



Fourth International TOCPA Conference
9-10 February, 2013, Tallinn, Estonia

TOC: the process of on-going improvement?

Some food for thought!

Dr Roy Stratton



TOC : the process of on-going improvement?

5 Conclusions

4 Process
improvement
philosophies
(Six Sigma
and Lean)

The 5 steps of focusing

1. **Identify** the System's Constraint
2. Decide how to **Exploit** the Constraint
3. **Subordinate** everything to the above decisions
4. **Elevate** the System Constraint
5. If in the previous steps a constraint has been broken, **Go back to step 1.**

3 Relationship to
generic TOC
applications

1 Systems
Thinking
vs.
Analysis
Thinking

2 Operations
Theory



Change of Age?

- Analysis – Scientific reductionism (Descartes, 1596-1650)
 - Take apart, understand, reassemble
- Systems thinking (*Von Bertalanffy*, 1954)
 - an approach to problem solving, by viewing "problems" as parts of an overall system

‘Efficiency is doing things right; Effectiveness is doing the right things’ (*Peter Drucker*)

‘We can't solve problems by using the same kind of thinking we used when we created them’ (*Albert Einstein*)



Systems Thinking (Russ Ackoff)

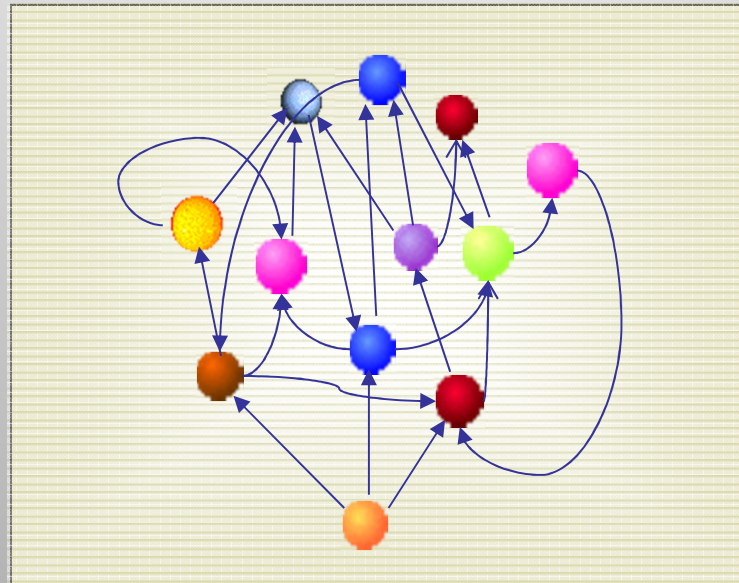
- A system is a whole that consists of parts, each of which can effect its behaviour or its properties
- Each part of the system is dependent on other parts for its effect on the system. All parts are interdependent in achieving a purpose
- Therefore:
 - When a system is taken apart it loses its essential properties
 - A system is not the sum of the behaviour of its parts but a product of their interactions.

‘If we have a system of improvement that is directed at improving the parts taken separately the performance of the whole will not be improved’.
(Ackoff, 1984)

- System performance measures : value, flow, throughput
 - chain analogy
- Anti-systemic performance measures: cost, efficiency
 - link analogy

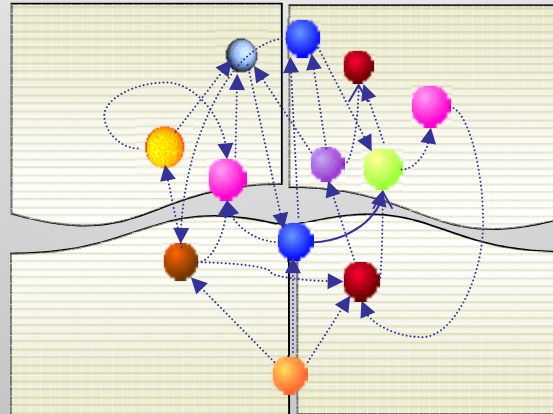


TAKE A COMPLEX SYSTEM





The Descartes (Scientific reductionism)

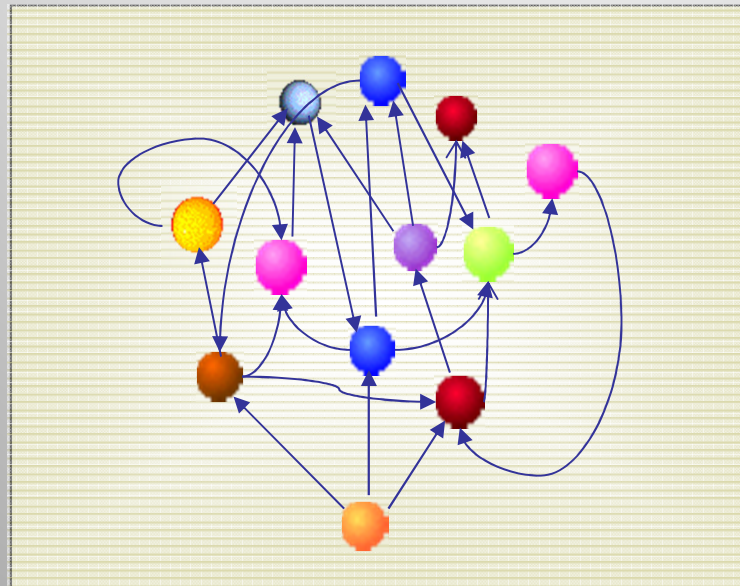


Divide the system up into specialist functions that are then locally optimised based on cost and efficiency

But... 'Local optima does not add up to the global optimum'



Systems thinking – viewing a problem as part of the overall system

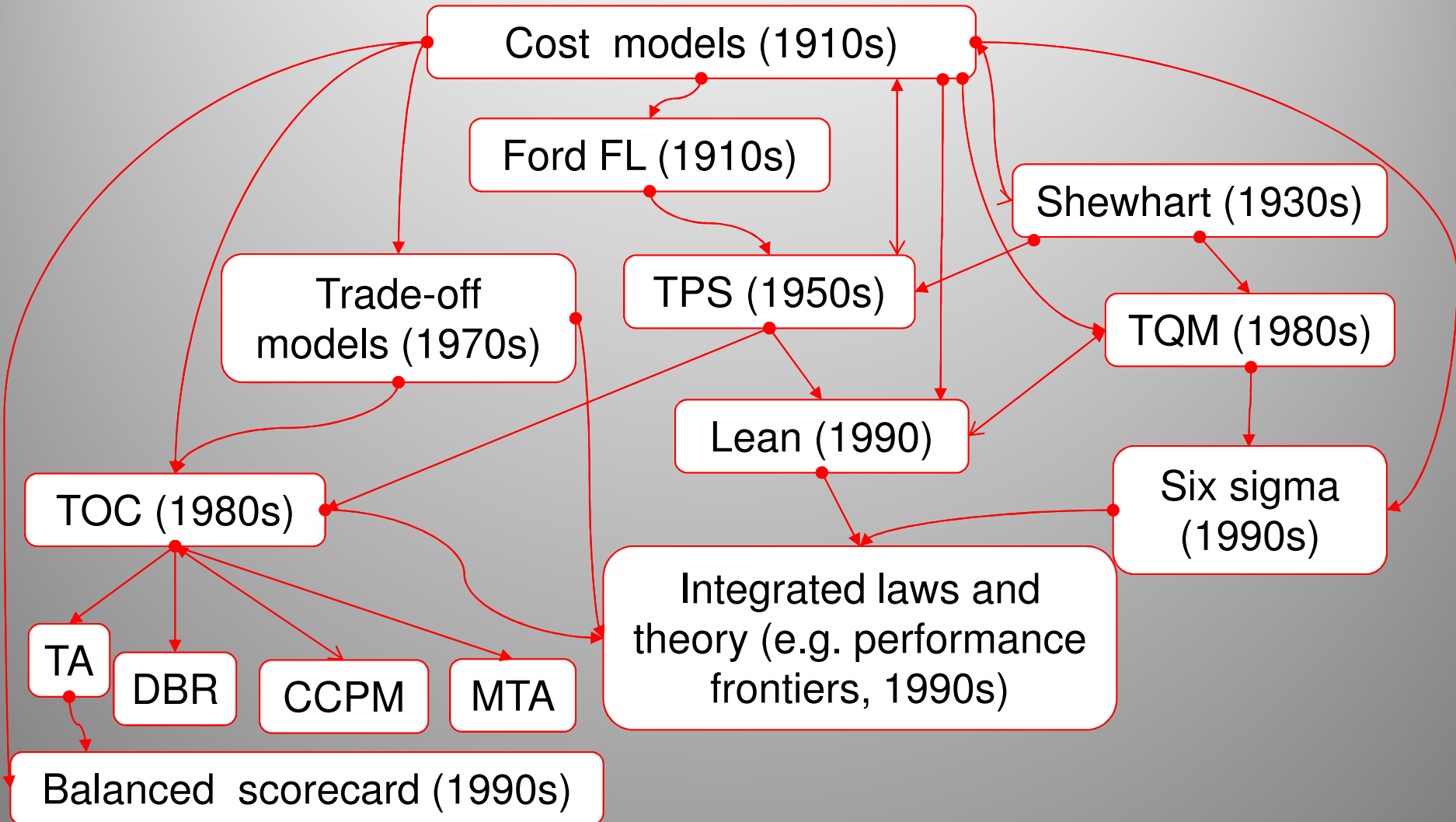


‘nature is exceedingly simple and harmonious with itself’ (Newton)

Mapping the relationship between the undesirable effects can be used to identify the underlying cost and efficiency based rules and policies.



Development of Operations Theory





Changes in Operations Thinking/Theory

Approach	Origin	Performance Focus	Key concepts
Economic	Harris, 1915	Dept. performance	Cost optimisation
Six Sigma	Shewhart, 1939	Reduce variation	Process Control
Manufacturing Strategy	Skinner, 1969 Hill, 1985	Strategic alignment	Focus and alignment of trade-offs
Lean (Just in Time)	Ohno, 1978; Womack et al., 2003	Increase flow	Kanban control
Theory of variability buffering	Schmenner and Swink, 1997; Fisher 1998; Hopp, 2011	Variation reduction / Buffering choice	Performance frontiers; coordinated strategies
TOC	Goldratt, 1984, 1990	Managing limiting factors	Buffer management and improvement
Balanced scorecard	Kaplan and Norton, 2006	Strategic alignment	Balanced measures

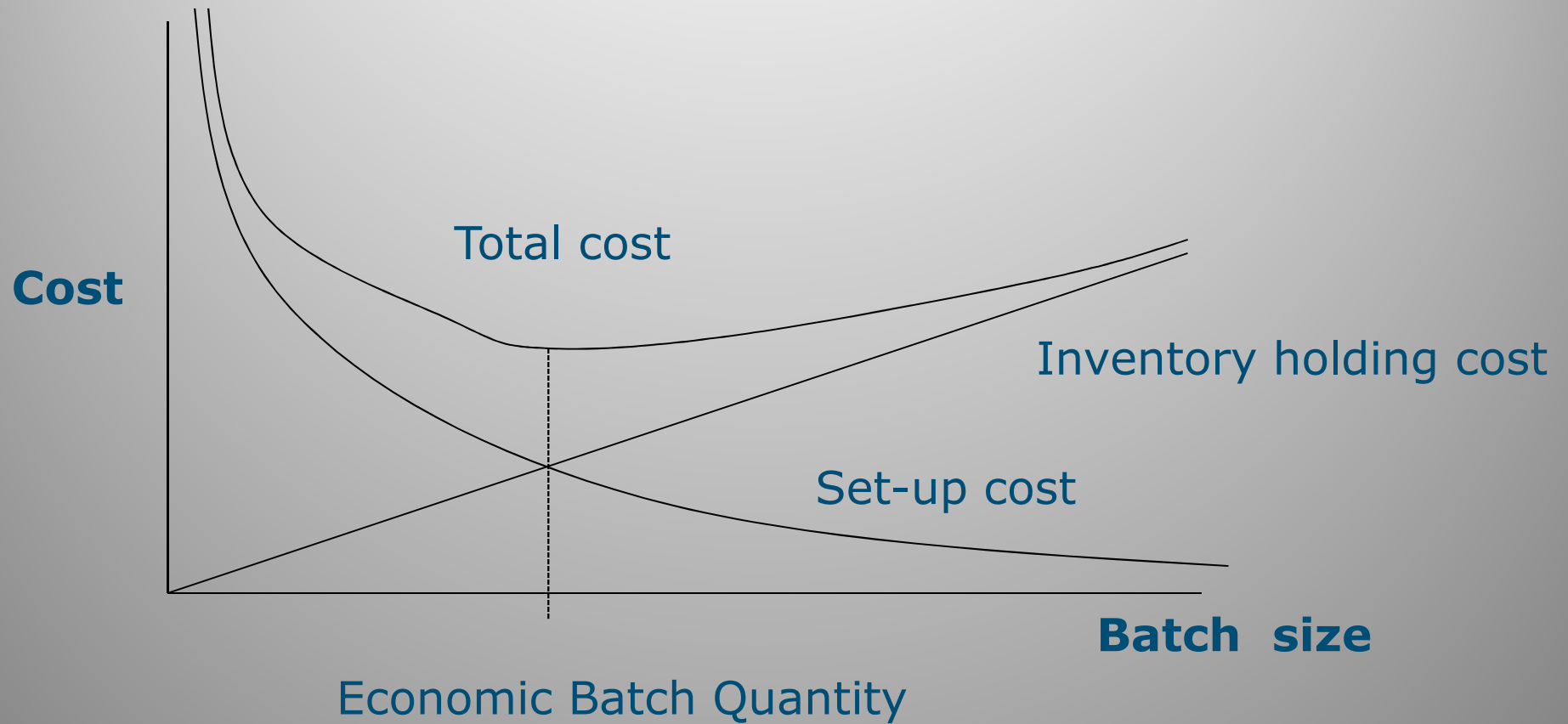


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**Lets consider how these different
approaches viewed batch / order
quantity sizing**

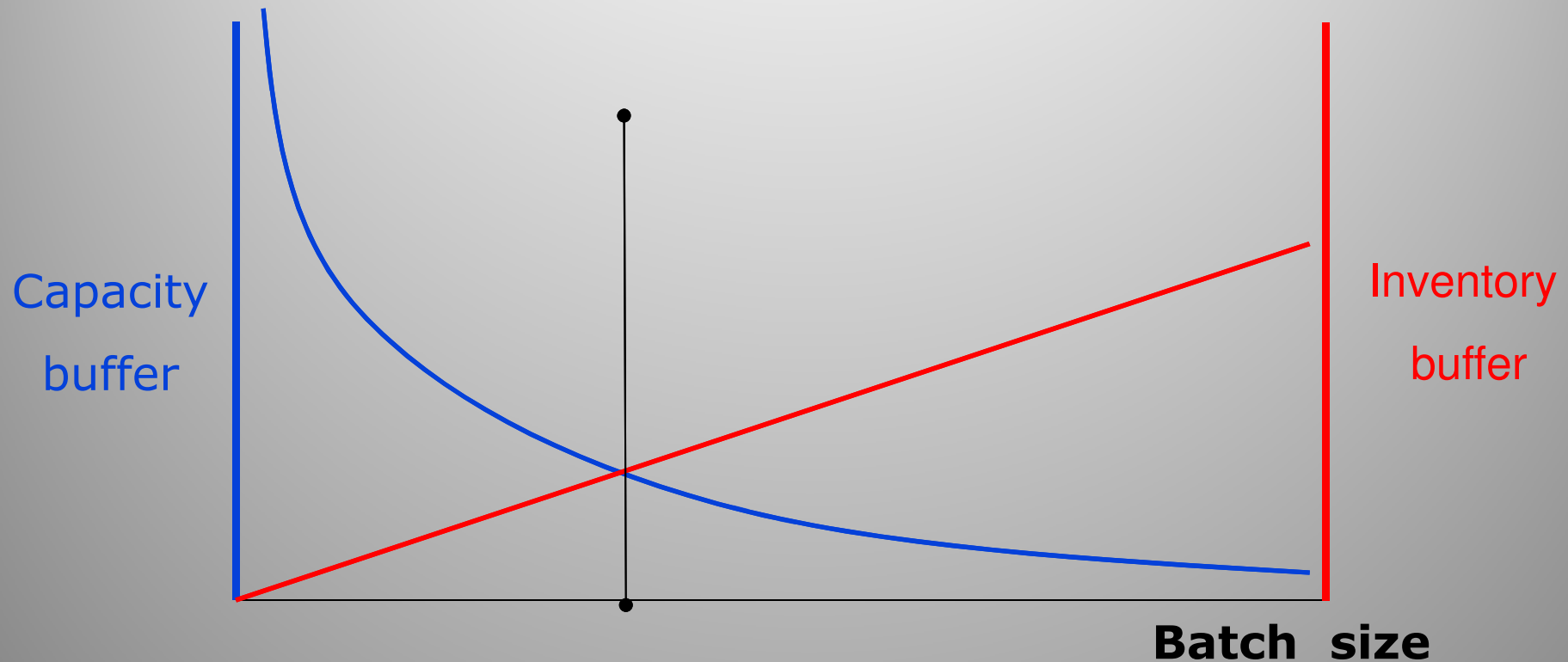


The Traditional Cost Modelling **(Harris 1915)**





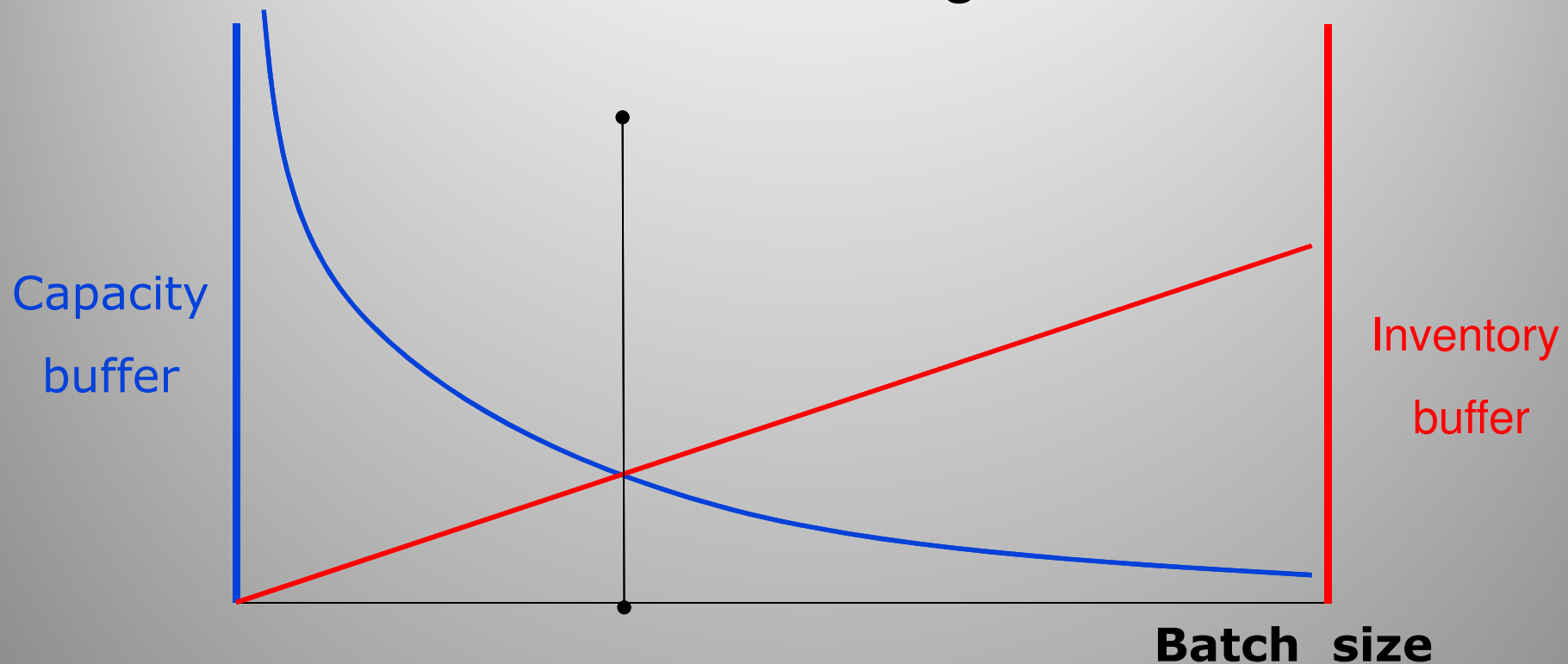
Manufacturing Strategy: trade-off choices and order winning criteria



Strategic choice of inventory over capacity buffering



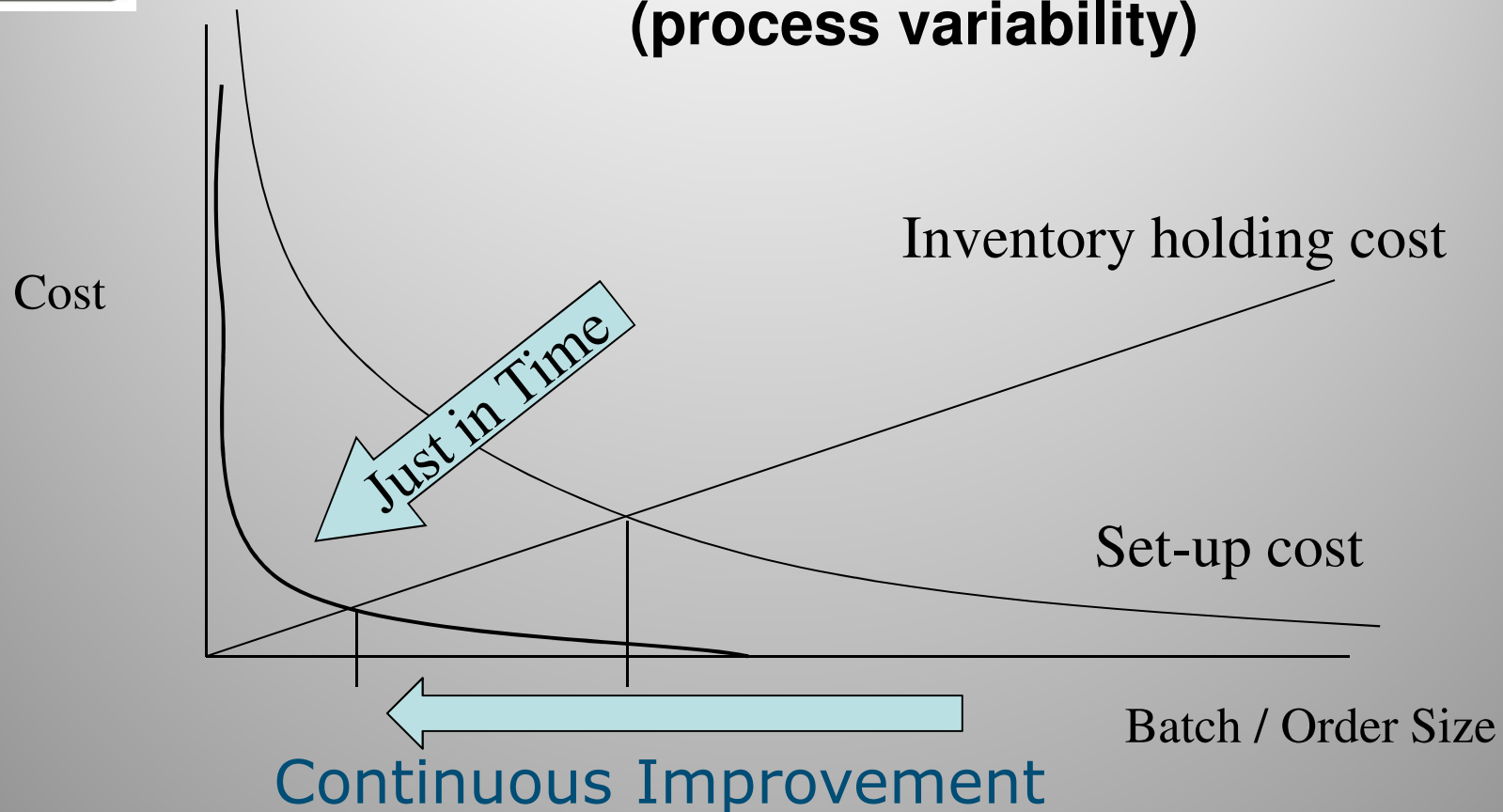
Manufacturing Strategy: trade-off choices and order winning criteria



Law (Variability Buffering): Variability in a production system will be buffered by some combination of Inventory, Capacity and Time. (Hopp and Spearman, 1995; 2007)



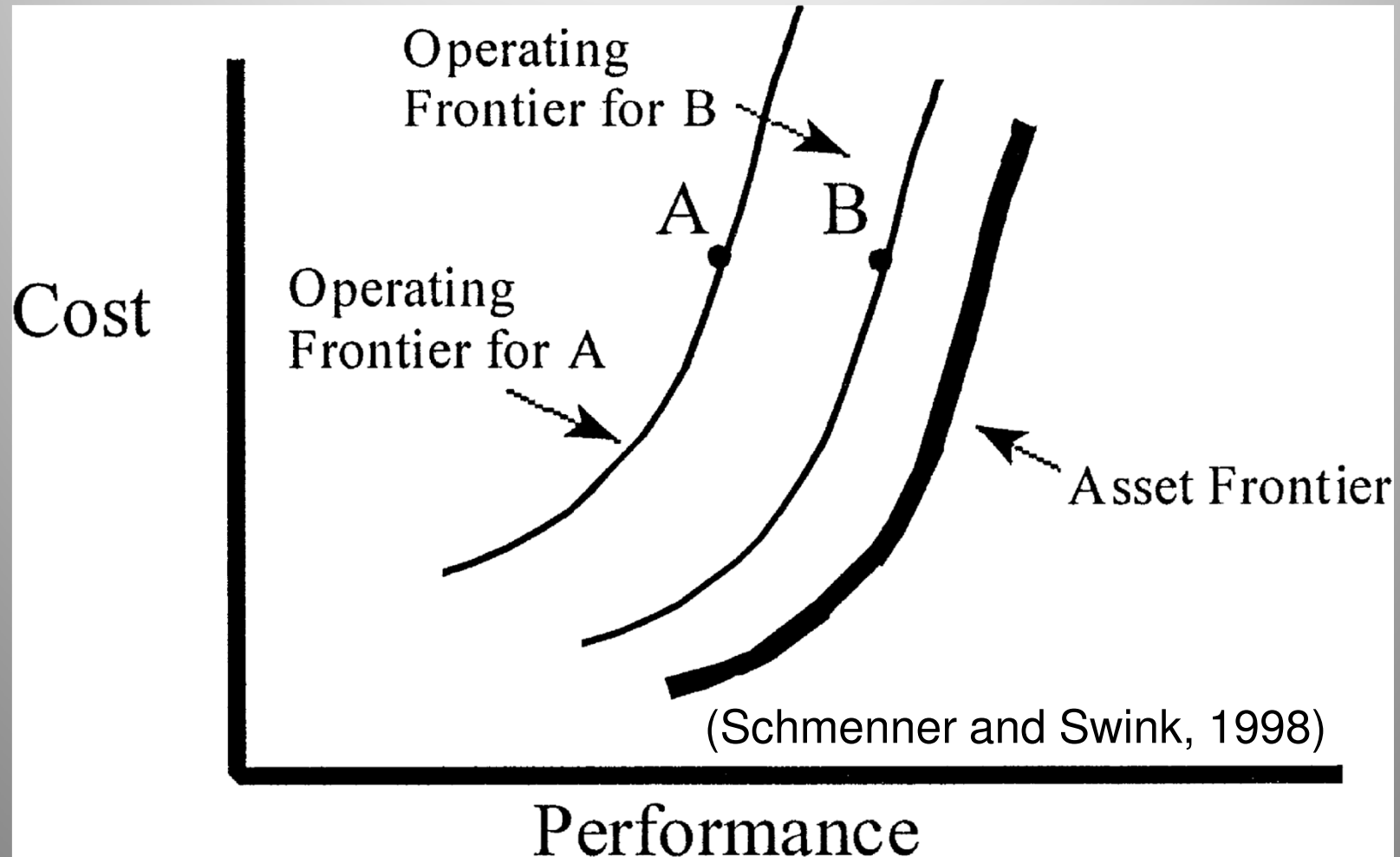
The Lean (JIT): Reducing set-up times (process variability)



Law (Variability): Decreasing variability always improves the performance of a production system. (Hopp and Spearman, 1995, 2007)

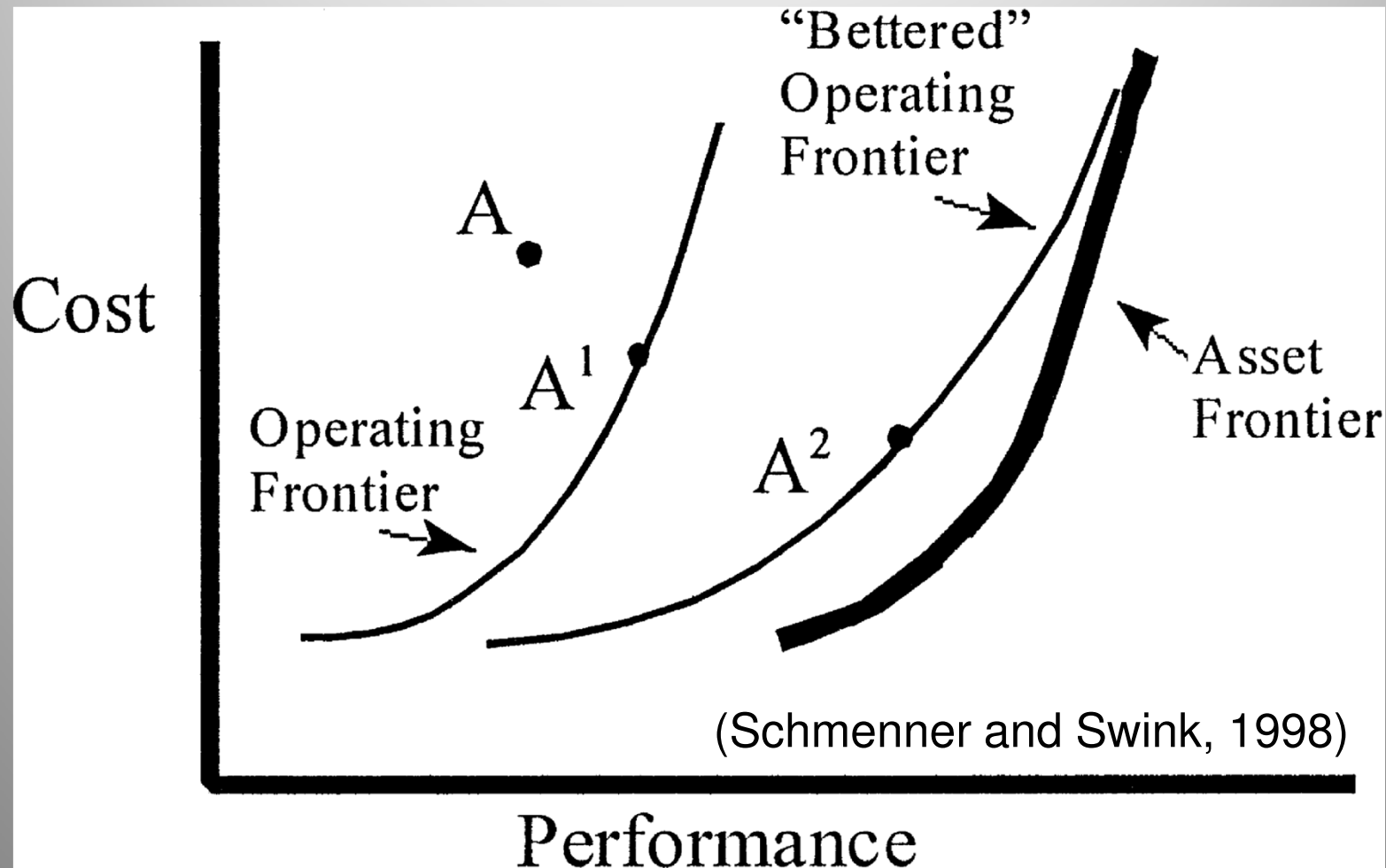


Theory of Performance Frontiers: (integrating trade-off and continual improvement thinking)



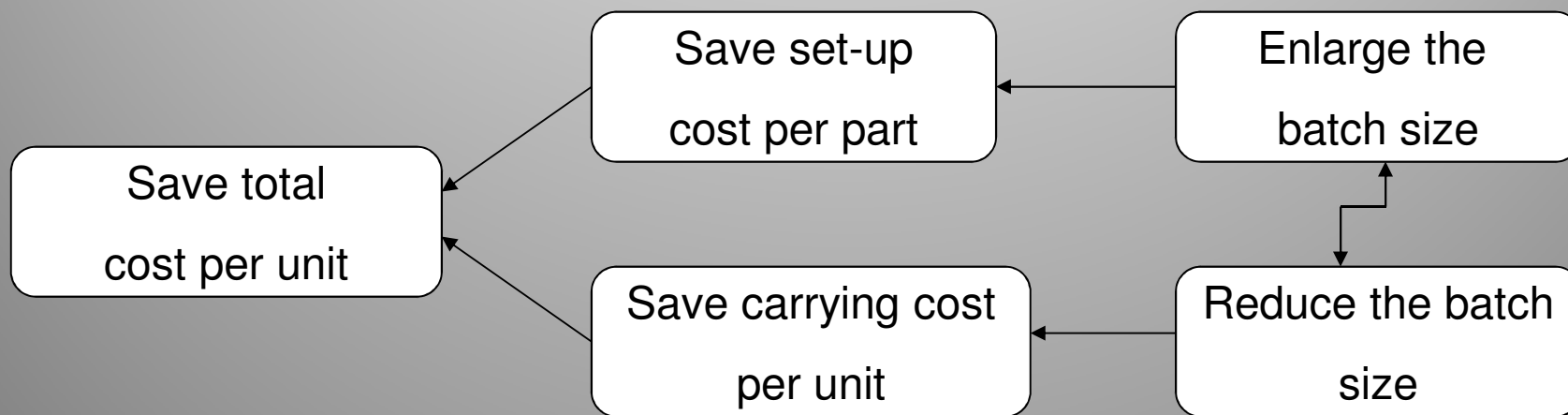
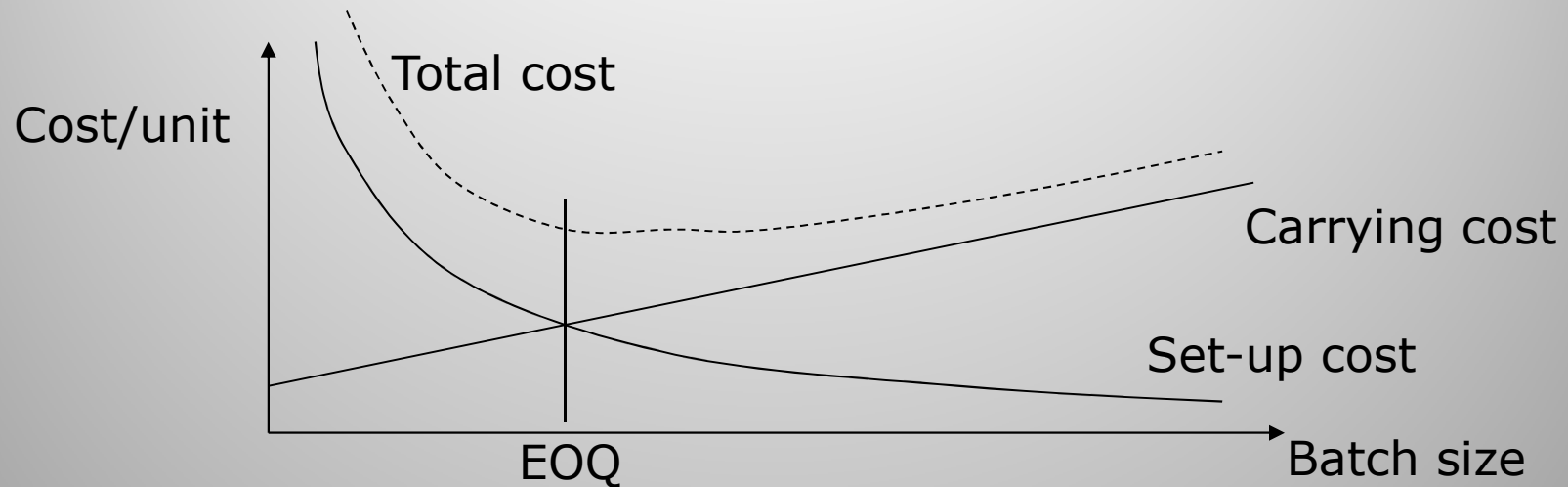


Theory of Performance Frontiers: integrating trade-off and continual improvement thinking





TOC directly challenges the cost paradigm

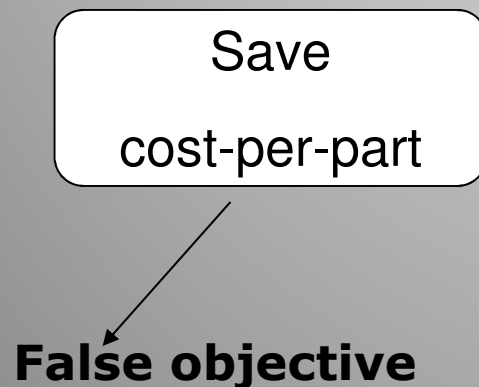




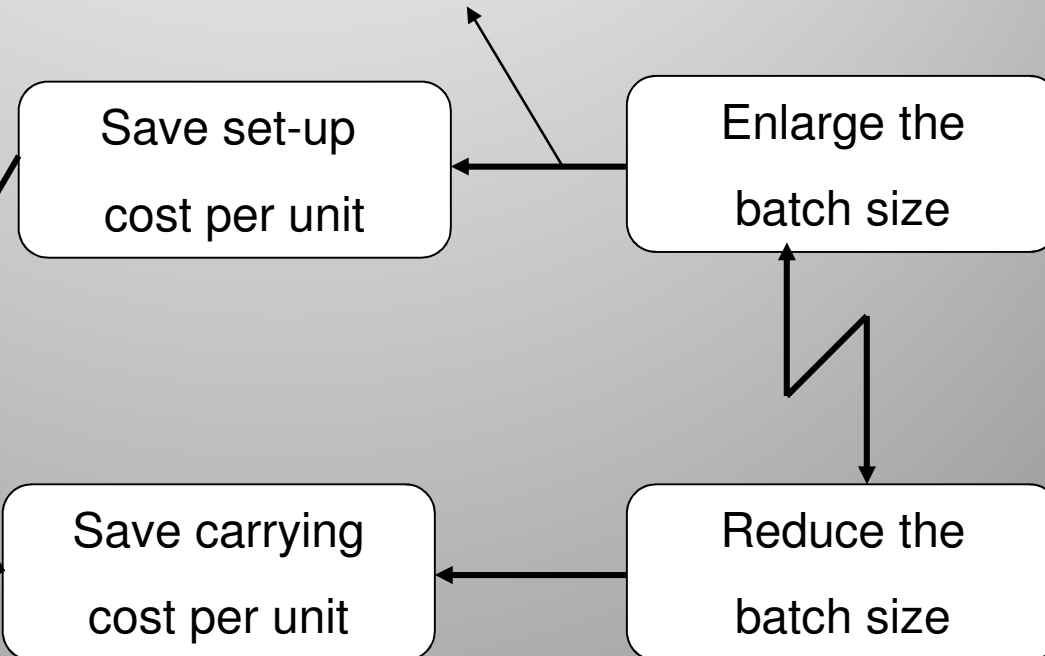
TOC directly challenges the cost paradigm

False assumption:

Set-up costs are not directly related to time.



False assumption: setup times are fixed





The cost accounting challenge

- This **challenging of basic assumptions is essential to breakthroughs**. Almost everyone who has worked in a plant is at least uneasy about the use of **cost accounting efficiencies** to control our actions. **Yet few have challenged this sacred cow directly**. Progress in understanding requires that we challenge basic assumptions about how the world is and why it is that way. If we can better understand our world and the principles that govern it, I suspect all our lives will be better.”
 - Goldratt’s forward to The Goal (1984)

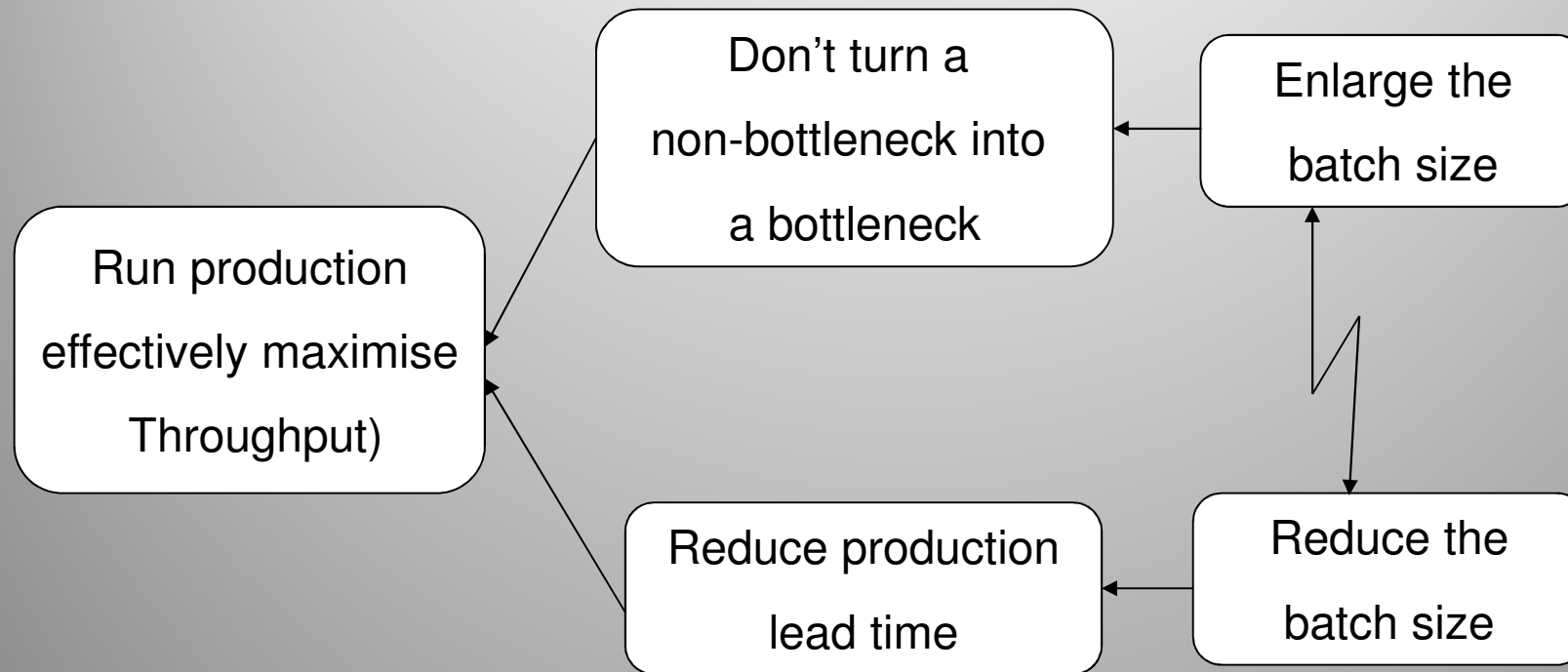


Underlying guidelines for supply chains **(Goldratt, 2008)**

- **1. Improving flow (or equivalently lead time) is a primary objective of operations.**
- **2. This primary objective should be translated into a practical mechanism that guides the operation when not to produce (prevents overproduction).**
 - Ford used space; Ohno used inventory; Goldratt used time and inventory.
- **3. Local efficiencies must be abolished.**
- **4. A focusing process to balance flow must be in place.**
 - Ford used direct observation.
 - Ohno used the gradual reduction of the number of containers and then gradual reduction of parts per container.
 - Goldratt used red zone buffer penetration signals.



TOC established new Throughput based rules



'Subordinate to the market constraint but do not create a resource constraint in the process'



TOC: The Five Steps of Focusing: The Value Added (Throughput) Paradigm

- 1 **Identify the system's constraint(s)**
 - (Improve T)
- 2 **Decide how to exploit the system's constraint(s)**
 - (Improve T)
- 3 **Subordinate everything else to the above decision**
 - Reducing variation reduces the levels of buffering (I) needed to protect T
- 4 **Elevate the system's constraint**
 - (Improve T)
- 5 **If in the previous steps a constraint has been broken, go back to step one.**
 - Warning – don't allow inertia to cause a system's constraint.
(Improve T)



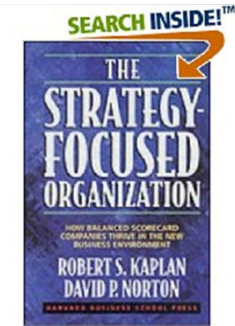
TOC – directly challenging the cost paradigm

- All these OM developments have addressed the operations need to manage or reduce variation in enabling flow of value.
- However, Goldratt overtly challenged the cost paradigm and its wider implications.
- The 5 steps reflect this emphasis on improving T and I.
- The outworking of this theory predictably led to a new perspective on wider applications (Project, Distribution, Marketing, Accounting).
- Kaplan in his debates with Goldratt also realised the need to think strategically about measurements in extending the balanced scorecard to encompass strategic focus and alignment.



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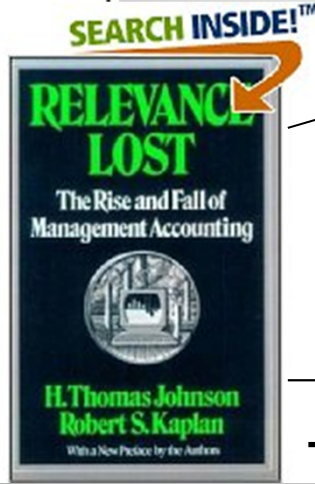
NO
TREN



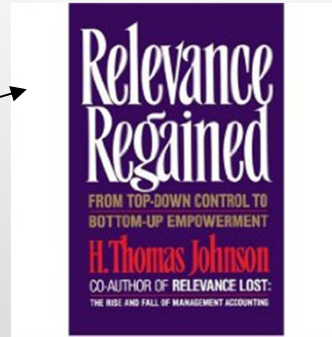
Strategy Focused (focus and alignment) Kaplan and Norton (2001)

- When talking about how they achieve these breakthrough results, the executives continually mention two words: ***focus and alignment***.
 - The laser operates nonlinearly; it leverages its limited power source to produce an incredibly bright and focused beam of light. Similarly, a well-crafted and well-understood strategy can, through alignment and coherence of the organisation's limited resources, produce a non-linear performance breakthrough.

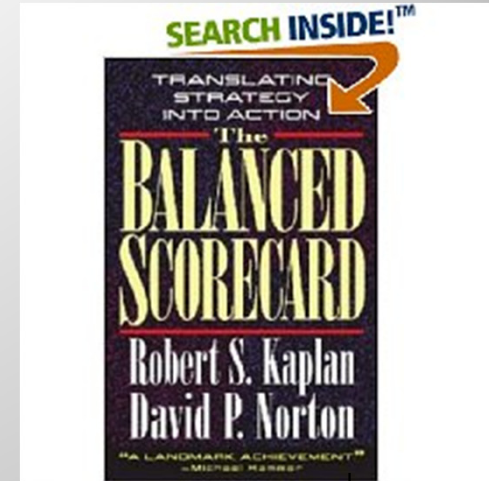
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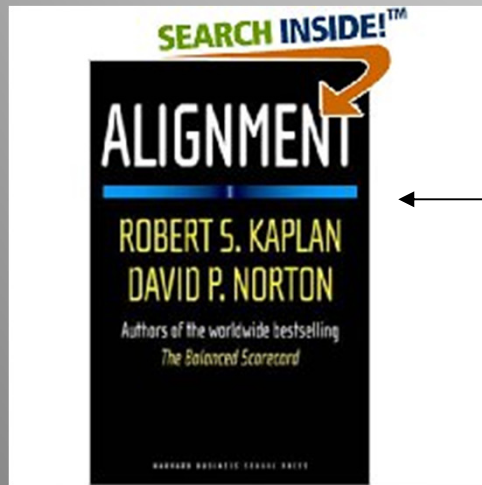
1987



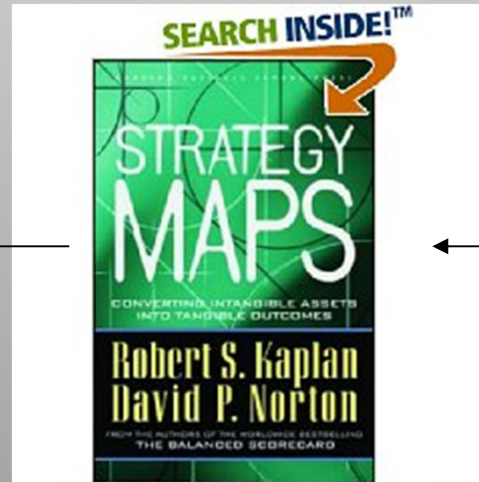
1992



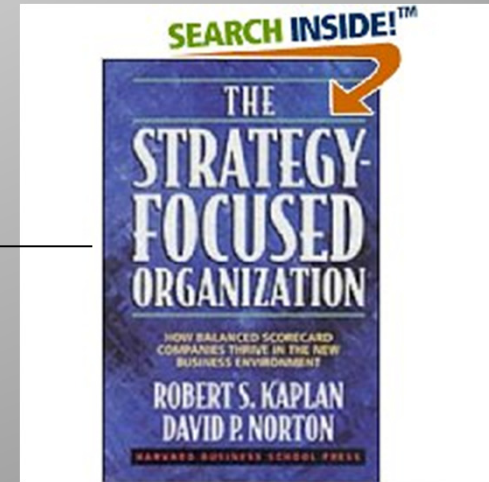
The Balanced Scorecard Journey 1992



2006



2004



2001



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and Lean)

The 5 steps of focusing

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**Understanding what thinking to change
still leaves the problem of what to change
to – let us look more closely at DBR,
CCPM and Distribution**

"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius -- and a lot of courage -- to move in the opposite direction." (Albert Einstein)



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NOTTINGHAM
TRENT UNIVERSITY



'Scissors' jump Olympic winner 1928

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Straddle high jump technique (1964 Olympics)



Bundesarchiv, Bild 183-S0305-0030
Foto: Mittelstädt, Rainer | 5. März 1977

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Rule changes enable step change improvements



Dick Fosbury's 1968 Olympic record was
65mm higher than the 1964 Olympic record

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The Five Steps of Focusing:
a process of on-going improvement

- 1 **Identify the system's constraint(s)**
- 2 **Decide how to exploit the system's constraint(s)**
- 3 **Subordinate everything else to the above decision**
- 4 **Elevate the system's constraint**
- 5 **If in the previous steps a constraint has been broken, go back to step one. Warning – don't allow inertia to cause a system's constraint.**



CONSTRAINTS

- **Constraint** – The factor that ultimately limits the performance of a system or organization. The factor that, if the organization were able to increase it, more fully exploit it, or more effectively subordinate to it, would result in achieving more of the goal. (TOCICO, 2012).
 - **Market demand, Resource, Supply, Lead time, management time**
 - **Policies?**
 - ‘Policy constraint – A common misnomer. Bad policies are not the constraint, rather they hinder effective constraint management by inhibiting the ability to fully exploit or subordinate to the constraint’. (TOCICO, 2012)

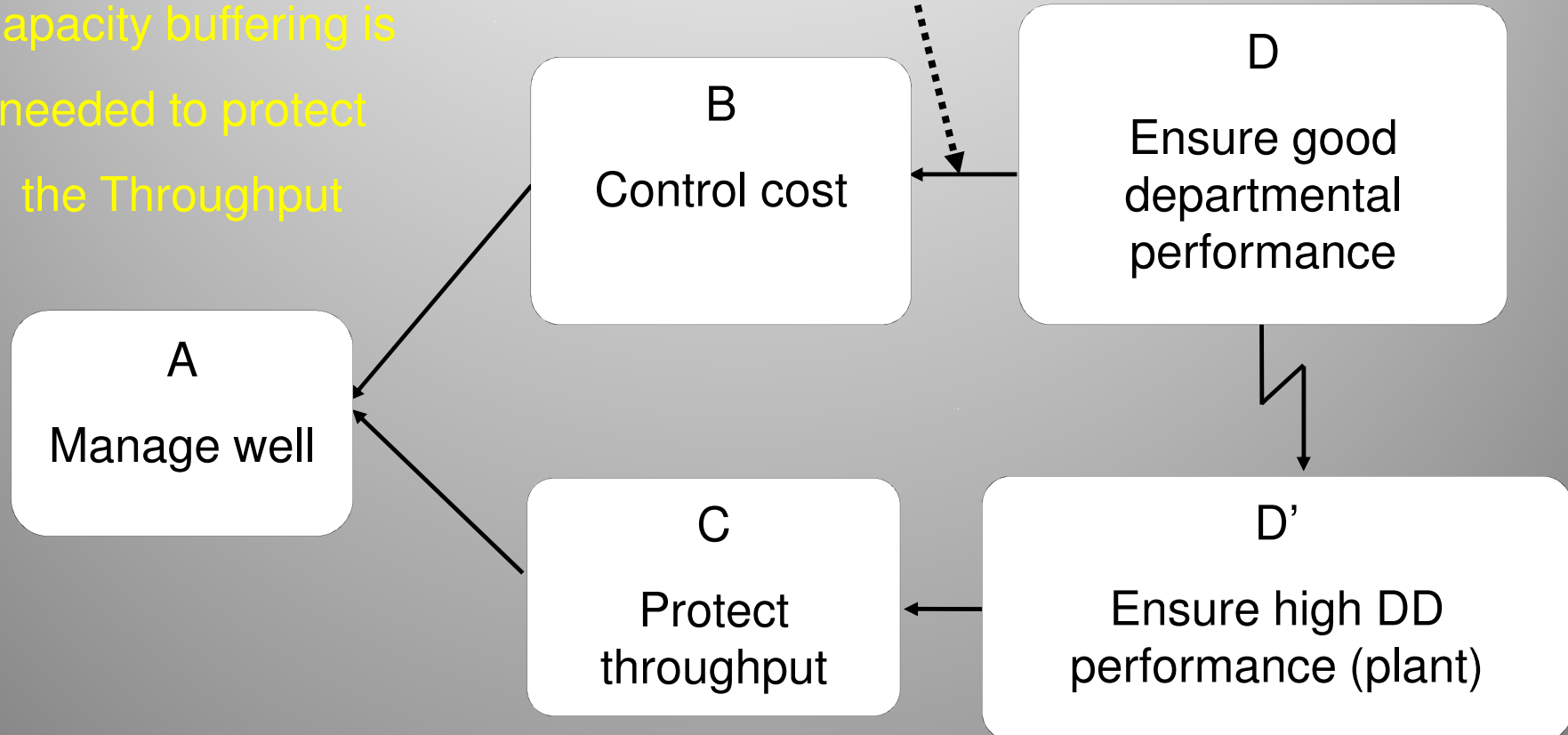


The cloud of operations.

Because...

A resource standing idle is a major waste.

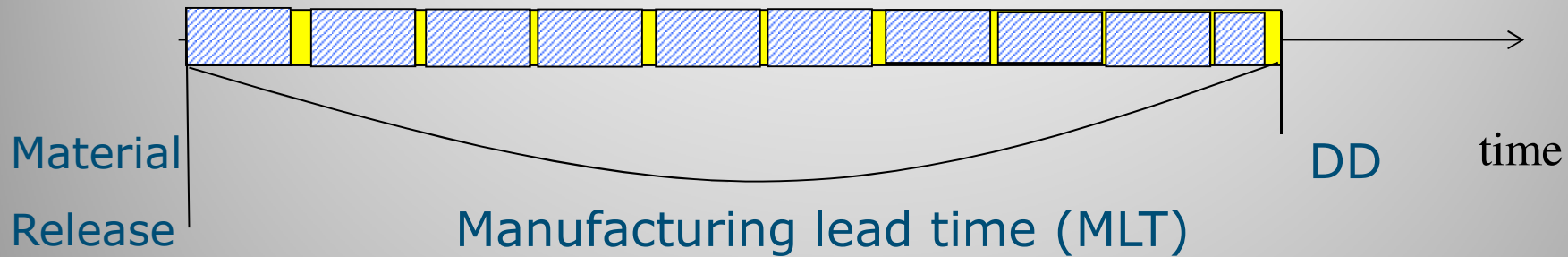
Capacity buffering is
needed to protect
the Throughput





Traditional Make To Order

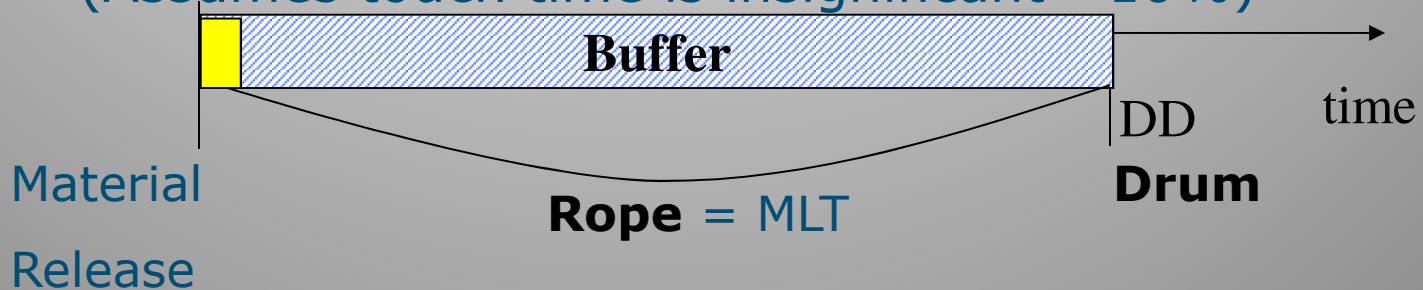
Departmental performance protected by separate queues



DBR

Buffer is aggregated: No intermediate due dates

(Assumes touch time is insignificant <10%)



Touch time:

Buffer:



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Operations Management (MTO)

- 1 Identify the system's constraint(s)
 - *Resource (DBR)*
 - *Market demand (SDBR)*
- 2 Decide how to exploit the systems constraint(s)
 - *Maximise bottleneck throughput*
 - *Order winning criteria (delivery speed)*
- 3 Subordinate everything to the above decision.
 - *Choke material release*
 - *Buffer aggregation*
 - *Buffer management*
 - *Cut batches on all products (Lean?)*
- 4 Elevate the system's constraint(s)
 - *Add capacity*
 - *New products / new market segments*
- 5 If the constraint is broken, go back to step 1 but do not let inertia become a system's constrain
 - *Stabilise policy changes by pre-empting emerging bottlenecks*



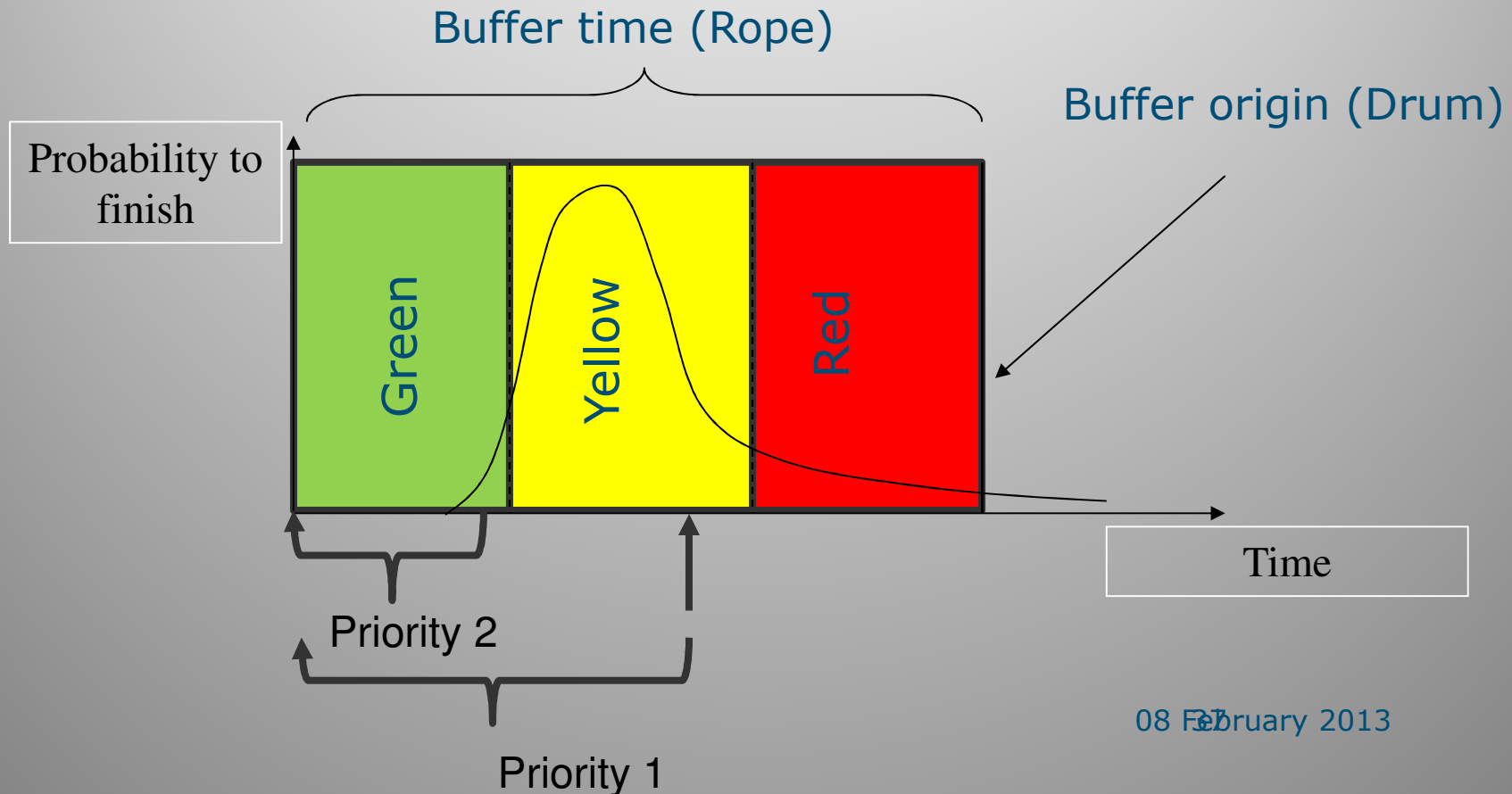
The functions of buffer management applied to Make to Order (DBR)

- ***Prioritise*** the flow of work
 - *buffer penetration*
- *Identify when to* ***expedite*** *potential delays.*
 - *Respond to individual red zone penetration*
- *Signals when there is a need to* ***escalate*** *intervention.*
 - *Respond to significant and growing red zone penetration*
- *Identify and* ***target*** *main sources of delay for improvement*
 - *Pareto analysis causes of red zone penetration*



Buffer Management – Function 1

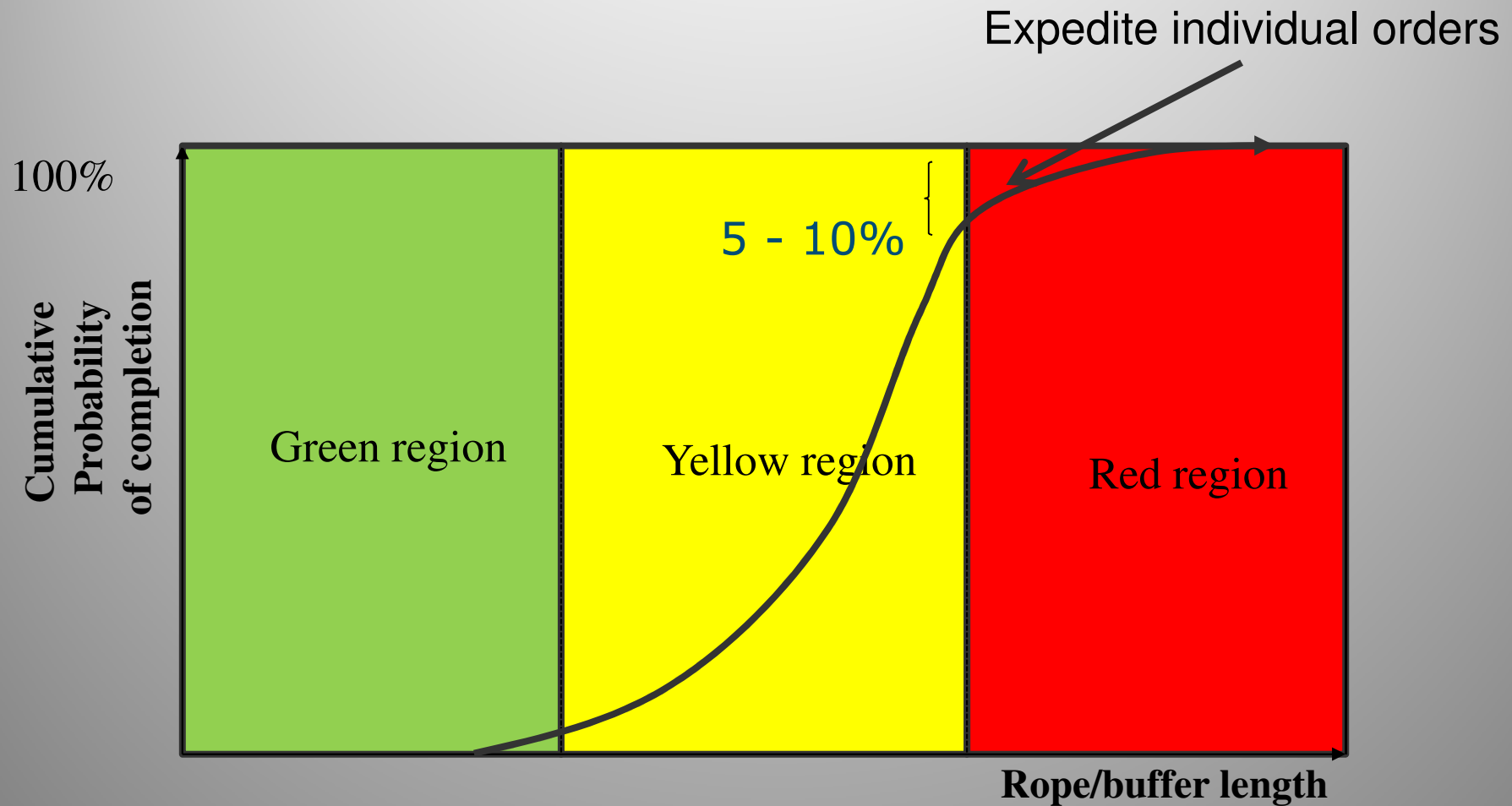
Erlang Distribution



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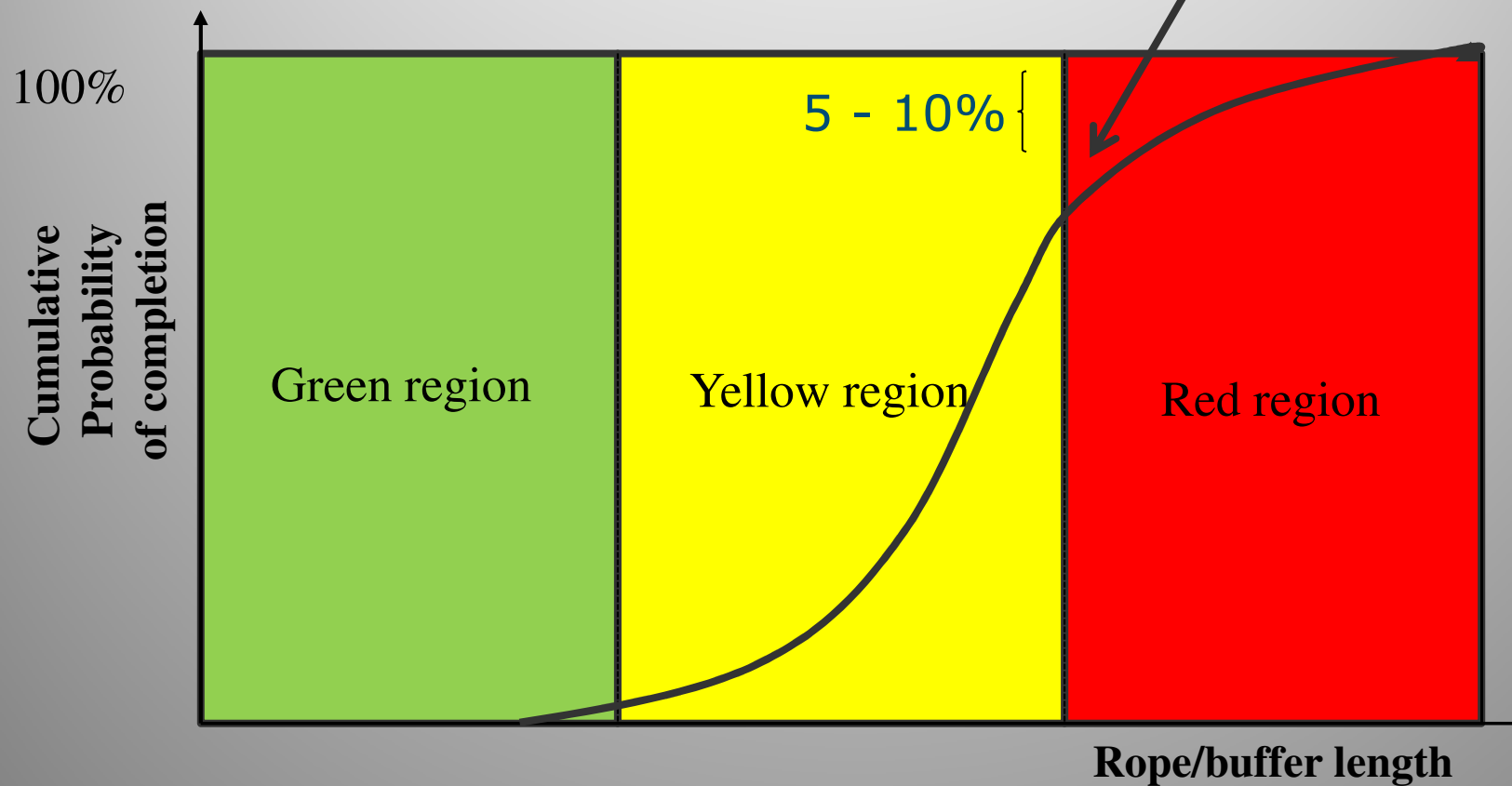
Buffer Management – Function 2





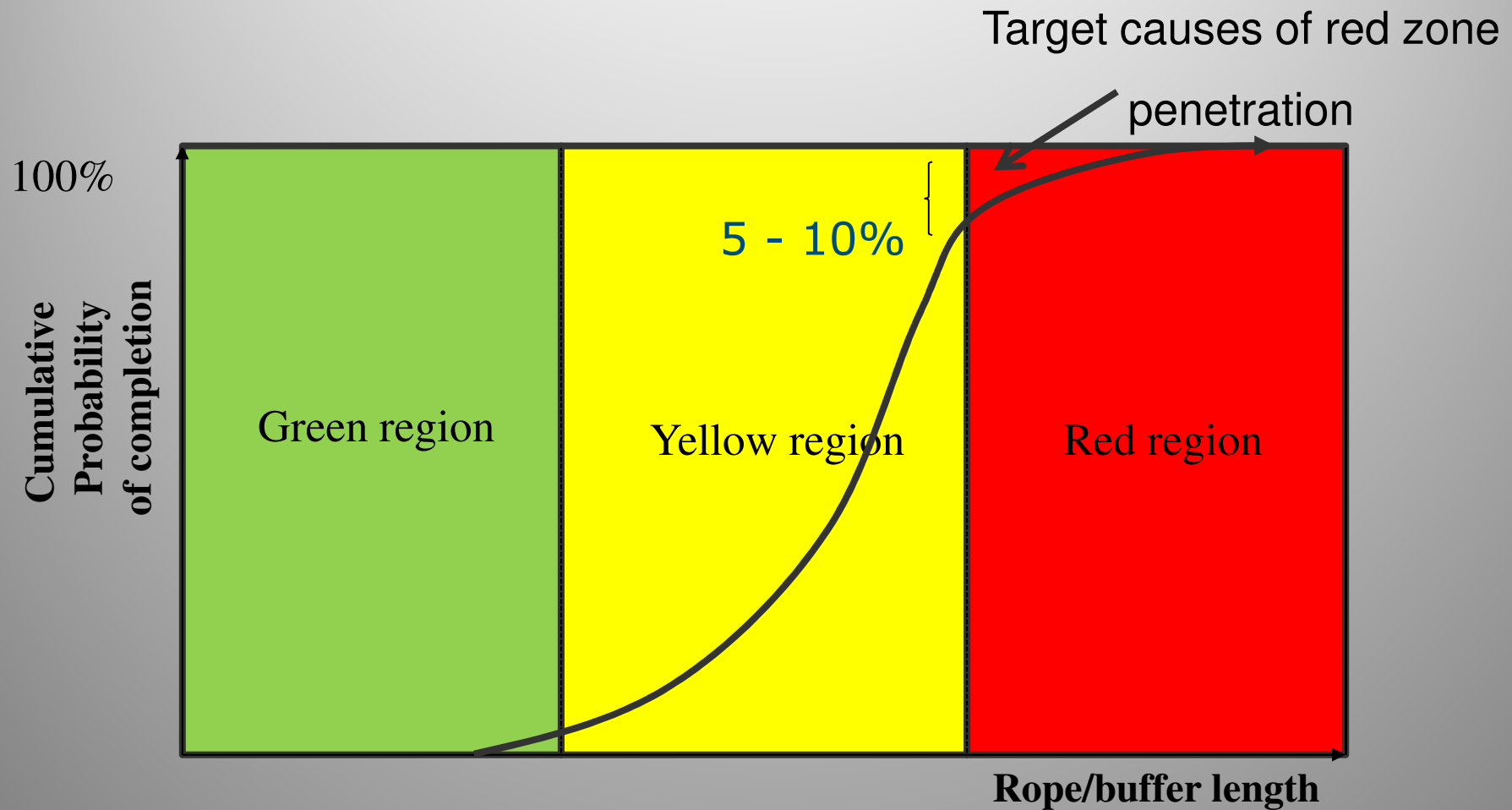
Buffer Management - Function 3

Growing red zone signals instability
Escalate immediate action





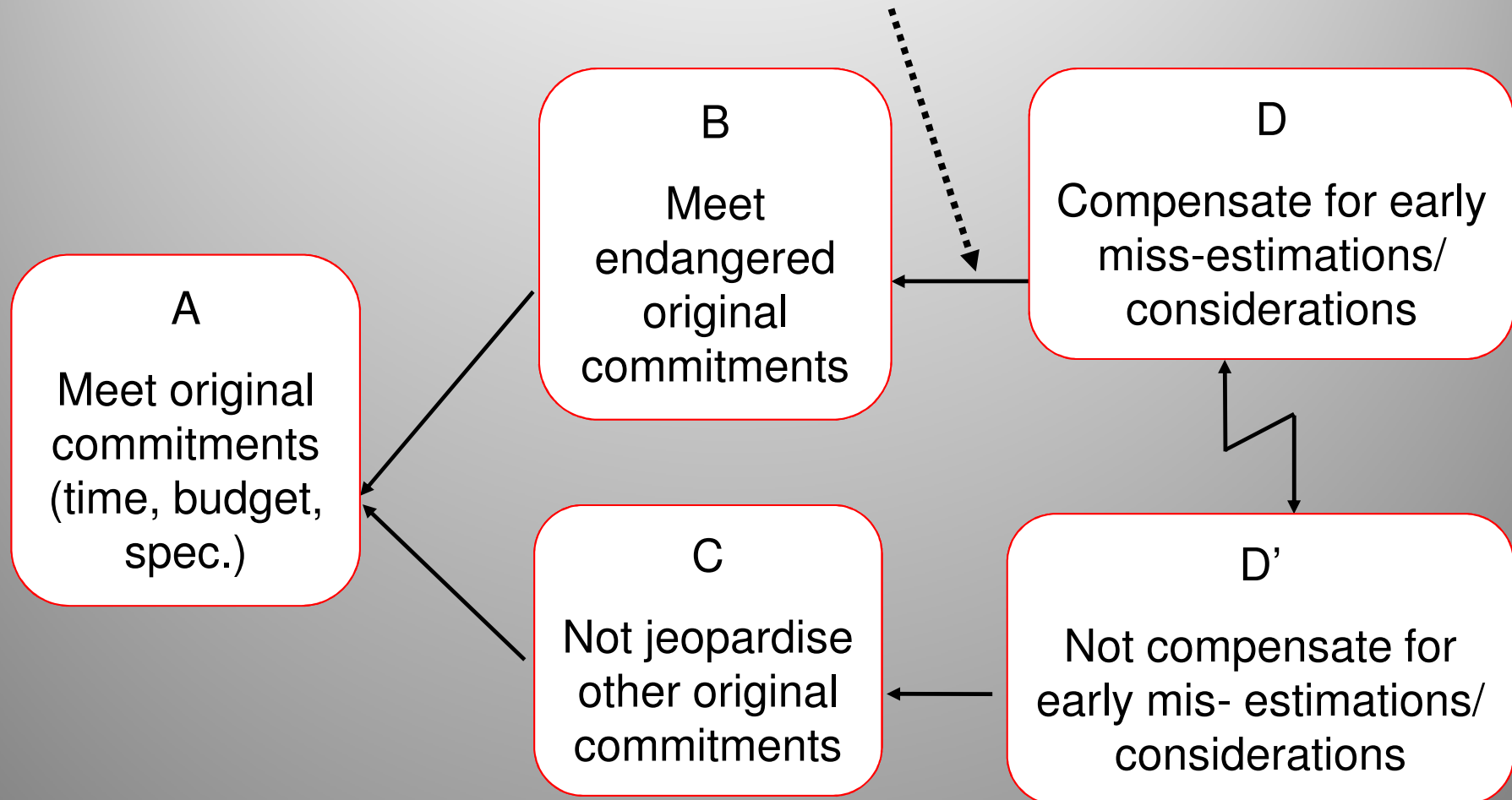
Buffer Management – Function 4





The cloud of projects

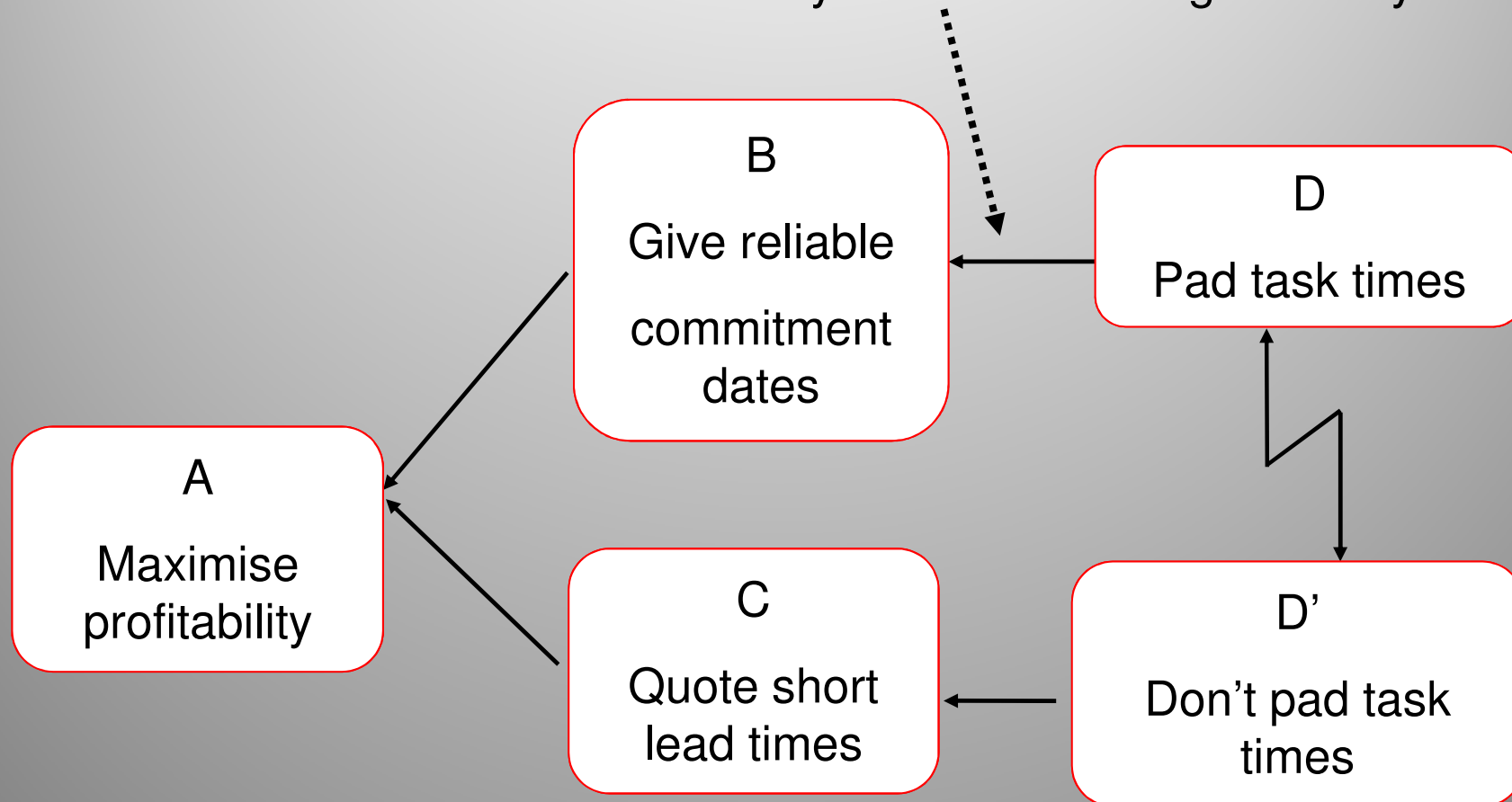
Because: estimations did not include sufficient buffer





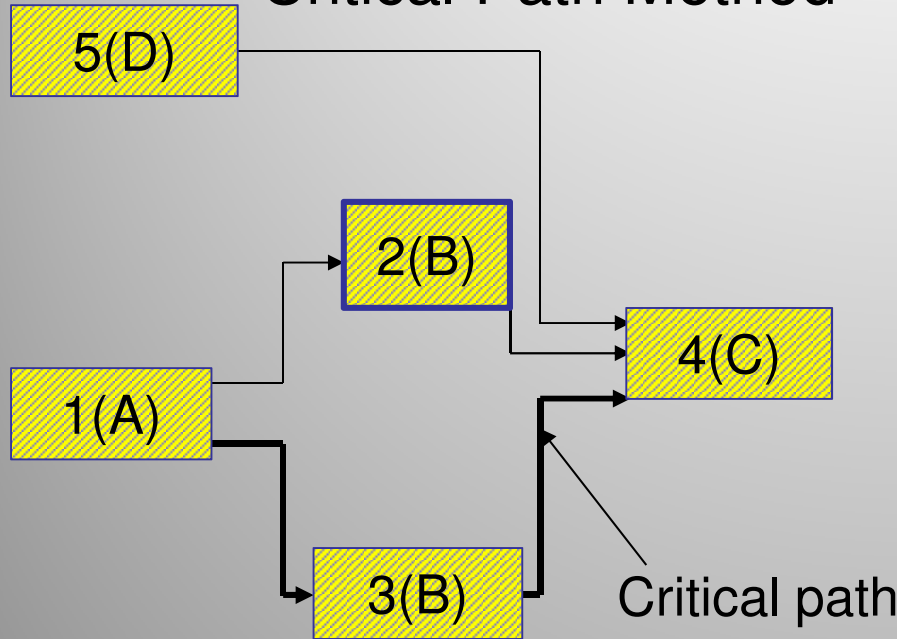
The cloud of projects

Because: uncertainty should be managed locally?



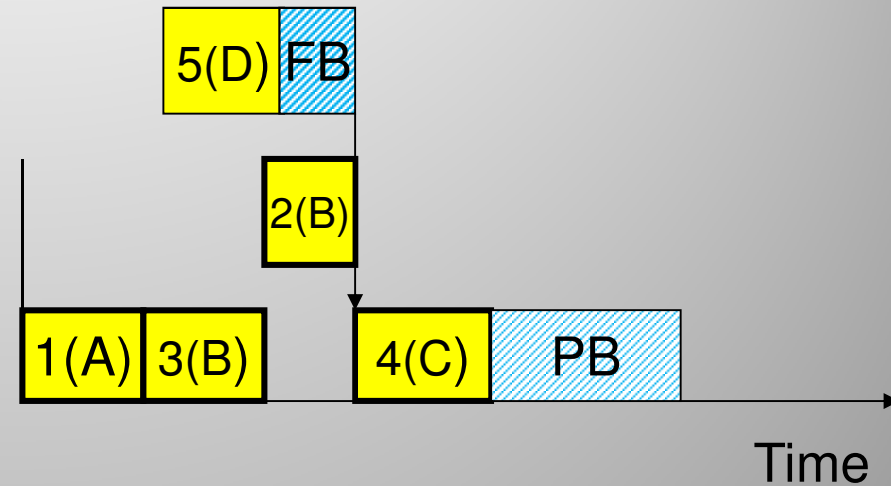


Critical Path Method



Resources: A,B,C,D

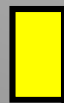
Critical Chain



FB: Feeding Buffer

PB: Project Buffer

Touch time:



Buffer:



Mixed:



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Project Management

- 1 Identify the system's constraint(s)
 - *Time (Critical path)*
- 2 Decide how to exploit the systems constraint(s)
 - *Aggregate Critical Path time buffers (project buffer)*
- 3 Subordinate everything to the above decision.
 - *Feeder buffers – protect non-critical tasks*
 - *Report tasks daily - projected completion*
 - *Buffer management - (prioritise, expedite, escalate, improve)*
 - *Choke project release - reduce number of live projects*
 - *Full kit - specifications are complete before release*

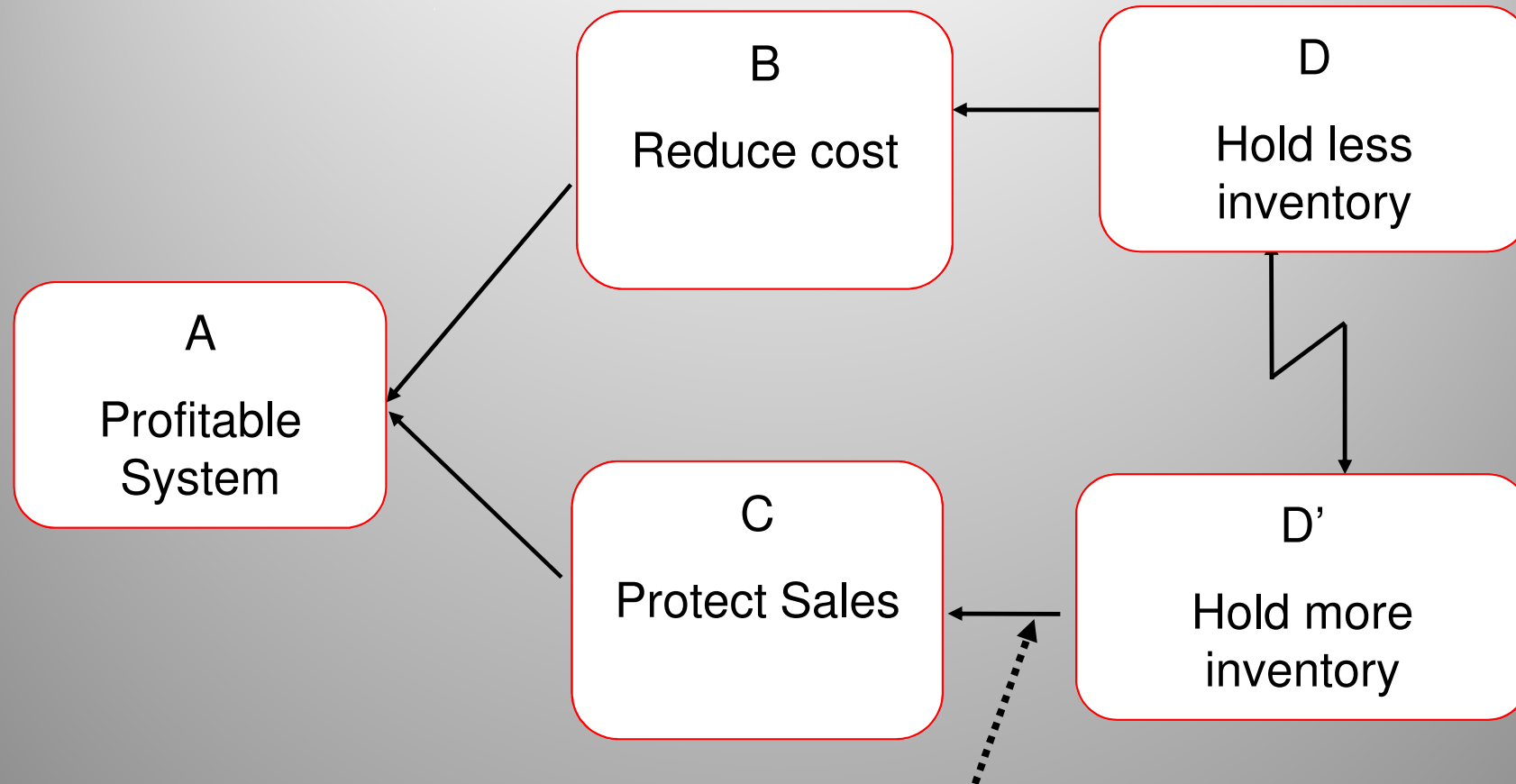


Functions of Buffer Management applied to Project Management

- ***Prioritise*** the flow of work
 - *Based on a ratio of buffer penetration to project CC completions*
- *Identify when to* ***expedite*** *potential delays.*
 - *Respond locally at the task level to minimise consumption of the buffers*
- *Signals when there is a need to* ***escalate*** *intervention*
 - *Respond to red zone penetration at the project/programme level.*
- *Identify and* ***target*** *main sources of delay for improvement*
 - *Pareto analyse causes of red zone penetration.*



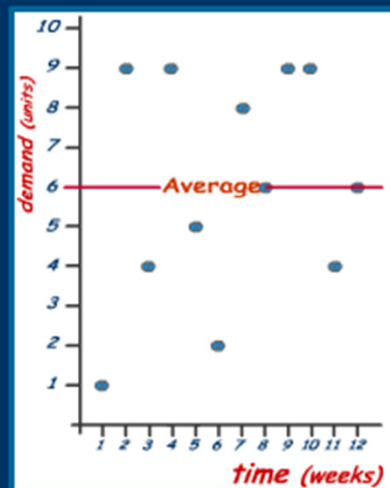
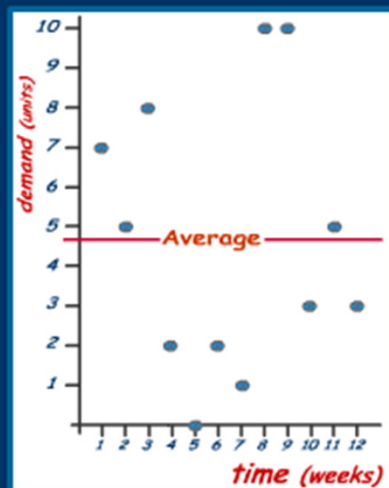
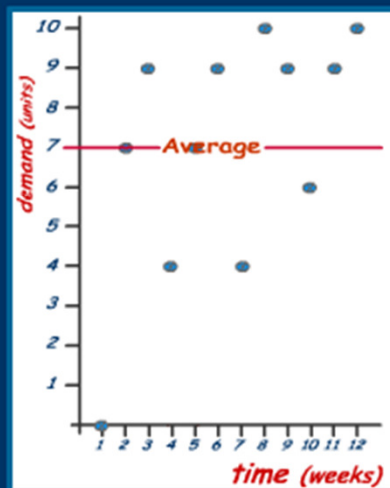
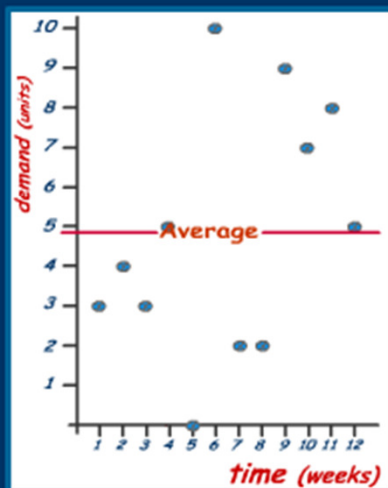
The cloud of Distribution



Because: there is no means of reducing uncertainty of demand?



The difference in variability of demand - supply point feeding 100 consumption points:

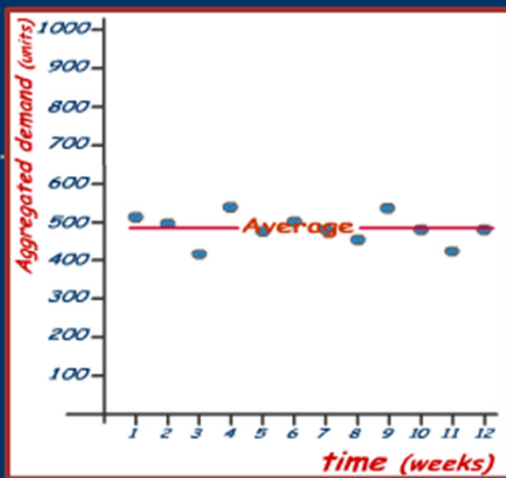


Click on the buttons for more random distributions



Notice the drop in variability with the number of consumption points:

- 4 points
- 10 points
- 100 points





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Distribution (MTA)

- 1 Identify the system's constraint(s)
 - *Footfall (customer entering shop)*
- 2 Decide how to exploit the systems constraint(s)
 - *Ensure products are available*
- 3 Subordinate everything to the above decision.
 - *Aggregate stock buffer (plant warehouse)*
 - *Set stock target level based on replenishment time*
 - *Signal consumption daily and replenishment periodically*
 - *Introduce buffer management*



Functions of Buffer Management applied to MTA and Distribution

- **Prioritise** the flow of work
 - % Buffer penetration
- Identify when to **expedite** potential delays.
 - If the stock buffer availability shows red then chased next order in the system
- Signals when there is a need to **escalate** intervention
 - If the red zone is repeatedly in the red increase the target level
- Identify and **target** main sources of delay for improvement
 - Pareto analyse causes of red zone penetration due to supply.



TOC : the process of on-going improvement?

5 Conclusions

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and Lean)

The 5 steps of focusing

1. **Identify** the System's Constraint
2. Decide how to **Exploit** the Constraint
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5. If in the previous steps a constraint has been broken, **Go back to step 1.**

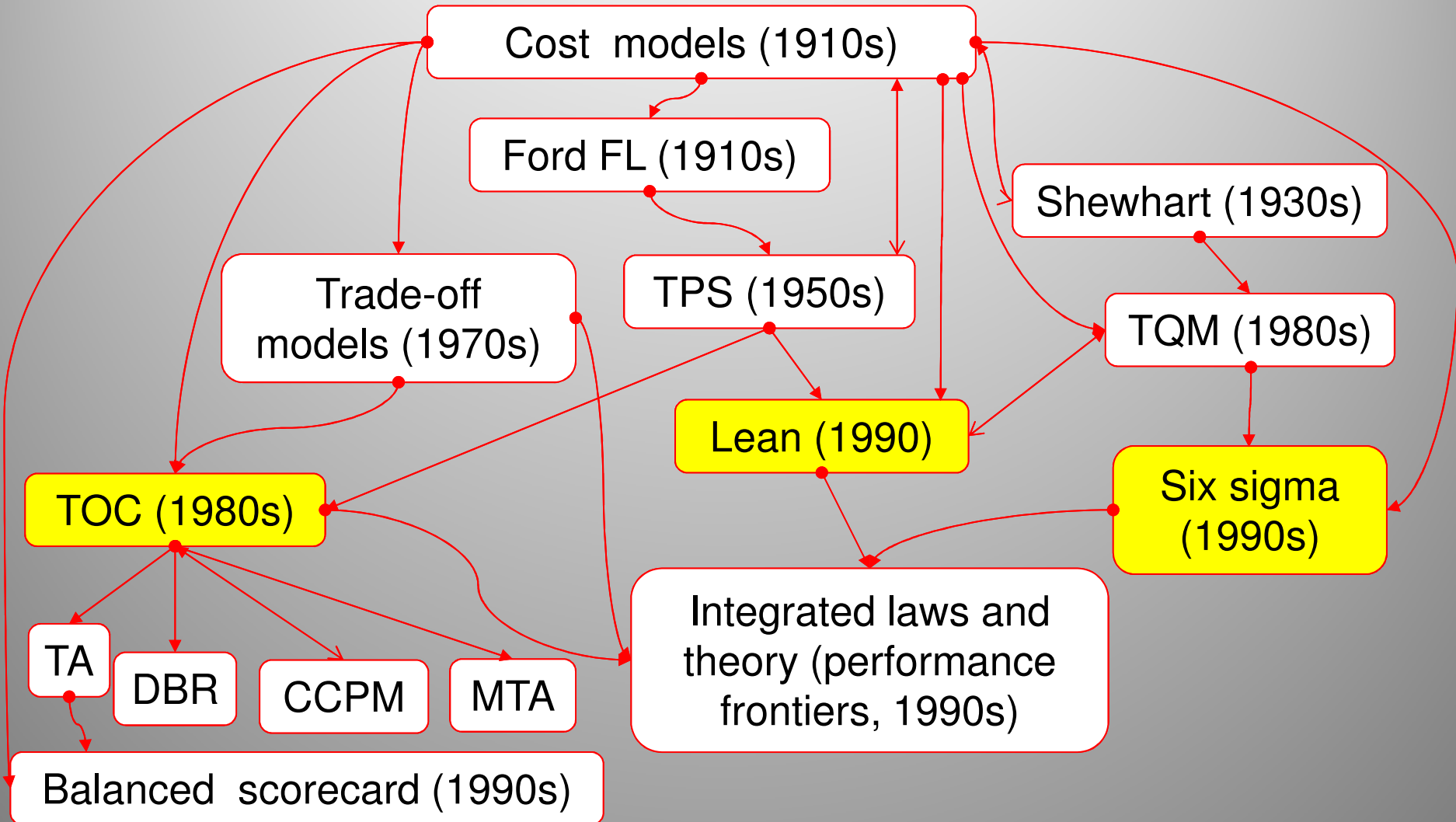
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Development of Ops Man Theory





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Attribute	Processes of on-going improvement?		
	Six Sigma	Lean	TOC
Process steps	Define Measure Analyse Improve Control	Identify value Map value stream Flow Pull Perfection	Identify constraint Exploit Subordinate Elevate Go back
Origins	Shewhart Western Electric 1930s	Ohno Toyota 1950s	Goldratt Creative Output 1980s
Emphasis	Reduce Defects	Reduce Waste	Manage variation
Perspective	Processes	Supply Chain	Wider system



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Attribute	Processes of on-going improvement		
	Six sigma	Lean	TOC
Environment	Standard processing	Stable flow	Complex flow
Key word	Variation	Flow	Focus
Key assumption	Process variation can be systematically reduced	Interruptions to flow can be simply reduced	Variation can be more effectively managed
Key scientific approach	Hypothesis testing (PDSA)	Hypothesis testing (PDSA)	Causal mapping (Necessity and sufficiency logic)
Key change	Specific processes	Process flow	Management rules
Distinguishing concept/tool	Statistical process control	Kanban control	Buffer management
Pre-requisite	Accurately measure parameters	Establish well defined value streams	Identify means of aggregating variation



Six Sigma: Reduce Variation

‘The central problem of management in all its aspects, including planning procurement, manufacturing, research, sales, personnel, accounting and law, is to understand better the meaning of variation and to extract the information contained in variation.’

Deming, 1986, p20

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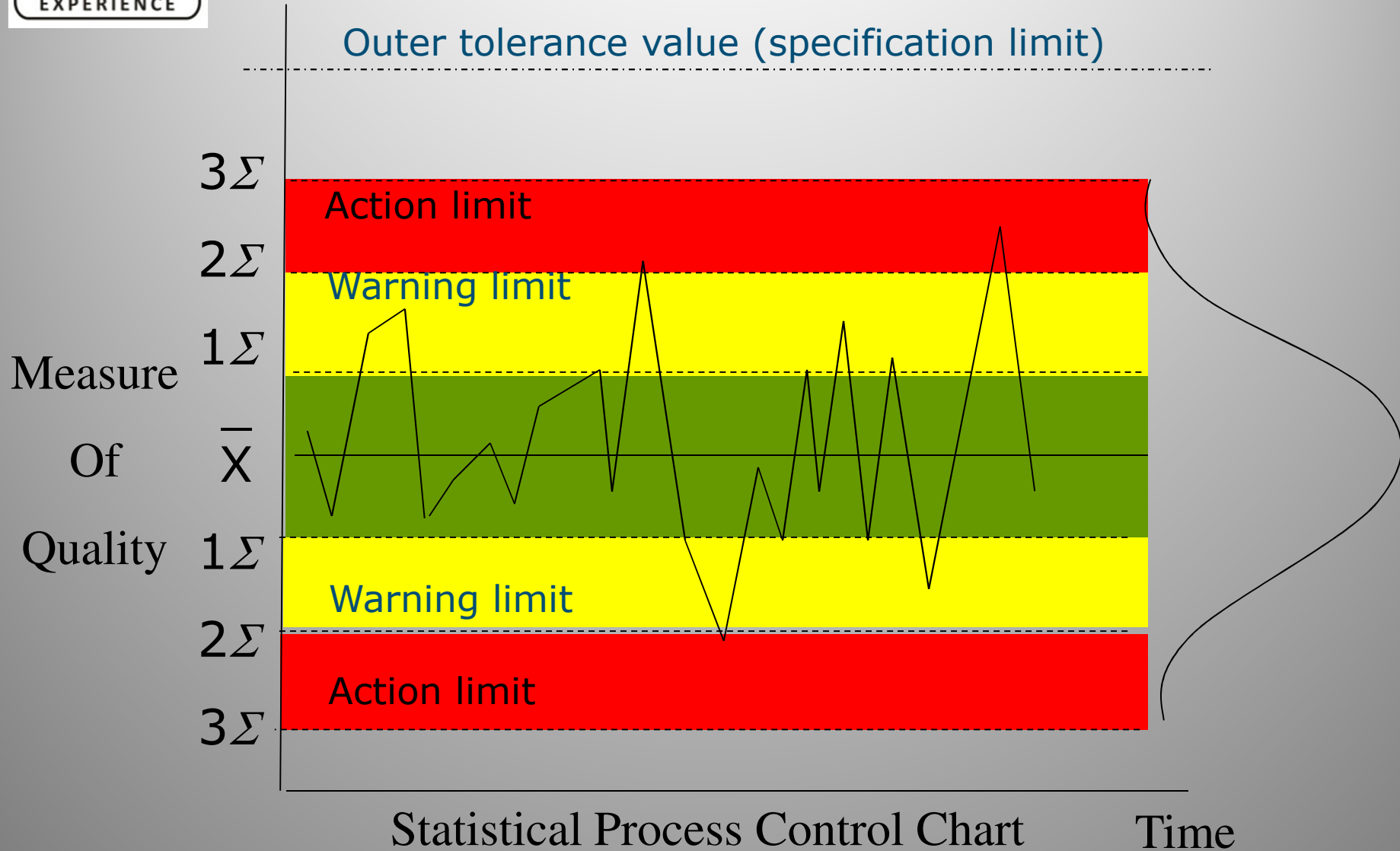


Where quality is the Order Winning Criteria?

- 1 **Identify** the system's constraint(s)
 - *Process variation (number of defects)*
- 2 **Decide how to exploit** the system's constraint(s)
 - *Systematic process improvement (DMAIC)*
- 3 **Subordinate** everything else to the above decision
 - *SPC signalling*
 - *Kaizen*
- 4 **Elevate** the system's constraint
 - *New process (investment)*
- 5 **If in the previous steps a constraint has been broken, go back to step one.**



Signalling: special and common cause

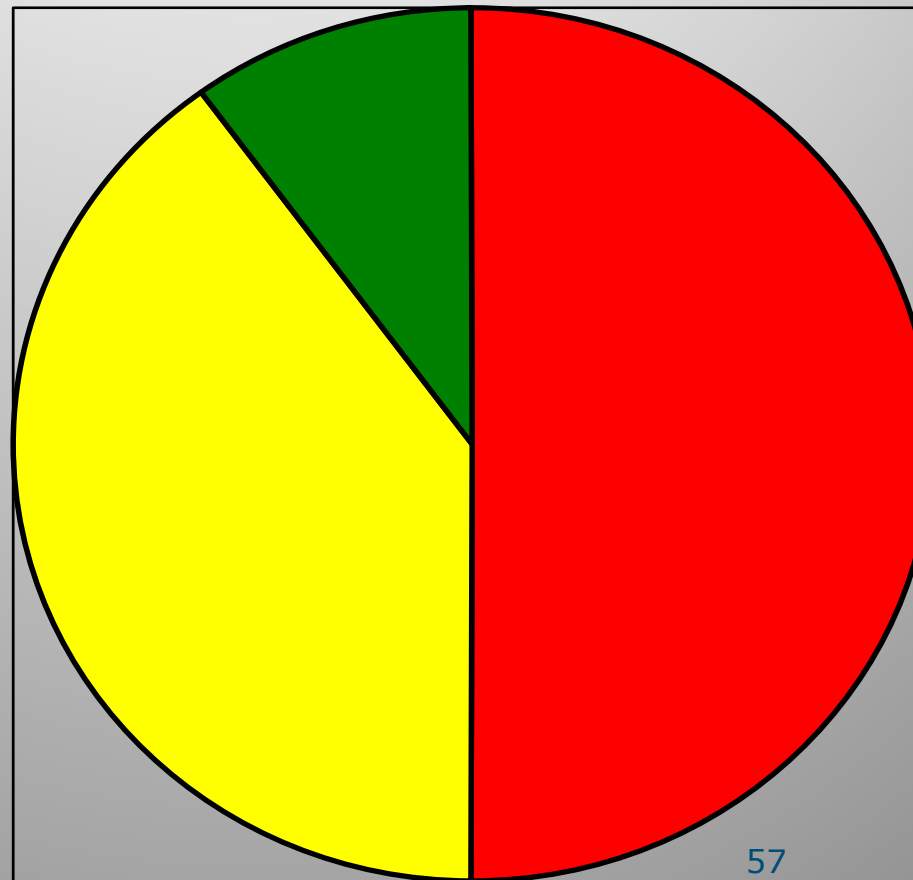


Statistical Process Control Chart

Time



Lean: the elimination of non value adding activities



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Four rules of the TPS
(Spear and Bowen, 1999)

- Rule 1 All work shall be highly specified as to content, sequence, timing, and outcome.
- Rule 2 Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses.
- Rule 3 The pathway for every product must be simple and direct.
- Rule 4 Any improvement must be in accordance with the scientific method, under the guidance of a teacher, the lowest possible level in the organisation.



A Lean interpretation?

- **1 Identify the system's constraint(s)**
 - *Interruptions to flow (demand, supply, process)*
- **2 Decide how to exploit the system's constraint(s)**
 - *Reduce non -value adding activities*
 - *(reduce wasteful variation everywhere)*
- **3 Subordinate everything else to the above decision**
 - *Kanban signalling*
 - *Limit inventory between work centres*
 - *Kaizen improvement*
- **4 Elevate the system's constraint**
 - *Introduce new products and new market segments*
- **5 If in the previous steps a constraint has been broken, go back to step one**

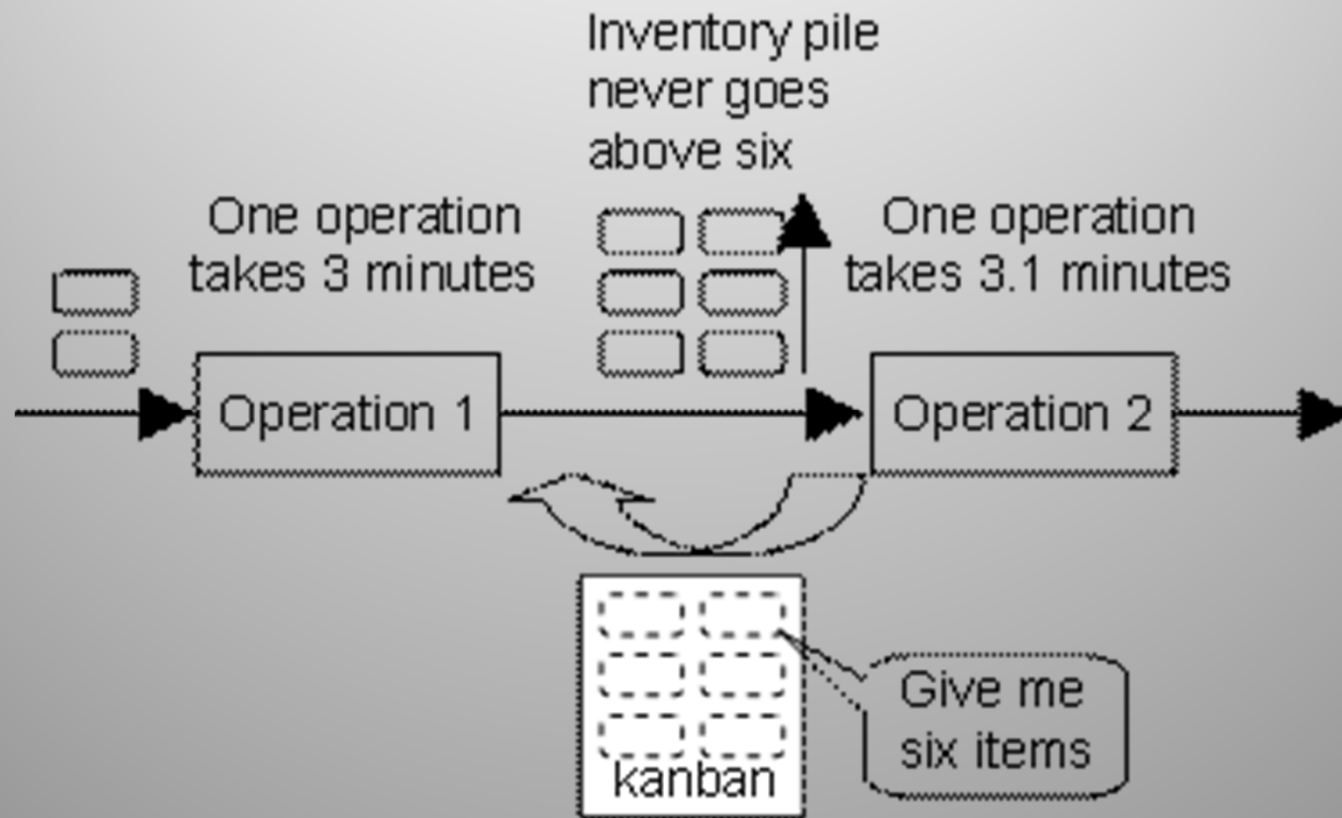


TPS kanban management system

- *In reality practicing these rules [the six rules of kanban] means nothing less than adopting the Toyota Production System as the management system of the whole company. (Ohno, 1988:41)*



Kanban illustration





TOC : the process of on-going improvement?

5 Conclusions

4 Process
improvement
philosophies
(Six Sigma
and Lean)

The 5 steps of focusing

1. **Identify** the System's Constraint
2. Decide how to **Exploit** the Constraint
3. **Subordinate** everything to the above decisions
4. **Elevate** the System Constraint
5. If in the previous steps a constraint has been broken, **Go back to step 1.**

3 Relationship to
generic TOC
applications

1 Systems
Thinking
vs.
Analysis
Thinking

2 Operations
Theory



Attribute	Processes of on-going improvement		
	Six sigma	Lean	TOC
Environment	Standard processing	Stable flow	Complex flow
Key word	Variation	Flow	Focus
Key assumption	Process variation can be systematically reduced	Interruptions to flow can be simply reduced	Variation can be more effectively managed
Key scientific approach	Hypothesis testing (PDSA)	Hypothesis testing (PDSA)	Causal mapping (Necessity and sufficiency logic)
Key change	Specific processes	Process flow	Management rules
Distinguishing concept/tool	Statistical process control	Kanban control	Buffer management
Pre-requisite	Accurately measure parameters	Establish well defined value streams	Identify means of aggregating variation



Comparison against the 5 steps of focusing

	DBR	SDBR	CCPM	Distrib'n	SS?	Lean?
Step 1 ID	-Bottlen'k resource	-Market demand	-Time (Critical Path)	-Customer footfall	-Defects	-Disruption to Flow
Step 2 Exploit	-Close scheduled bottleneck	-Delivery speed	-Aggregate project time buffer	-Ensure product availability	-Process variation reduction	-Reduce non-value adding activities
Step 3 Subordinate	-Choke material release -Buffer m'g't	-Choke release -Buffer m'g't - Cut batches	-Feeder buffers -Buffer m'g't	-Aggreg't'd stock buffers -Buffer m'g't	-SPC -Kaizen	- Choke release -Kanban -Cut batches -Kaizen

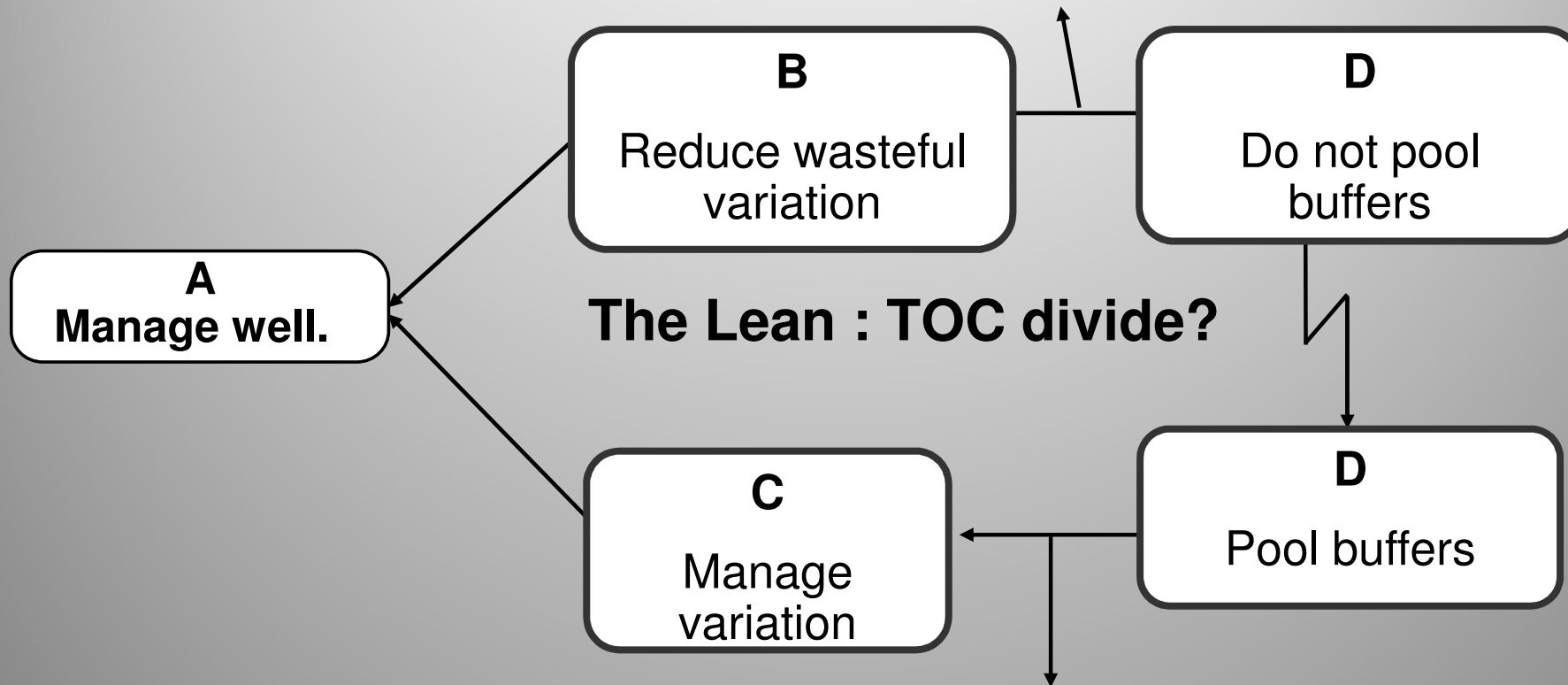


Kanban and Buffer Management Assumptions

TPS/Kanban assumes:	Buffer Management assumes:
Predefined process steps	No predefined processing steps
Buffering is based on inventory and held at each processing step	Buffering is based on time or stock and pooled
Process delays (quality problems) are not passed on to the next process	'Delays' are only expedited when they threaten delivery / availability
Level scheduling	Demand may vary, triggering (timely) escalation
Continual improvement is encouraged through reducing inventory to expose problems that are then targeted.	Continual improvement is enabled by targeting the causes of delay (e.g. red zone penetration) then reducing the buffer.



Because... buffer aggregation masks the source of the variation



The Lean : TOC divide?

Because... aggregation of variation reduces buffer requirements



Conclusions

- All the OM developments have helped to **shift the thinking** from cost/efficiency to variation/flow/throughput.
- Focusing on variation and flow in place of cost/efficiency **enabled a step change** in performance that was underpinned by new management signalling systems (SPC and Kanban).
- TOC has more **directly challenged the cost paradigm** and developed Thinking Process tools to support the development of new rules and tools for more complex environments.
- The TOC 5 step process offers a generalised theory that **embraces** the TOC applications and can also be used to outline the SS and lean applications.
- The subordination step in all the TOC applications utilises **buffer aggregation** and buffer management which contrasts with the use of disaggregated inventory buffering in kanban.
- The **5 steps** provide a more explicit theoretical model for developing systems as opposed to a cost / efficiency centred management solutions.



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