Understanding the Magic of Lean Product Development

JAOO 2010
Århus, Danmark
October 4, 2010

No part of this presentation may be reproduced without the written permission of the author.

Donald G. Reinertsen
Reinertsen & Associates
600 Via Monte D’Oro
Redondo Beach, CA 90277 U.S.A.
(310)-373-5332
Internet: Don@ReinertsenAssociates.com
www.ReinertsenAssociates.com
Any sufficiently advanced technology is indistinguishable from magic.

– Arthur C. Clarke
Lean Manufacturing

• Lean Manufacturing is a best practice.
• Best practices lead to superior performance.
• Why not adopt these best practices in product development?
The TPS Emergency Room

- We desire to rigorously imitate the practices of Toyota.
- All arriving patients will be processed on a FIFO basis.
- We will stop admitting work when we reach our preset WIP limit.
Thus, since the Toyota Production System has been created from actual practices in the factories of Toyota, it has a strong feature of emphasizing practical effects, and actual practice and implementation over theoretical analysis.

– Taiichi Ohno

From Foreword to 1983 First Edition of *Toyota Production System* by Yasuhiro Monden,
Turning Magic into Technology

Use Some Ideas of Lean Manufacturing

- Repetitive Tasks
- Low Variability
- Homogenous Flows

Add Concepts and Science from other Domains

- Non-Repetitive Tasks
- High Variability
- Non-Homogenous Flows

Lean Manufacturing

Toyota

Queueing Theory
Traffic Flow Theory
Computer OS Design
Maneuver Warfare
The Internet
Queueing Theory
Hvem er jeg?
Alle har mødt Erlang men ingen ved rigtig hvem har er! Det skyldes, at de berømte fircifrede logaritmetabeller, som fleste har brugt i skolerne, baerer Erlangs navn.

Det, han virkelig blev verdensberømt for, var teletrafik-teorier.

– Bjarne Kousholt
Traffic at rush hour illustrates the classic characteristics of a queueing system.
The Effect of Capacity Utilization

Queue Size vs. Capacity Utilization

Note: Assumes M/M/1/Infinite Queue
Economics of Queues

Dollars

Excess Product Development Resource

- Total Cost
- Cost of Excess Capacity
- Cost of Delay
Batch Size
Benefits of Small Batch Testing

Smaller Changes

- Less Debug Complexity
- More Efficient Debug

Cheaper Debug

Faster Cycle Time

- More Uptime
- Higher Validity
- Fewer Status Reports

Cheaper Testing

Less Non-Value-Added

Better Economics

Fewer Open Bugs

- Less Requirements Change

Better Code

Early Feedback

- Faster Learning
- Lower Cost Changes

Cheaper Correction
WIP Constraints
Little’s Famous Formula

\[ W_q = \frac{L_q}{\lambda} \]

Average Wait Time in Queue = \( W_q \)

Average Number of Customers in Queue = \( L_q \)

Average Departure Rate = \( \lambda \)
<table>
<thead>
<tr>
<th>Ready Queue</th>
<th>Coding</th>
<th>Ready to Test</th>
<th>Testing</th>
<th>Test Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**WIP Constraint = 10 units**
Cumulative Flow Diagram

- Arrivals
- Quantity in Queue
- Time in Queue
- Departures
- Queue
• Queues give instant indication of a problem.
• This is very important when problems age poorly and when fast response times matter.
Synchronized Cadence
Interval: Fixed
Train Length: Variable
Cadenced Purchasing Availability

BEFORE

• One buyer will support you with 10 percent of his time.

AFTER

• Buyer will be at desk in team area from 8:00 AM to 9:00 AM daily.

• During this period his highest priority is supporting your project.
Asynchronous Processing

THE THEORY

• With the new IT system we can tell exactly who has each ECR at any point in time.
• Work could be done instantly instead of waiting for a meeting.

THE REALITY

• 40 day Processing Time
• Low First Pass Yield
• High Processing Cost
Variability
# Taking Rational Risks

<table>
<thead>
<tr>
<th>Choice</th>
<th>Stakes</th>
<th>Payoff</th>
<th>Probability</th>
<th>EMV</th>
<th>Bet?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$15,000</td>
<td>$100,000</td>
<td>50%</td>
<td>$35,000</td>
<td>?</td>
</tr>
<tr>
<td>B</td>
<td>$15,000</td>
<td>$20,000</td>
<td>90%</td>
<td>$3,000</td>
<td>?</td>
</tr>
<tr>
<td>C</td>
<td>$15,000</td>
<td>$16,000</td>
<td>100%</td>
<td>$1,000</td>
<td>?</td>
</tr>
</tbody>
</table>

*We cannot maximize economic value by eliminating all bets with uncertain outcomes.*

EMV = Expected Monetary Value
Asymmetric Payoffs and Option Pricing

Expected Price

Payoff vs. Price

Expected Payoff

Strikes Price

Expected Payoff

Price
Sequencing
Queueing Disciplines

- FIFO
- Highest Profit (or ROI/IRR/EVA) First (HPF)
- SJF (FCFS)
- High Cost of Delay First (HDCF)
- Minimum Slack Time First (MSTF)
- Weighted Shortest Job First (WSJF)
Fast Feedback
The Value of Feedback

Front-Loaded Two Digits at Same Time

- Pay $2
  - 99% Make Nothing
  - 1% Make $200

- Expected Payoff: Zero

Buy Second Digit After Receiving Feedback

- Pay $1
  - 90% Make Nothing
  - 10% Pay $1
- Pay $1
  - 9% Make Nothing
  - 1% Make $200

- Expected Payoff: $0.90
The Importance of Math

• There are underlying mechanisms of action behind lean methods.
• These mechanisms can be used in LPD.
• These methods affect more than one measure of performance, so tradeoffs are necessary.
• This requires that you use a common unit of measure for your decisions.
Economics
Making Economic Decisions

Transformations

Proxy Variable Space
- Waste
- Cycle Time
- Variability
- Efficiency
- Revenue
- Unit Cost
- Value-Added

Economic Space
- Life Cycle Profits
The Modeling Process

Create Baseline Model

- Model Expense Overrun
- Model Cost Overrun
- Model Value Shortfall
- Model Schedule Delay
- Model Risk Change

Determine Total Profit Impact of Missing a MOP

Calculate Sensitivity Factors
The Model Output

<table>
<thead>
<tr>
<th>Category</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Percent Expense Overrun</td>
<td>-$40,000</td>
</tr>
<tr>
<td>1 Percent Product Cost Overrun</td>
<td>-$150,000</td>
</tr>
<tr>
<td>1 Percent Value Shortfall</td>
<td>-$100,000</td>
</tr>
<tr>
<td>1 Month Delay</td>
<td>-$500,000</td>
</tr>
<tr>
<td>1 Percent Increase in Risk</td>
<td>-$80,000</td>
</tr>
</tbody>
</table>
Any Analysis Beats Intuition

Range of Cost of Delay Estimates

- Quality Analysis: 1.2:1
- Average Analysis: 2:1
- Best Case Intuition: 10:1
- Average Intuition: 50:1
- Poor Intuition: 200:1

Source: Reinertsen & Associates Clients
Example: The Goal of Conformance

- Feature A
  - Actual: 101%

- Feature B
  - Actual: 90%

Correct the Performance Gap
Marginal Economics

Should our goal be to optimize conformance, or to make good economic choices?
Decentralizing Control

Boeing 777 Weight Reduction Decision Authority

<table>
<thead>
<tr>
<th>Role</th>
<th>Dollars per Pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer</td>
<td>$300</td>
</tr>
<tr>
<td>Supervisor</td>
<td>$600</td>
</tr>
<tr>
<td>Program Manager</td>
<td>$2,500</td>
</tr>
</tbody>
</table>
Going Further

1991 / 1997

1997

2009
Seminars in Scandinavia

Copenhagen:

November 29-30, 2010

Stockholm:

December 2-3, 2010