Lancaster University
Management School

Introduction to Operations Management

Lecture 2: Capacity planning and analyses

Anas Iftikhar

Capacity planning & analysis

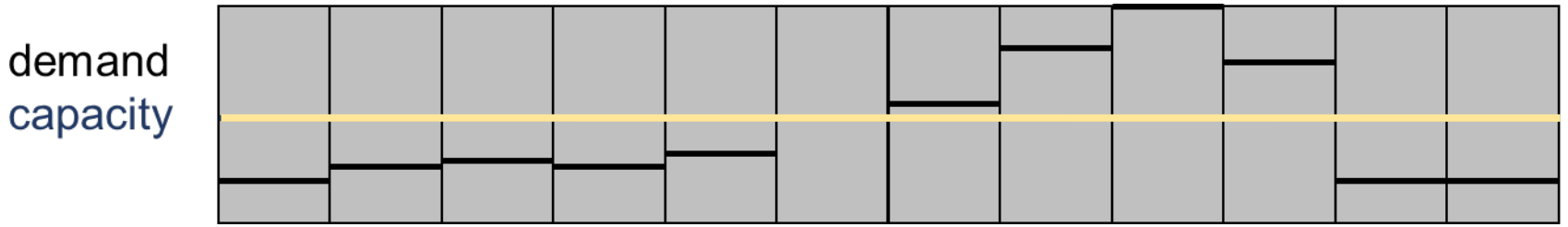
- How capacity is defined
  - Throughput
  - Design capacity vs effective capacity, planned and avoidable losses
  - Utilisation and efficiency,
- How demand is responded to
  - Chase demand, Level, Mixed plans, manage demand
- How capacity is analysed in relation to demand
- How we think about constraints on capacity

How capacity is analysed

Is the capacity shown in the table below appropriate to meet demand between July - August?

- if the data shows airline capacity & demand on 1 route
- if the data shows auto part production capacity & demand
- if the data shows clinic capacity & demand

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Demand	100	150	175	150	200	300	350	500	650	450	100	100
Capacity	300	300	300	300	300	300	300	300	300	300	300	300



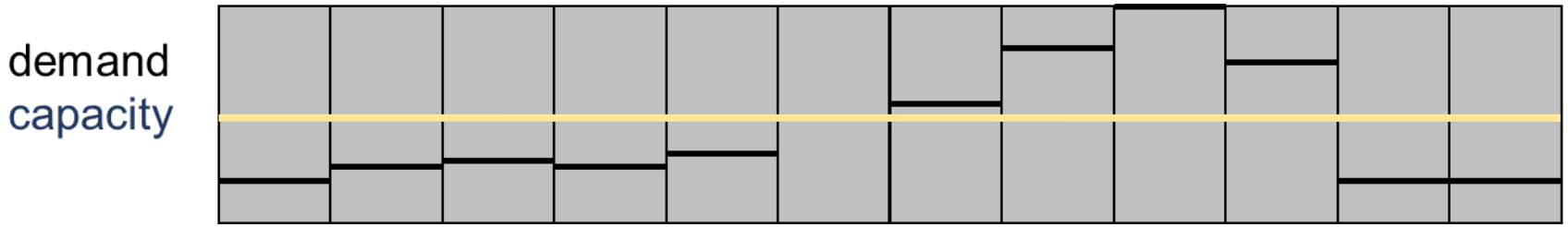
How capacity is analysed

How we define capacity is a function of circumstances and assumptions.

Depending on the context:

- we may only be able to make instantaneous comparisons
- we may be able to accumulate production
- we may have to accumulate demand
- Giving us different evaluations of capacity

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Demand	100	150	175	150	200	300	350	500	650	450	100	100
Capacity	300	300	300	300	300	300	300	300	300	300	300	300



Production operations that can accumulate products

- need to check supply precedes demand
- E.g. at start Sep total production is 8 x 300 = 2 400
- total demand is 100+150+175+150+200+300+350+500 = 1,925

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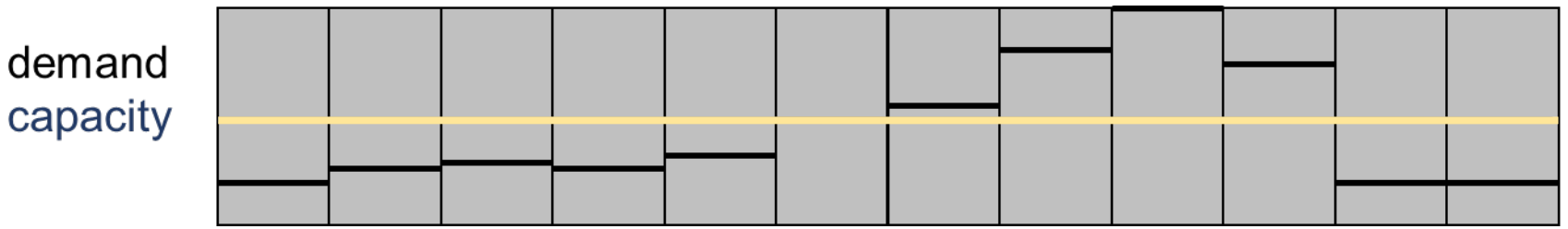

Production operations that can accumulate products

- In general need a cumulative analysis
- and need to keep track of surplus of products

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Orders	100	150	175									
Acc. Orders	100	250	425									
Produced	300	300	300									
Acc. Produced	300	600	900									
Surplus	200	350	475									

Production operations that can accumulate products

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	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Orders	100	150	175	150	200	300	350	500	650	450	100	100
Acc. Orders	100	250	425	575	775	1075						
Produced	300	300	300	300	300	300						
Acc. Produced	300	600	900	1200	1500	1800						
Surplus	200	350	475	625	725	725						

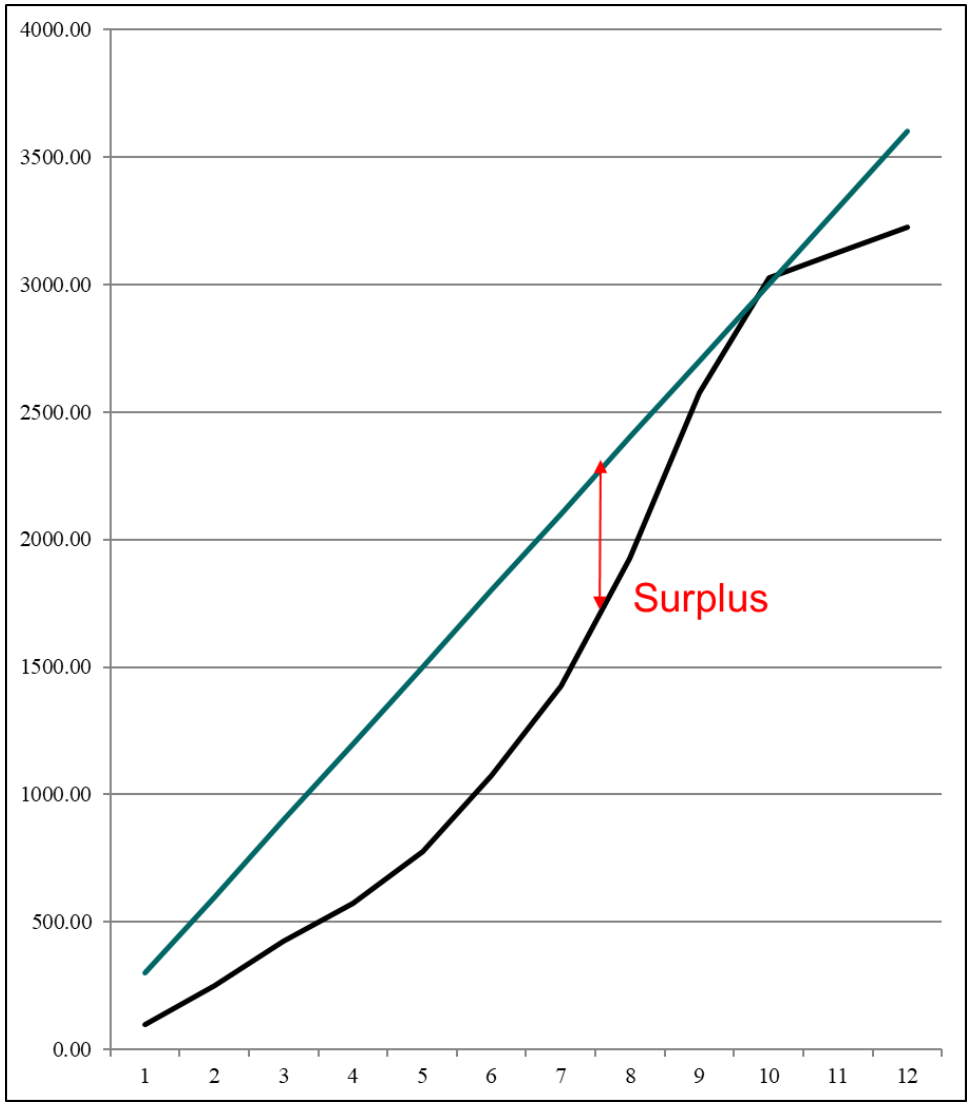
Production operations that can accumulate products

- In general need a cumulative analysis
- and need to keep track of surplus of products
- unmet demand assumed to be carried forward
  - but if unordered it may disappear

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Orders	100	150	175	150	200	300	350	500	650	450	100	100
Acc. Orders	100	250	425	575	775	1075	1425	1925	2575	3025	3125	3225
Produced	300	300	300	300	300	300	300	300	300	300	300	300
Acc. Produced	300	600	900	1200	1500	1800	2100	2400	2700	3000	3300	3600
Surplus	200	350	475	625	725	725	675	475	125	(25)	175	375

How capacity is Evaluated

Production operations that can accumulate products



Cumulative demand vs cumulative production

How capacity is analysed

When the output can't be stored & clients can wait

- Accumulating demand only makes sense if it can be carried forward
- E.g. 1st-come 1st-serve clinic: patients join a waiting list
- demand comes from arrivals, production means departures
- and now unused capacity is lost

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Arrivals	100	150	175	150	200	300	350	500	650	450	100	100
Acc. Arrivals												
Capacity	300	300	300	300	300	300	300	300	300	300	300	300
Waiting												
Departures												
Acc.												

When the output can't be stored & clients can wait

- so work out accumulated demand (arrivals) as before
- but find *used* capacity (departures) before accumulating
- keep track of those carried over waiting

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Arrivals	100	150	175									
Acc. Arrivals	100	250	425									
Capacity	300	300	300									
Waiting	0	0	0									
Departures	**100**	**150**	**175**									
Acc.	**100**	**250**	**425**									

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Arrivals	100	150	175	150	200	300	350					
Acc. Arrivals	100	250	425	575	775	1075	1425					
Capacity	300	300	300	300	300	300	300					
Waiting	0	0	0	0	0	0	50					
Departures	**100**	**150**	**175**	**150**	**200**	**300**	**300**					
Acc.	**100**	**250**	**425**	**575**	**775**	**1075**	**1375**					

When the output can't be stored & clients can wait

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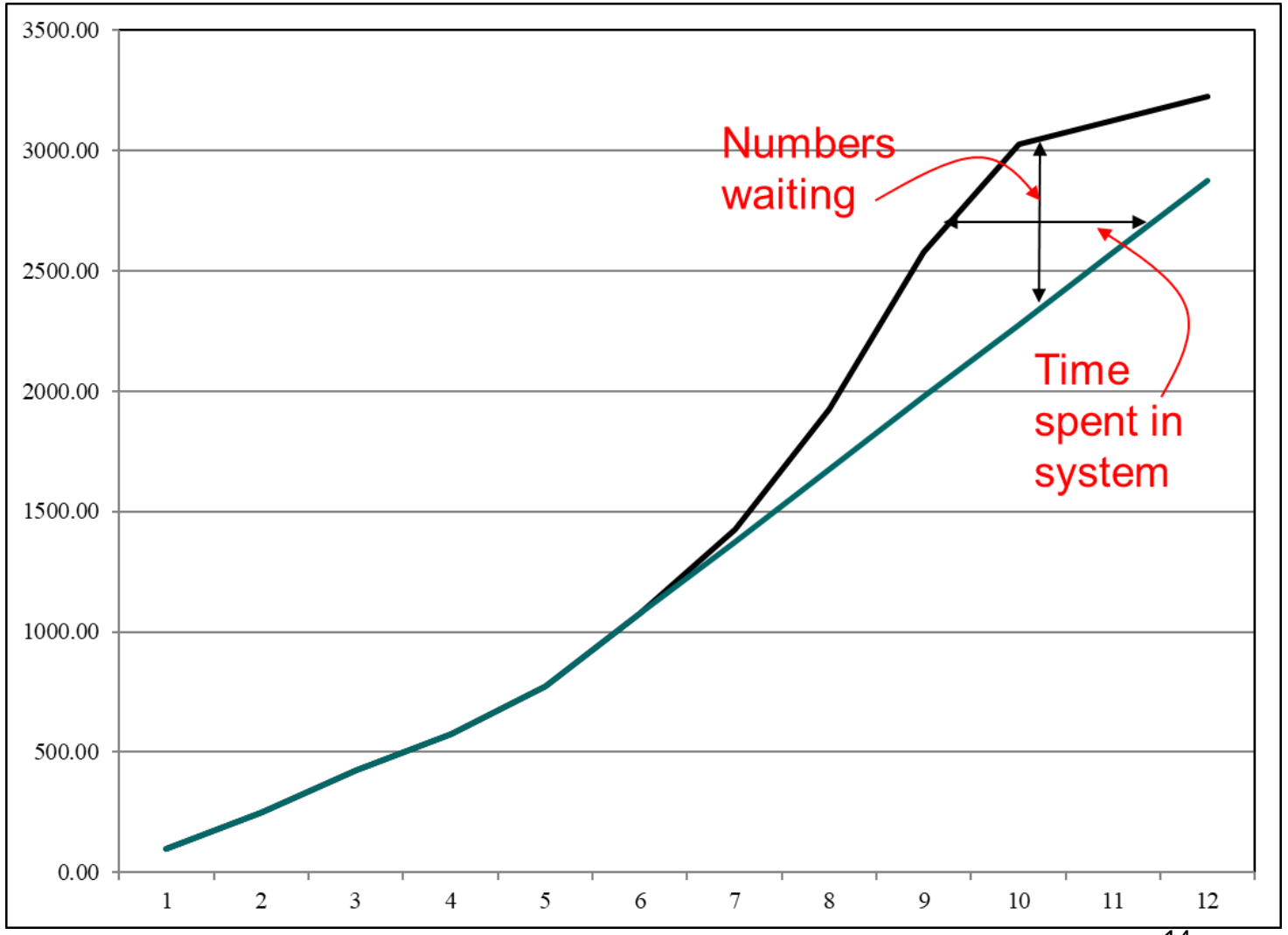
Acc. Arrivals	100	250	425	575	775	1075	1425	1925	2575	3025	3125	3225
Capacity	300	300	300	300	300	300	300	300	300	300	300	300
Waiting	0	0	0	0	0	0	50	250	600	750	550	350
Departures	**100**	**150**	**175**	**150**	**200**	**300**	**300**	**300**	**300**	**300**	**300**	**300**
Acc.	**100**	**250**	**425**	**575**	**775**	**1075**	**1375**	**1675**	**1975**	**2275**	**2575**	**2875**

How capacity is Evaluated

When the output can't be stored & clients can wait

waiting list: accum. demand – accum. used capacity



How capacity is Managed

- Understanding of aggregate demand and capacity essential
  - Think of capacity is either too high vs too low (implications)
- Three basic steps
  - Set / know operation's ‘base’ capacity
  - Decide how to deal with demand variability
  - Evaluate capacity options (Level, Chase, Mixed)

RECAP: Case: Heathrow campaigners lose challenge against third runway

https://www.bbc.co.uk/news/business-48118100

Campaigners have lost a High Court challenge against the government's decision to approve plans for a third runway at London's Heathrow airport.

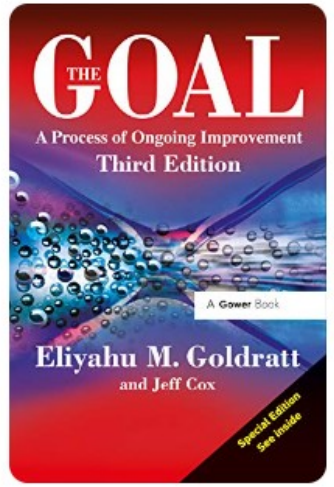
The theory of constraints (ToC)

The Heathrow case

- New terminal buildings did not increase airport capacity
- Because the runways were the bottleneck
- And the bottleneck at any instant sets the operation’s capacity
- ToC is based on this fundamental point

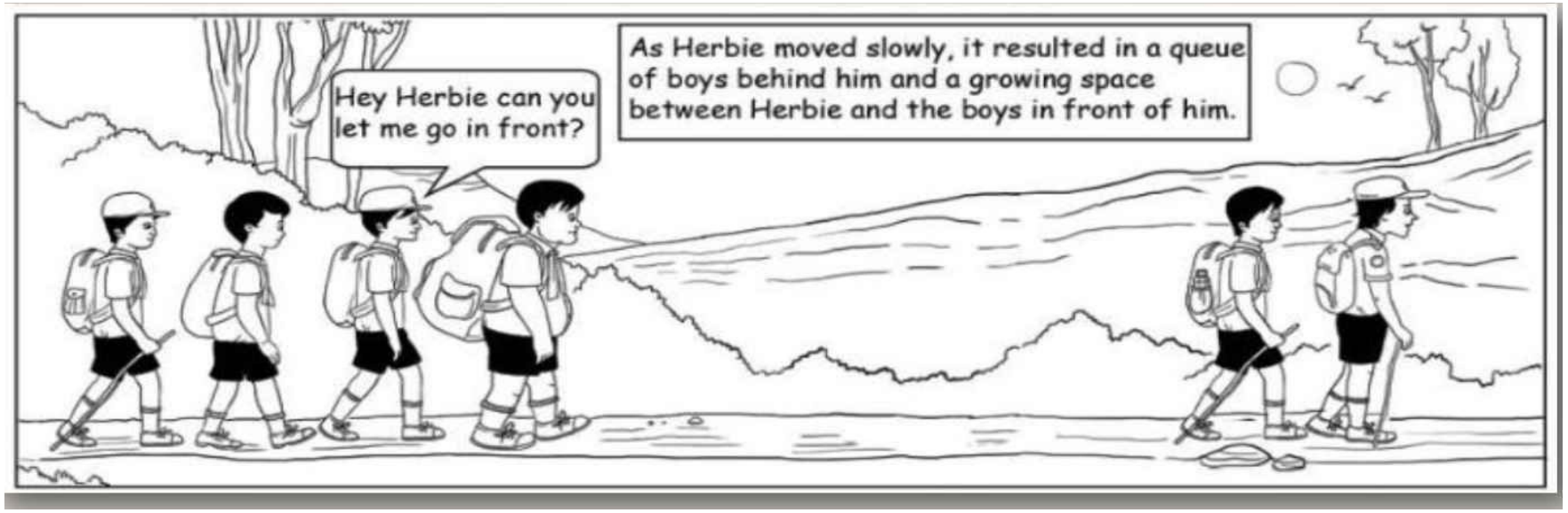
Goldratt's *The Goal*

- A very busy but poorly-performing US manufacturing plant
  - Despite a major robot investment
- A regional VP visits (Jonah)
  - An important customer didn't get delivery on time
  - Demand for a major efficiency improvement
- The over-worked plant manager's (Alex) marriage on the rocks
  - He misses a dinner date!



Goldratt's *The Goal*

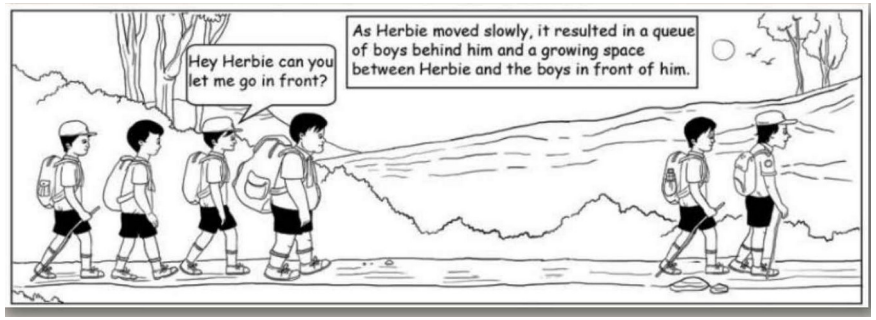
- A kids' hike
  - The objective is to get the whole group to the end
  - However, the group can't stay together
  - Even when the leader keeps an even pace
  - So the slowest has to lead
  - But it's not fast enough so his load has to be lightened



Goldratt's *The Goal*

This is a metaphor for the factory

- It has a bottleneck: the task with the lowest throughput
  - (The slow kid)
- Downstream tasks are starved of work
  - (The fast kid)
- Upstream tasks build up inventory
  - (The kids behind the slow kid)



- They gradually work out what to do
  - Stop slowing the bottleneck: these are a priority
  - Don't let upstream processes over-produce: pace them
  - Raise the bottleneck throughput: improve its working (even an old machine will do)

Goldratt's *The Goal*

- The constraint is managed
- Alex's marriage is saved!
- The goal was not to work as hard as possible

The theory of constraints (ToC)

So what is a bottleneck?

- A process where demand > capacity

Why does it matter?

- It determines the throughput of the whole operation

What should we do with a bottleneck first?

- Ensure it never runs out of work

Then what should we do with it?

- Improve it

What should we do with non-bottlenecks?

- Pace them to the bottleneck ensuring they never leave the bottleneck without work i.e. subordinate them, otherwise they produce costly-to-hold inventory

Why is it easy to think about things the wrong way?

- You concentrate on what's consuming cost
- You look at averages of throughput overall process
- You want to keep all tasks busy

The theory of constraints (ToC)

The core analysis: the process of analysis & improvement

or five focussing steps (FFS):

1. Identify system constraints - *bottlenecks*
2. Exploit system constraint – *never runs out of work*
3. Subordinate to system constraint – *paced to the bottleneck's pace*
4. Elevate system constraint – *improve the bottleneck*
5. Back to step one

Quiz

- Please attempt the quiz on Moodle
- Answers will be released on Moodle – please remind me

Questions

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Thank you