ABEPRO

Principles and Characteristics of Lean Product Development Systems

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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

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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

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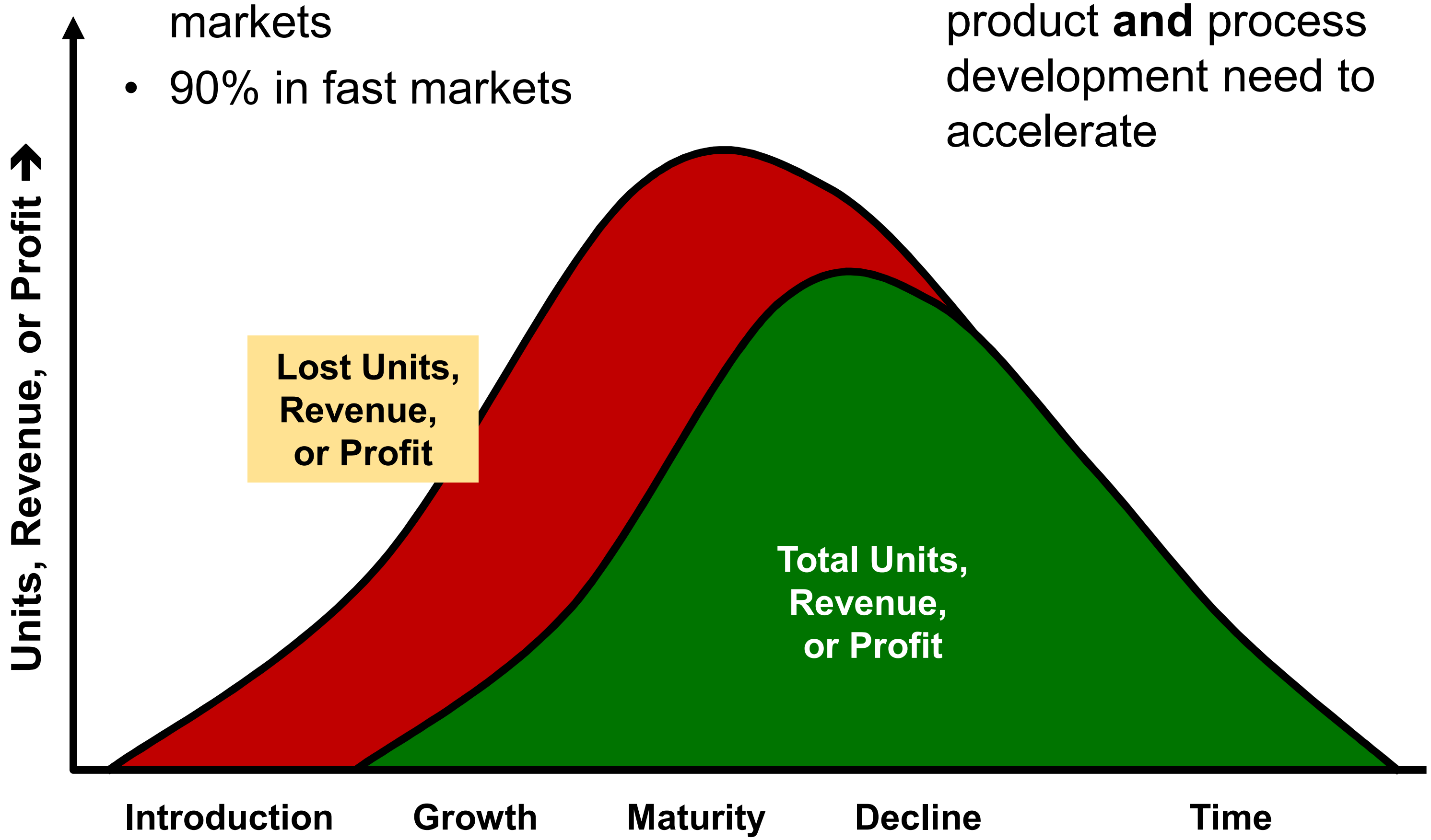
Fast Product and Process Development is Key for the Success of Organizations

- 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



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.

Bart Huthwaite, The Lean Design Solution (2004)

- Hasty development decisions can lead to:
  - Quality loss
  - Additional costs
  - Slow market introduction
- Challenges include
  - Continuously changing customer requirements
  - Accelerated learning
  - Knowledge retention

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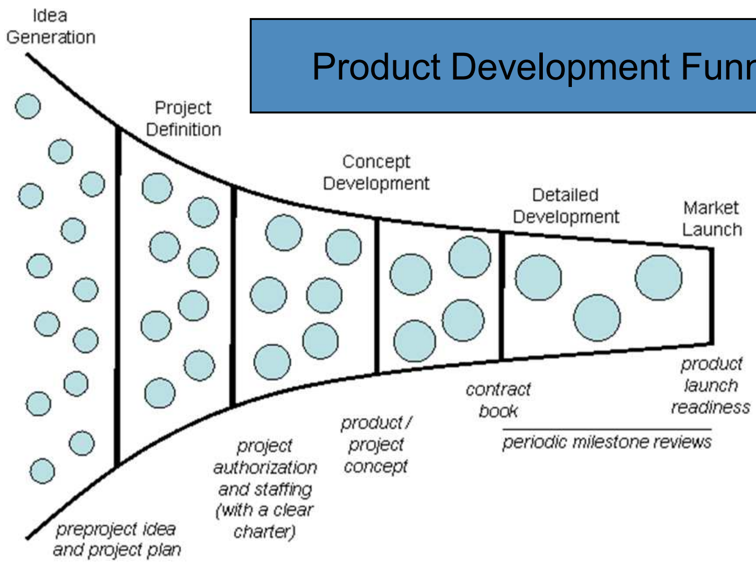
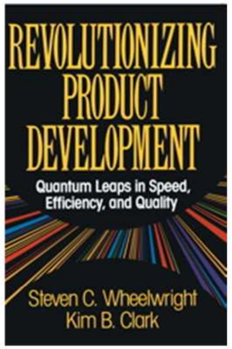
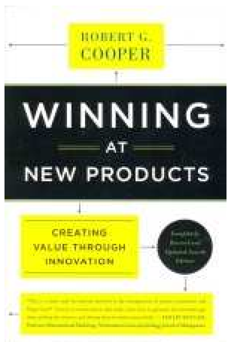
Traditional Product & Process Development Approaches are Under Pressure

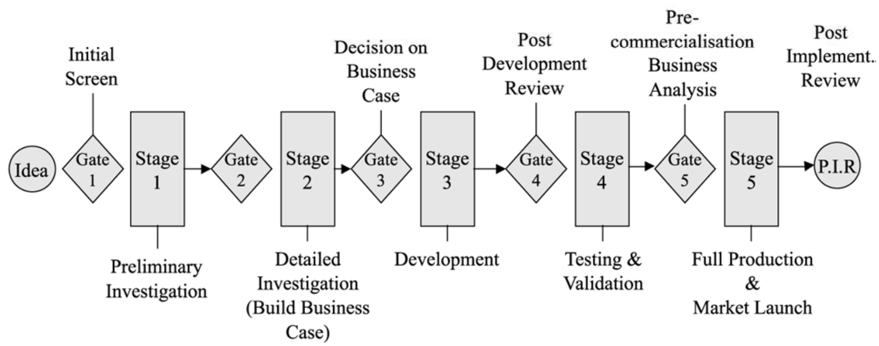
Product Development Funnel





Stage Gate System





Source: Cooper (1994)

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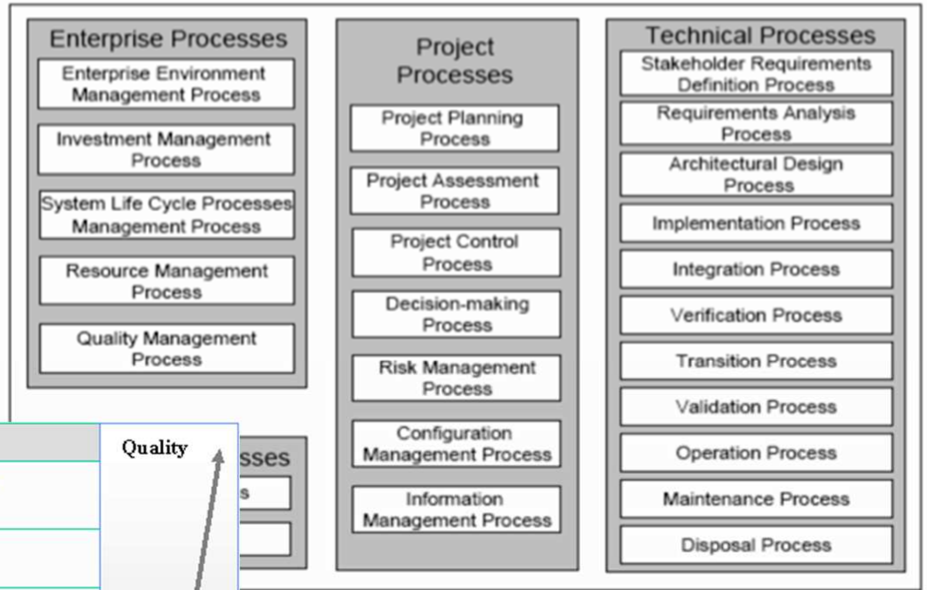
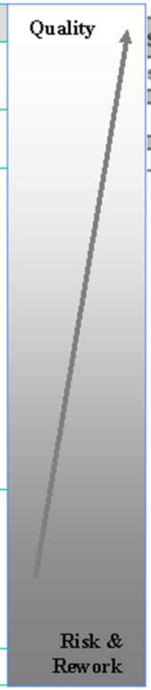
Traditional Product development approaches are under pressure



Capability Maturity Models Integrated

Maturity Level	Focus	Process Areas
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		



ISO 15288 – Systems Engineering Life Cycle Processes

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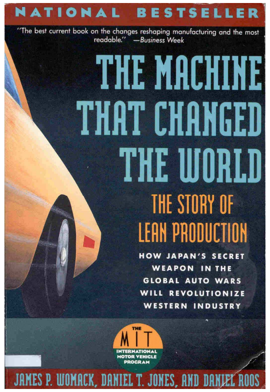
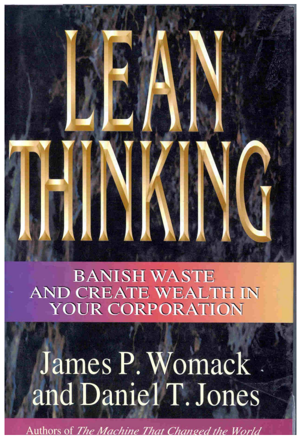
Evolution of Lean

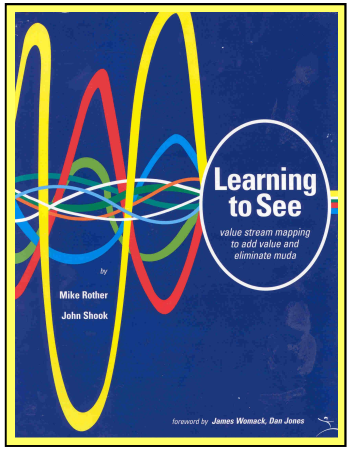
Taiichi Ono and Eiji Toyoda – Toyota Production System (1949)



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

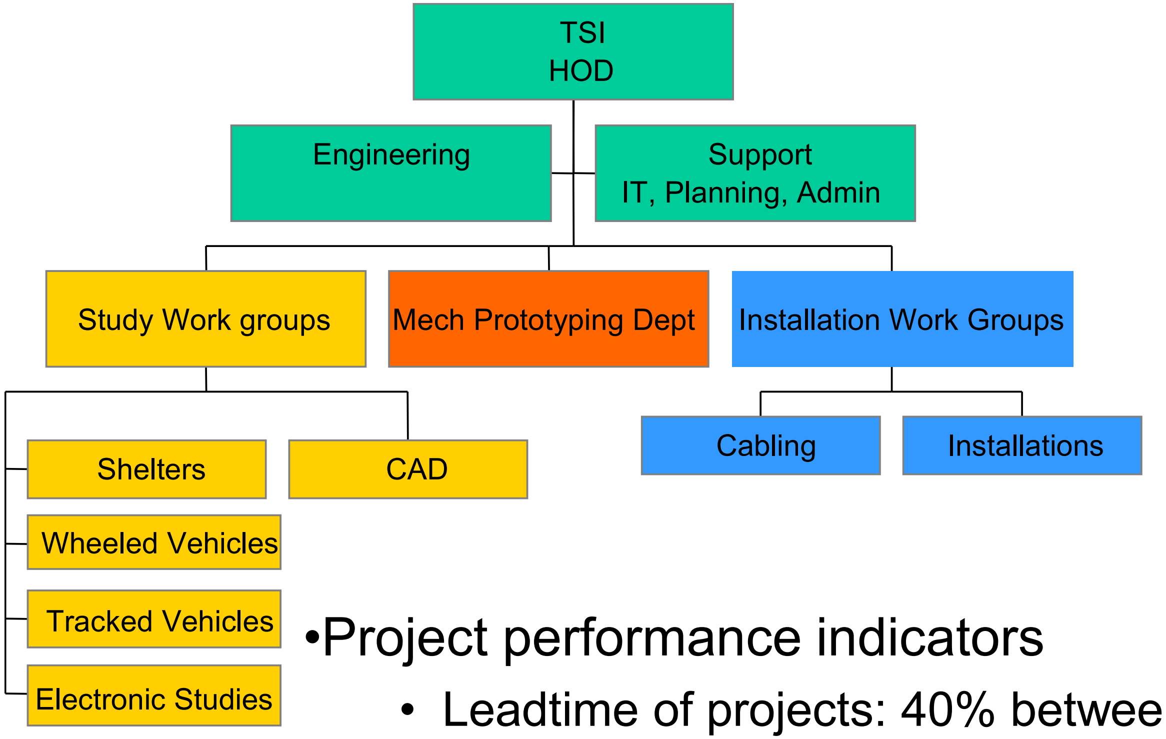
Case Study Environment

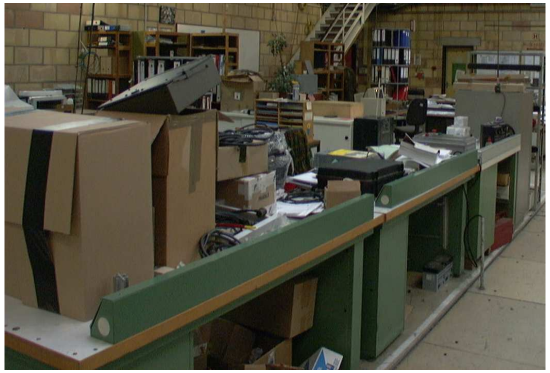
- Department of Technical Studies and Installations of the Belgian Armed Forces
    - Design and installation of Communication and Information Systems (CIS) in military vehicles
    - Radio-transmitters, satellite communication systems, GPS, etc.
    - 74 personnel, 82 ongoing projects

    - Poor performance on project lead time
    - Threath of outsourcing

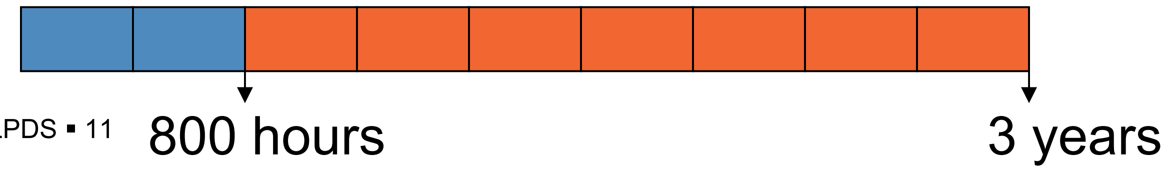
- Integrated Transformation Effort
    - Initial improvement initiative focussed on a complex and critical installation project
    - Roll-out of new process to other projects after initial success.

Department Structure and Functional Groups





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



Waiting: at least 78%!

There is Plenty of Waste in Product Development

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

Additional illustrations:
"Value Stream Analysis and Mapping for PD",
R. Millard, MS Thesis, MIT, June 2001

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

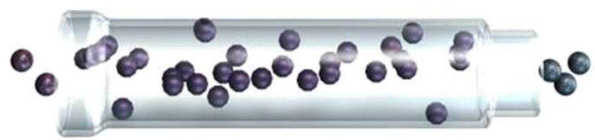
$$Value \cong \frac{Performance \times Service}{Cost \times Time}$$

The Identification of Value

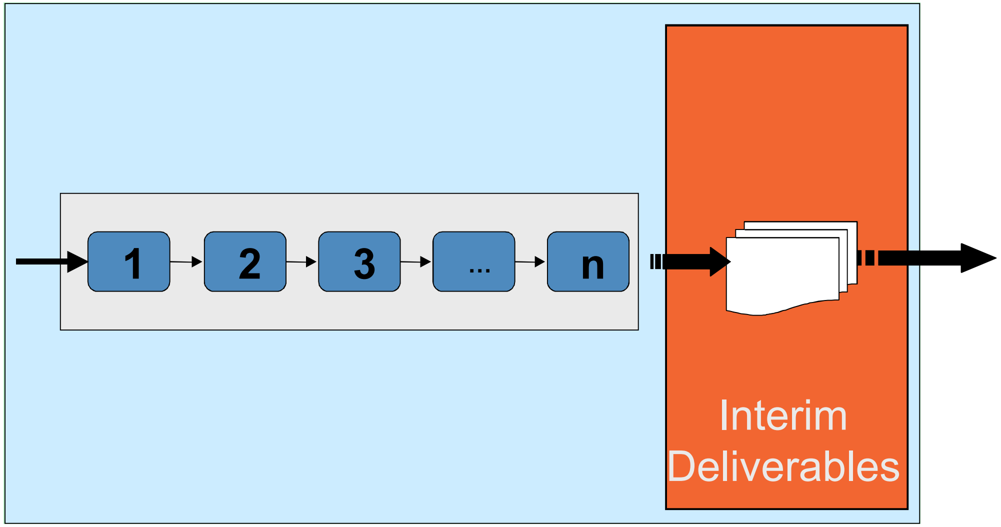
- To support the identification and creation of Value, Browning introduced the “Atoms of Value” concept:
  - Atom of value are a set of activities that lead to valuable interim deliverables
  - These atoms of value
    - increase stakeholder value
    - by enhancing performance and reducing risks

- 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”

$$Value \cong \frac{Performance \times Service}{Cost \times Time}$$



Atoms of Value (Browning)

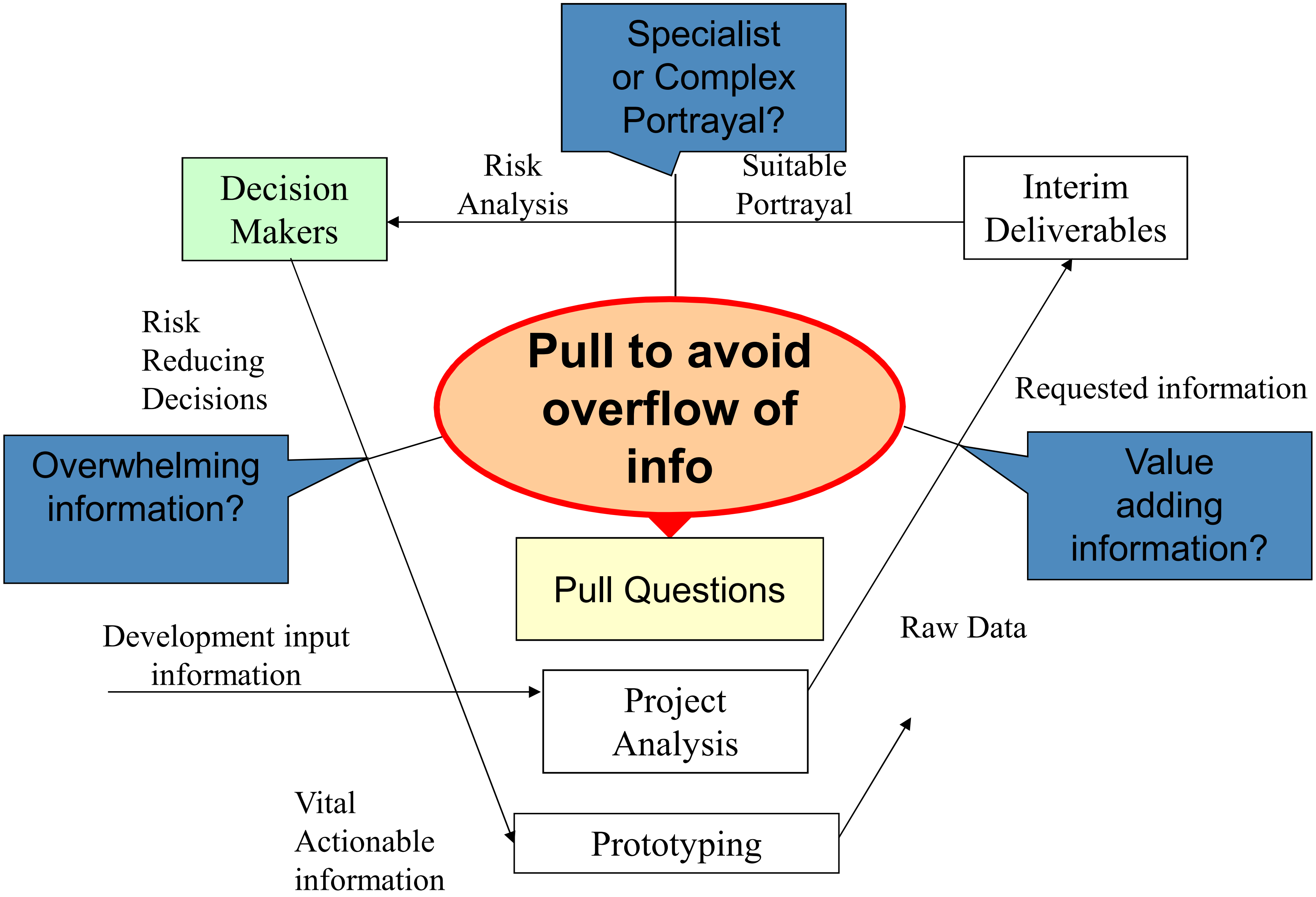


Increase stakeholder value by enhancing performance and reducing risks

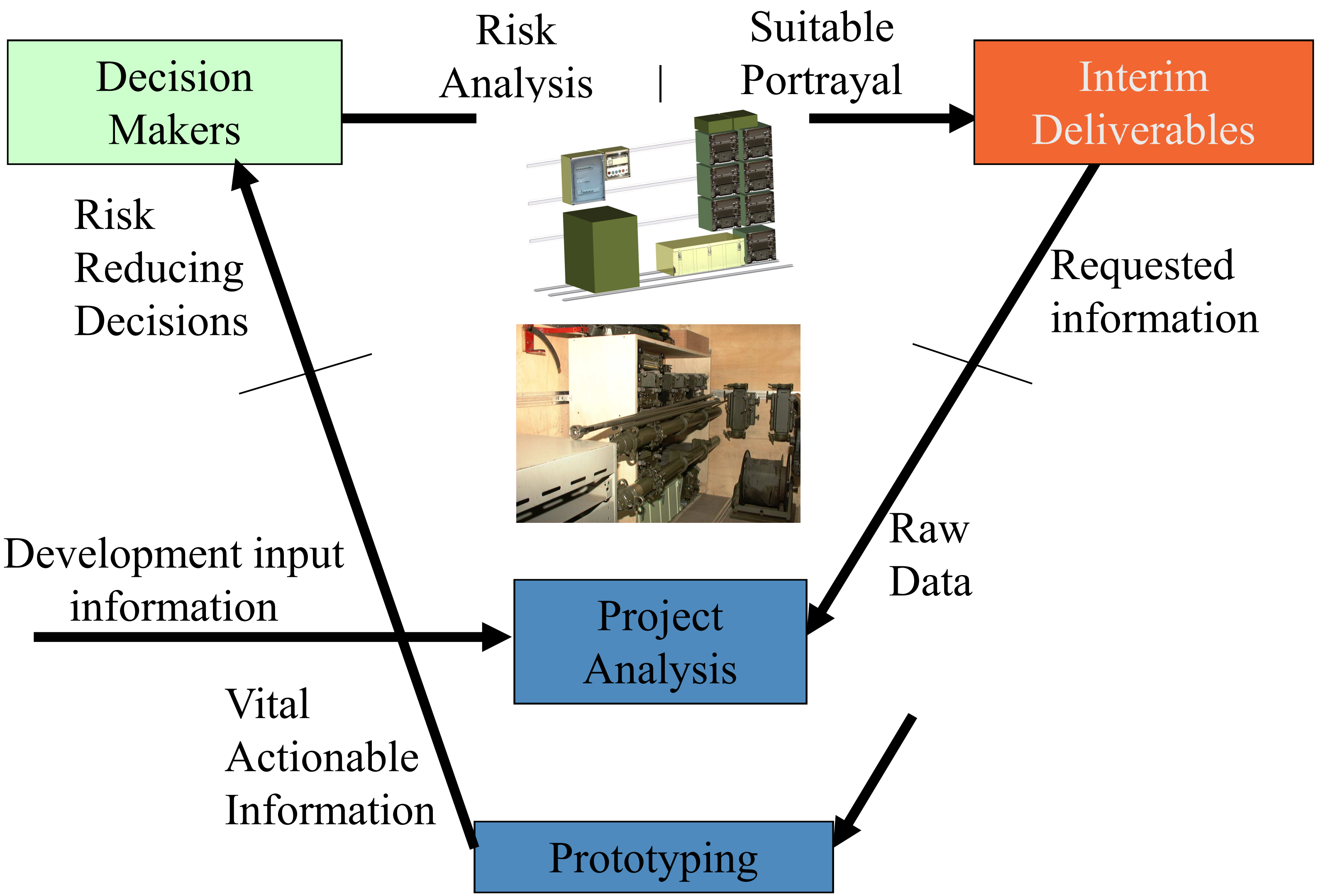
- <u>Atoms of Value</u>
    - Development activities that lead to valuable interim deliverables

Mind the ISO/CMMI Trap!

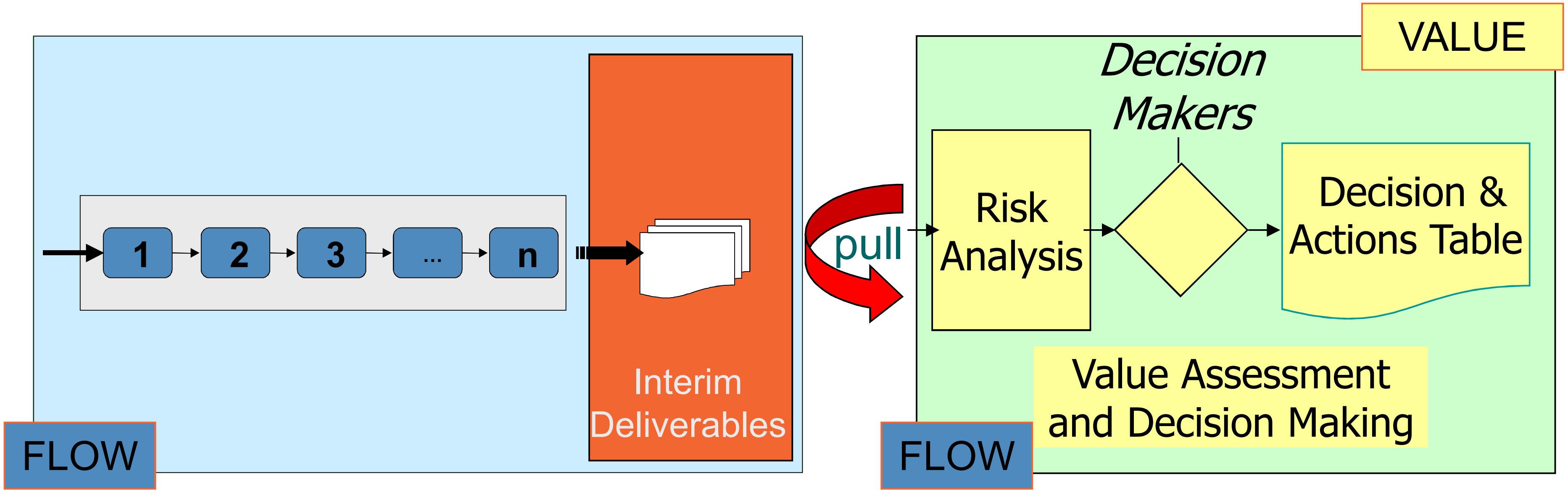
Product Development Push



Pull-based Product Development



The Lean Atom of VAlue (LAVA) Model



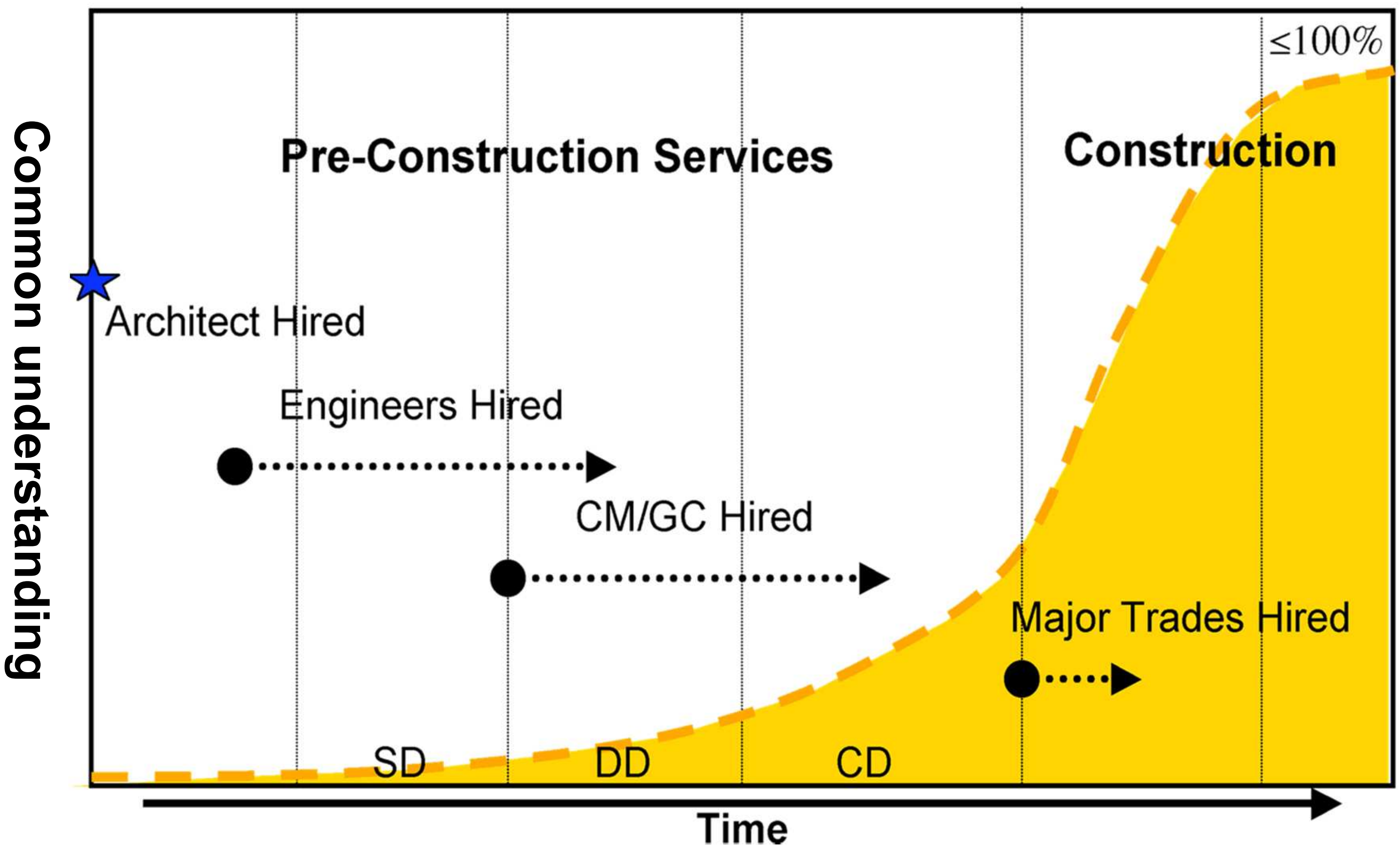
- <u>Atoms of Value (Browning):</u>
  - Development activities that lead to valuable interim deliverables

- <u>Lean Atoms of VAlue:</u>
  - 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

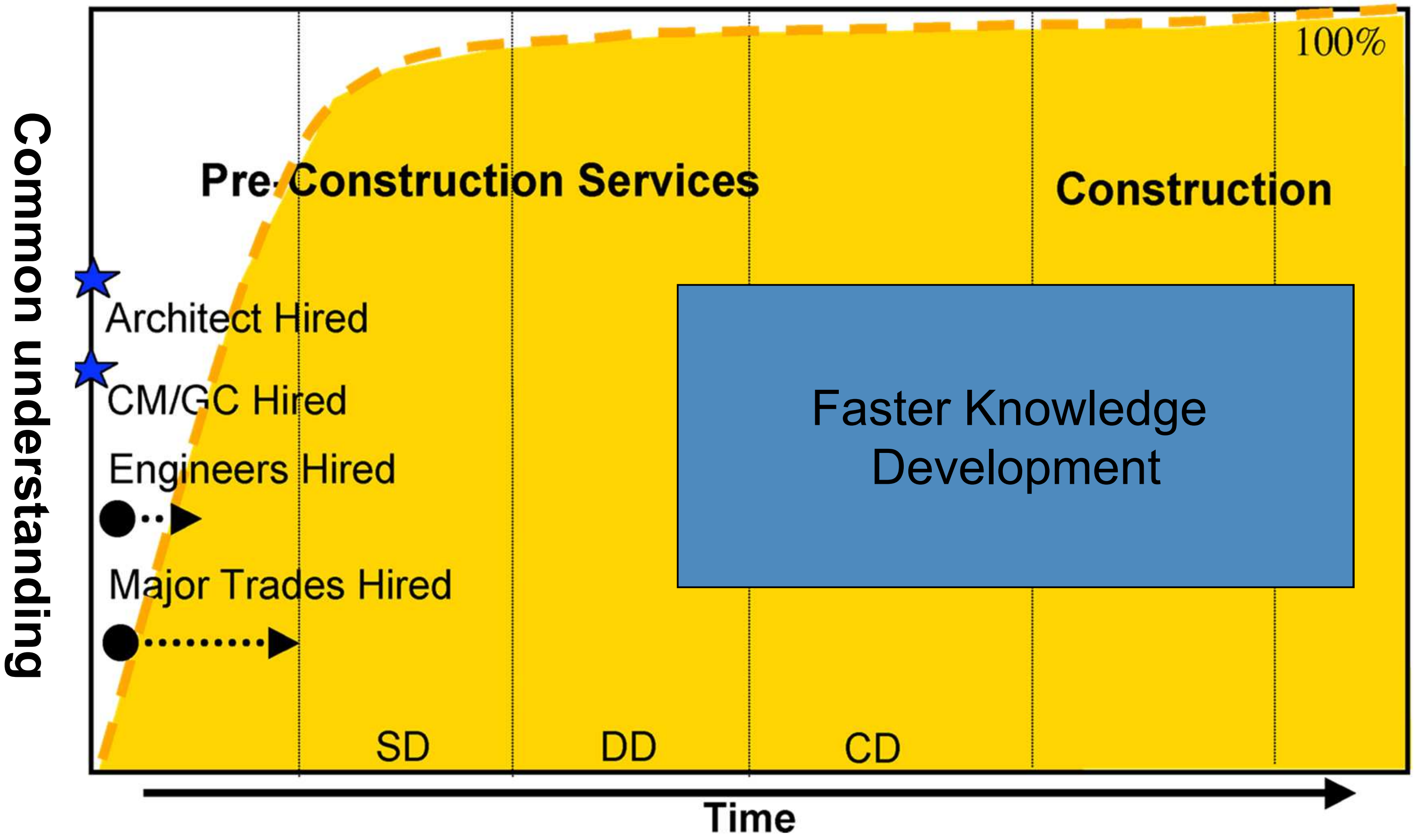
Traditional Product Development



Source: McDonough Holland & Allen PC - Lean Construction Institute

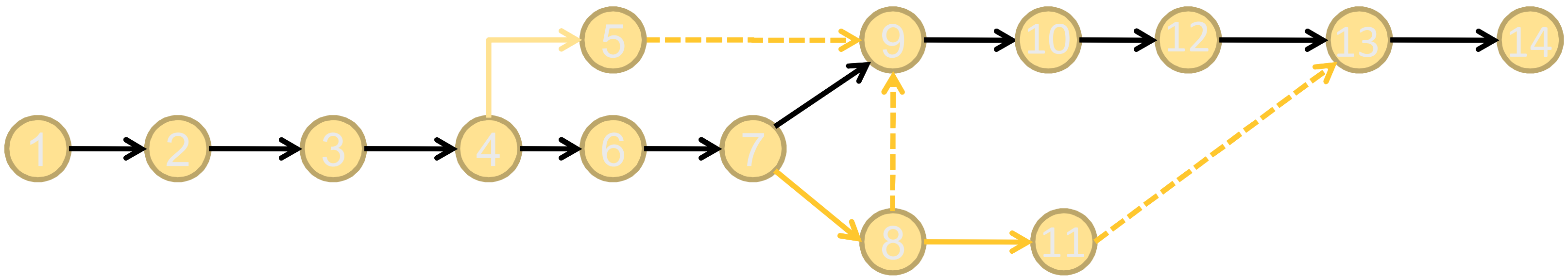
Increase the Level of Common Understanding

Lean Product Development



Source: McDonough Holland & Allen PC - Lean Construction Institute

The Importance of Rework

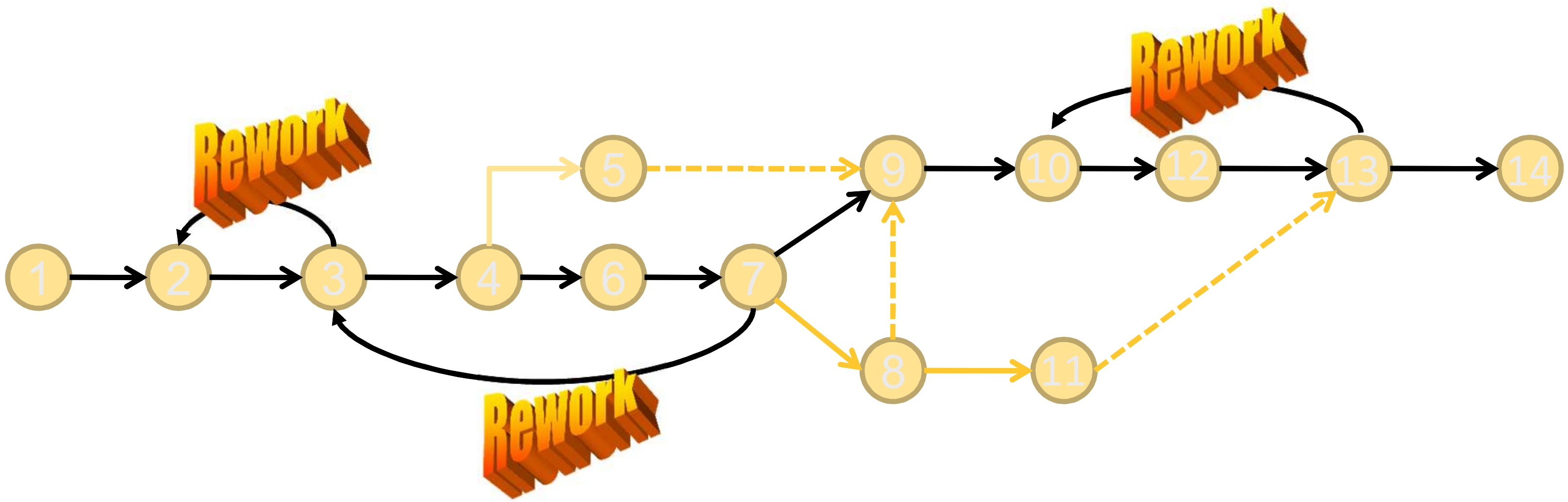


Event

Non-critical activity

Critical activity

Dummy Activity



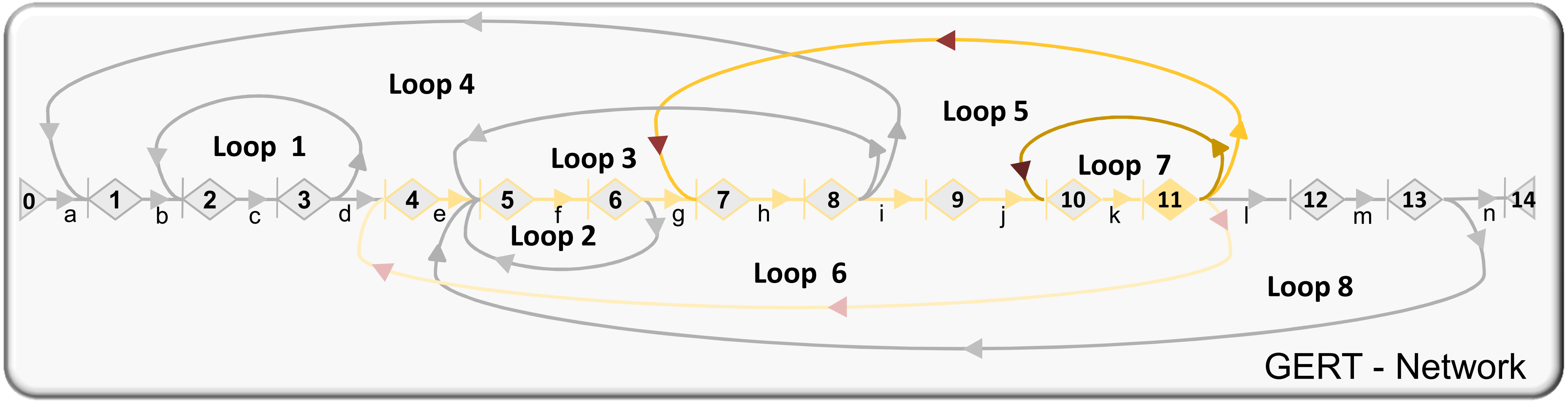
AOA-network diagram

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

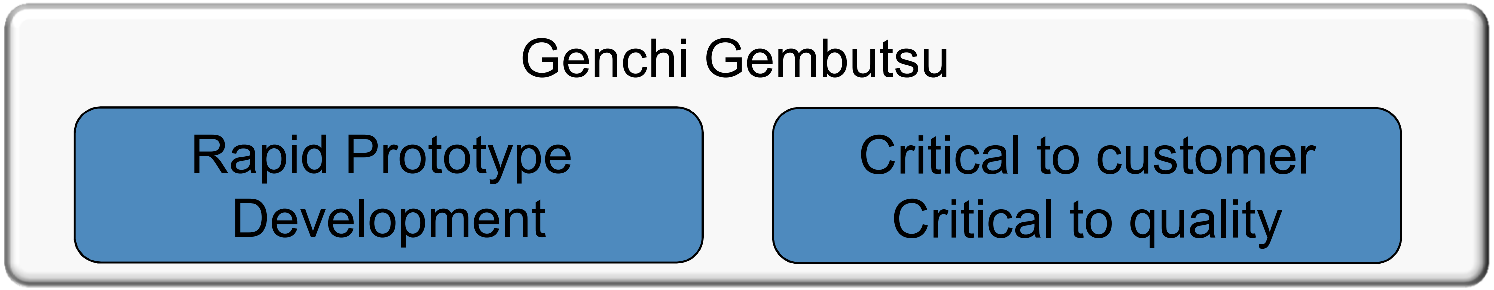
Risk-based decision making



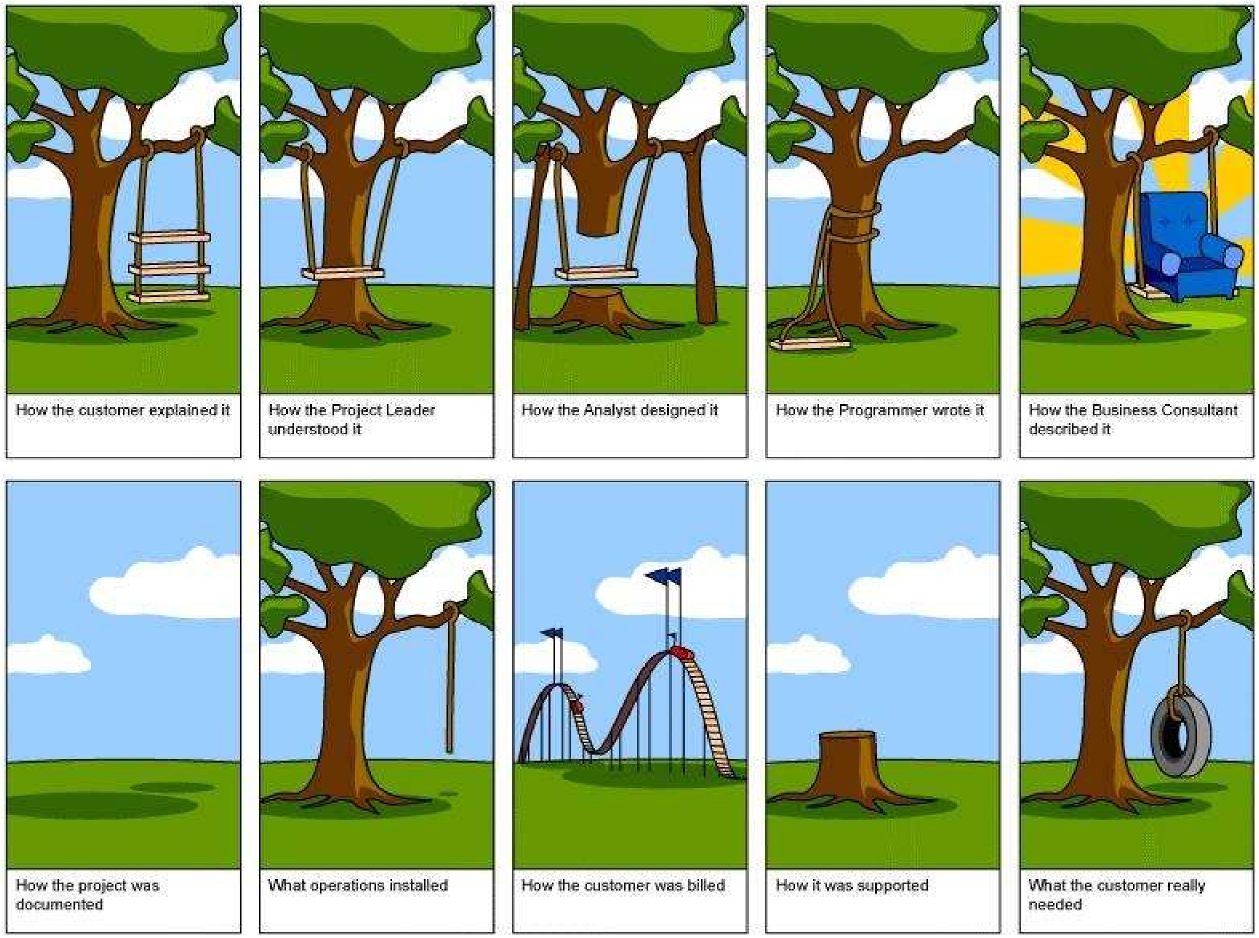
Martínez, Farris & Hernández 2010

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)



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

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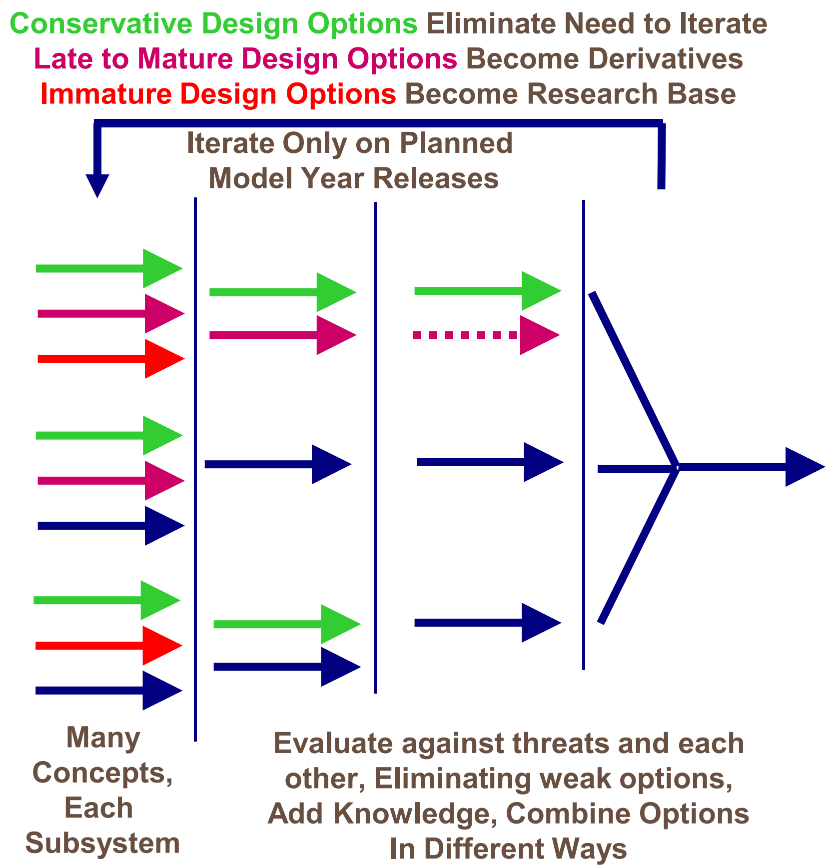
Set-based Concurrent Engineering

- 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

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

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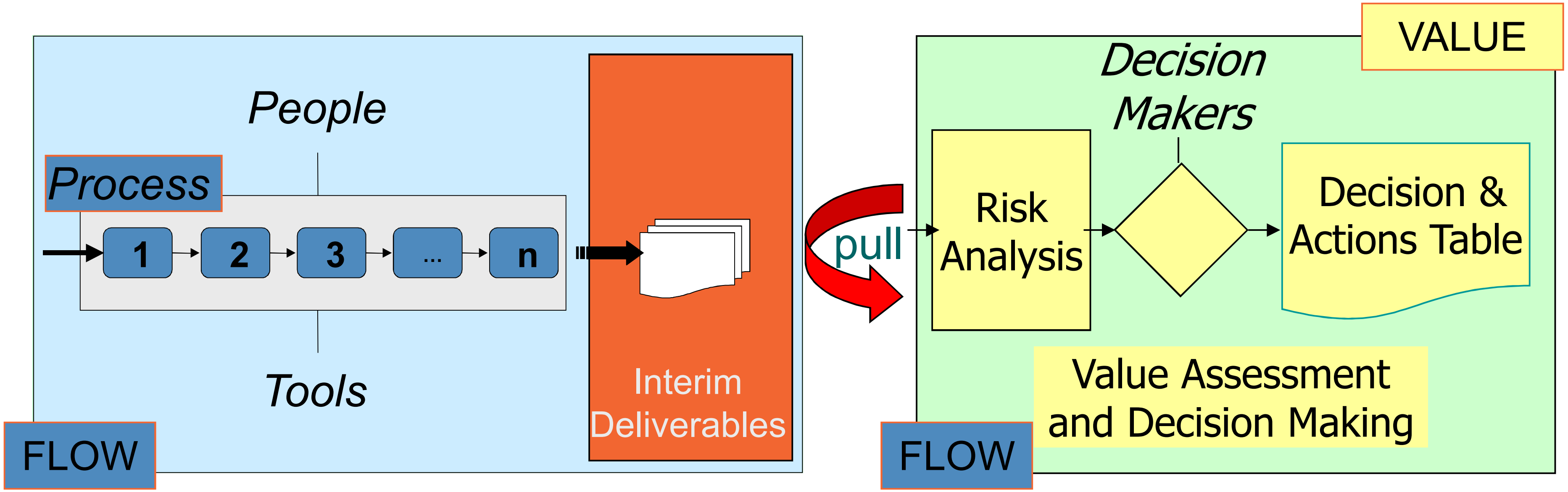
Characteristics of LAVAs



- <u>People:</u>
  - Concurrent team
- <u>Process:</u>
  - Only required steps
- <u>Tools & guidelines</u>
  - Virtual Prototypes, Mockups: Enabling suitable portrayal of interim deliverables

- <u>Interim Deliverables:</u>
  - Facilitating Risk Analysis and Value Identification
- <u>Decision makers</u>
  - Balance importance of different stakeholders
- <u>Decision & Actions Table</u>
  - Lean documentation (A3-Reports)

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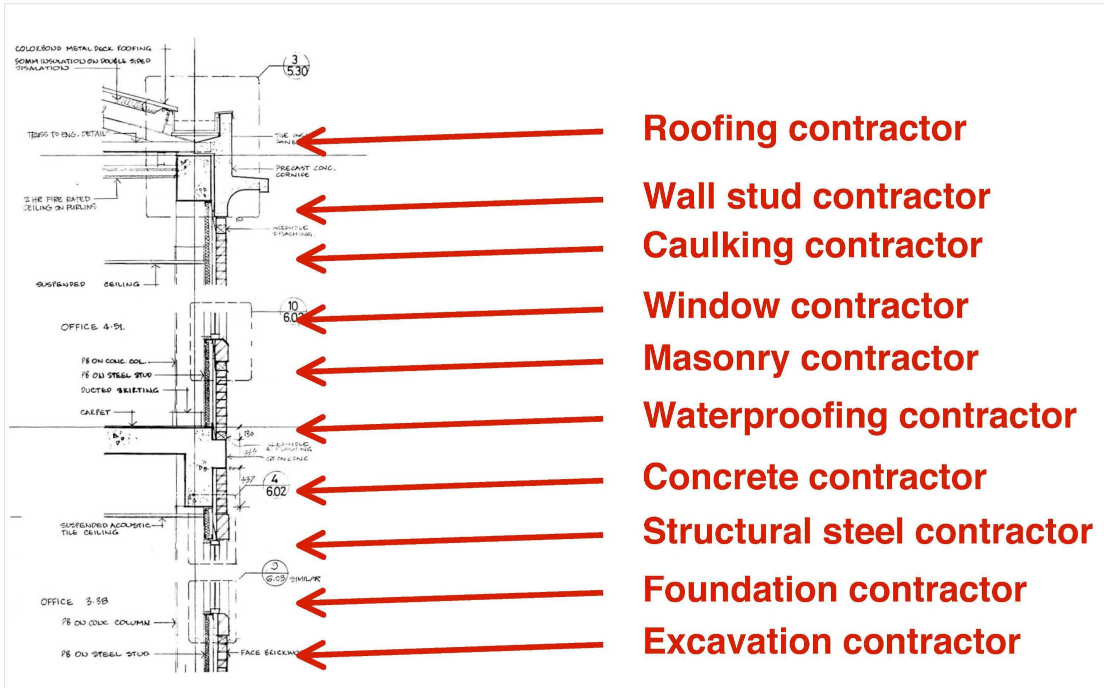
Socio-technical dimensions of LPPD

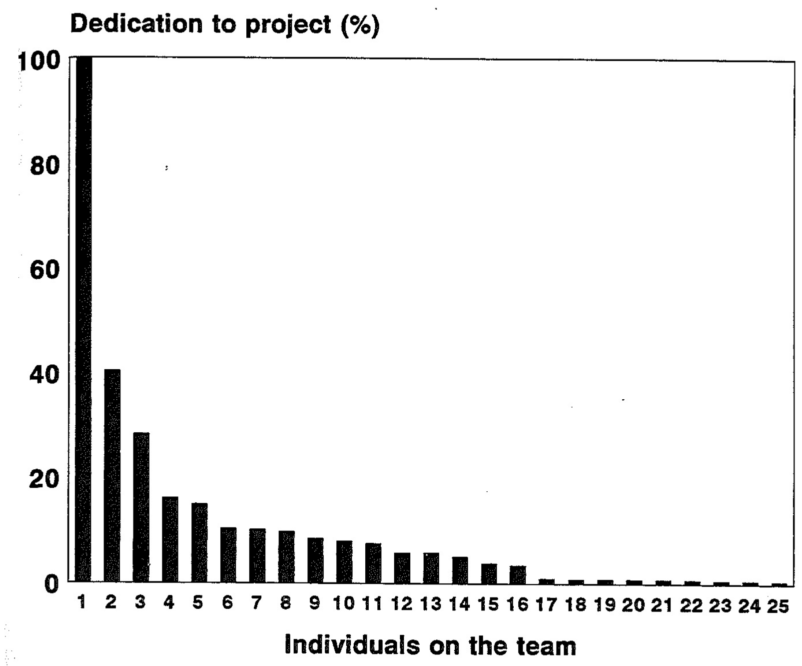
Buildings Leak at the Intersection of Contracts



Source: McDonough Holland & Allen PC – Lean Construction Institute

- Successful LPPD is more than the application of tools the successful application of Lean tools
- It implies the creation of project and functional teams
  - Communication
  - Trust
  - Shared identity
- The creation of a learning environment

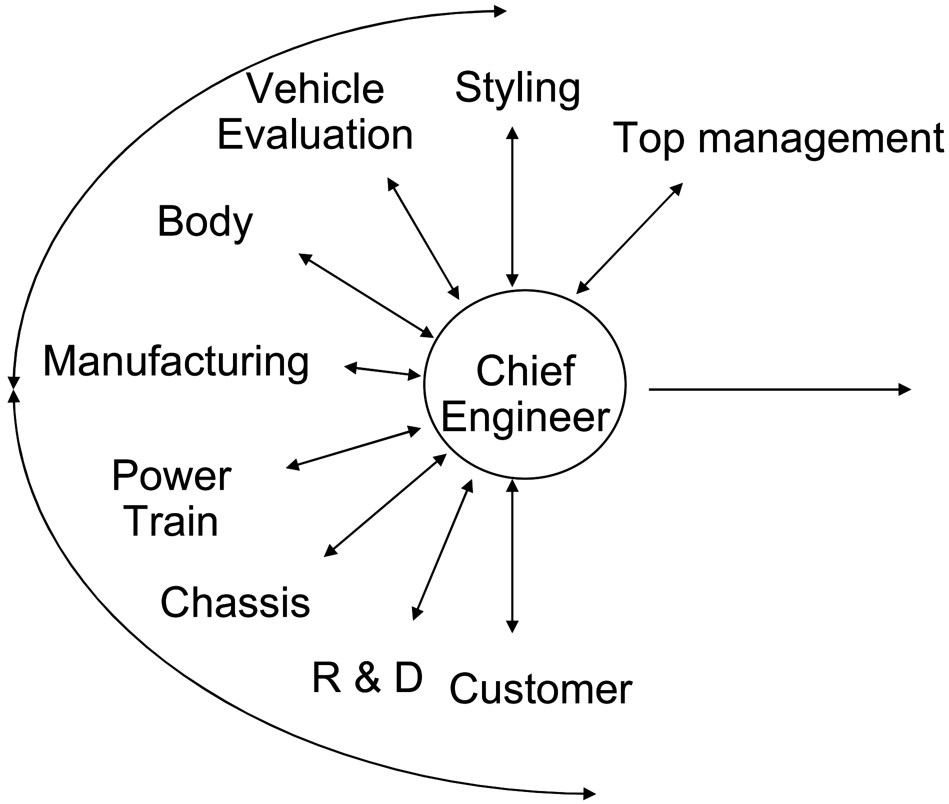
Development Kaizen Events



Staffing with many specialists that have low dedication to the project

- 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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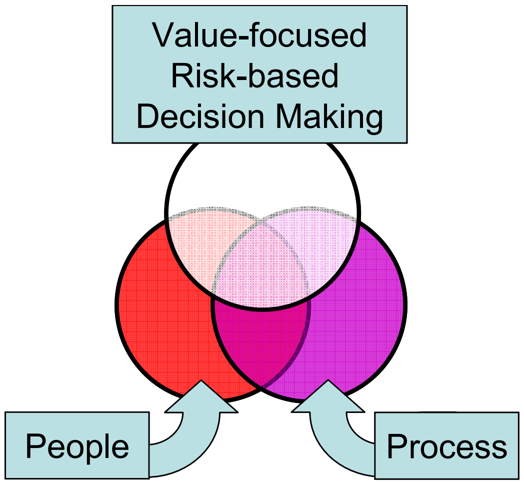
Top 10 Problems in Product Development Organizations

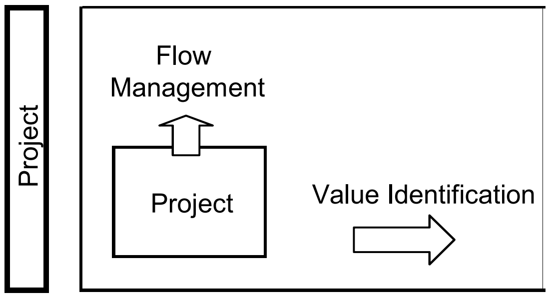
- Poorly defined product requirements
- Gold plating, analysis paralysis
- Late consideration of manufacturability
- Too many meetings
- Poor communication across functional barriers



- Chaotic environment: constant interruptions
- Lack of resources: bottlenecks
- No prioritization of projects/tasks
- Email avalanche
- Disruptive changes to product requirements

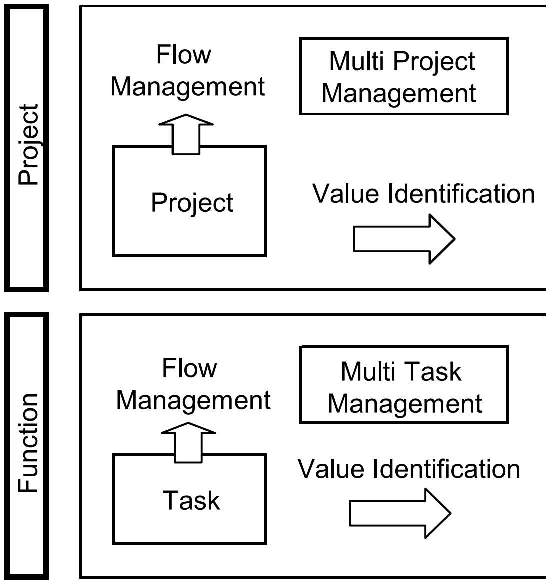
Source: Lean Product Development Guidebook – Mascitelli

Single Project versus Multi-project Management



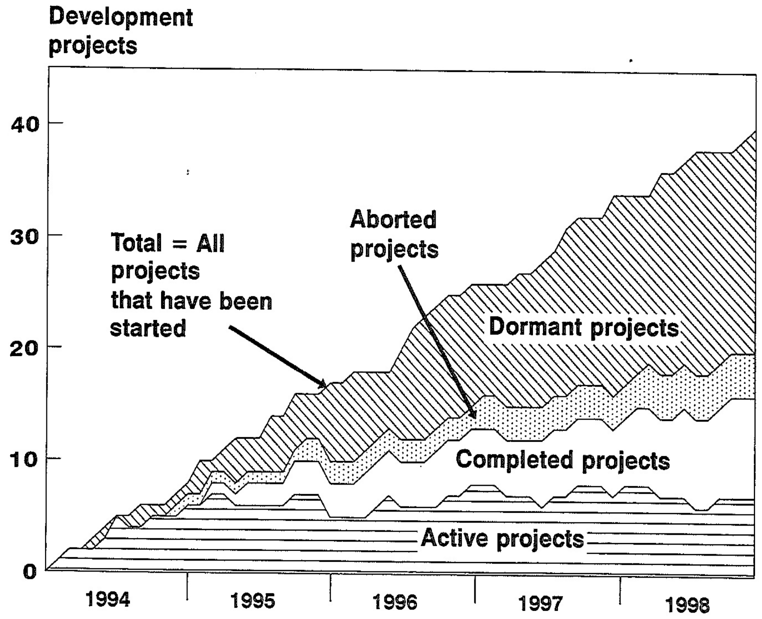
- An important part of the lean product development literature seems to focus on the single project level only
  - Value, concurrent engineering, leadership of the Chief Engineer
- The overall success of organizations is determined by the overall performance of multiples projects
  - Portfolio management
  - Multi-project management
  - Functional constraints

Multiple Projects in Matrix Organizations



- At Toyota, functional specialists build knowledge about one function for several year (Haque and James-Moore, 2004)
- They maintains 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

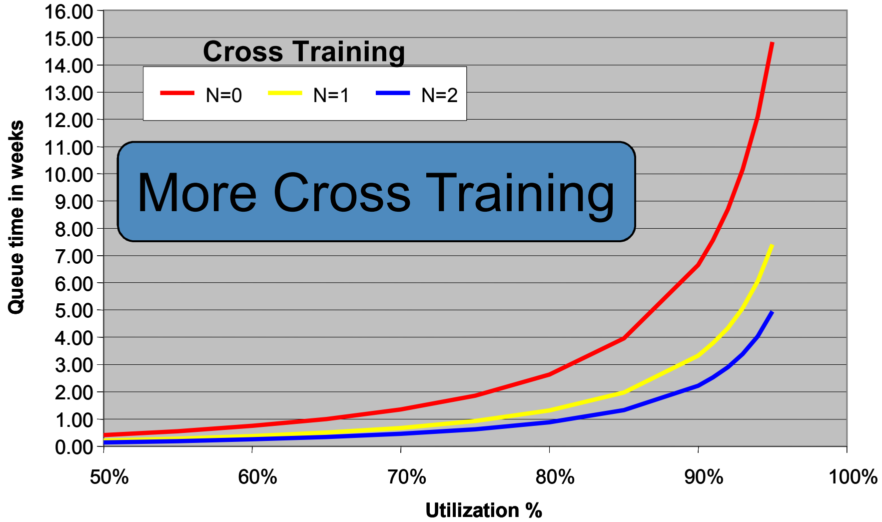


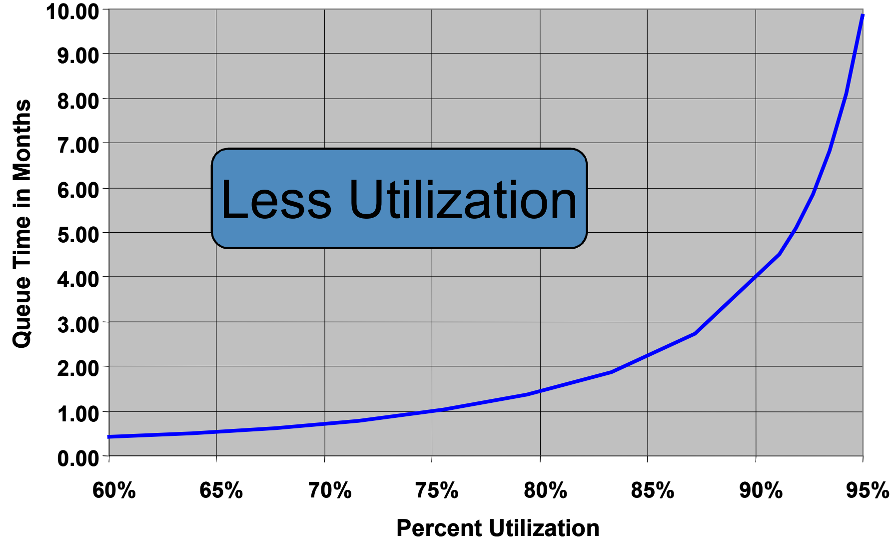
- Little's law:

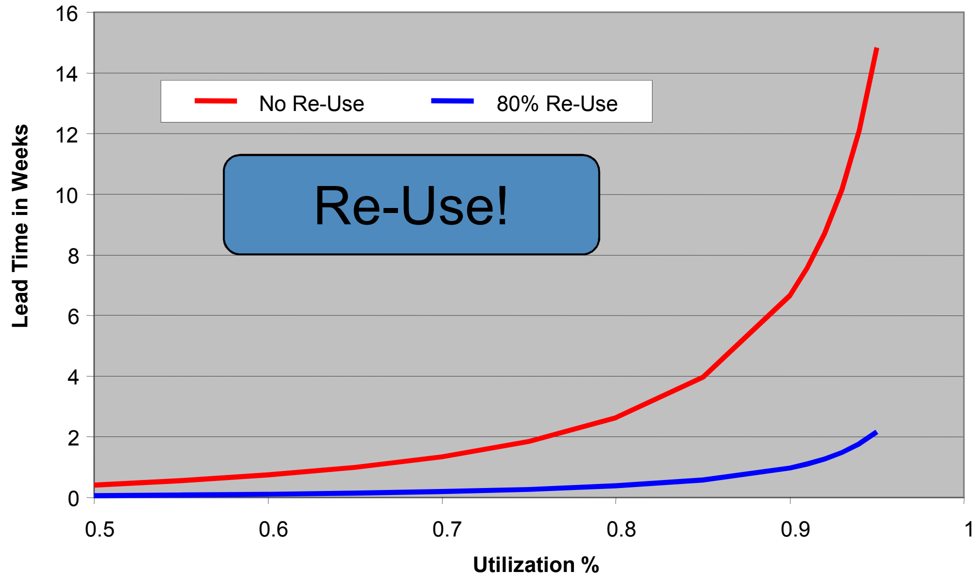
$$\text{PD Lead Time} = \frac{\text{No.of Projects In Process}}{\text{Avg. Completion Rate}}$$

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

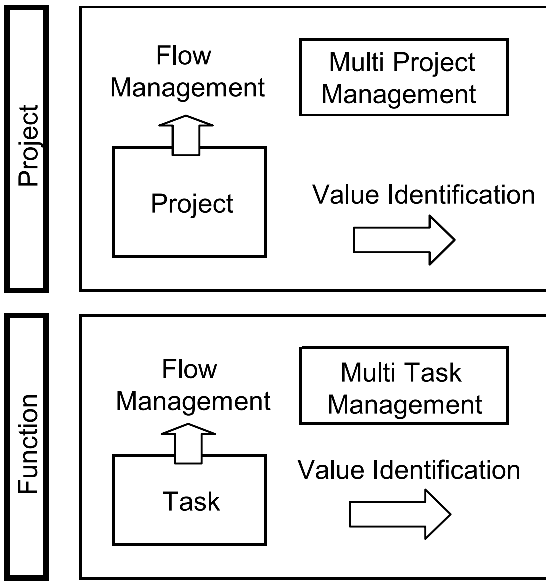
Strategies to reduce WIP



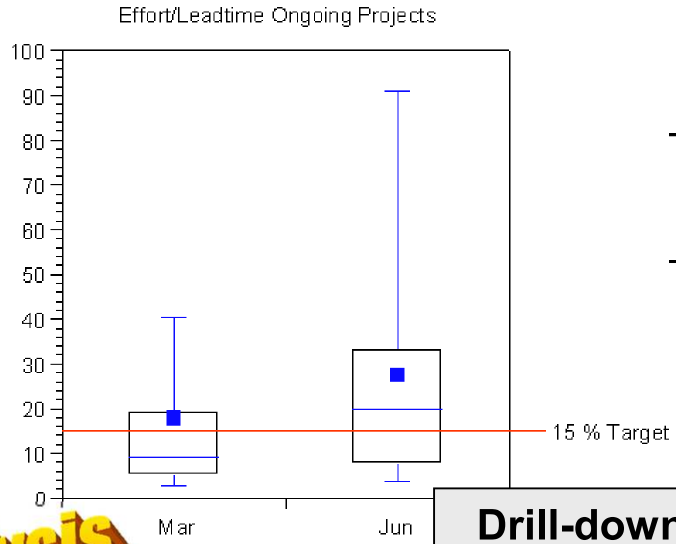




Optimizing value and flow from a functional and project perspective



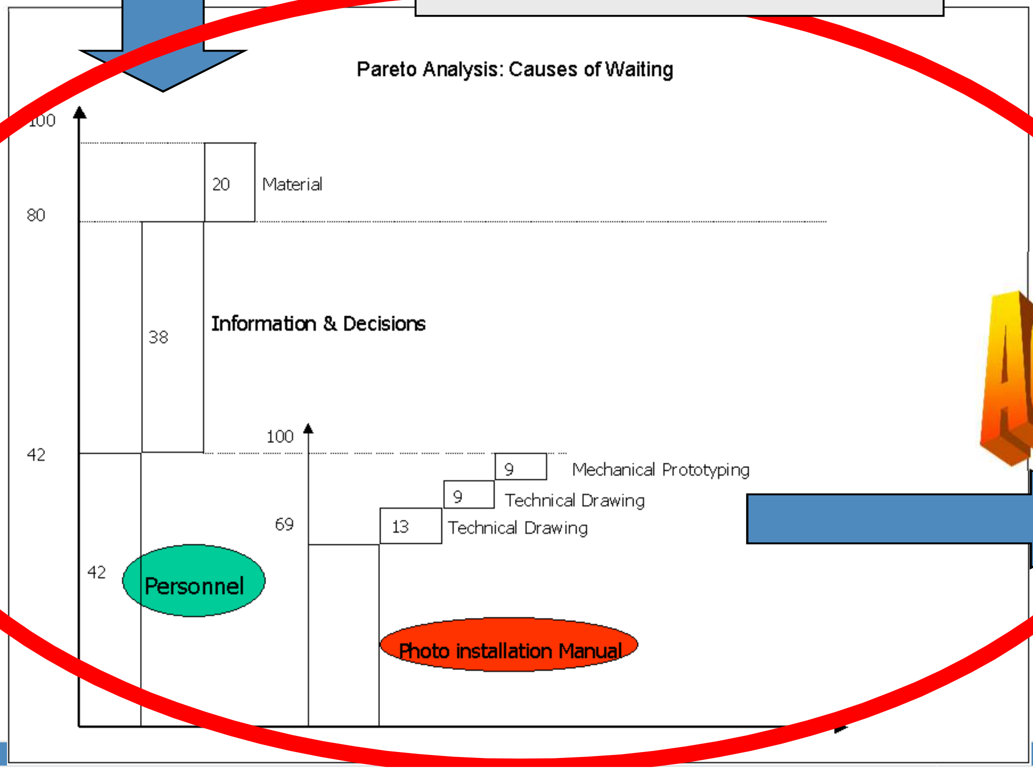
- Bottleneck Management – Critical chain (Goldratt, 1997)
- Managing functional queues (Reinertsen, 1997; Mascitelli 2007)
  - 5S
  - SMED
  - Resource pull
- Prioritization and coordination of multiple projects (Cusumano and Nobeaka, 1998)



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

Analysis

Drill-down Analysis to Identify and Eliminate Constraints



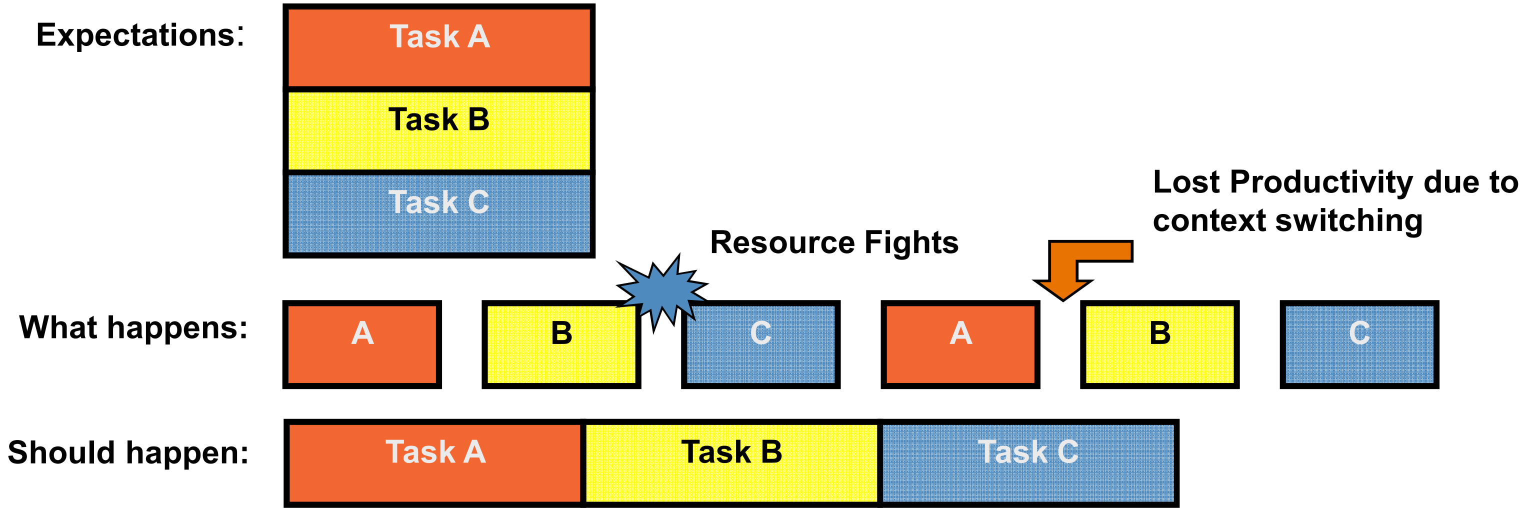
- Optimize functional constraints:
  - 5S
  - Standard Work

Action

Focused initiative to eliminate bottleneck: TOC - Goldratt

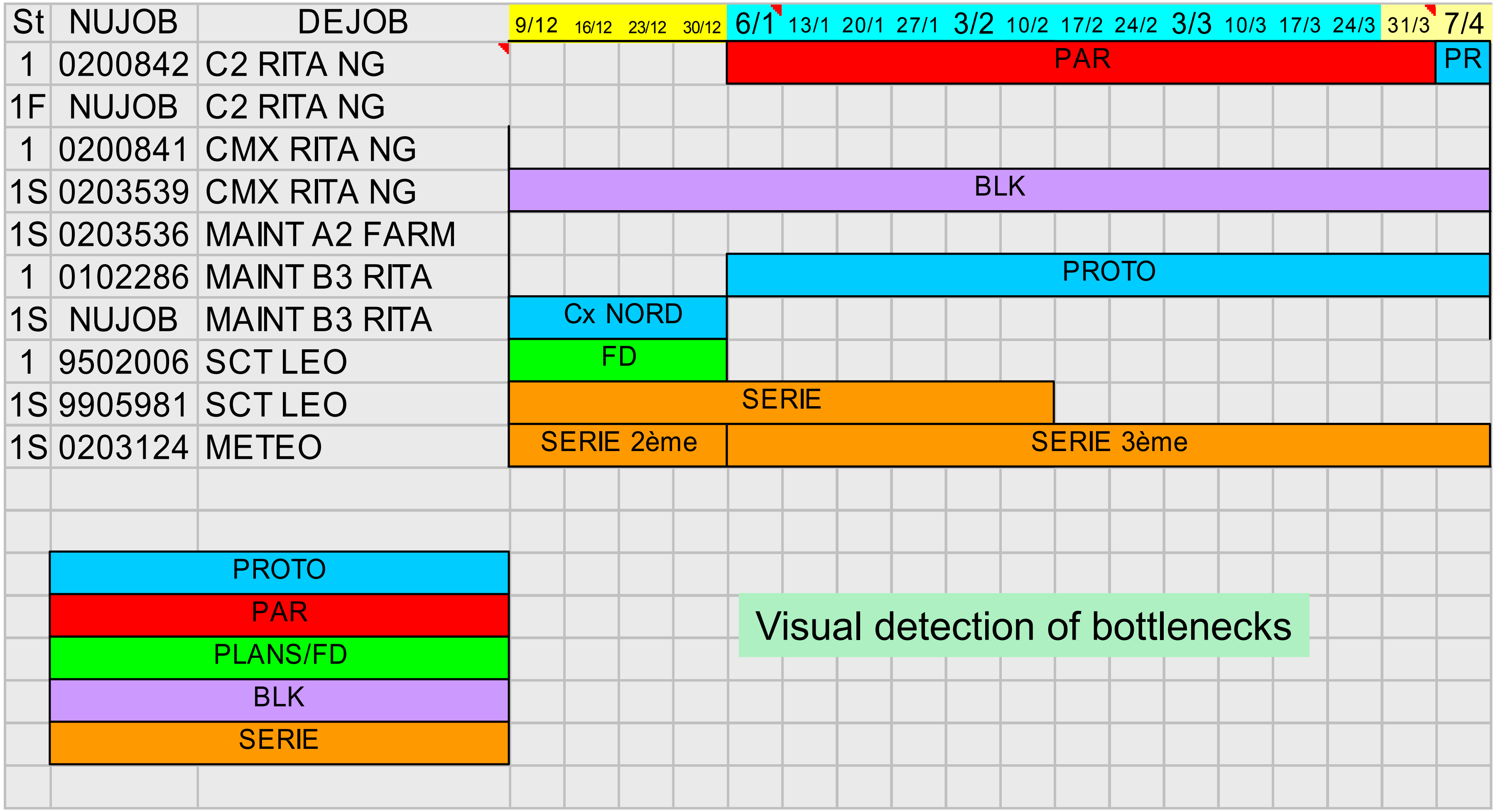
Lean Pipeline Management

- Multitasking can become an insidious generator of waste



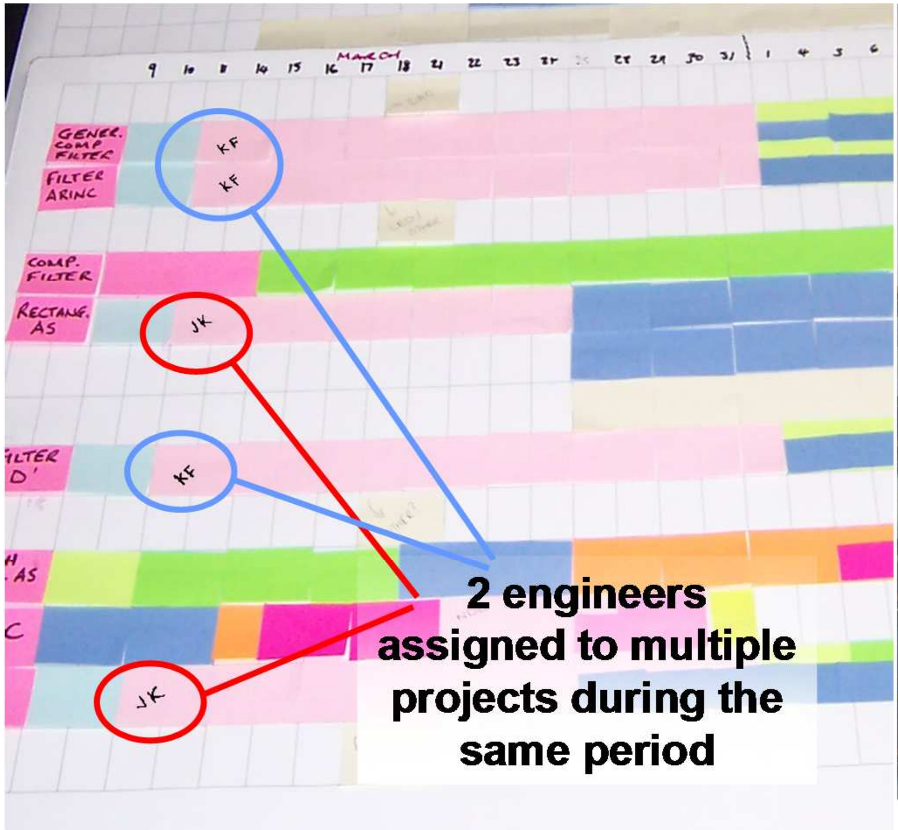
- Rough-cut capacity plan to manage constraints:
  - External : facilitate customer and supplier contacts
  - Internal : Coordinate at:
    - Project Level: avoid push of non-prioritized activities
    - Functional Level: pull excess resources

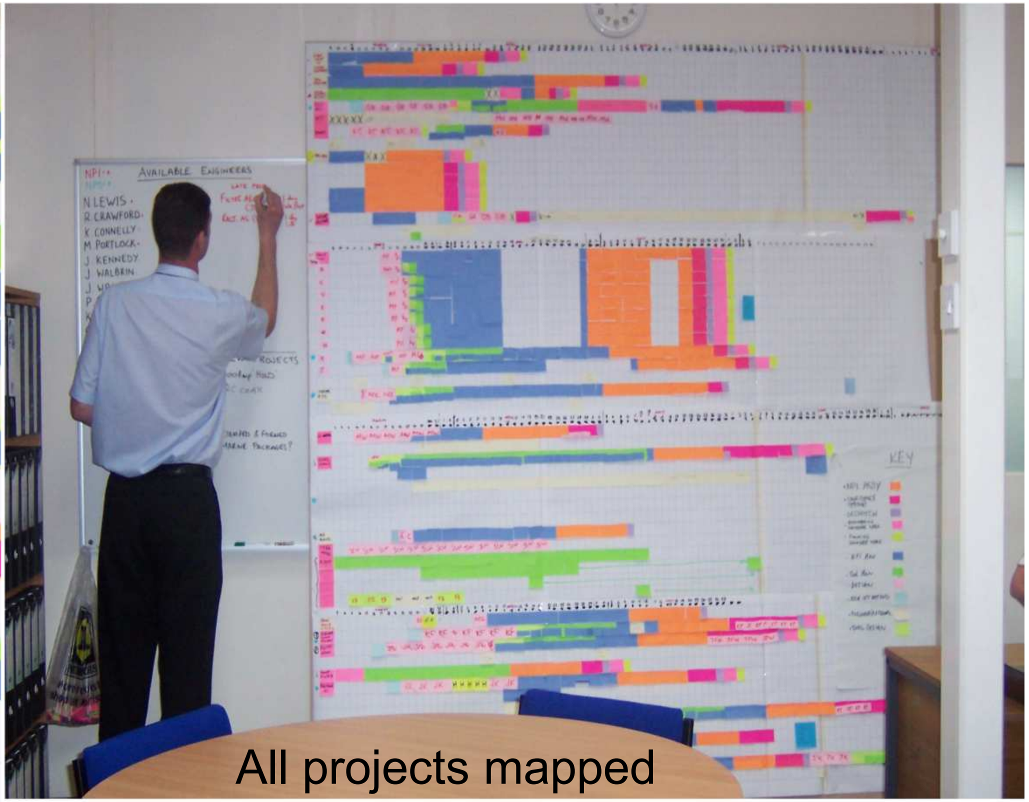
Master Project & Development Schedule
Trimester Planning



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%

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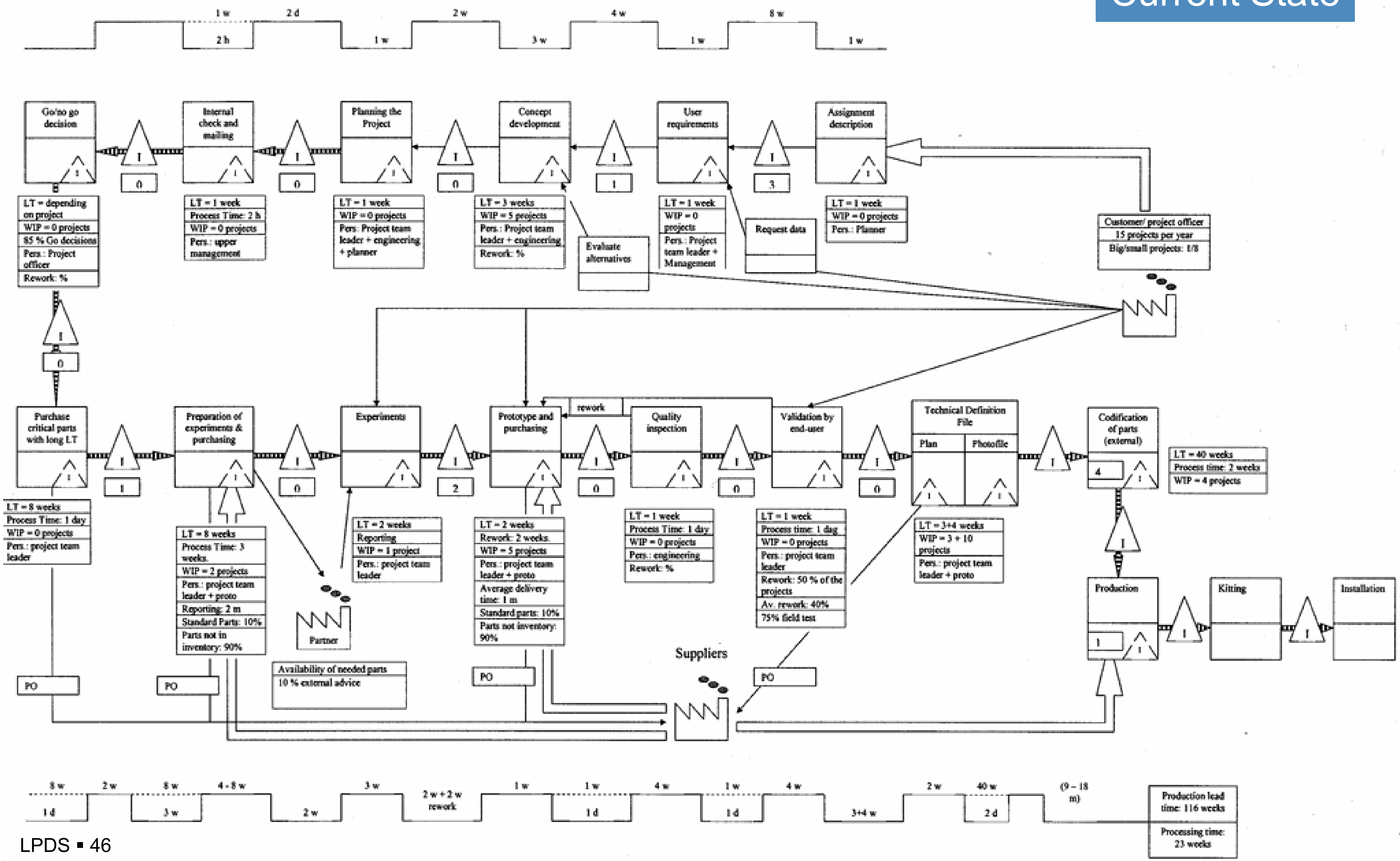
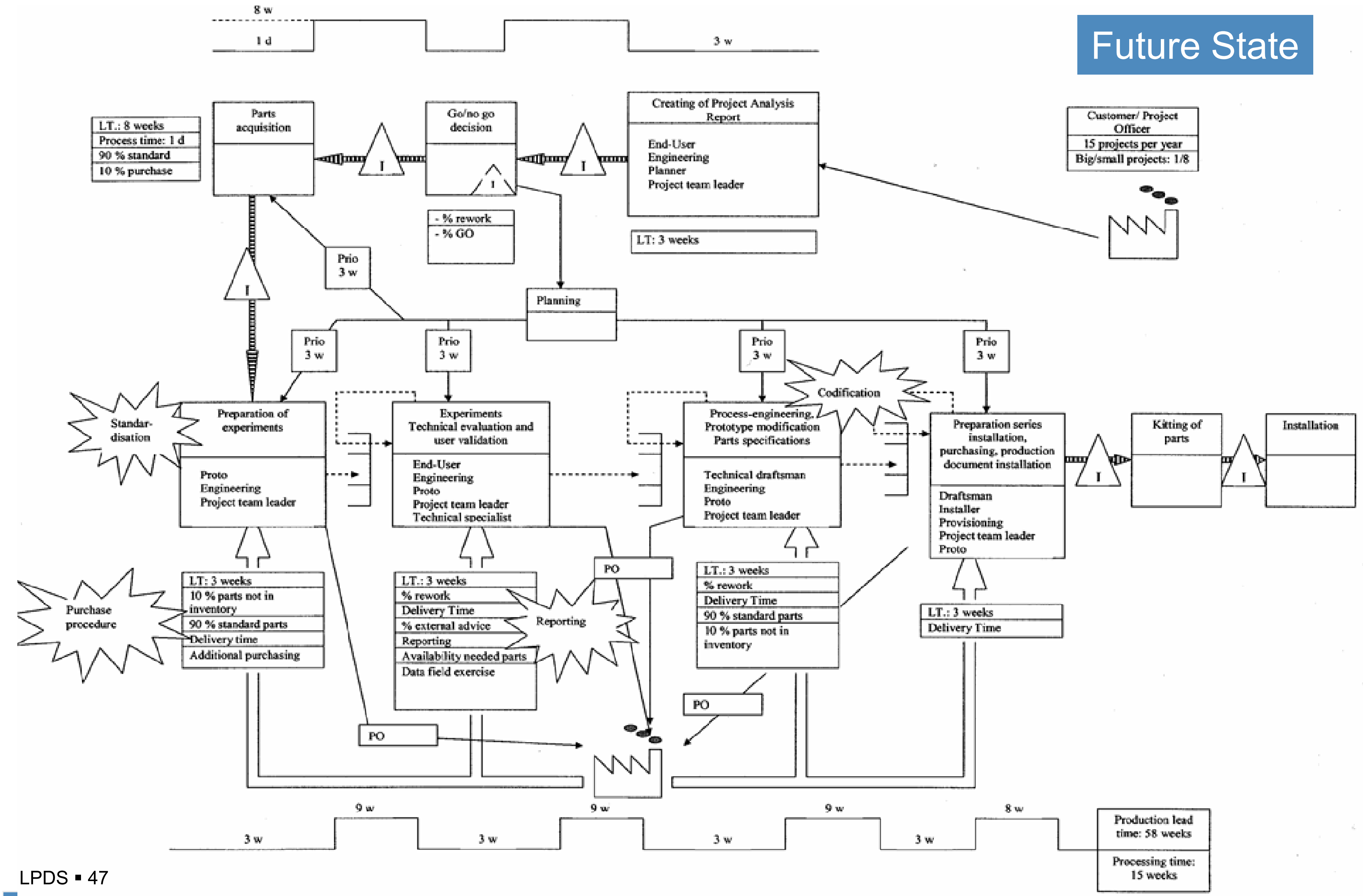
Value Stream Mapping of the Project Pipeline

Current State

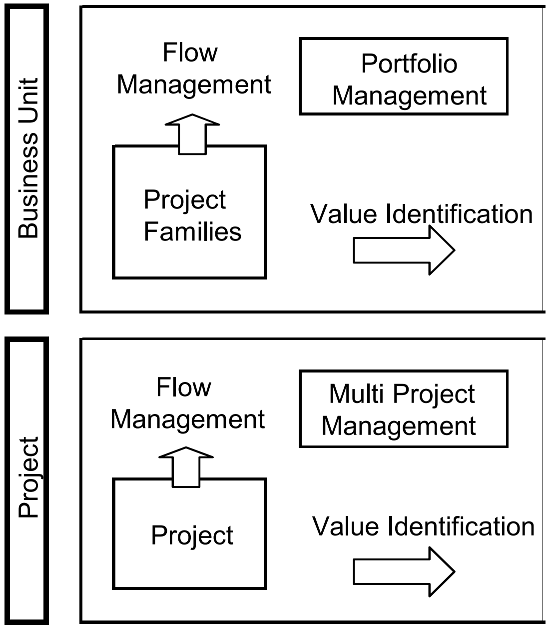


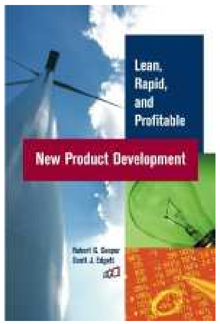
Value Stream Mapping of the Project Pipeline

Future State

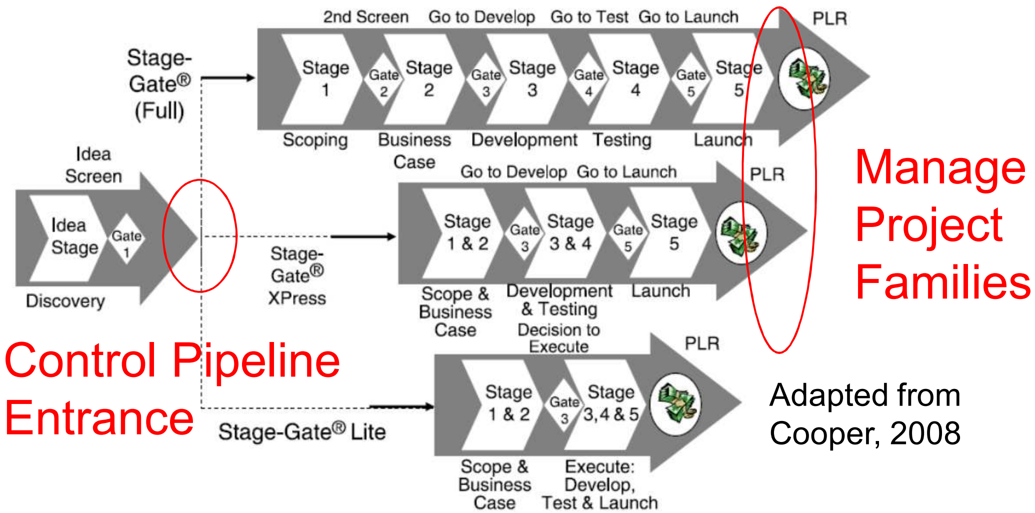


Improved Product Development at the Business Level





- 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

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**

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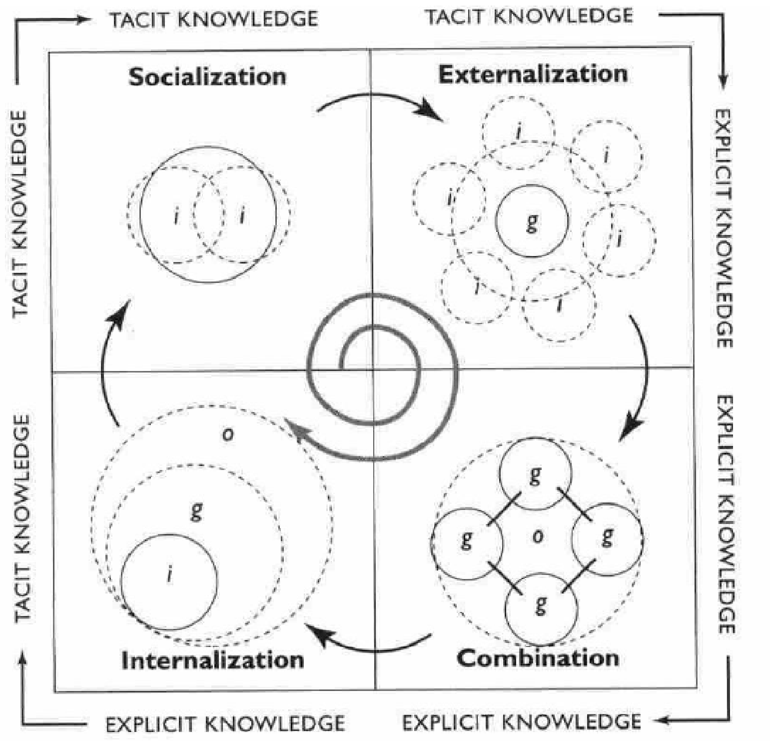
Knowledge Management Cycle



- 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

Nonaka

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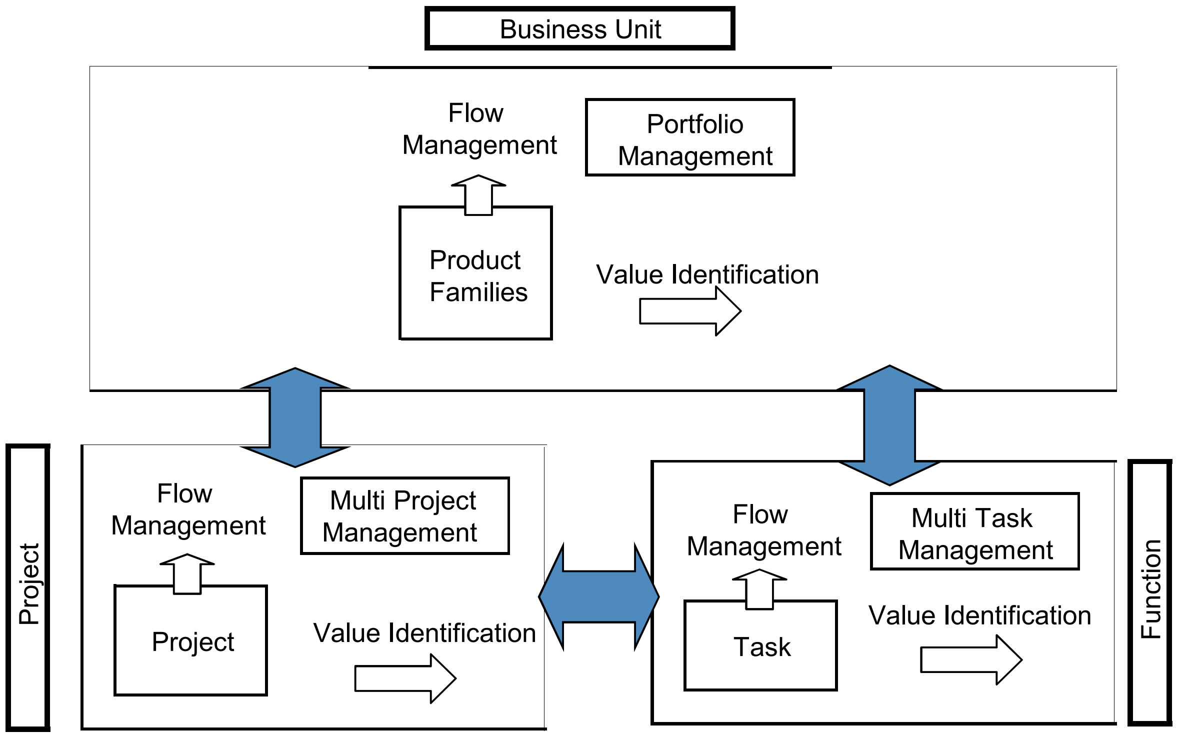
XXXII ENEGEP - LPD

It may be simple, but…….

It's not easy…………

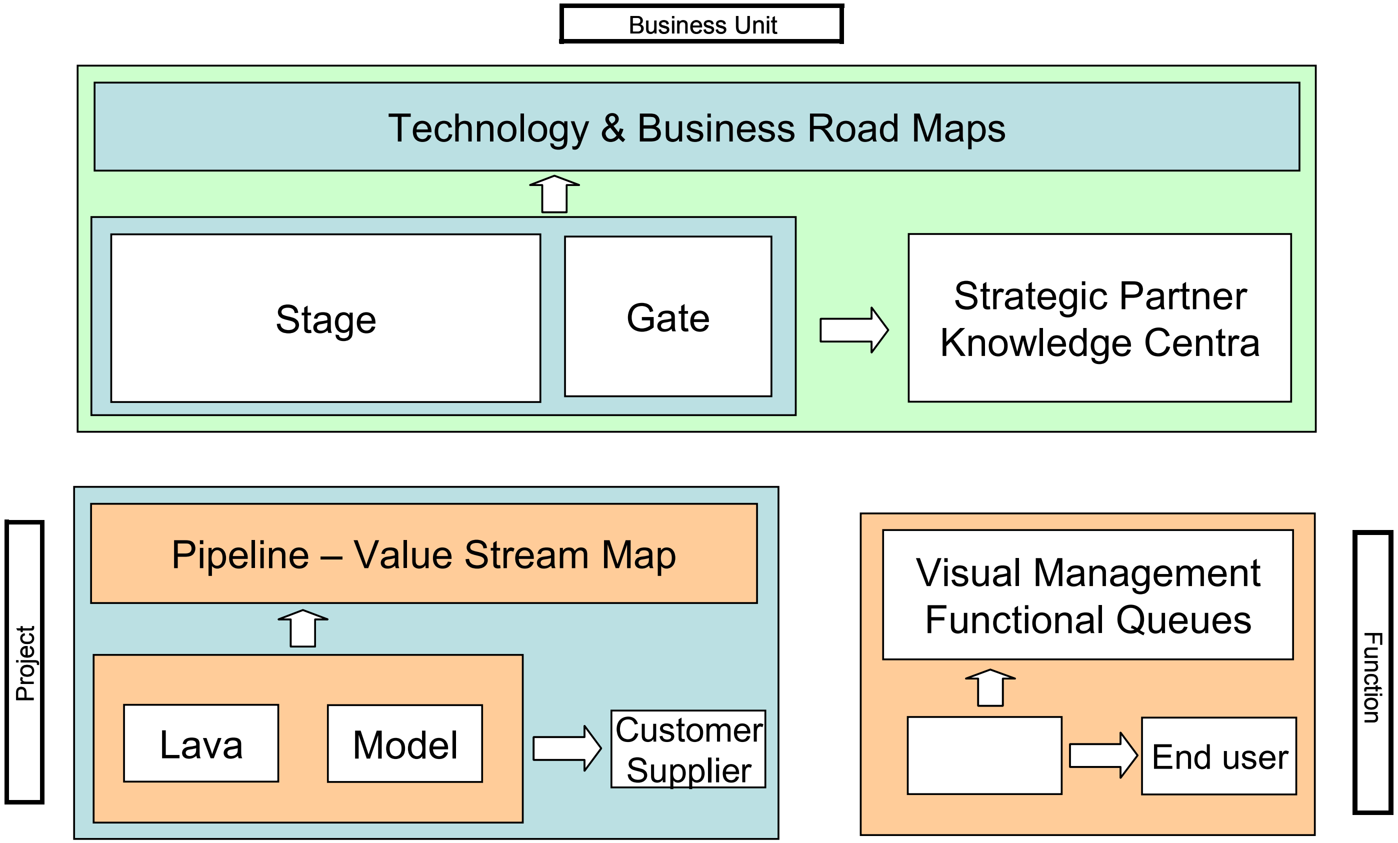
Future research is needed!

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

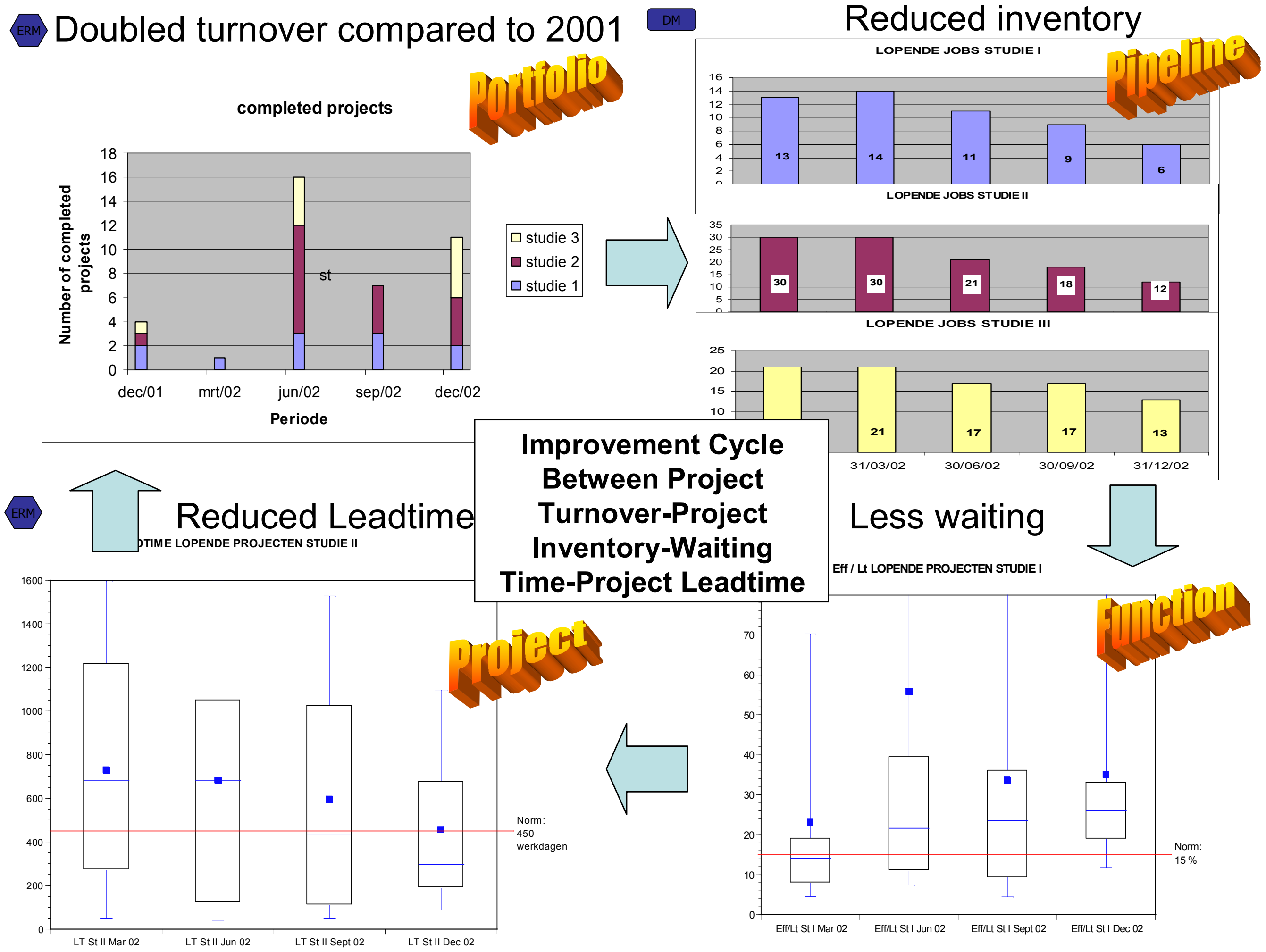


Identify potential best practices

Develop the framework into an assessment tool

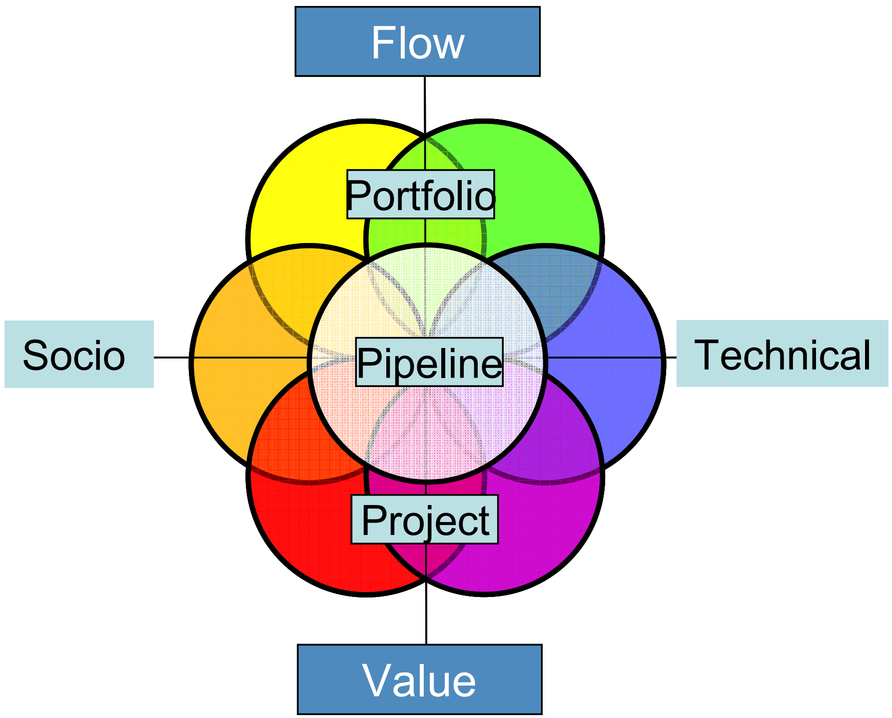
Learning to see the whole LPD system

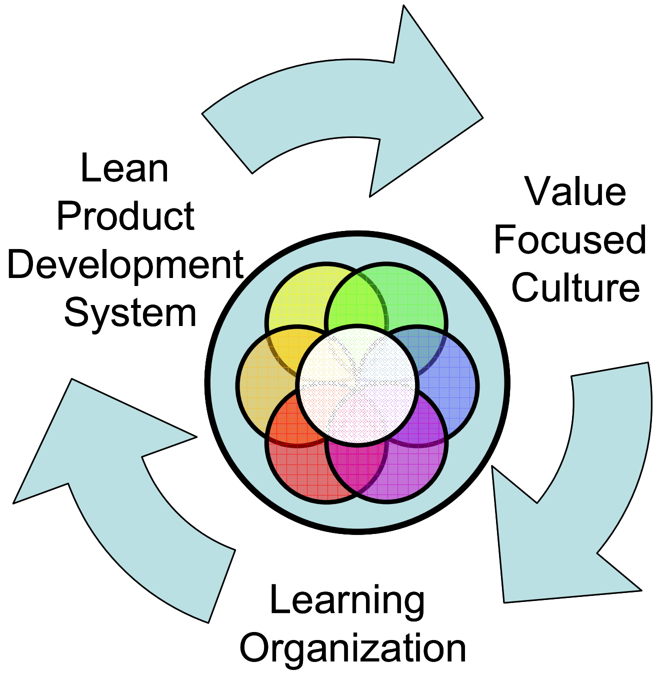
3. Study the dynamics of LPD systems



Study role of performance measurement
to optimize LPD systems

Questions?





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