A Contingency Theory Approach to the Deployment of Lean Principles: The Case of Advanced Research and Complex Product Development Environments

Katrina Appell
Industrial and Operations Engineering
University of Michigan
August 12th, 2011

Dissertation Committee:
Professor Jeffrey K. Liker, Chair
Professor Lawrence M. Seiford
Associate Professor Young K. Ro, University of Michigan – Dearborn
James M. Morgan, Ford Motor Company

Agenda

- Introduction / Motivation
- Comparison of Deployment Approaches
- Value Stream Mapping & *Obeya*
- Standardization
- Conclusion / Future Research

Research Motivation

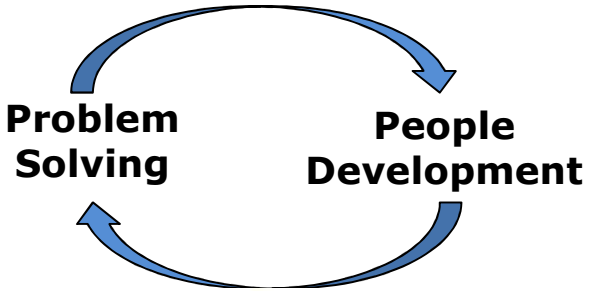
- Improve Product Development Performance
- Transforming to “lean”
  - Shingo Prize winners didn’t sustain gains without cultural transformation
  - Change culture with technical changes that support the desired culture (Nadler & Tushman 1980, Morgan & Liker 2006, Shook 2010)

THE SHINGO PRIZE
for Operational Excellence

- Deploy Lean in Complex Environments
  - Understanding challenges can guide deployments in other complex environments
  - Different Environments (Contingency Theory)
    - Different problems to be addressed
    - Deploy “lean PD” outside of Toyota

What is Lean Product Development?

- Enables
  - People development
  - Problem solving
  - Organizational learning
- Modeled after Toyota's product development system (Ward, Liker, Sobek, Morgan)
- Lean manufacturing tools adapted to product development (Reinertsen, Smith)



While creating products that customers value

Not mutually exclusive, The perceived definition impacts the deployment approach and results

Lean Product Development: A Comparative Case Analysis of Rational Planning and Disciplined Problem Solving Approaches

A Contingency Theory Approach to the Deployment of Lean Principles: The Case of Advanced Research and Complex Product Development Environments

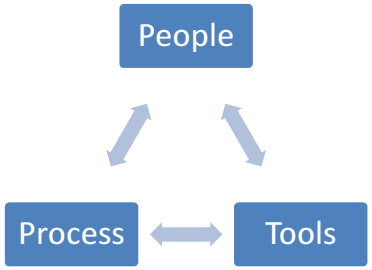
Overview

- Research Objectives
  - Determine advantages and disadvantages of approaches to lean methodology deployments in complex product development environments.
  - Identify organizational characteristics that enable successful deployment of lean methodology in complex product development environments.
- Methodology
  - Comparative case study of early stage deployments
    - Contrasting approaches

	Consumer Goods	Turbine Gen
Industry	Consumer Goods	Gas Turbines
Development Location	Dispersed Globally	Centralized
Objective	Reduce Time to Market Reduce Costs Improve Quality Alignment w/ Market Needs	Reduce Time to Market Reduce Costs Improve Quality Increase Sales Volume
Approach	Deploy Globally	Pilot Model Line Organic Growth

Lean Deployment

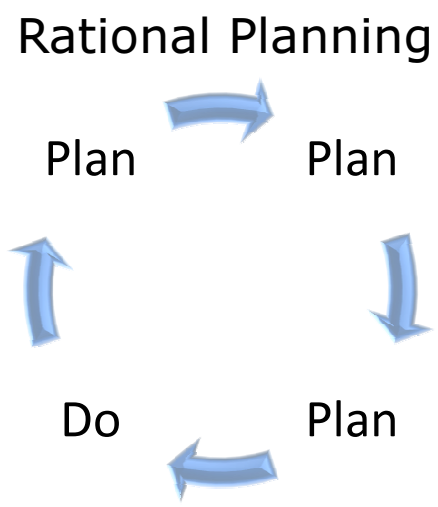
- Deploy in phases supporting the integrated system
  - Too complex to deploy all at once
  - No one best way (Liker & Meier 2006, Liker & Franz 2011)
    - Objective
    - History
    - Culture
    - Internal & External Environments
- Key attributes
  - Achieve Stability (Liker & Meier 2006)
  - Establish culture of problem solving
    - Providing tools and resources to identify & solve problems (Shook 2010)

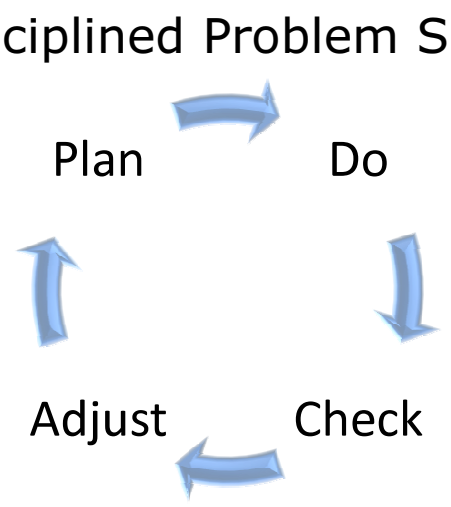


Problem Solving Processes

- Organizational Change (March & Simon 1958)
- Product Development (Clark & Fujimoto 1991, Brown & Eisenhardt 1995)

Approach towards Deployment (Organizational Change) serves as a model for Product Development & Problem Solving





Case Analysis

	Consumer Goods	Turbine Gen
Deployment Strategy	Rational Planning	Disciplined Problem Solving
Perception of Lean PD Principles (Morgan & Liker 2006)	Countermeasures to overcome problems	Example to be learned from and adapted to fit unique organization

- Achievement of Stability (Liker & Meier 2006)
- Problem Solving Culture (Shook 2010, Liker & Franz 2011)
  - Problem Solving / Learning Cycles (Rother 2010)
  - Coordination and Integration (Lawrence & Lorsch 1969)
- Breadth & Depth of Deployment (Kucner 2008, Liker & Franz 2011)

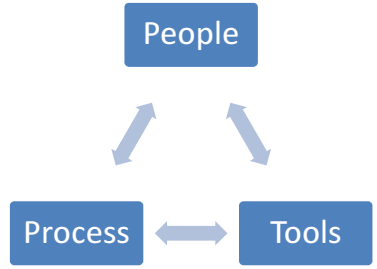
Lean Deployment Approaches (initial deployment)

	Consumer Goods	Turbine Gen
Achievement of Stability	Standardize tasks to be more predictable with centralized control for compliance. Standardize routine support functions.	Accountability to complete tasks when commitments are made.
Learning cycles	Long learning cycles.	Short learning cycles: adapt & improve quicker
How Coordination & Integration is achieved	Following the standard process is intended to force cross-functional coordination across projects and time.	Cross-functional integration and coordination within projects.
How breadth of implementation is achieved	The same process controlled by a staff function is deployed to multiple projects.	Organic spread: As value is seen it is implemented & adapted to fit throughout the organization.

Findings

	Consumer Goods	Turbine Gen
Advantages	Infrastructure that enabled standardizing common routine tasks. Coordination across projects & time (knowledge management)	Ability to adjust in the uncertain environment of PD. Learning lean as a socio-technical transformation.
Disadvantages	Process focused - limited consideration as a socio-technical system	Limited & slow spread of lean

- Achieving Stability through People
  - More effective than through Process
- Enabling Systems
  - Created by people doing the work to support the work
    - Disciplined Problem Solving Approach
      - Turbine Gen
      - Consumer Goods – Design Guides
- Enabling Bureaucracy
  - Balance between two approaches



Facilitating Cross-Functional Teamwork in Lean Product Development: The Role of *Obeya* and Value Stream Mapping

A Contingency Theory Approach to the Deployment of Lean Principles: The Case of Advanced Research and Complex Product Development Environments

Overview

- Research Questions
  - How can lean tools, specifically value stream mapping and *obeya,* act as enablers in the transformation to product development organizations to more efficiently & effectively introduce products?
  - What are organizational characteristics that enable successful use of these tools to begin the process of cultural transformation to a lean enterprise?
- Methodology
  - In depth case study (Turbine Gen)
    - Value stream mapping & *obeya*
      - Introduce lean principles
      - Achieve coordination & integration

Complexity

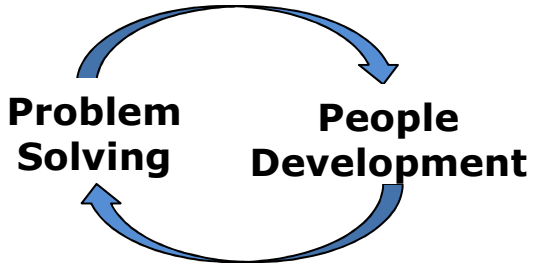
- Increasing Complexity in Product Development
  - Global Competition
  - Demanding Customers
  - Technology Developments

  (Lawrence & Lorsch 1967, Wheelwright & Clark 1992)

Complexity → Specialization → Interdependence & Differentiation

(Thompson 1967) (Lawrence & Lorsch)

- Lack of effective coordination & integration are the biggest barriers to fast and effective problem solving in product development.



Case Analysis

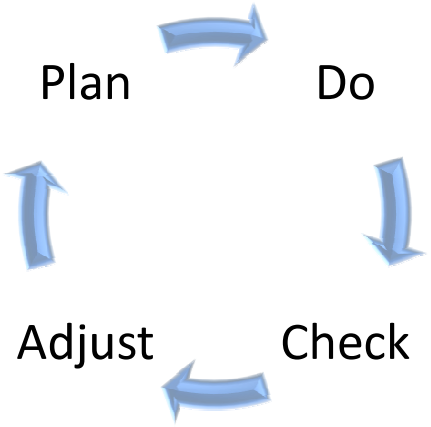
Lean Tool	Technical Purpose	People Development Purpose
Value Stream Mapping (Rother & Shook 2003, Morgan & Liker 2006)	•Highlight waste and improvement opportunities •Establish project plan	•Establish common understanding of processes, waste drivers, and task interdependencies
Obeya (Morgan 2002, Baker 2011)	•Coordinate tasks, see interdependencies, and solve cross-functional issues (weekly cadence) •Highlight gaps between current and target conditions focusing attention on problems to be solved	•Establish disciplined problem solving leading to stability •Quick PDCA cycles allows the project and tools to be adjusted as learning occurs
"Nick Charts" (within *Obeya*)	•Visual display of deliverables, status, and accountability for tasks	•Nick developed the tool, others saw value, started using and improving it
"Andon lights" (within *Obeya*)	•Highlight deviations from the standard (plan) and call for help to solve problems	•Allows "managing by exception" to focus efforts on problems and not reporting tasks on track

How VSM & *Obeya* Enabled Integration

- Cross-functional VSM workshop
  - Common understanding of current state, wastes, & future state that is developed by the team
  - Team members engaged in planning process
    - Empowered to plan own work w/ understanding of interdependencies
- *Obeya*
  - Visibility to interdependencies
  - Accountability
    - Understanding of consequences if commitments aren't met (also visible to other team members)

Lean Deployment: Enabling Problem Solving

- Weekly PDCA loops
  - Project
  - Tools supporting the project
- Managing by exception
  - Focus on deviations from standard
- Cross-functional solving of cross-functional issues



Findings

- Project completed in 17 months
  - 18 month schedule
  - 24-27 months (for similar projects)

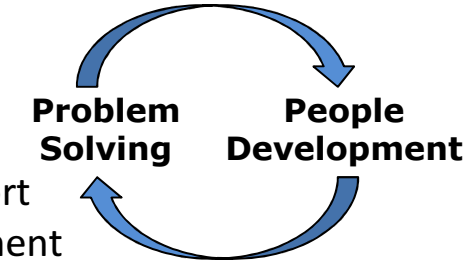
- Success factors for lean
  - A firm conviction that lean principles can be adapted to work in your setting, coupled with a willingness to try, fail, and learn (Rother & Shook 2003)
  - Program Manager w/ "right" skill set
    - Job is to get everyone engaged
    - Coach and support the process
  - Employee engagement – Seeing the value of lean
    - Team owns success
      - Commitment and accountability

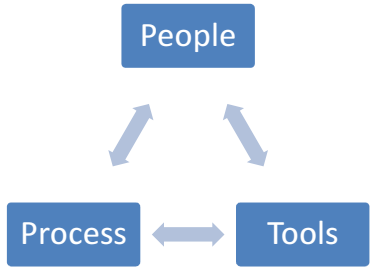
The Technical System of Lean: How Standardization can Support Problem Solving and People Development in Complex Product Development

A Contingency Theory Approach to the Deployment of Lean Principles: The Case of Advanced Research and Complex Product Development Environments

Overview

- Research Objective
  - Socio-Technical System
    - Design of Technical System to Support Problem Solving & People Development

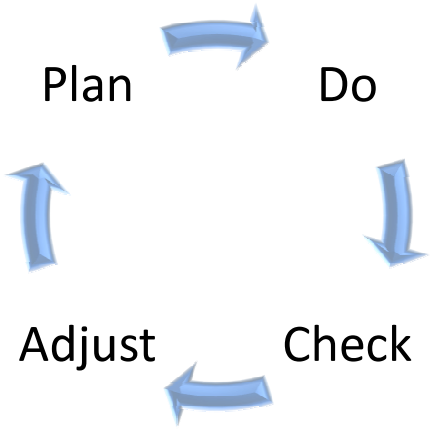




- Research Questions
  - How can standardization simultaneously be used to create predictability while enabling innovation?
  - How can standardization be used as a mechanism to achieve integration & coordination?
  - How can standardization support problem solving?
  - How can standardization enable organizational learning?
- Methodology
  - Analysis of how standardization was used within 2 organizations in early stages of lean product development deployment
    - Consumer Goods
    - Turbine Gen

Roles of Standardization in Lean

- Problem solving
  - Problems identified by gap between actual and standard
    (Liker & Hoseus 2008, Shook 2008, Rother 2010, Liker & Franz 2011)



- Stability
  - Foundation of continuous improvement (Liker & Meier 2006)
- Coordination & Integration
  - Common understanding (Sobek, Liker et al. 1998, Morgan & Liker 2006)

Coercive vs. Enabling Bureaucracies (Adler & Borys 1996)

- Formalization of design (or perception of formalization)

Coercive Systems and Procedures	Enabling Systems and Procedures
Rules, procedures, and structure control employees to ensure they do the right thing	Rules, procedures, and structure support the work of employees

- Fit of organizational design with task requirements

Interdependence level (Thompson 1967)	Coordination Mechanism	Lean Example
Pooled	Standardization	Standardization
Sequential	By Plan	Milestones for alignment & coordination
Reciprocal	Mutual Adjustment	*Obeya* – Mutual adjustment when creating the plan, weekly as the project is managed

Consumer Goods

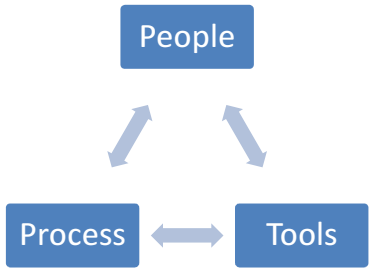
- Attempt to Standardize the Entire Product Development Process
  - Define, document, standardize processes
    - Identify and eliminate or control all sources of variation
    - Be predictable through process compliance after people are informed of their accountabilities
- Standardizing Routine Aspects of Product Development Process
  - Standardize common routine tasks to remove non-value added variation for predictability while maintaining flexibility
    - FMEA
    - A3
- Design Guides
    - Created by engineers who saw value
    - Standardized sections so information could be found
    - Flexible sections to meet specific needs of modules & technologies
- Speeding up the Experimental Learning Cycle
    - Coordination to enable better scheduling in testing and projects
    - Visual Management for problem solving (actual vs. standard)

Turbine Gen

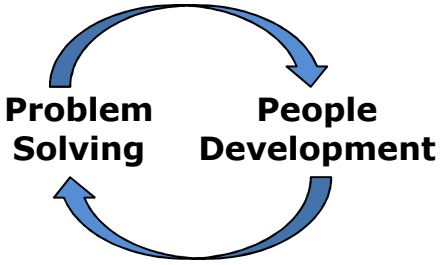
- Speeding up the Experimental Learning Cycle
  - *Kanban* to enable better scheduling & coordination in testing and projects
  - Visual Management for problem solving (actual vs. standard)
- *Obeya*
  - Visual Management for problem solving (actual vs. standard)
  - "*Andon* lights" to bring attention to problems
  - Borrowing, improving, adapting standards across *obeyas*
    - "Nick Charts"
    - "*Andon* lights"

Findings

- Effective standardization
  - Fit w/ intent of the effort
  - Fit w/ task requirements
  - Used in an enabling way



- Can be achieved by
  - People using the standards
    - Develop, maintain, update
      - Updating includes continuous improvement and adapting for use in different environmental contexts



Conclusion / Future Research

- Summary of Findings
  - Successful efforts had characteristics of an enabling bureaucracy of supporting people to do their work
- Future Research
  - Generalizability limited by case study methodology
  - Intent was to understand challenges, organizational characteristics, & effective approaches
    - Complex Environments
      - Product Development
      - Healthcare

Thank you

Back up slides

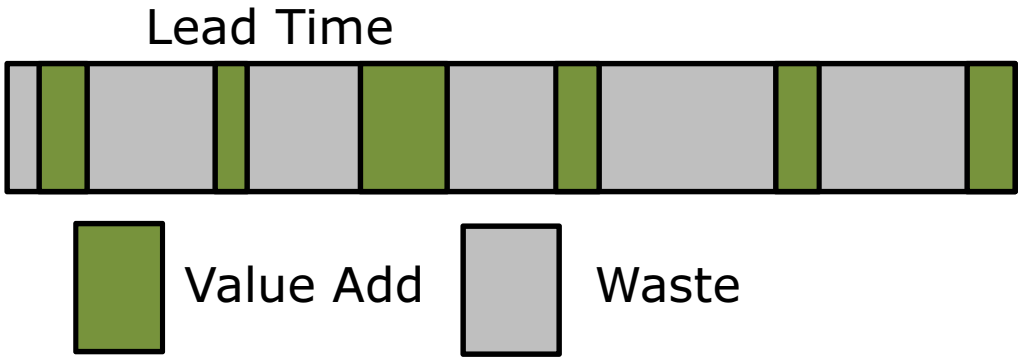
Lean Product Development Principles

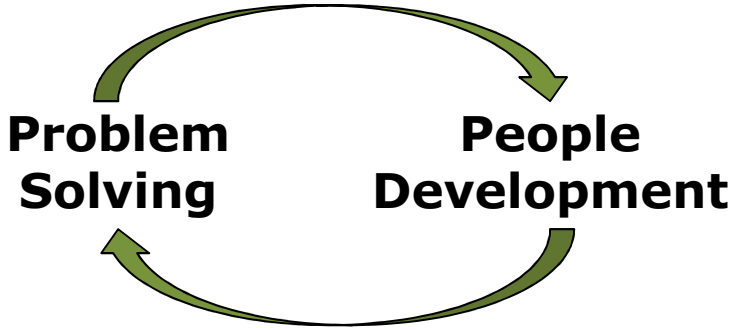
5. Develop a "Chief Engineer System" to Integrate Development from start to finish.
6. Organize to balance Functional Expertise and Cross-functional Integration.
7. Develop Towering Technical Competence in all Engineers.
8. Fully Integrate Suppliers into the Product Development System.
9. Build in Learning and Continuous Improvement.
10. Build a Culture to Support Excellence and Relentless Improvement.

11. Adapt Technology to Fit your People and Process.
12. Align your Organization through Simple, Visual Communication.
13. Use Powerful Tools for Standardization and Organizational Learning.

1. Establish customer-defined value to separate value added from waste.
2. Front load the product development process to thoroughly explore alternative Solutions while there is Maximum Design Space.
3. Create a leveled Product Development Process Flow.
4. Utilize Rigorous Standardization to Reduce Variation, and Create Flexibility and Predictable Outcomes.

What is Lean?





"Lean Thinking provides a way to make work more satisfying by providing immediate feedback on efforts to convert *muda* (waste) into value." (Womack & Jones 1996)

"The real goal of lean is excellence, which means creating a flexible, adaptable learning organization of people and processes that can achieve ever more challenging business goals." (Liker & Franz 2011)

Are problems solved to eliminate waste or is waste removed to make problems easier solve?

Challenges in Complex Product Development

Manufacturing	Complex Product Development
Repetitive production.	Every project is unique.
Cycle time measured in seconds, minutes.	Cycle time measured in weeks, months, years.
Lower levels of differentiation with most workers from the same region and similar technical depth levels (within a plant).	High levels of differentiation leading to communication breakdowns across a diverse group with regional and technical depth differences.
Sequential interdependence within a function.	Reciprocal interdependence across functions.
Line workers usually working together on the same unit.	Technical specialists working semi-autonomously for a group goal.
Tasks and expected durations are clearly defined (cycle time 45 seconds).	High degree of ambiguity for the task at hand. What is / are the task(s) to be done?
Finite value added tasks. Focus on eliminating waste to increase the ratio of value added time / total time.	Objective is value creation. Focus on enabling value creation in addition to eliminating waste to increase the ratio of value added time / total time.
Knowledge created not usually incorporated into the work for that unit.	Knowledge generated might change the next step.
Opportunities are usually related to eliminating waste in processes (barriers to effective problem solving).	Opportunities are usually related to achieving integration / alignment (barriers to effective problem solving).

Approaches to Achieve Integration

Approach	Methodology	Interdependence	Key Tools
Stage Gate System	Reduce variation w/ defined activities within stages. Gate reviews between stages to determine if project proceeds	Sequential within defined stages. Reciprocal at gate reviews.	High level definition for common understanding. Gate reviews for discipline, evaluation, and alignment of resources.
Product Lifecycle Management	Manage product lifecycle by defining and making available all relevant information	Sequential with all aspects defined	High level definition for common understanding. Software provides access to all information.
Concurrent Engineering: Dedicated Collocated Teams	Cross-functional teams dedicated to project. Team members share all information to ensure mutual understanding	Reciprocal with mutual adjustment in meetings	Dedicated collocated teams
Lean Product Development	Cross-functional teams meet to resolve cross-functional issues and achieve mutual understanding while remaining in functional areas to maintain technical competence	Reciprocal with mutual adjustment	Standardized processes for common understanding. Chief engineer to coordinate and integrate work across functions. *Obeya* to highlight and enable the solving of cross-functional issues