Understanding the Magic of Lean Product Development

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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

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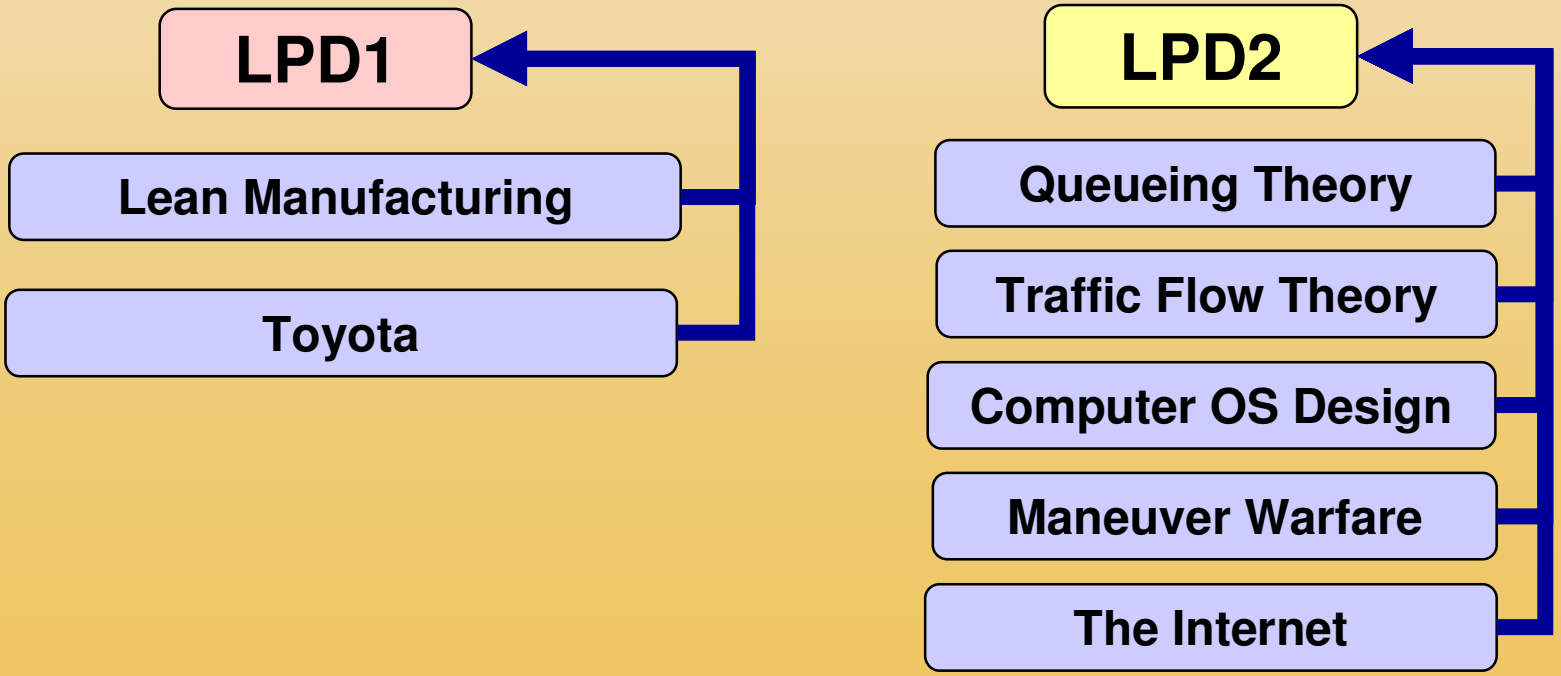
Add Concepts and Science from other Domains

DOMAIN

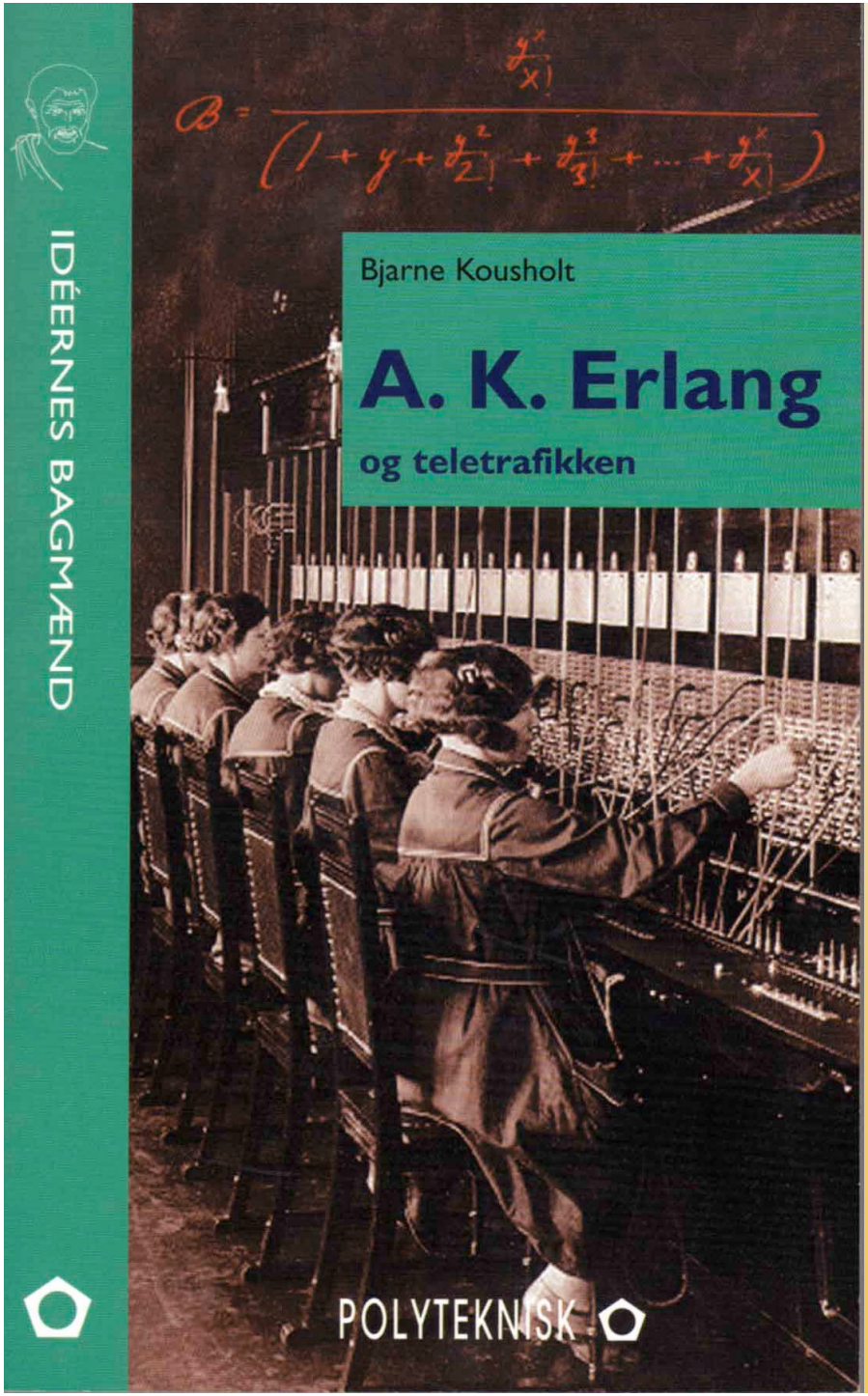
- Repetitive Tasks
- Low Variability
- Homogenous Flows

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



Queueing Theory

Hvem er jeg?



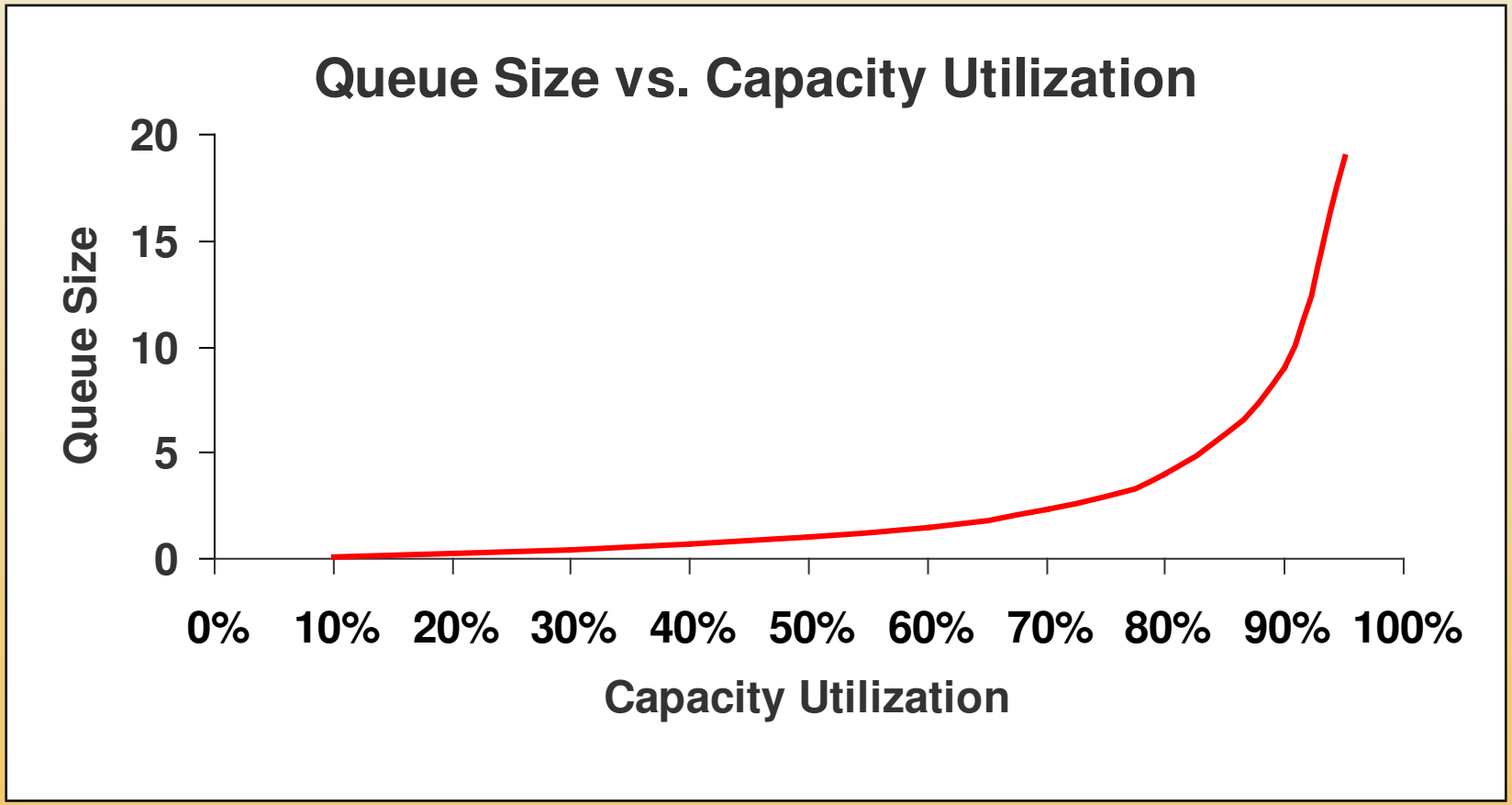
Alle har mødt Erlang men ingen ved rigtig hvem har er! Det skyldes, at de berømte fircifrede logaritmetabeller, som fleste har brugt i skolerne, baerer Erlangs navn.

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

– Bjarne Kousholt

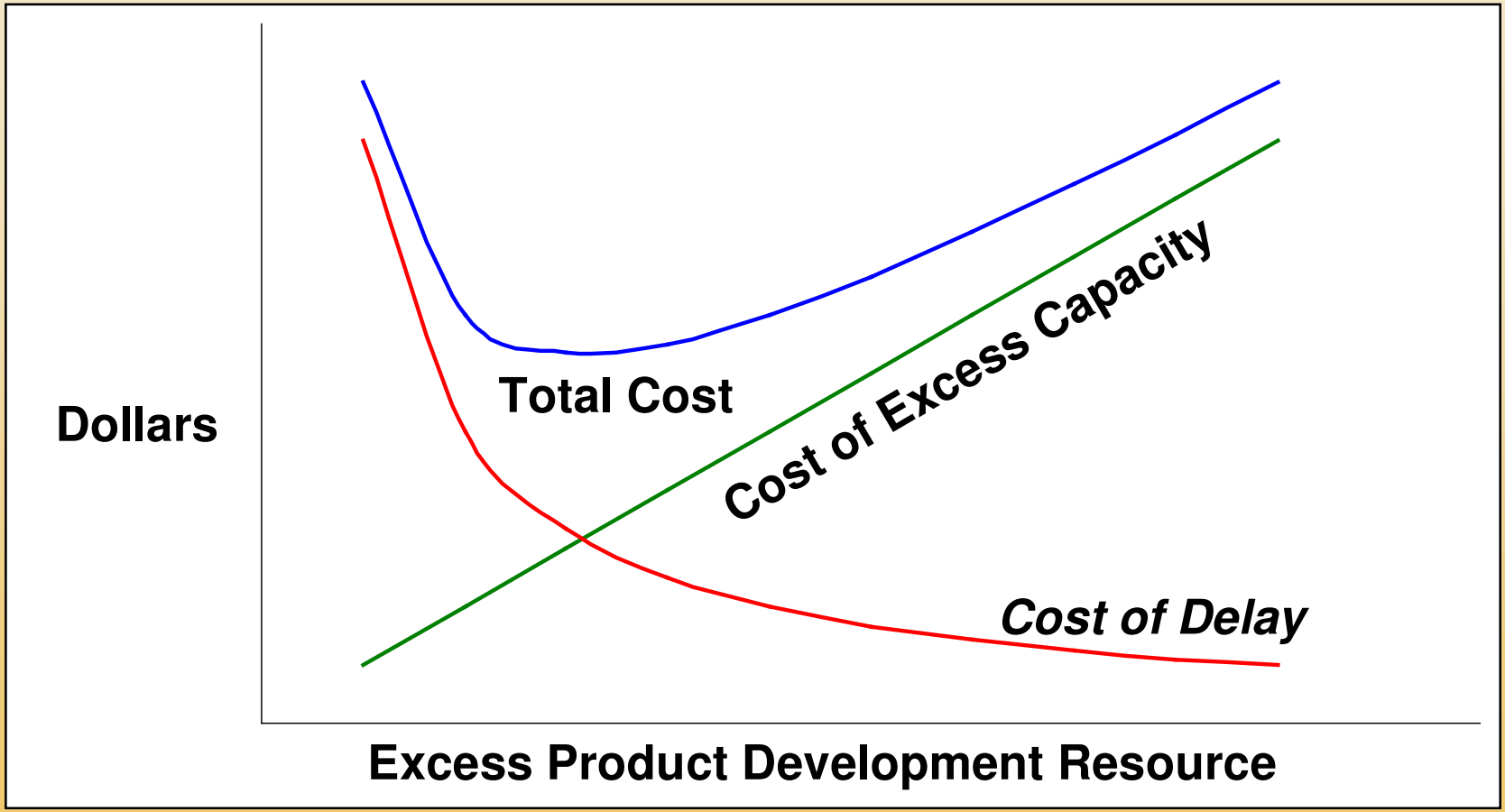
Traffic at rush hour illustrates the classic characteristics of a queueing system.

The Effect of Capacity Utilization



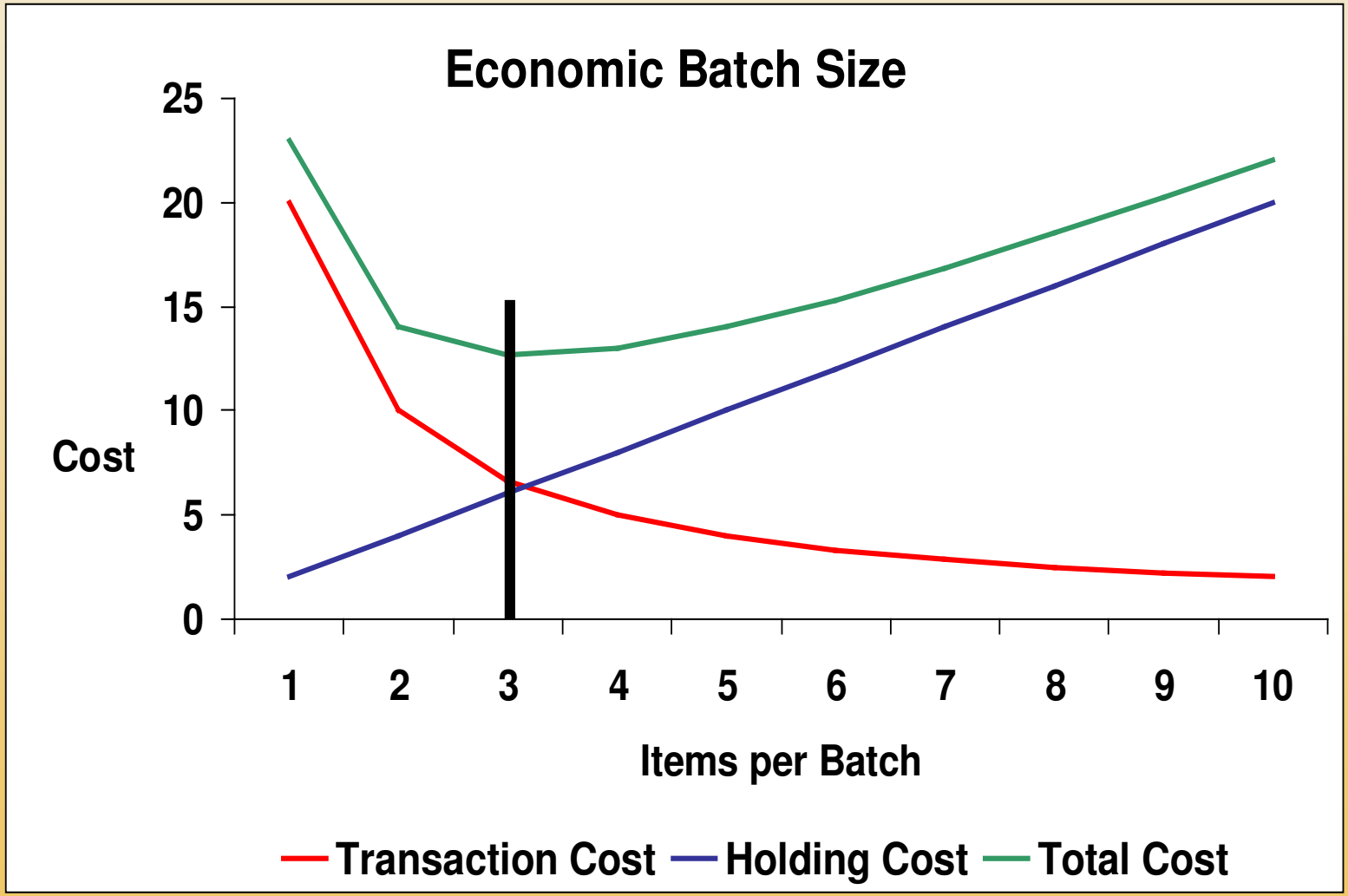
Note: Assumes M/M/1/Infinite Queue

Economics of Queues

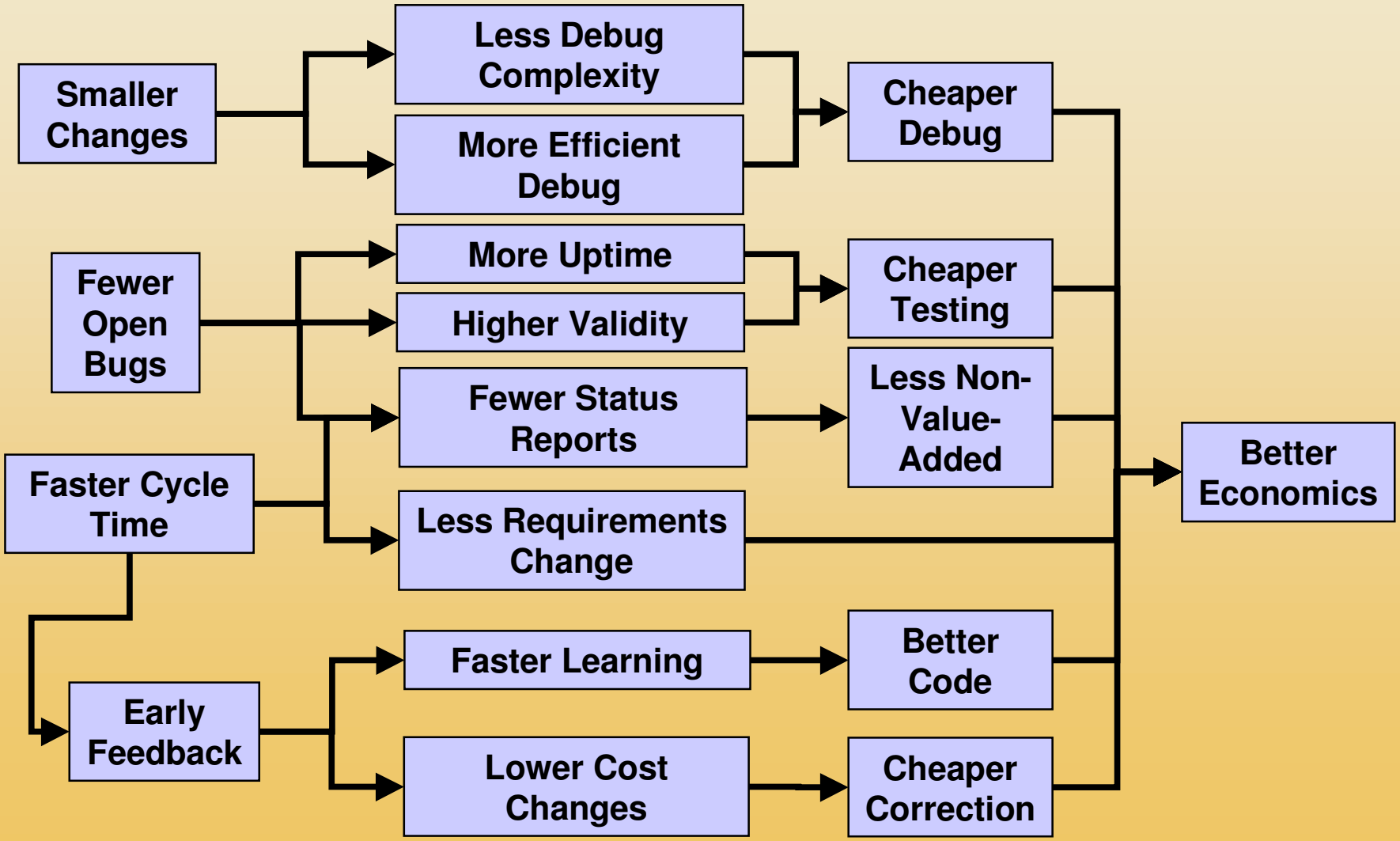


Batch Size

Setting Batch Size



Benefits of Small Batch Testing



WIP Constraints

Little's Famous Formula

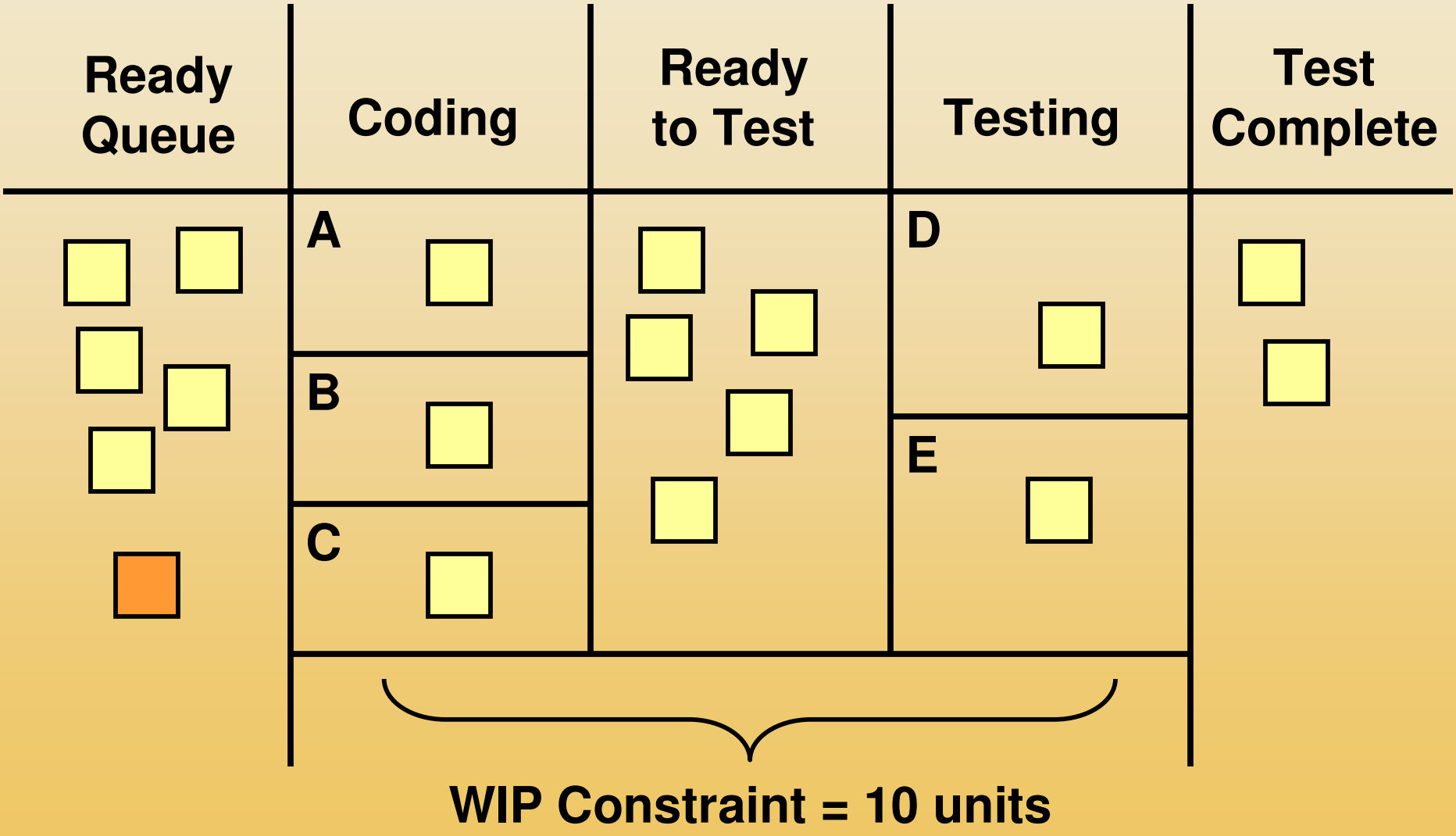
$$W_q = \frac{L_q}{\lambda}$$

Average Wait Time in Queue $= W_q$

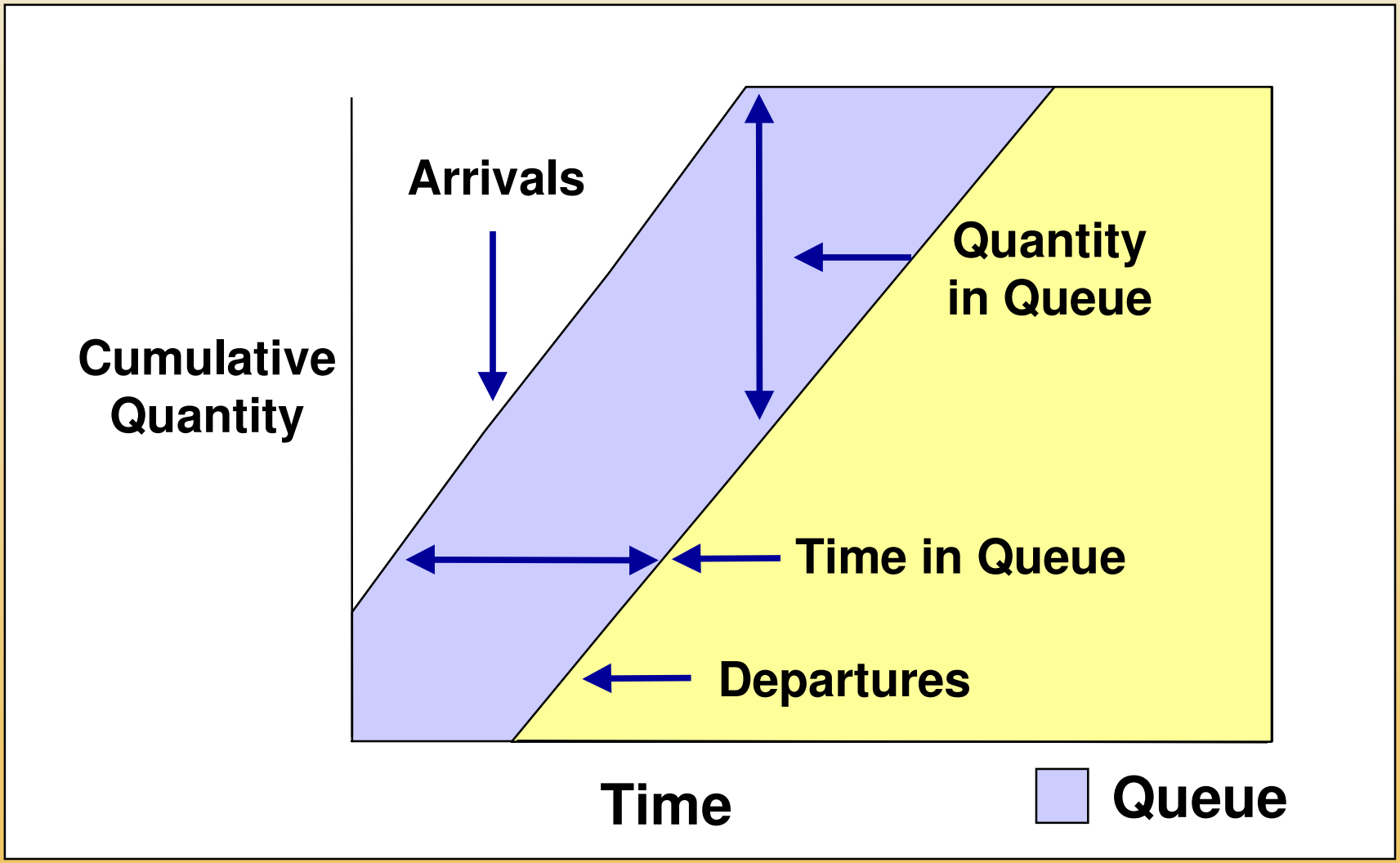
Average Number of Customers in Queue $= L_q$

Average Departure Rate $= \lambda$

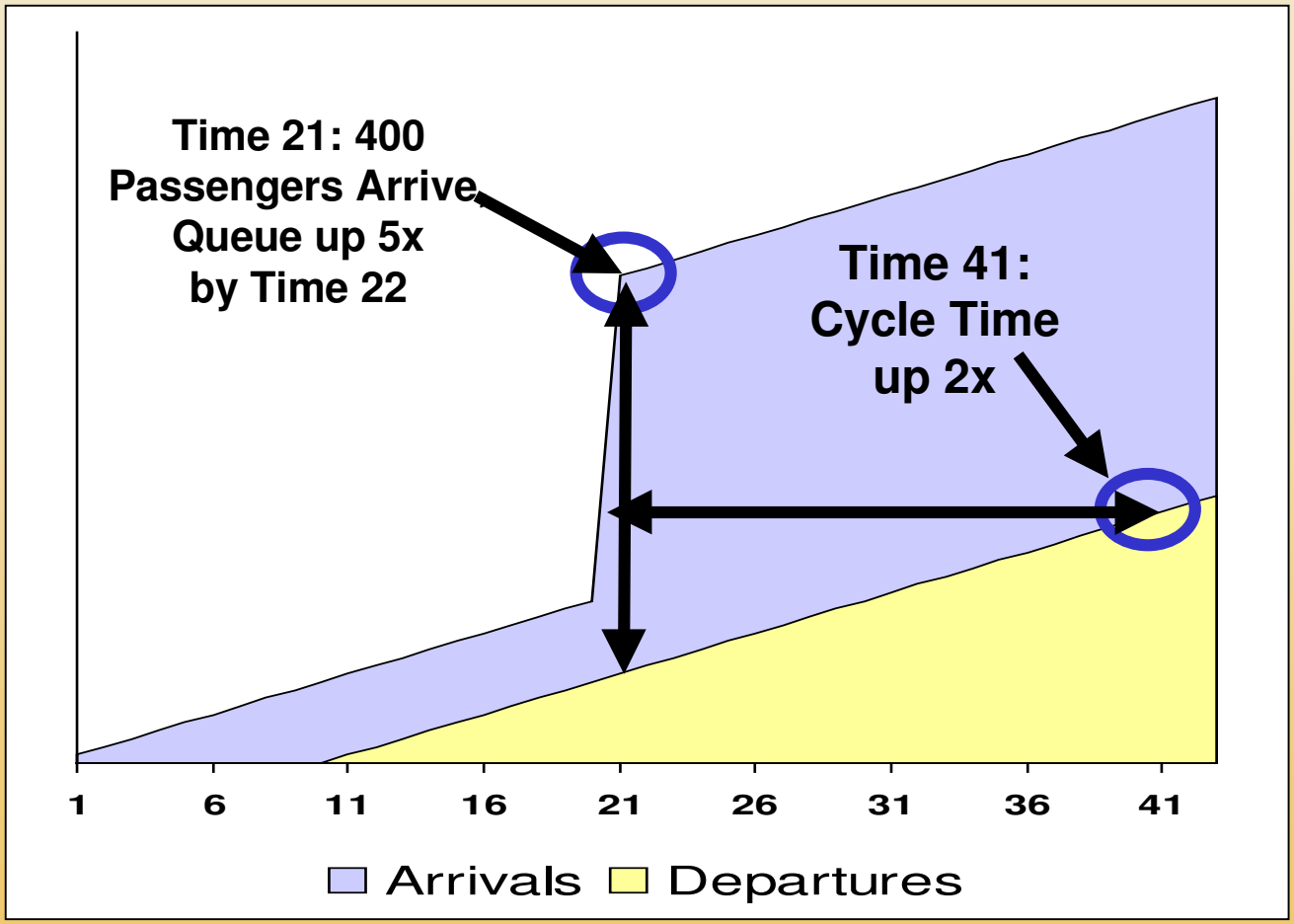
Visual WIP Boards



Cumulative Flow Diagram



Control Queues Not Cycle Time



- 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**	**Variable**
Train Length	**Variable**	**Fixed**

Cadenced Purchasing Availability

BEFORE

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

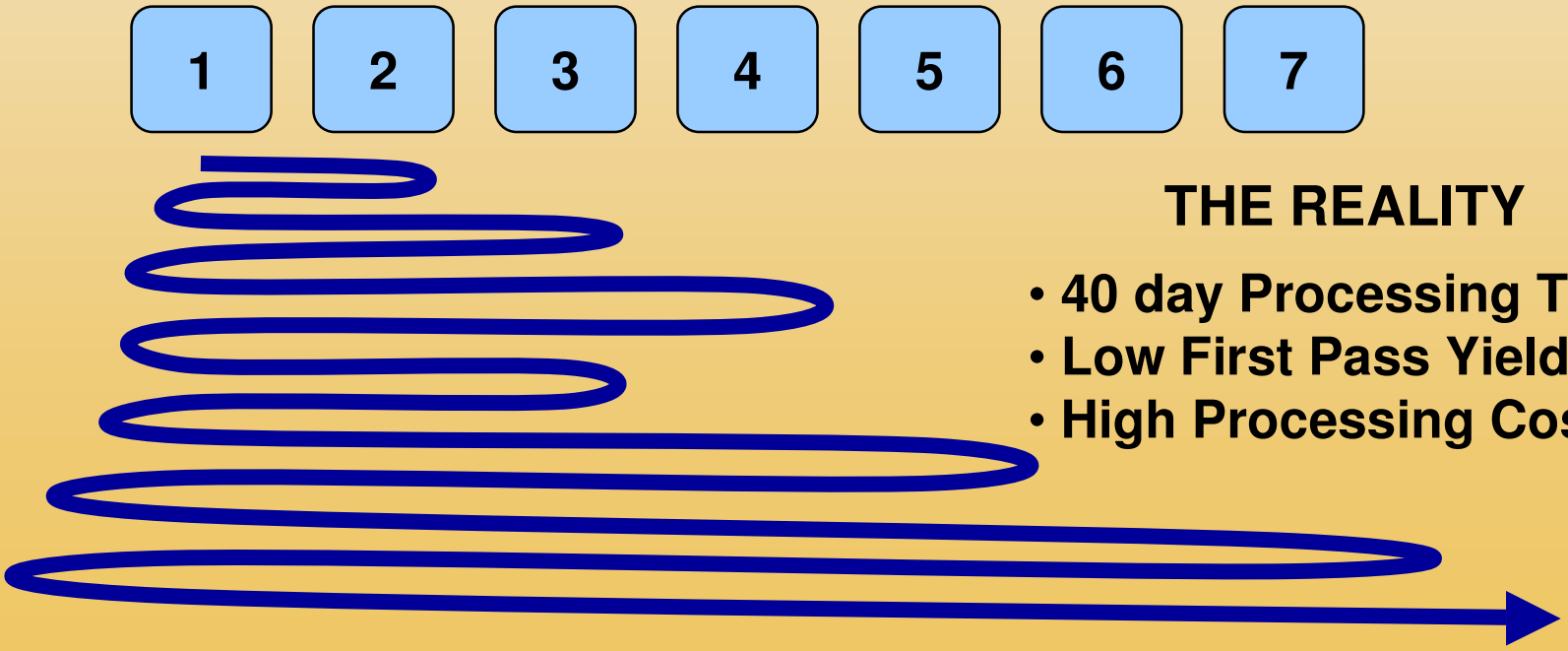
AFTER

- 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

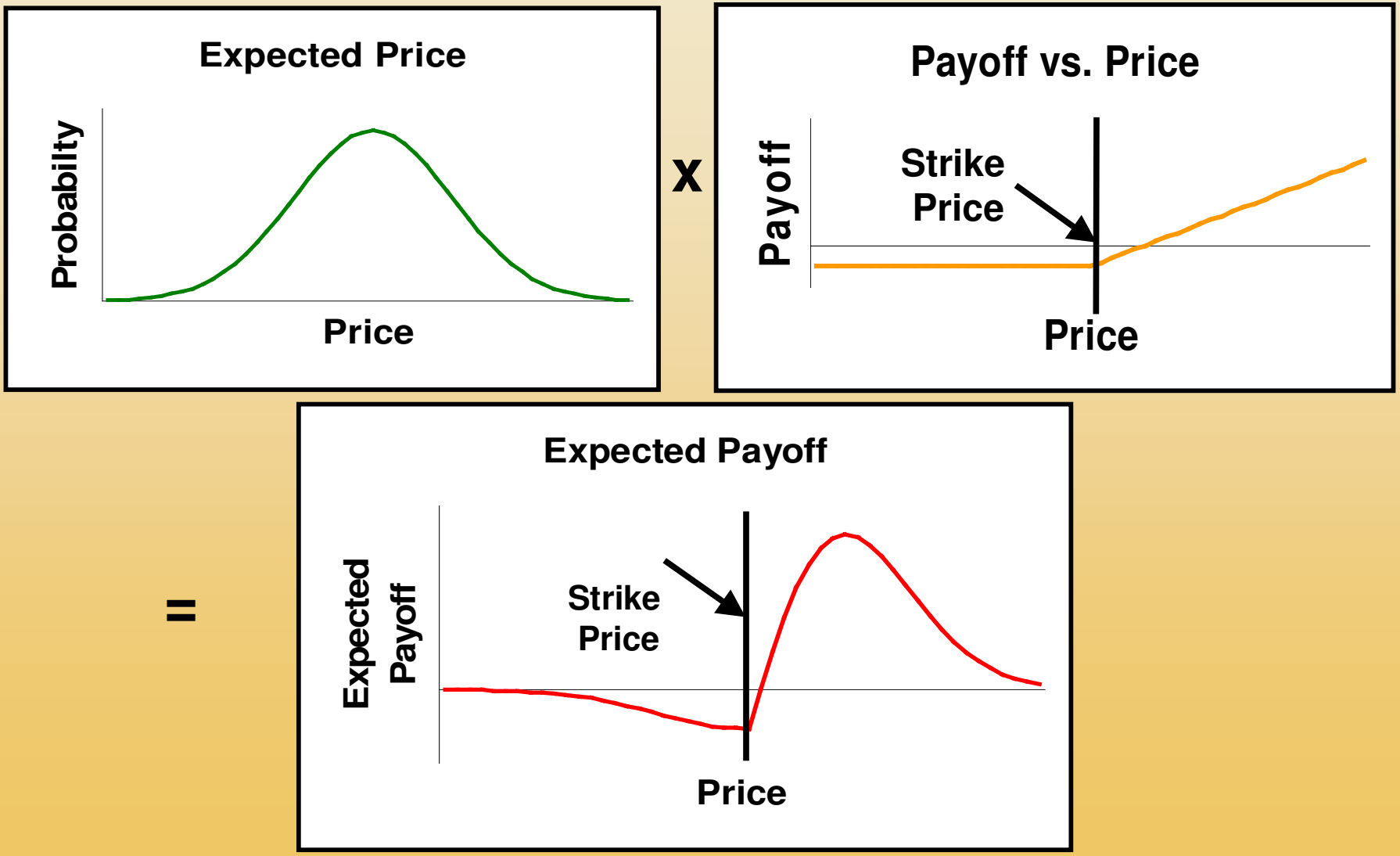
Taking Rational Risks

Choice	Stakes	Payoff	Probability	EMV	Bet?
A	$15,000	$100,000	50%	$35,000	?
B	$15,000	$20,000	90%	$3,000	?
C	$15,000	$16,000	100%	$1,000	?

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

EMV=Expected Monetary Value

Asymmetric Payoffs and Option Pricing



Sequencing

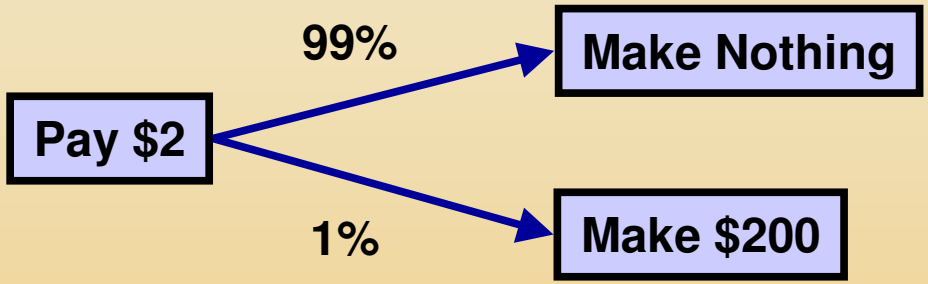
Queueing Disciplines

- 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

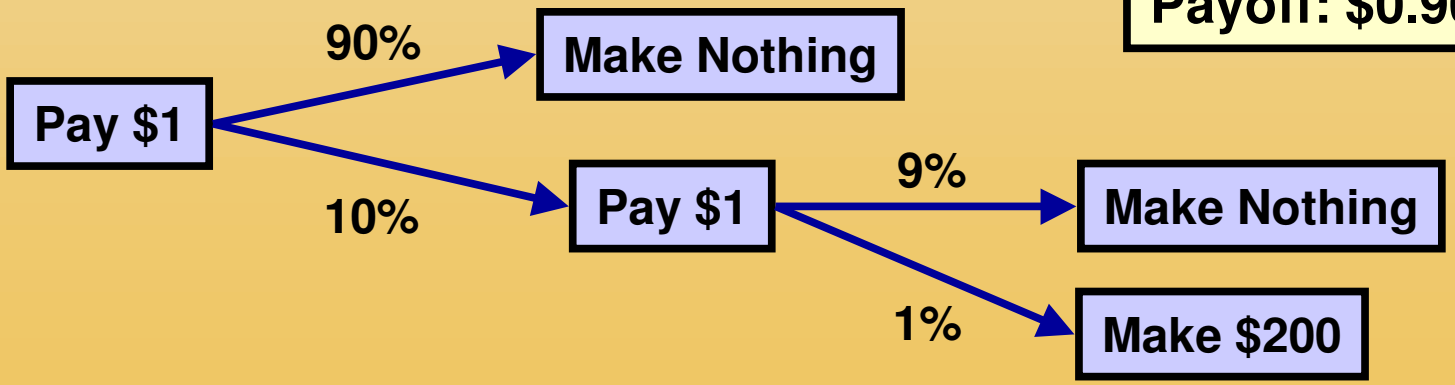
Front-Loaded Two Digits at Same Time



Expected Payoff: Zero

Buy Second Digit After Receiving Feedback

Expected Payoff: $0.90

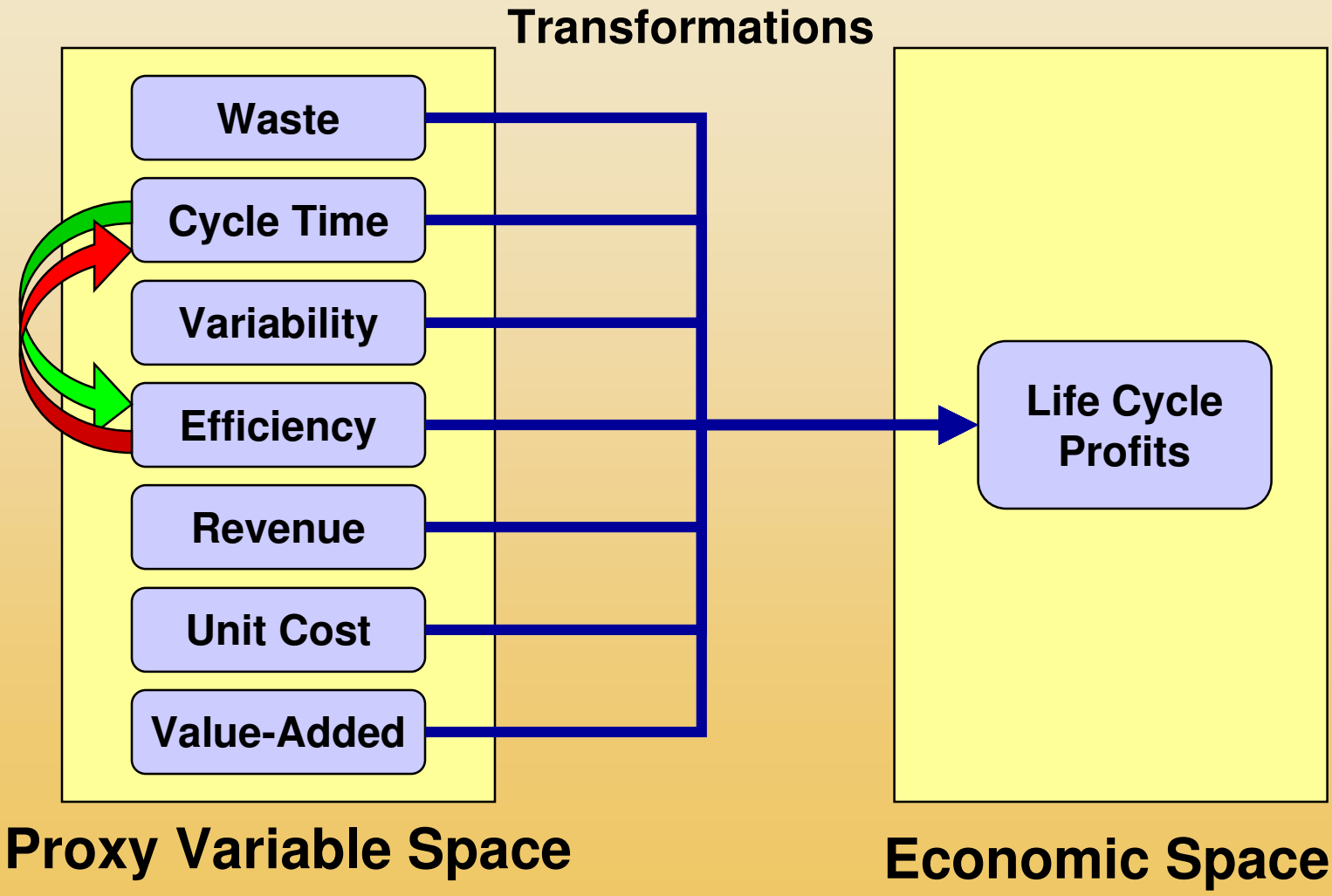


The Importance of Math

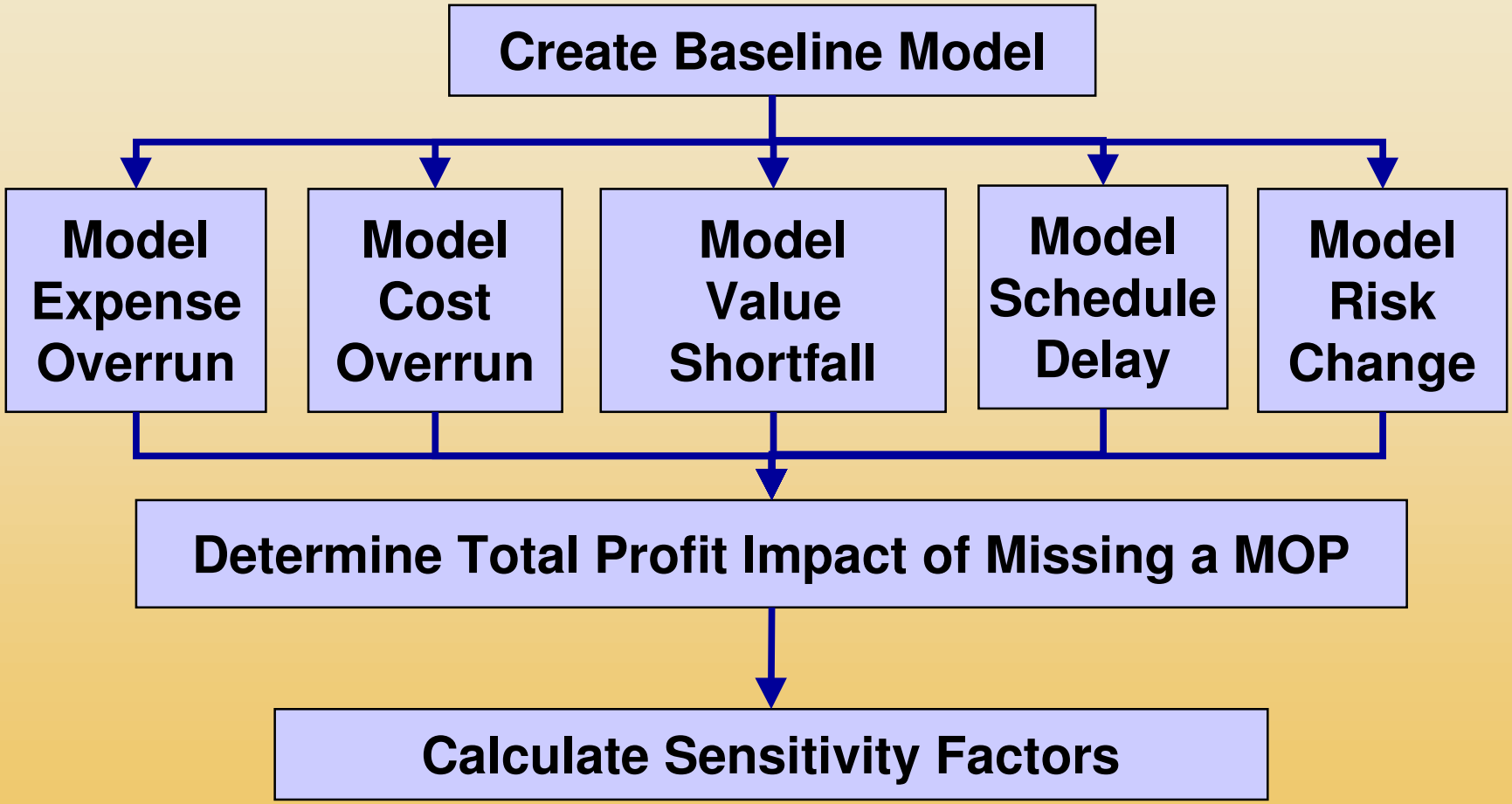
- There are underlying mechanisms of action behind lean methods.
- These mechanisms can be used in LPD.
- These methods affect more than one measure of performance, so tradeoffs are necessary.
- This requires that you use a common unit of measure for your decisions.

Economics

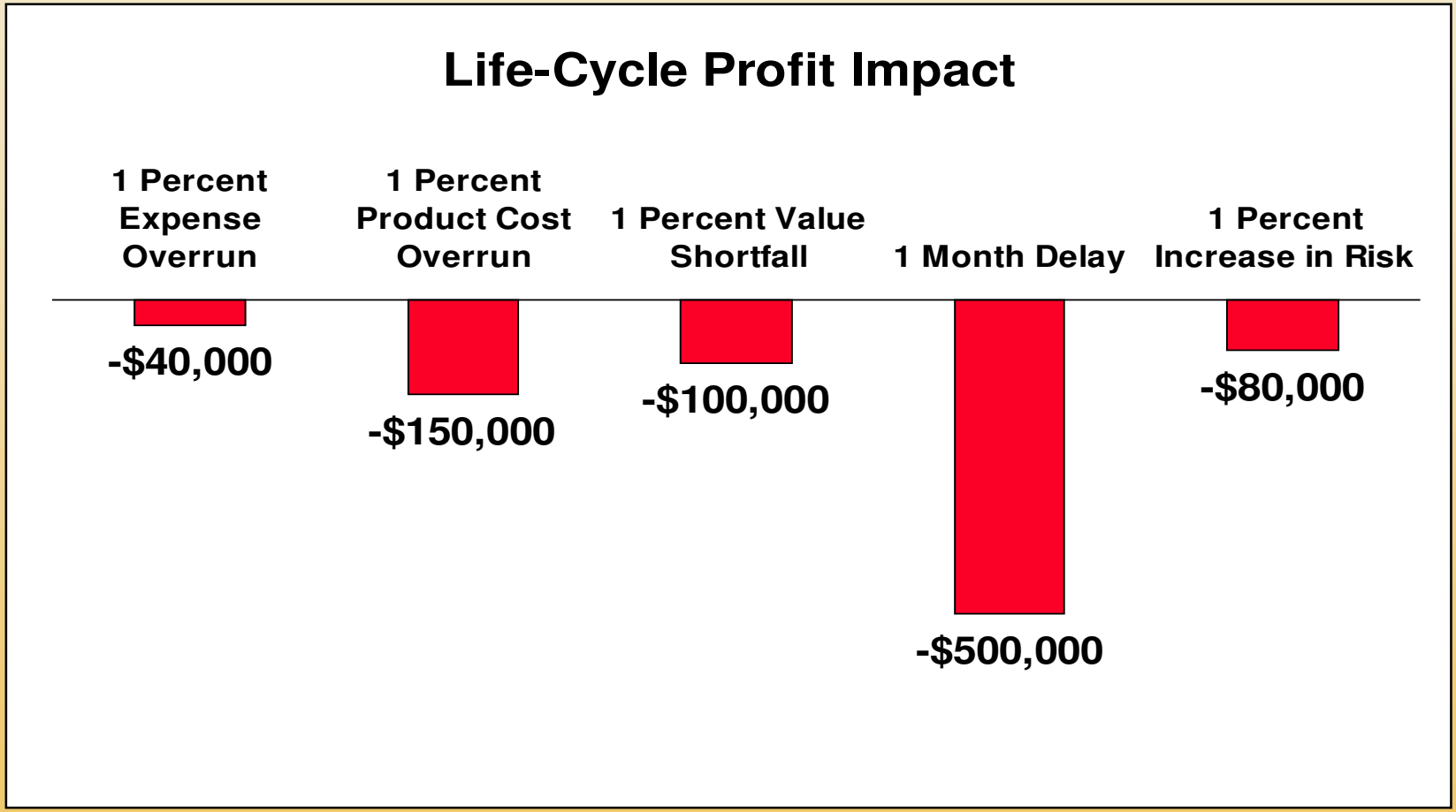
Making Economic Decisions



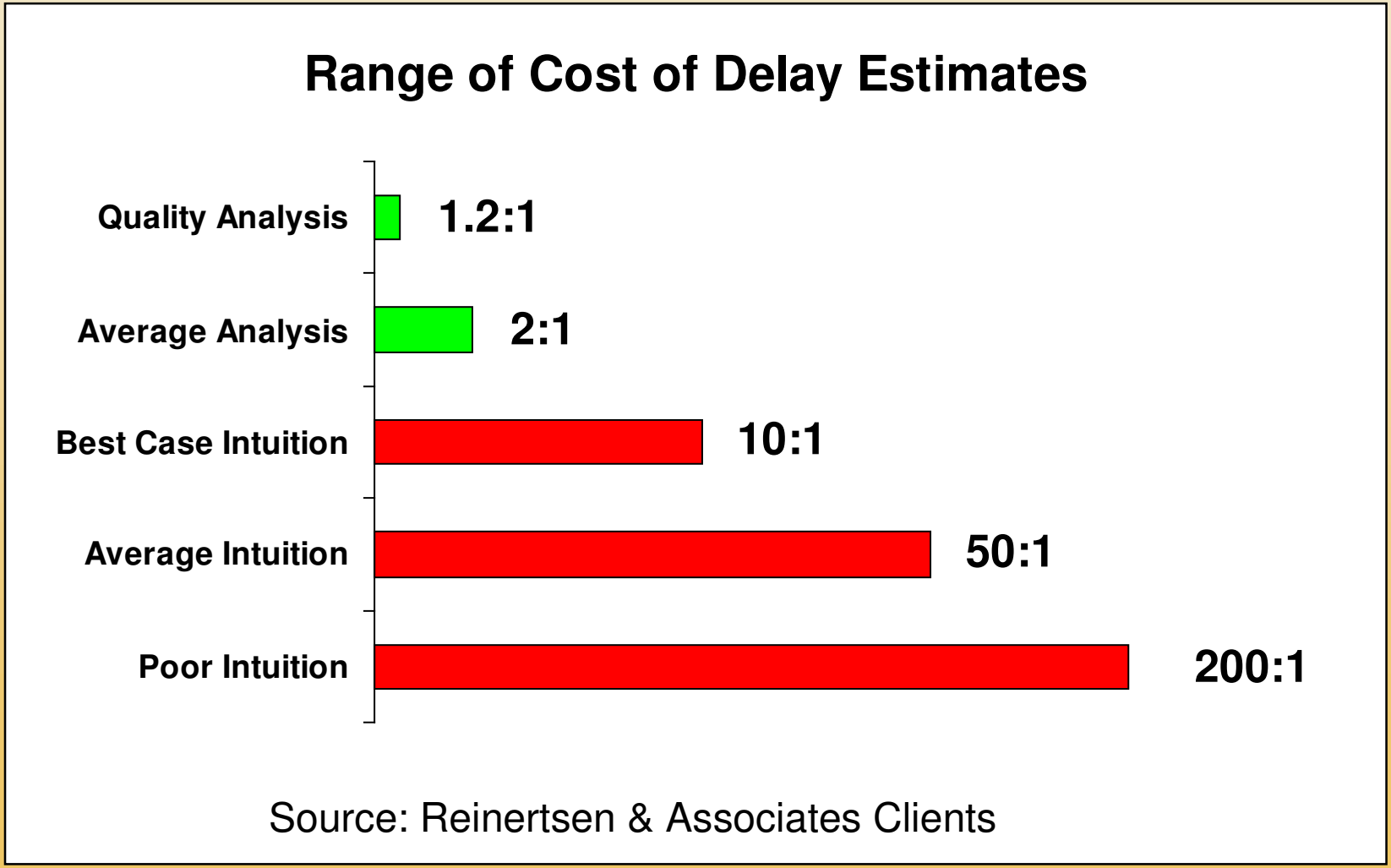
The Modeling Process



The Model Output

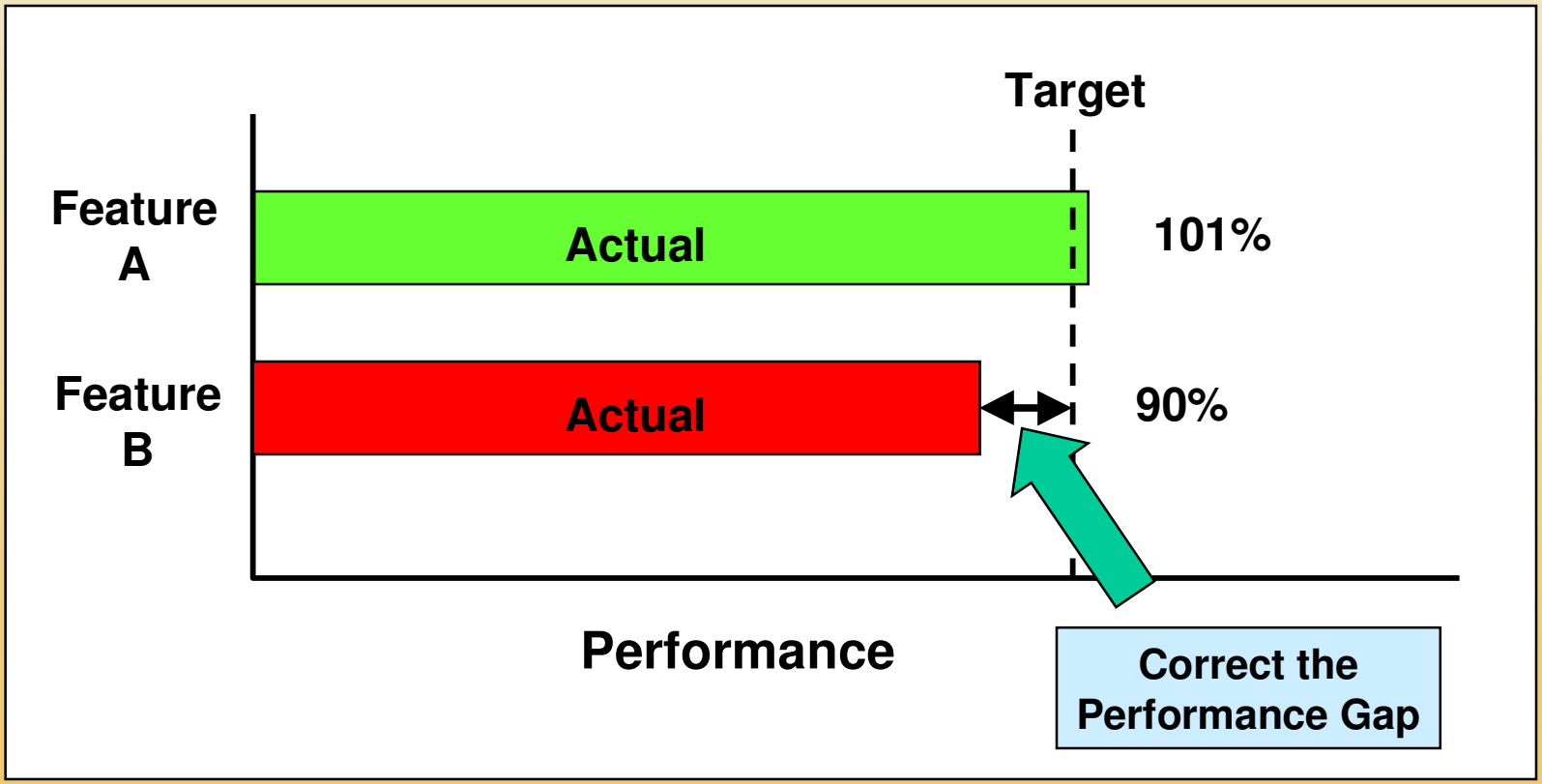


Any Analysis Beats Intuition

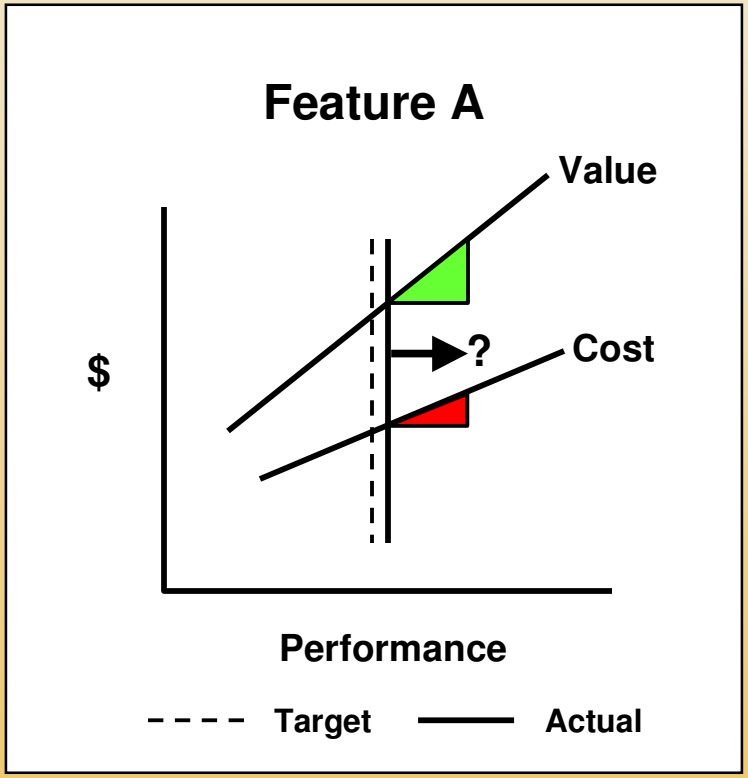


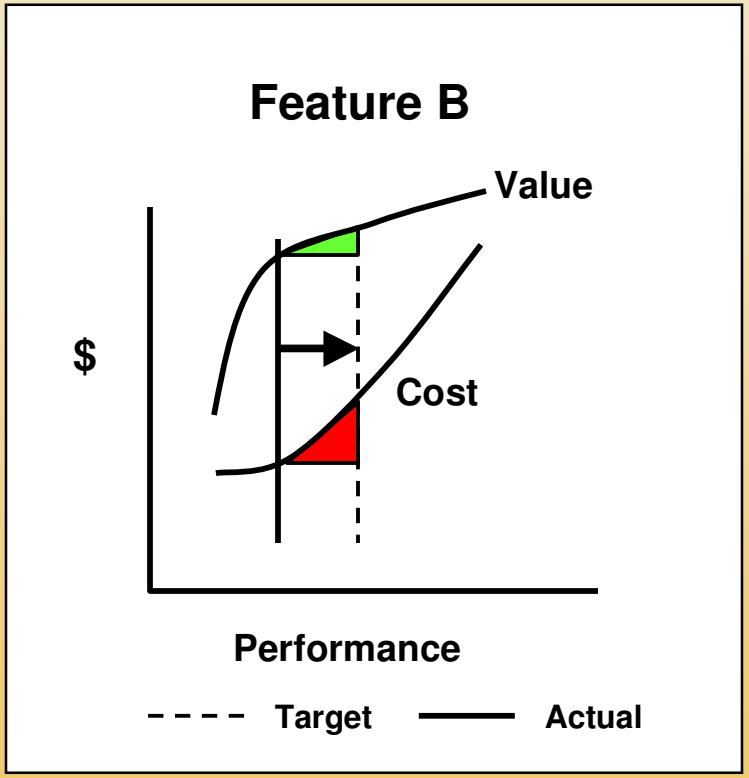
Source: Reinertsen & Associates Clients

Example: The Goal of Conformance



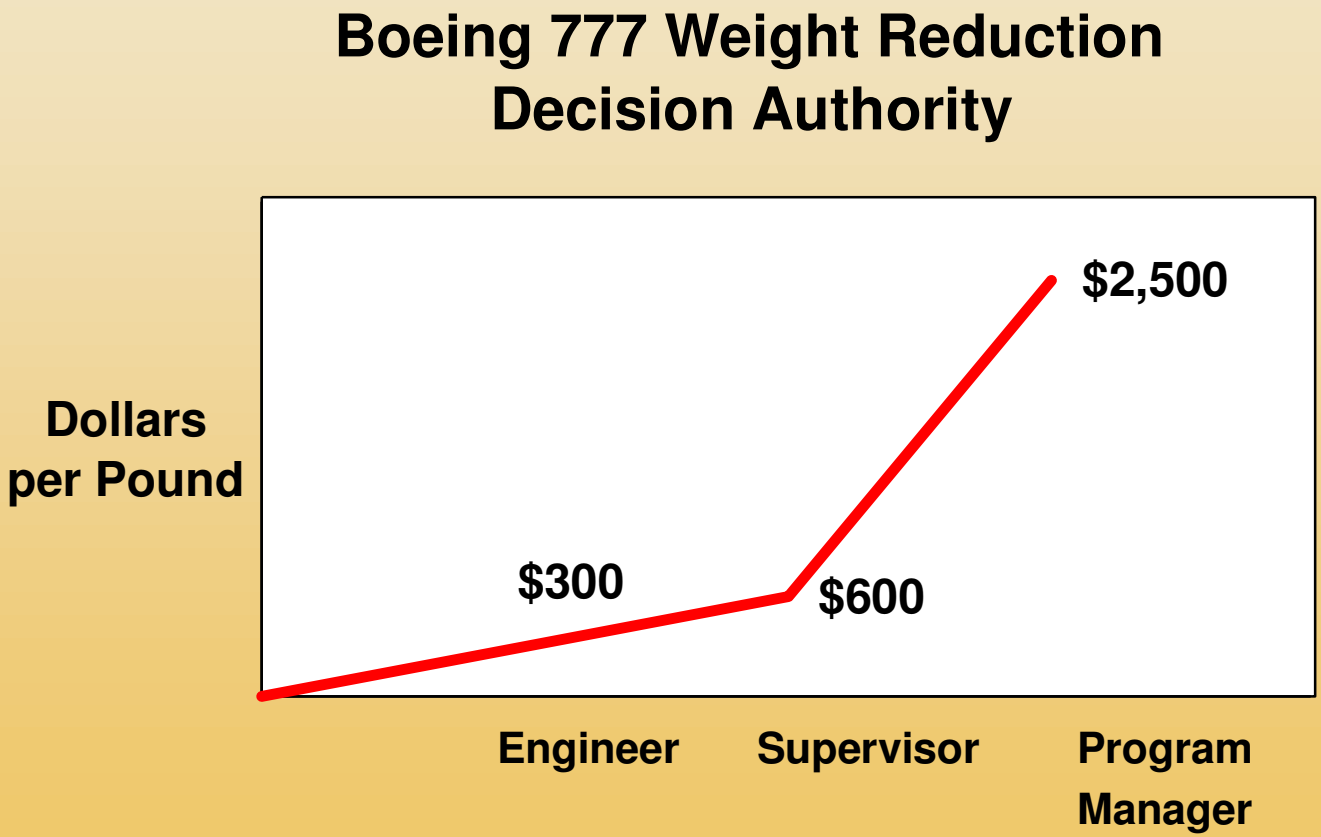
Marginal Economics



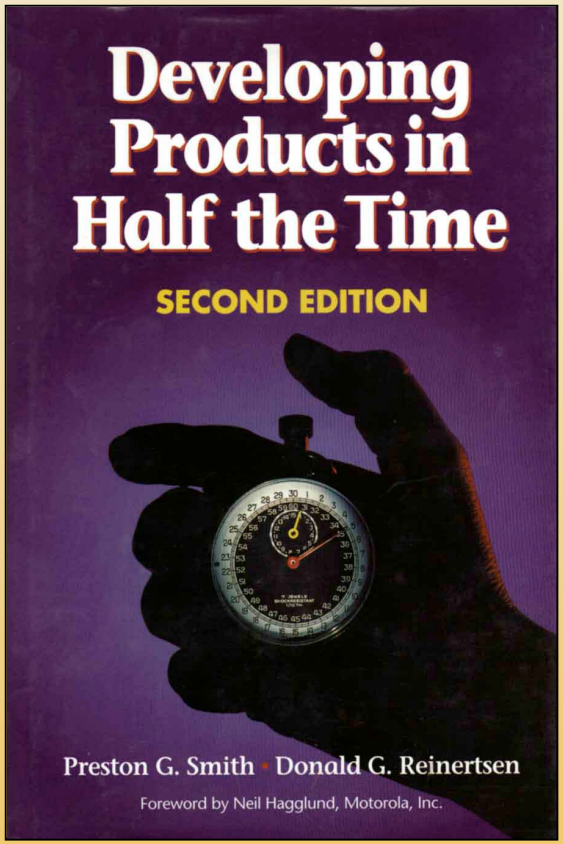


Should our goal be to optimize conformance, or to make good economic choices?

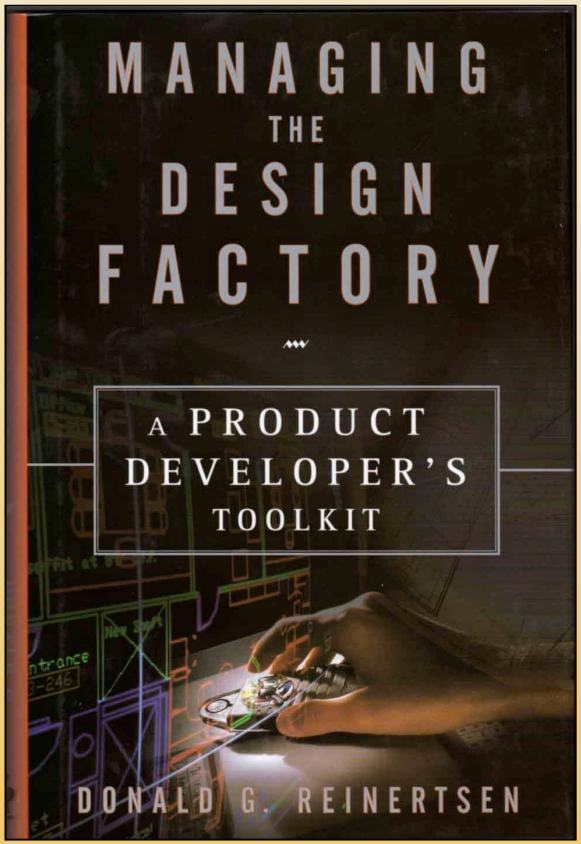
Decentralizing Control



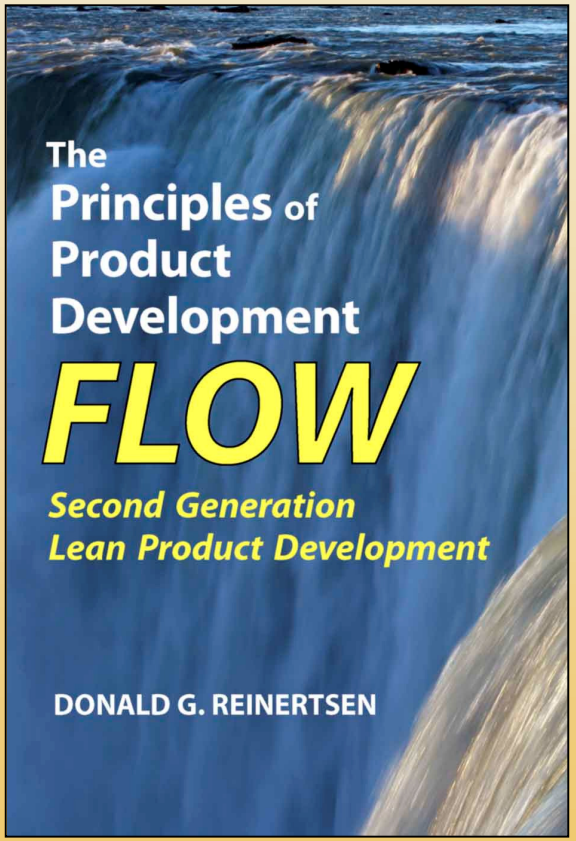
Going Further



1991 / 1997



1997



2009

Seminars in Scandinavia

Copenhagen:

November 29-30, 2010

Stockholm:

December 2-3, 2010