set-based Concurrent Engineering

- A broad range of alternatives are narrowed down until a superior solution is found.
- Design information is gathered from different functional groups. The overlap between these perspectives creates a range from which to develop sets.
- Front-loading of this information minimizes risk of future engineering changes and rework.
- Potential solutions are developed in parallel until the last responsible moment for a decision.

Reduces risk through redundancy, robustness, and knowledge capture
To eliminate waste early in the product design

Conservative Design Options Eliminate Need to Iterate
Late to Mature Design Options Become Derivatives
Immature Design Options Become Research Base

Iterate Only on Planned Model Year Releases

Many Concepts, Each Subsystem
Evaluate against threats and each other, Eliminating weak options, Add Knowledge, Combine Options In Different Ways

Adapted From: Product Development for the Lean Enterprise, by M. Kennedy
Other Supporting Techniques

- Value Analysis and Value Engineering
- Function Analysis System Technique
- Quality function deployment
- Choosing by Advantage
- Decision mapping
- Design Structure Matrix
- Trade off curves
- Design For Manufacturing, Assembly, Testing
Characteristics of LAVAs

- **People:**
  - Concurrent team

- **Process:**
  - Only required steps

- **Tools & guidelines**
  - Virtual Prototypes, Mockups: Enabling suitable portrayal of interim deliverables

- **Interim Deliverables:**
  - Facilitating Risk Analysis and Value Identification

- **Decision makers**
  - Balance importance of different stakeholders

- **Decision & Actions Table**
  - Lean documentation (A3-Reports)
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Socio-technical dimensions of LPPD

Successful LPPD is more than the application of tools; the successful application of Lean tools implies the creation of project and functional teams—Communication, Trust, and Shared identity.

The creation of a learning environment

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Source: McDonough Holland & Allen PC – Lean Construction Institute
Development Kaizen Events

Definition:
- Cross-functional concurrent teams
- That works together on the creation and assessment of focused interim deliverables
- For a short period of time: typically one to three weeks
- In a shared location

Benefits:
- Focus: minimal interruptions
- Continuous communication - reduced reporting overhead
- Improved ownership creates a team identity
- Optimize transfer of knowledge
- Fast delivery and fast decision making: no delays at the decision gates
This implies strong leadership

- Chief Engineer (CE) integrates everything
  - product plan
  - concept
  - design architecture
  - targets and specifications
  - schedule
  - budget
  - drawing approval

- He is judged on corporate objectives
  - Profit
  - Share
  - Learning

Liker, 2006
CE at Toyota: Leadership by expertise

- Technical expertise: Minimum 20 years experience as engineer
  - Deep grasp of engineering fundamentals (communication with any engineer)
  - Assignment outside original area of expertise (ability to adapt and learn quickly)

- System design skills and attitudes; strong personalities
  - Assignment(s) as assistant chief engineer (integration experience)
  - “Push very hard — but know when to stop”

- Communication skills and knowing the company

This implies sound career planning

Liker, 2006
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The Creation of a Learning Organization
Top 10 Problems in Product Development Organizations

- Poorly defined product requirements
- Gold plating, analysis paralysis
- Late consideration of manufacturability
- Too many meetings
- Poor communication across functional barriers
- Chaotic environment: constant interruptions
- Lack of resources: bottlenecks
- No prioritization of projects/tasks
- Email avalanche
- Disruptive changes to product requirements

Source: Lean Product Development Guidebook – Mascitelli
An important part of the lean product development literature seems to focus on the single project level only

- Value, concurrent engineering, leadership of the Chief Engineer

The overall success of organizations is determined by the overall performance of multiples projects

- Portfolio management
- Multi-project management
- Functional constraints
Multiple Projects in Matrix Organizations

- At Toyota, functional specialists build knowledge about one function for several years (Haque and James-Moore, 2004).
- They maintain a functionally-based organization but with impressive integration that manages product development as a system (Sobek, Liker, and Ward, 1998).
Problems related to Multi-project Management

- Little’s law:

  \[ \text{PD Lead Time} = \frac{\text{No. of Projects In Process}}{\text{Avg. Completion Rate}} \]

- Projects in Progress depends on:
  - Task Time Variation (>50%!)
  - Utilization % (of Engineers)
  - Cross training
Strategies to reduce WIP

- More Cross Training
- Less Utilization
- Re-Use!
Optimizing value and flow from a functional and project perspective

- Bottleneck Management – Critical chain (Goldratt, 1997)

- Managing functional queues (Reinertsen, 1997; Mascitelli 2007)
  - 5S
  - SMED
  - Resource pull

- Prioritization and coordination of multiple projects (Cusumano and Nobeaka, 1998)
Focused initiative to eliminate bottleneck:

- Visualize functional queues to prioritize day-to-day activities
- Pull cross-trained resources to temporal bottlenecks

Drill-down Analysis to Identify and Eliminate Constraints

- Optimize functional constraints:
  - 5S
  - Standard Work

Focused initiative to eliminate bottleneck: TOC - Goldratt
Multitasking can become an insidious generator of waste

- What happens:
  - A
  - B
  - C
  - A
  - B
  - C
  - A
  - B
  - C
  - Lost Productivity due to context switching

- Should happen:
  - Task A
  - Task B
  - Task C

Rough-cut capacity plan to manage constraints:
- External: facilitate customer and supplier contacts
- Internal: Coordinate at:
  - Project Level: avoid push of non-prioritized activities
  - Functional Level: pull excess resources
Master Project & Development Schedule
Trimester Planning

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Visual detection of bottlenecks
Knowledge Innovation Visible Planning

Pipeline priorities need to be established based on resource allocations

- Year 1 Result: **Average** lead times fell 56%, OTIF reached 89%

2 engineers assigned to multiple projects during the same period

All projects mapped
Value Stream Mapping of the Project Pipeline

Current State

[Diagram showing the process flow of project pipeline with various stages and timeframes.]
Value Stream Mapping of the Project Pipeline

Future State

[Diagram showing the project pipeline with various stages and timelines, including parts acquisition, go/no go decision, planning, preparation of experiments, technical evaluation, technical specifications, and process engineering, followed by series preparation, installation, and fitting of parts.]
Improved Product Development at the Business Level

- Cooper (2008):
  - Families of stage gate systems to manage a diversity of new product development projects with various risks

Adapted from Cooper, 2008
Portfolio Management

Create a valuable portfolio that determines long-term success:

- Improved project selection:
  - Less is more (Mandelbaum and Schwerer, 1996)
  - Define value from a resource-constrained business perspective
    - Find ways to overcome political pressures
    - Front-end loading: increase investment in early market and feasibility analysis

- Enable long-term thinking:
  - Build relationships with customers and suppliers to further optimize flow and value
  - Planning of critical resources - pull strategic resources and knowledge to the organization
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Knowledge Management Cycle

- A sole focus on externalization through the storing of lessons learned in a database is ineffective.

- Data-mining techniques should be used to further improve knowledge combination.

- Social systems need to be defined to address internalization and socialization.
It may be simple, but........

Future research is needed!
1. Investigate the role of systems thinking to manage the lean principles at multiple levels

Additional research is needed to further validate and refine the conceptual framework
2. Clarify the use of existing tools from various disciplines within the overall framework

Identify potential best practices
Develop the framework into an assessment tool
Learning to see the whole LPD system
3. Study the dynamics of LPD systems

- Doubled turnover compared to 2001
- Reduced inventory
- Reduced Leadtime
- Improved Cycle Between Project Turnover-Project Inventory-Waiting Time-Project Leadtime
- Less waiting

Study role of performance measurement to optimize LPD systems
Questions?

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