Buffer Management in context

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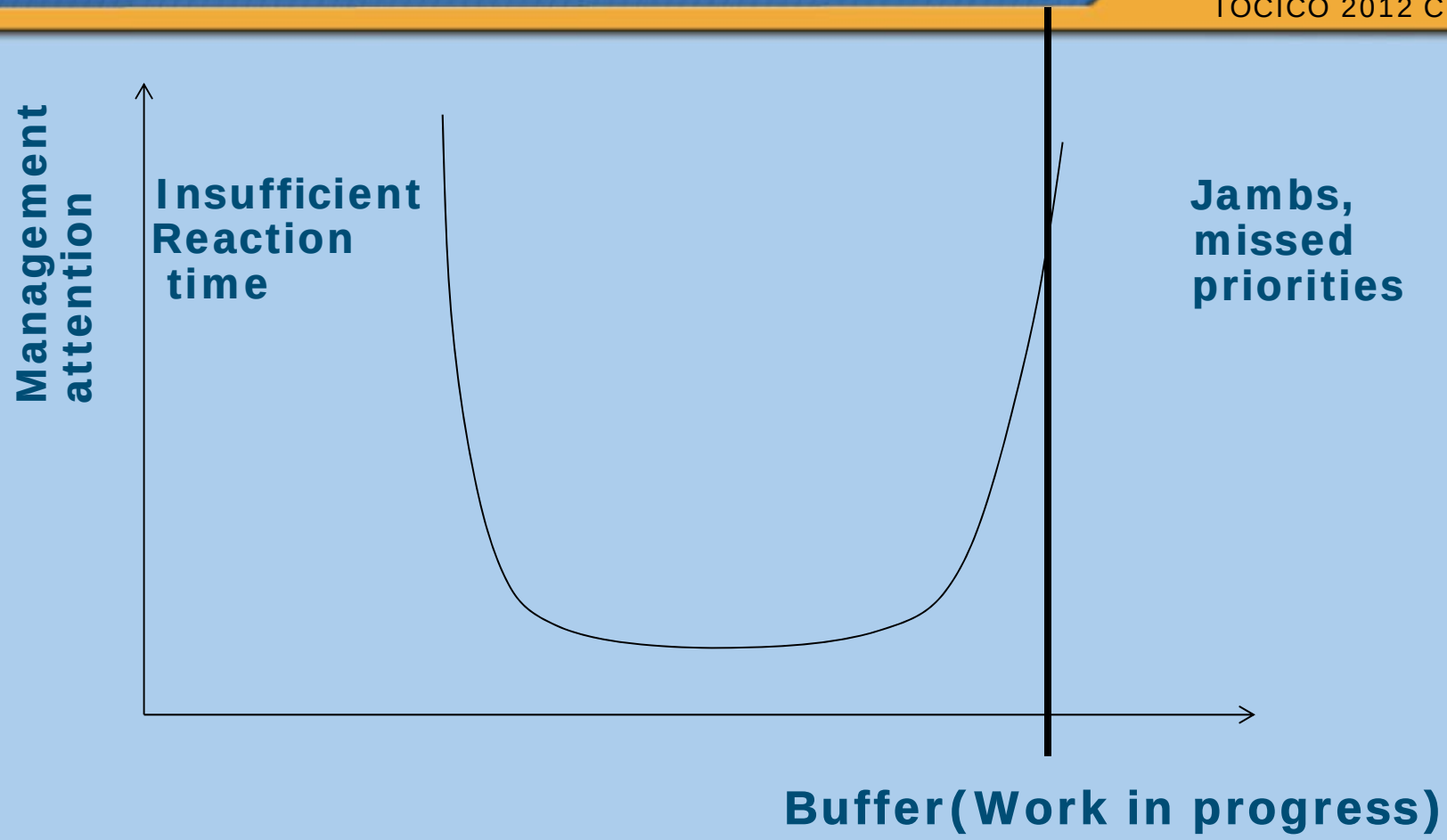
Key Supply Chain Elements (Goldratt, 2008)

- **1. Improving flow**
- **2. Prevent overproduction**
  - **Ford used space; Ohno used inventory**
  - ***Goldratt used aggregated buffers***
- **3. Abolish local efficiencies**
- **4. Focus activity to balance flow**
  - **Ford used direct observation.**
  - **Ohno used kanban removal**
  - ***Goldratt used red zone signals*.**

Concept 2 (Goldratt, 2008;p19: modified)



Reduced variation – Ford and Ohno

Aggregate variation - Goldratt

Structure of presentation

- **Buffer management**
  - **Aggregation of variation**
  - **Functions of BM**
- **Synergies with other approaches**
  - **The scientific method**
  - **Statistical Process Control**
  - **TPS (Kanban)**
- **Wider applications**
  - **Health**
- **Scientific Method**
  - **Synergies**
  - **Core conflict**

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Buffer Management

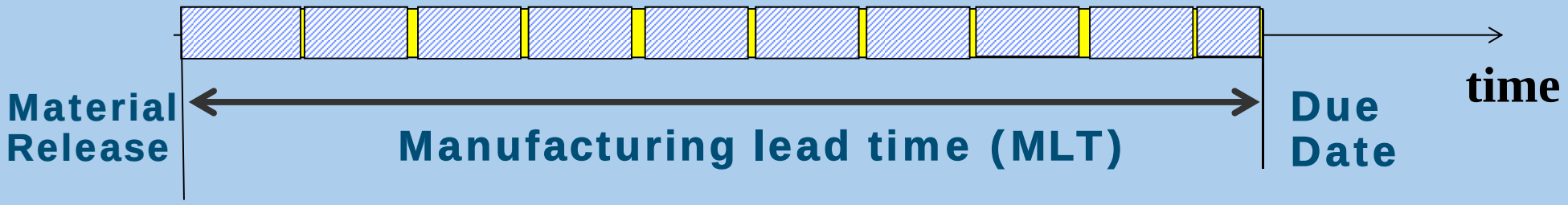
Aggregation of variability

- **'The aggregated buffer is less than the sum of the parts'**
- **Buffer aggregation - key to the TOC applications**
  - **MTO - Drum Buffer Rope**
    - **Shipping buffer, Constraint buffer**
  - **ETO - Critical Chain Project Management**
    - **Project buffer, Feeder buffer**
  - **MTA - Distribution/replenishment solution**
    - **Plant warehouse**
    - **Network inventory buffers**

Buffer Aggregation and DBR

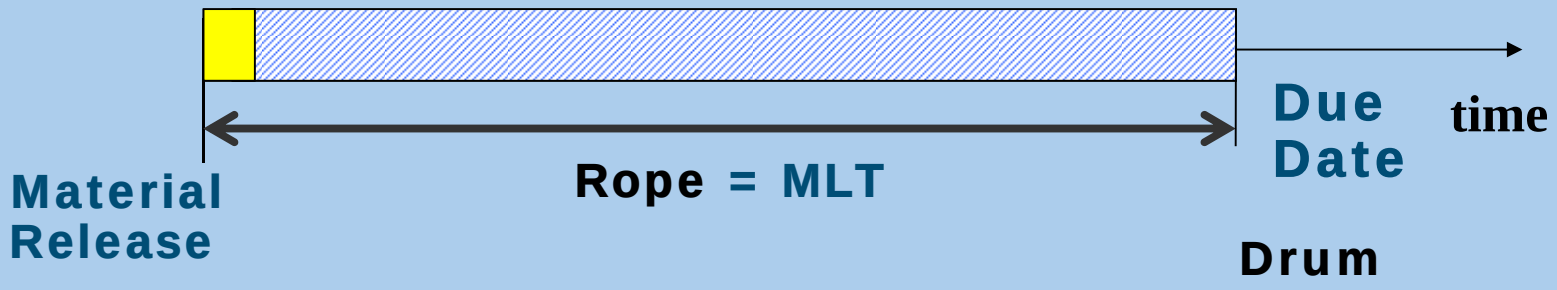
Traditional Make To Order

Intermediate due dates protected by separate buffers



Drum Buffer Rope

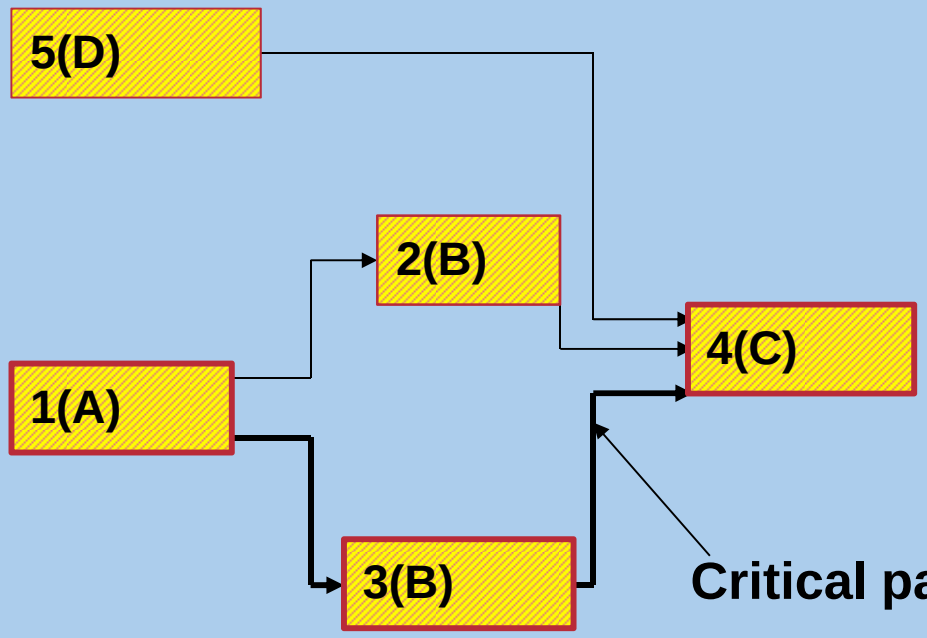
Buffer is aggregated: No intermediate due dates
(Assumes touch time is not significant <10%)



Touch time: Buffer:

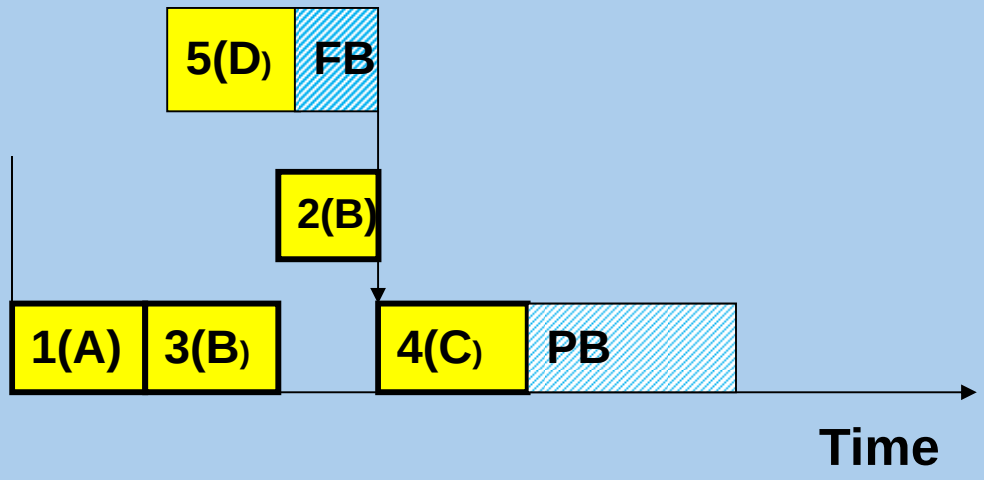
Buffer Aggregation and Critical Chain

Critical Path Method



Resources: A,B,C,D

Critical Chain



FB: Feeding Buffer
PB: Project Buffer

Touch time: Buffer: Mixed:

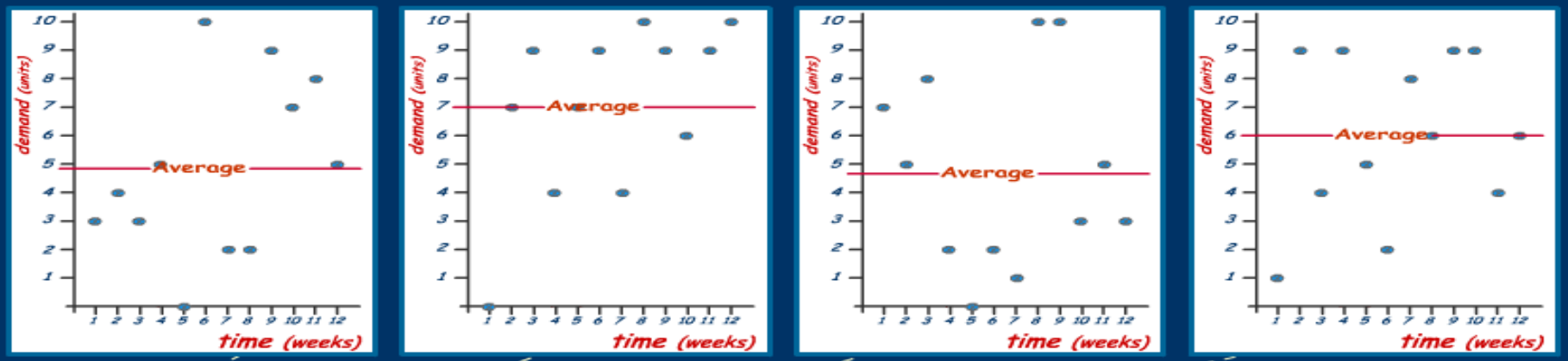
Buffer Aggregation and Distribution

OC Insights into Distribution and Supply Chain - Goldratt's Marketing Group

Go To ?

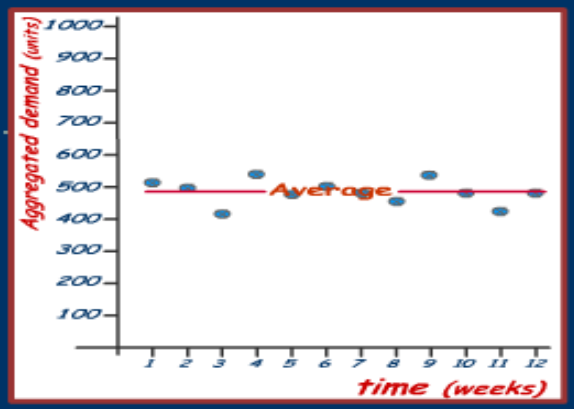
Skip

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



Consumption point | Consumption point | Consumption point | Consumption point ... 100

Supply point



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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Buffer Management

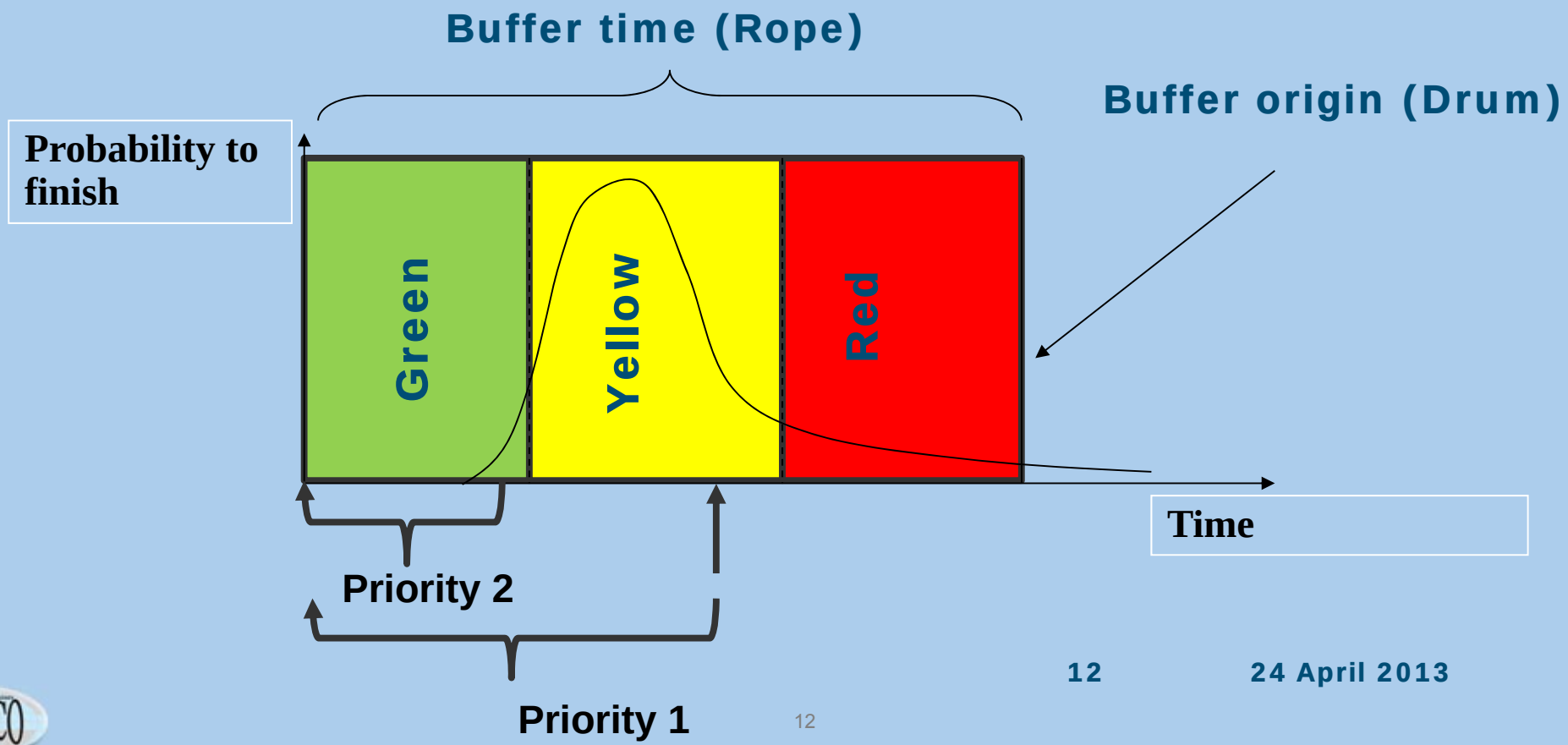
- **TOC ICO 2007 Definition**
  - **Buffer management** (BM) – A feedback mechanism used during the execution phase of operations, distribution, and project management that provides a means to **prioritize work**, to know when to **expedite**, to **identify** where protective capacity is insufficient, and to resize buffers when needed.
- **TOCICO 2012 Definition**
  - **Buffer management** (BM) - A control mechanism based on the amount of time (till the due date) or stock remaining used in the execution phase of TOC applications (operations, project and distribution). **Buffer management consists of four main functions:**

Buffer Management – 4 Functions

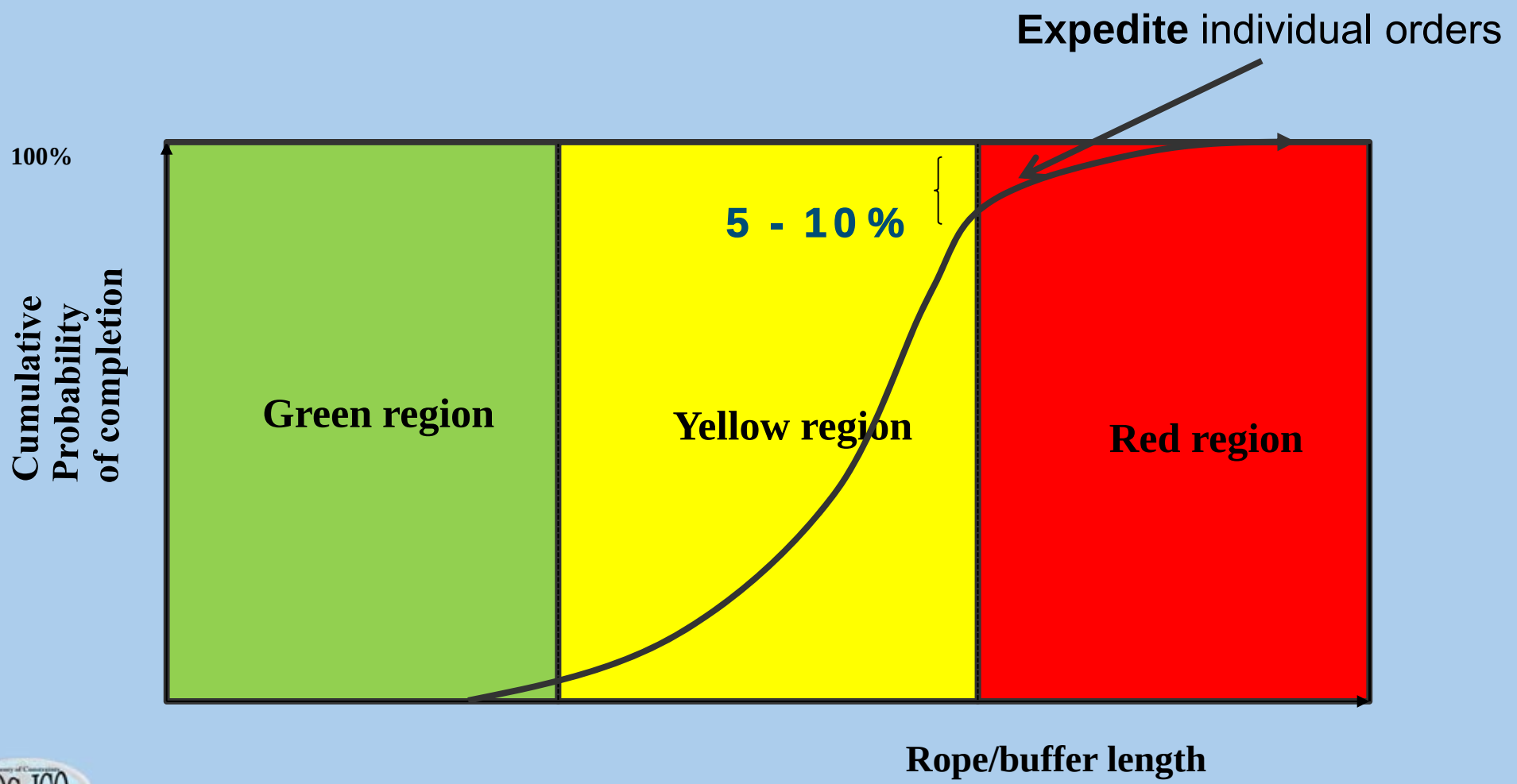
- **Prioritise** based on buffer penetration/consumption
- Signal when to **Expedite** individual tasks or orders
- Signal system instability and the need to **Escalate** urgent action or simply adjust system parameters.
- Identify prime causes of delay to **Target** continuous improvement.

Buffer Management – Function 1

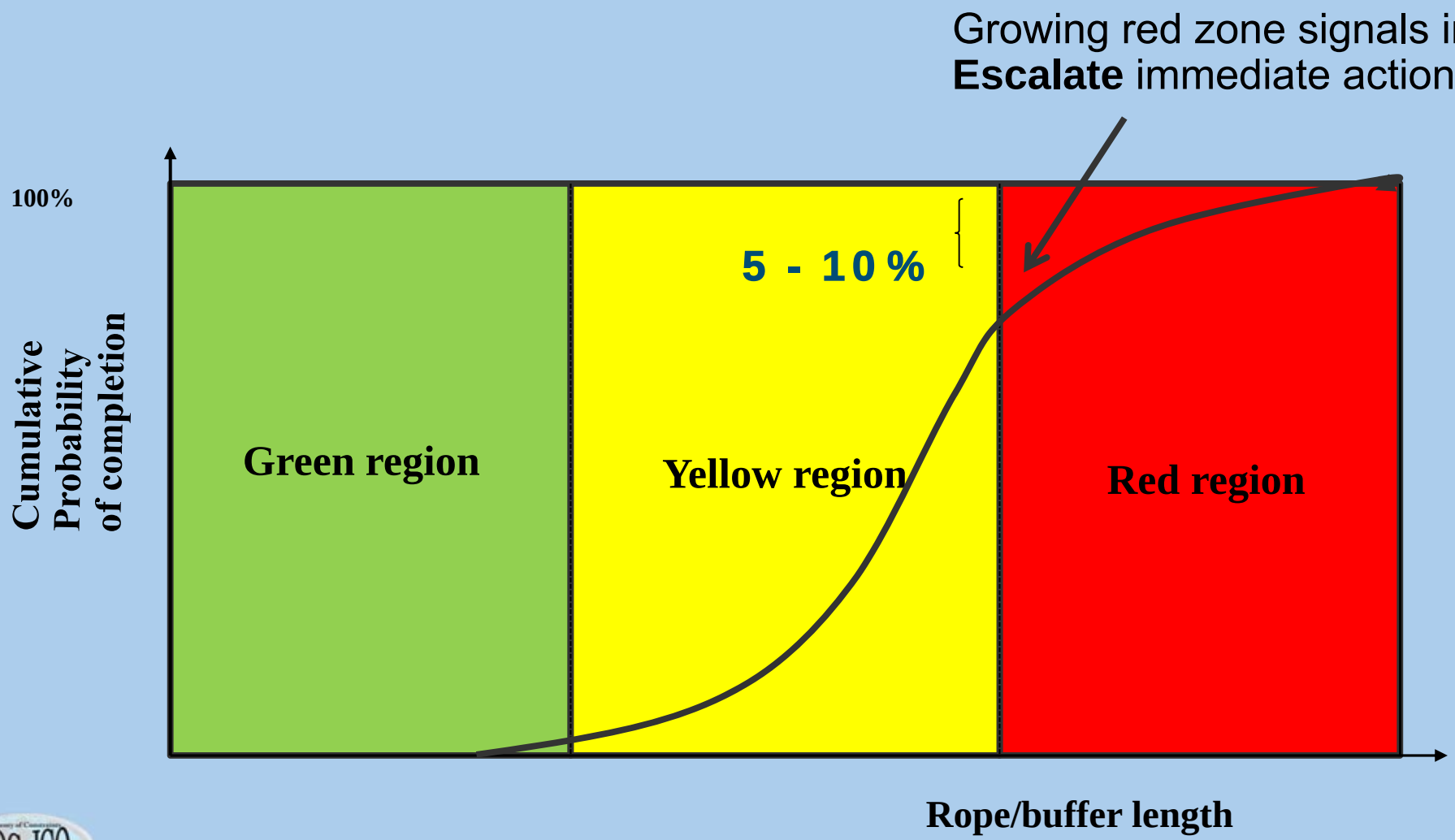
Erlang Distribution



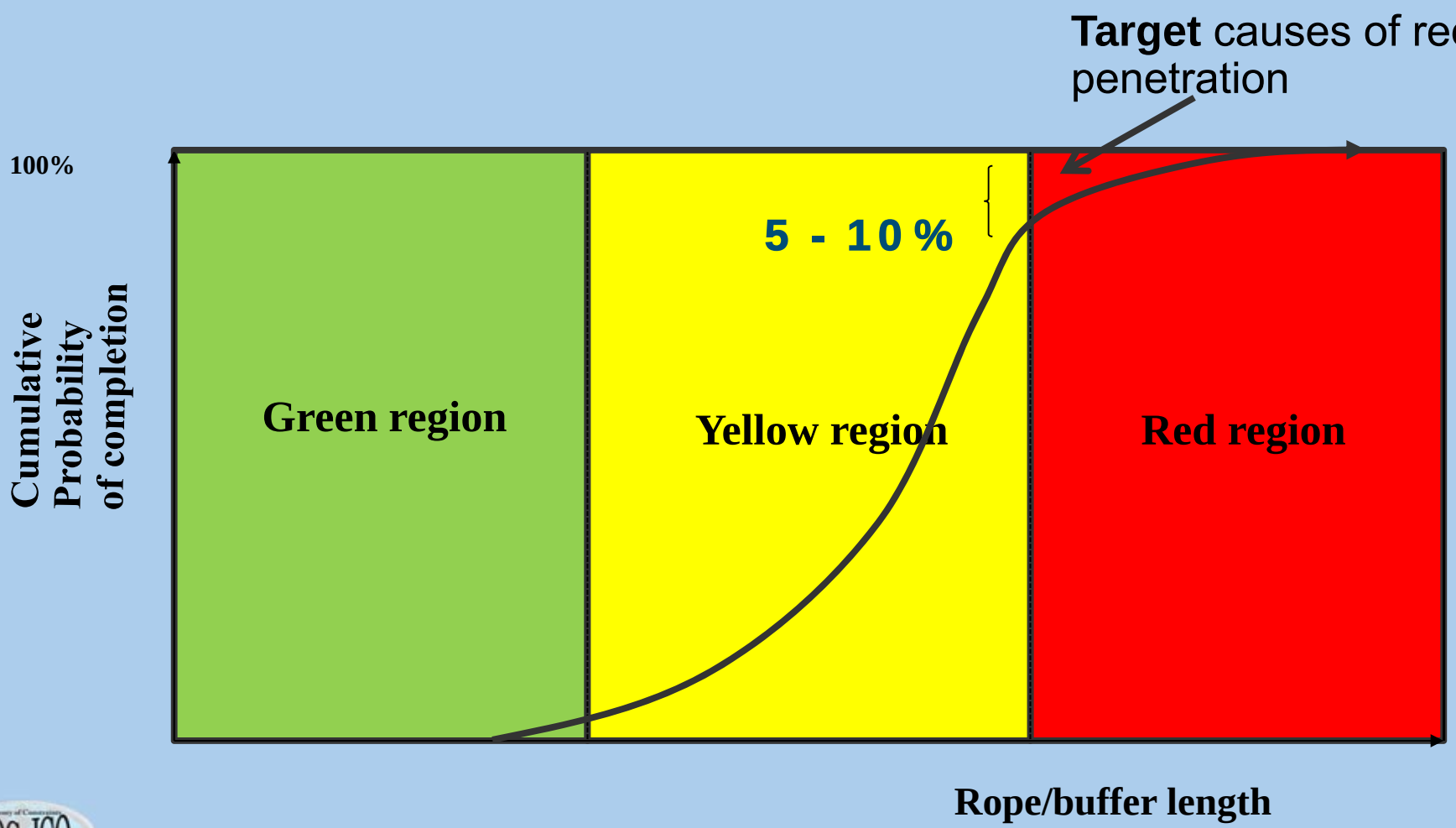
Buffer Management – Function 2



Buffer Management - Function 3



Buffer Management – Function 4



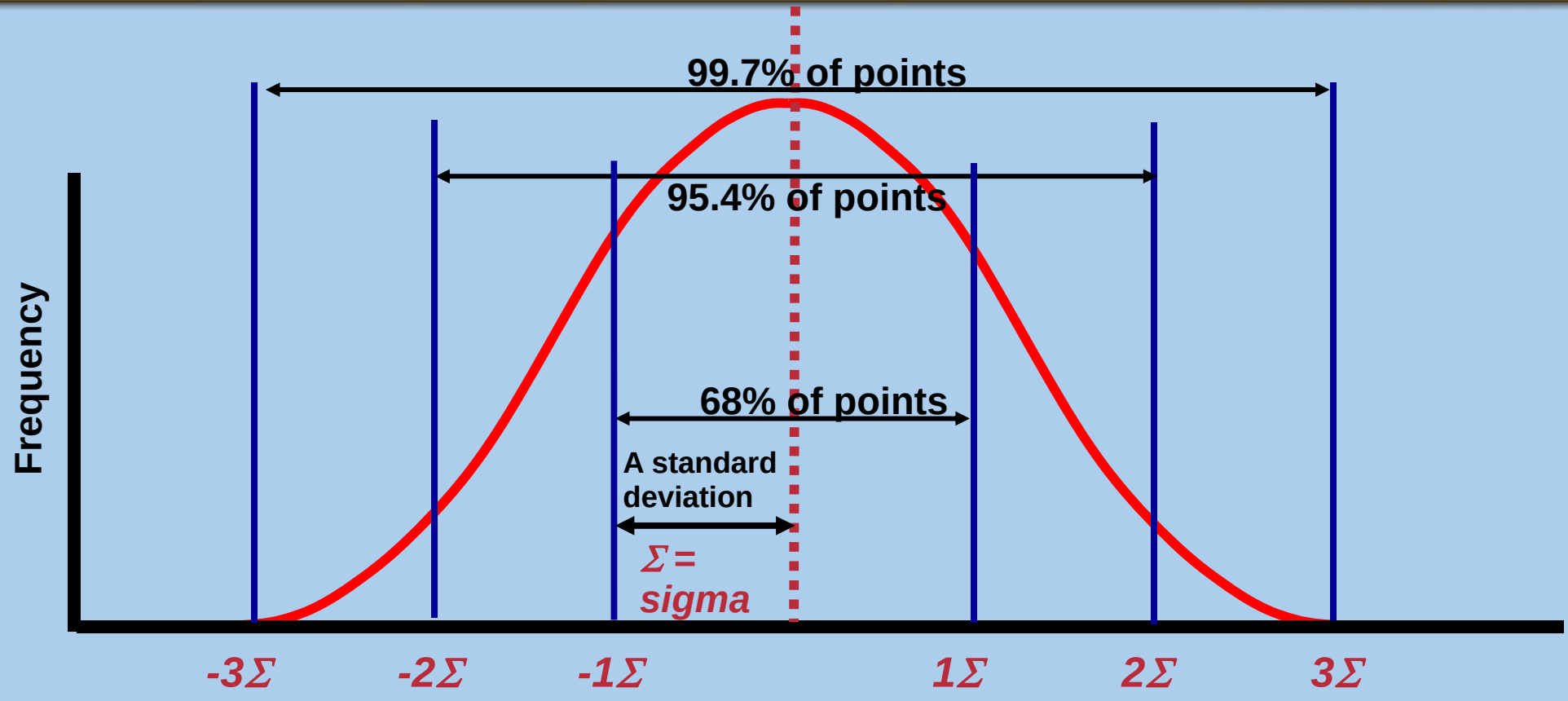
Synergies with SPC

Synergies with SPC

'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.'**

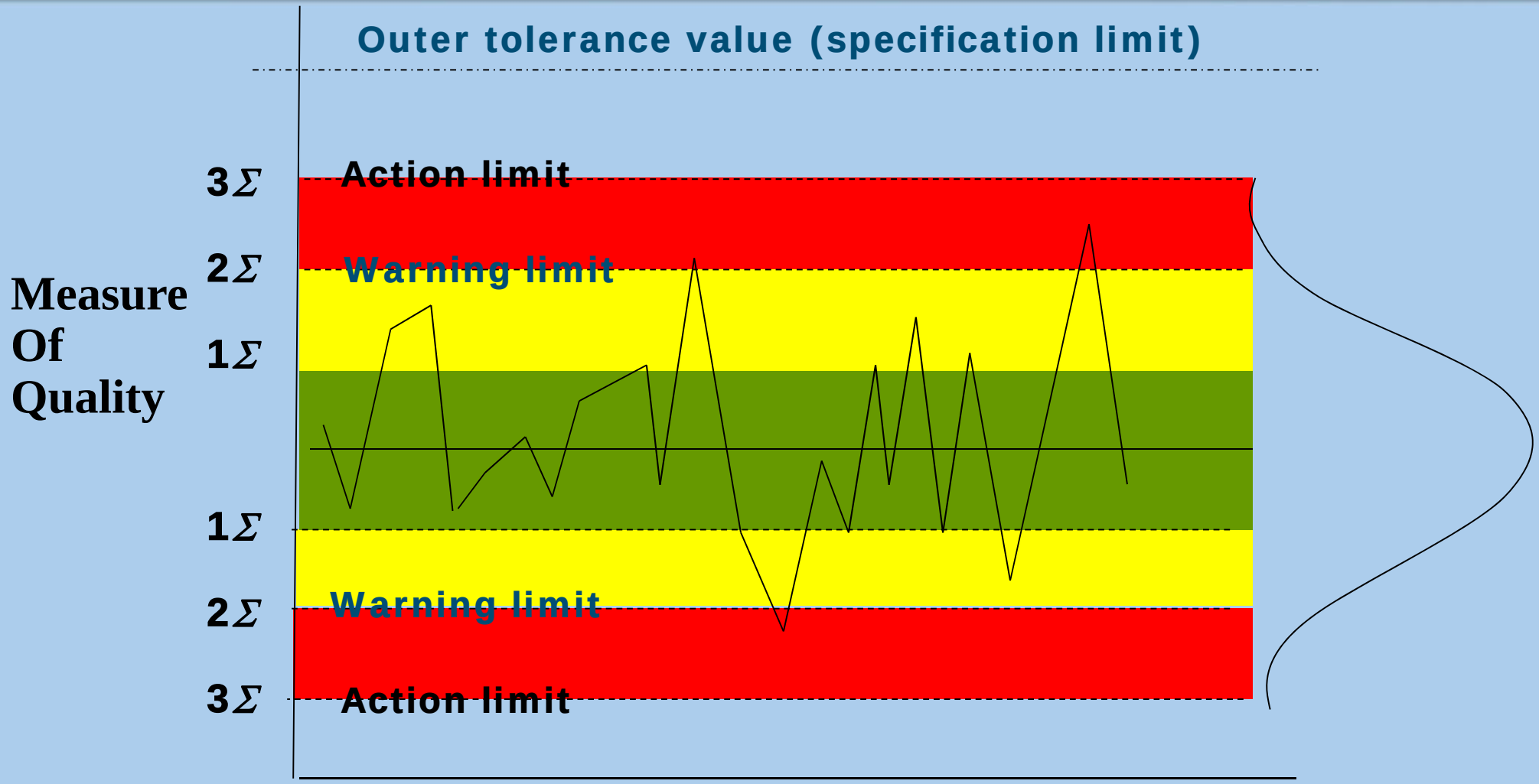
Deming, 1986, p20

Process control charting



Chances of a measurement point deviating from the average – assuming a normal distribution

SPC signalling system



SPC and BM functions

- Gaining statistical control also applies to flow.
- In BM the level of stability is determined by the level of variation in combination with the level of buffering (inventory and capacity).
- Entry into the red zone is a warning signal - ensure there isn't a 'special cause' and **Expedite** if necessary.
- Increasing red zone penetration (> 5-10%) signals system instability and the need to **Escalate** immediate action 'special cause'.
- Causes of red zone penetration 'common cause' are analysed over time to **Target** improvement effort (e.g. set-up reduction, machine availability, process reliability, etc).

Synergies with TPS kanban

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)

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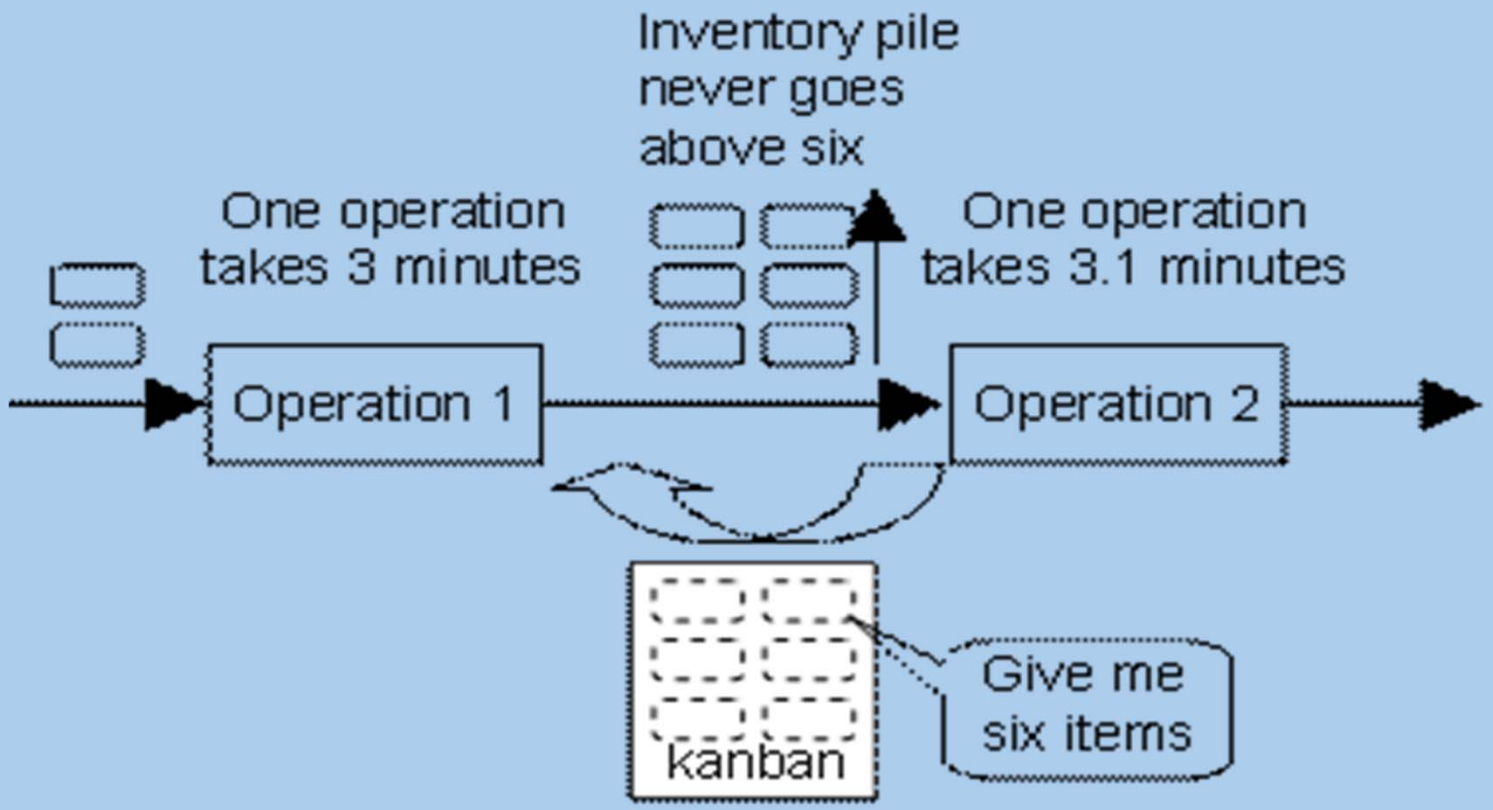
Ohno (1978) understood buffering

- *'Just-in-time means that, in a flow process, the right parts needed in assembly, reaching the assembly line at the same time they are needed and only in the amount needed. A company establishing this approach throughout can* ***approach zero inventories****. From the standpoint of production management, this is an ideal state.'* (Ohno, 1988: 4)
- '*The greater the fluctuations in quantity picked up, the more* ***excess capacity*** *is required by the earlier processes… Ideally, levelling should result in zero fluctuations in the final assembly line.'* (:36-37)

Shingo (1981) understood buffering

- *'In a kanban system, semi-processed parts waiting between processes may take the place of **minimum inventory in providing a cushioning effect**. Fluctuation beyond a certain magnitude, however, cannot be absorbed in this fashion, and level production becomes necessary…Obviously, thorough consideration should be given to levelling production so that such fluctuations can be prevented.'* (Shingo, 1989: 187)

Kanban illustration



Kanban functions/rules

Functions of kanban	Kanban rules of use
1. Provides pick-up or transmission information.	1. Later process picks up the number of items indicated by the kanban at the earlier process.
2. Provides production information.	2. Earlier process produces items in the quantity and sequence indicated by the kanban.
3. Prevents over production and excessive transport.	3. No items are made or transported without a kanban.
4. Serves as a work order attached to goods.	4. Always attached a kanban to the goods.
5. Prevents defective products by identifying the process making the defectives.	5. Defective products are not sent on to the subsequent process. The result is 100% defect free goods.
6. Reveals existing problems and maintains inventory control.	6. Reducing the number of kanban increases their sesitivity.

The functions and rules of kanban (source: Ohno, 1988: 30)

Interpreting Ohno's Functions

- **Functions/rules 1, 2 and 4 are concerned with the transfer and production of information associated with standard predefined specifications, routings and transfer data.**
- **Function 3 is vital to the lean focus on Just-in-Time production and ensuring inventory between each work centre is kept to a predefined maximum level.**
- **Function 5 ensures the source of defects is made immediately visible, therefore ensuring rapid problem identification and resolution.**
- **Function 6 enforces continuous improvement. The number of kanbans in the replenishment cycle represents the inventory currently needed to ensure reliable supply. Reducing the number of kanbans reduces the buffer inventory and therefore time, so making the system more sensitive to problems in the drive towards perfection.**

Buffer Management (BM) and Kanban: Functional Comparison

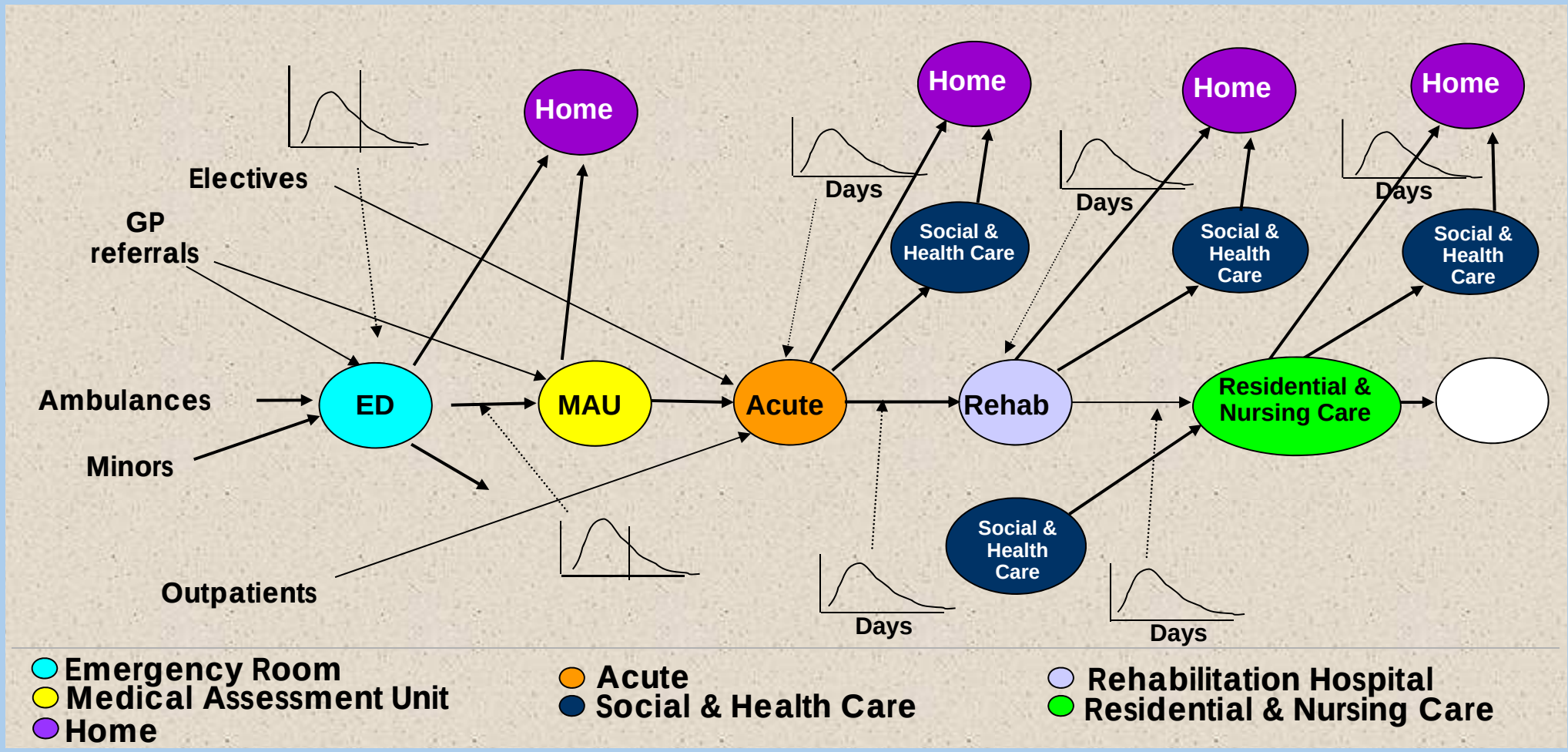
TBM Functions	Kanban Functions
Prioritize - Provides relative priority based on planned completion time or availability rather than intermediate processing steps and inventory. **Choke material release (e.g. Rope)**	F1 – Pull intermediate inventory F2 – Pre-planned quantity and routing sequence **F3 – Prevents over production at each stage** F4 – Predefined works order data
Expedite - Proactive time based signalling of potentially late completion or shortages (red zone penetration).	F5 – Quality (variability in the process) signals immediate action.
Escalate - Proactive signalling of growing levels of expediting	
Targeting the repeated causes of expediting (red zone penetration) reduces the need for buffer (time or stock) and improves flow	F6 – Reducing the number of kanbans (inventory) is used to clearly expose causes of disruption to flow.

Kanban and Buffer Management Assumptions

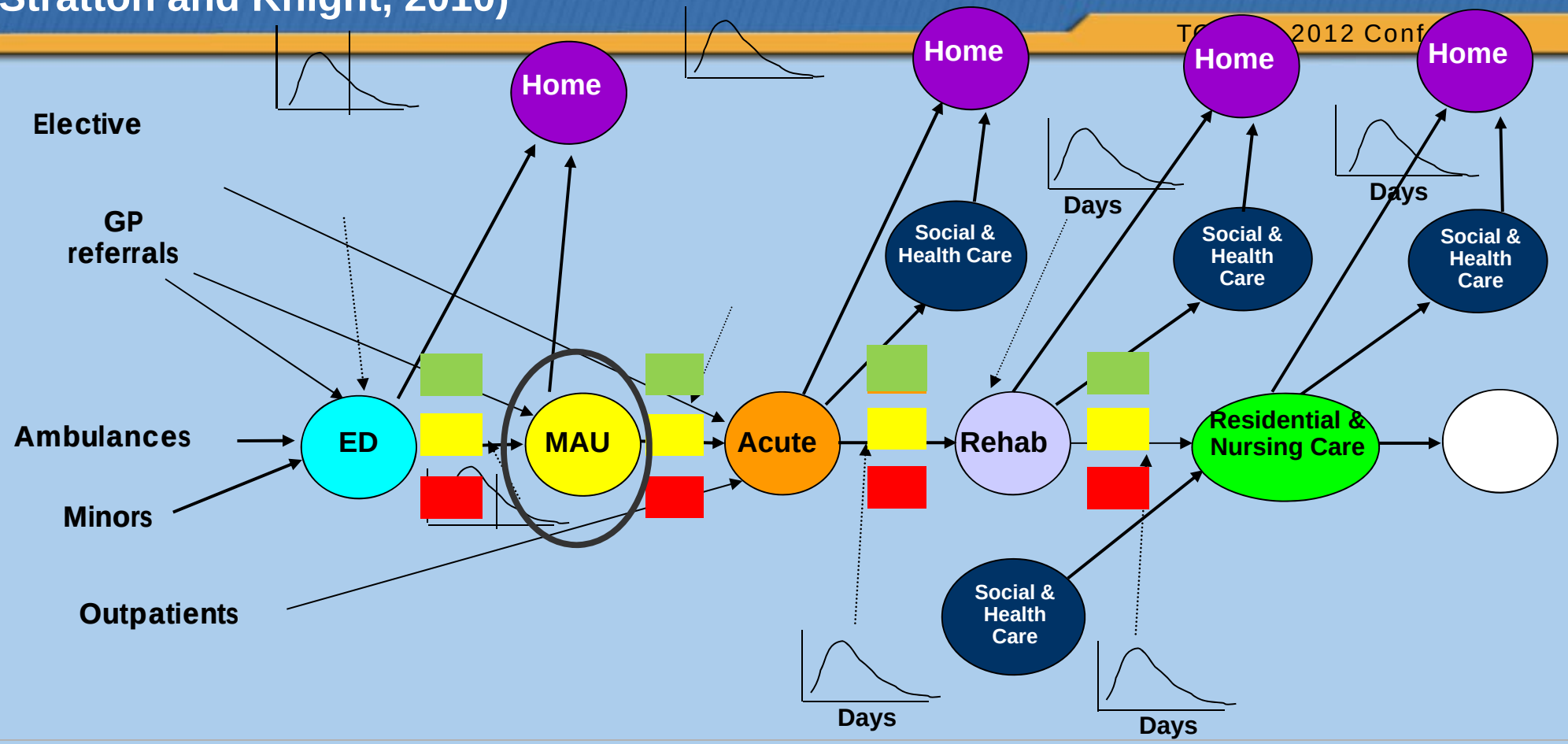
TPS/Kanban assumes:	TBM assumes:
Predefined process steps	No predefined processing steps
Buffering is based on inventory and held at each processing step	Buffering is based on time or stock and pooled
Process delays (quality problems) are not passed on to the next process	'Delays' are only expedited 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.

Healthcare: Does it fit the assumptions?

Health and social care system - the chain of activities



Buffer Management applications
(Stratton and Knight, 2010)



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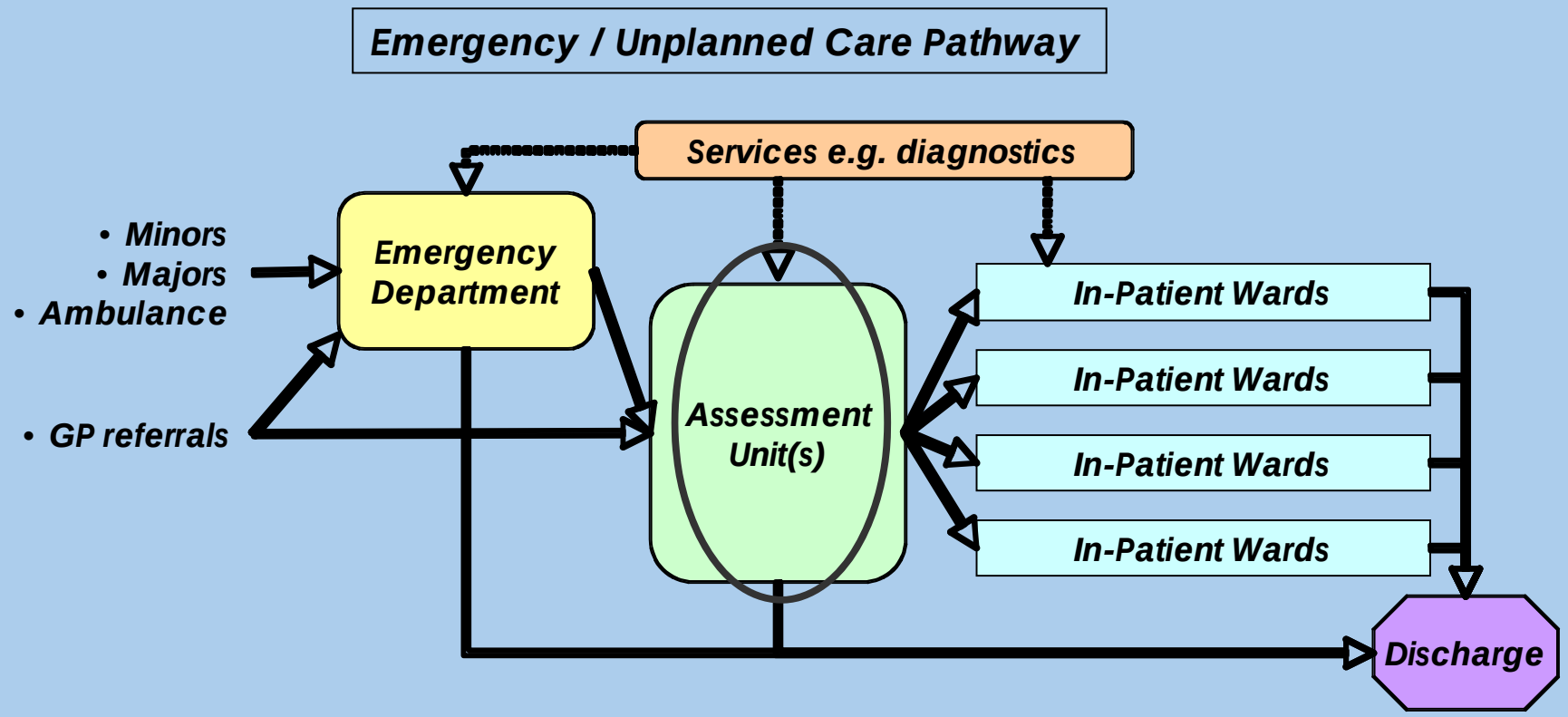
Buffer aggregation in healthcare



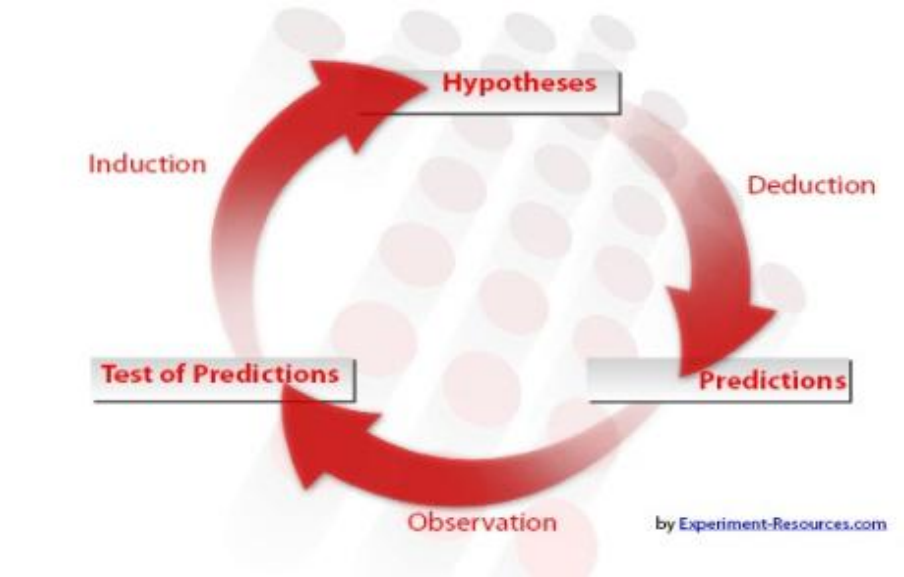
Scientific method: synergies and core conflict?

Scientific Method

Contribution

- **SS (Shewhart)**
  - **Process control**
  - **PDSA Cycle**
- **TPS (Ohno)**
  - **Local causal predictions**
  - **Direct cause effect hypothesis test**
  - **Challenge local assumptions**
- **TOC (Goldratt)**
  - **System wide causal predictions**
  - **Core problem identification**
  - **Challenge global assumptions**

Experiments to test prediction



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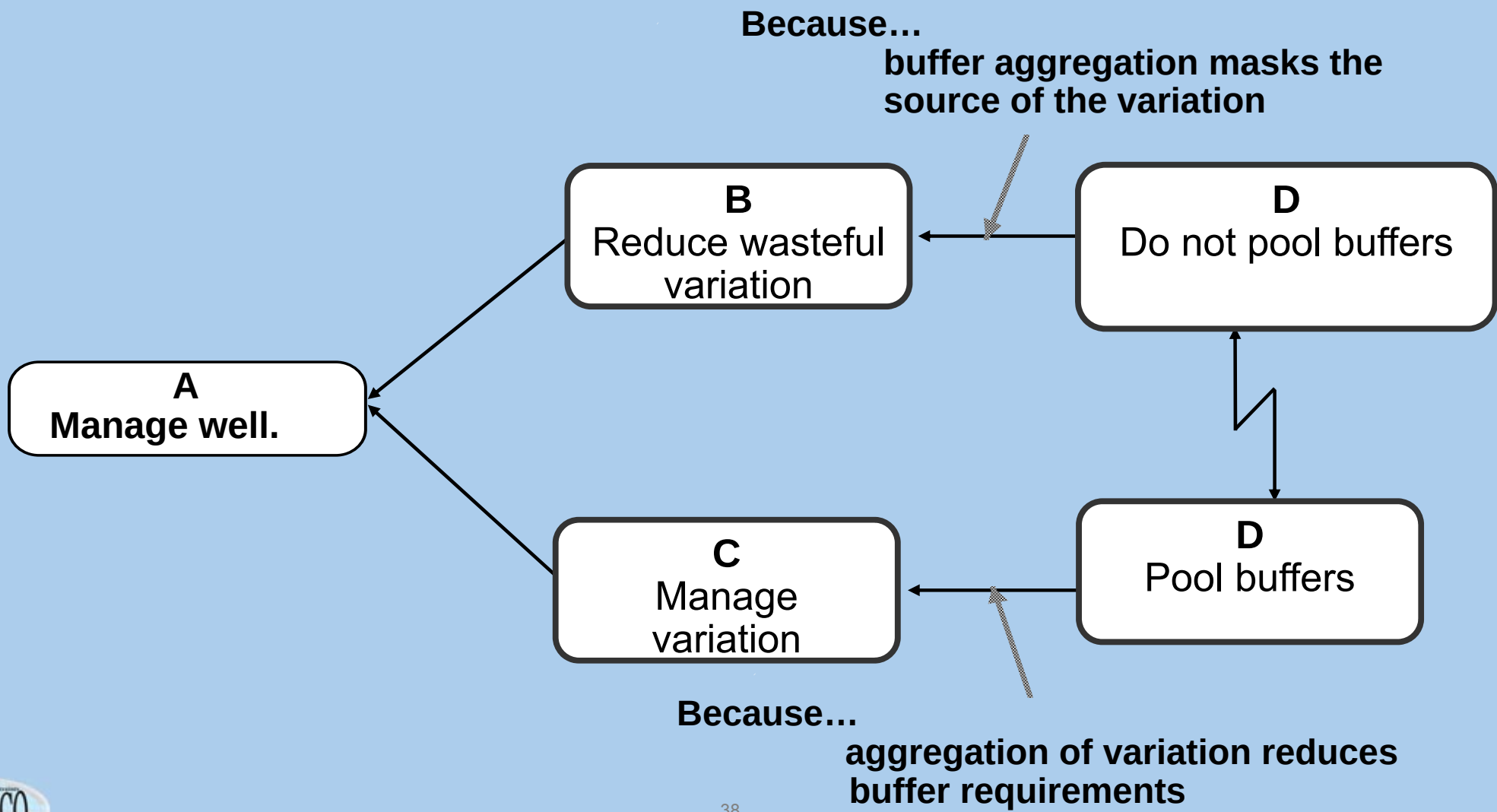
Four rules of the TPS (Spear and Bowen, 1999)

- 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.

Rule implications (Spears and Bowmen, 1999)

- Rule 3 – the pathway for every product and service must be simple and direct
  - ‘contrary to conventional wisdom about production lines and **pooling** resources’ (p7)
  - ‘By requiring that every pathway be specified, the rule ensures that an **experiment** will occur each time a path is used’ (p7).
- Rule 4 – any improvement must be made in accordance with the scientific method
  - Stresses the need to **predict** and then **test hypotheses** and with that **challenge assumption** (p8).

The Lean : TOC divide



Direction for improvement

- BM - function 4 has been largely ignored in the past
  - The emphasis was on the merits of buffer aggregation which was rapidly achieved.
  - More recently Eli emphasised the potential of targeting and incrementally reducing the variation.
  - To what extent does aggregation hide the source of the variation?
- Is more sophisticated data capture the answer?
- Can we stand on two shoulders to see further?

Conclusion

Attribute	Philosophy		
	Six sigma	**Lean**	**TOC**
Environment	Repeat process	Stable flow	Complex flow
Key word	Variation	Flow	Focus
Key assumption	Process variation drives both cost and quality.	Disruptions to flow drives buffering and waste	All systems exhibit inherent simplicity
Distinguishing Methodology	Plan, Do, Study, Act (	Closely defined process flow supports hypothesis testing	System level causal mapping of core conflict / challenge assumptions
Key change	Process variation	Disruption to flow	Management rules
Distinguishing improvement concept/tool	Statistical Process Control	Kanban control	Buffer management
Pre-requisite	Process data availability	Specify and simplify value streams	Aggregate buffers

Questions