# Introduction to Operations Management

Lecture 1: Capacity planning and analysis

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# Capacity planning & analysis

- Slack et al, Chapter 11 p. 358 (10th ed.)

- How capacity is defined
- How demand is responded to
- How capacity is analysed in relation to demand
- How we think about constraints on capacity
- Slack et al, chapter 11

# Case: Heathrow campaigners lose challenge against third runway

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

# Heathrow's capacity challenges

There is no other airport that does so much with so little as Heathrow. Its capacity utilisation is ordinarily around 99%, way above the UK national average of approx. 40%, and also considerably higher than other major European Hub airports such as Paris Charles De Gaulle (70%) and Amsterdam Airport Schiphol (65%)

Pre COVID, Heathrow flew more than 78m passengers, 213,000 each day, with a plane taking off or landing every 45 seconds — about 1,300 a day.

However, the constraints on its capacity have made it the busiest two-runway airport in the world, leading to catastrophic delays if anything goes wrong.

Heathrow has tried almost every short-term trick in the book to try and boost capacity within current regulatory restrictions on night flights, the maximum number of movements per year, and air space restrictions. It has introduced robotic baggage handlers and F1-inspired simulation software so that arriving planes can land closer together…

# Questions

Why aren't we happy Heathrow is so efficient?

- It simply means more profits for the owners at the cost of sustainability and environmental concerns
- Local residents don't want so many aircraft movements
- Any problems means the system stops working

Why attempts to boost capability have had little effect on Heathrow's overall capacity?

- These are not the Bottlenecks, which are the runways

Why isn't the number of runways a good measure of what the airport accomplishes?

- This only weakly determines aircraft Throughput

Why can't we simply add more capacity at Heathrow?

- There is unlikely to be enough room
- There are strong social constraints on doing so
- It would cost an unreasonable amount of money
- It will eventually fill up again unless air travel is redistributed to make use of spare capacity at other UK airports

# How is capacity defined?

- *Capacity as volume or throughput*
- Physical volume or resource the most obvious definition
  - e.g. vessel size, seating quantity, workforce
- But this is not the same as capacity for work
  - i.e. need flow, turnover, output etc.
- OM is usually more concerned with "throughput"
  - i.e. the amount of work done (or people, materials, etc. that are dealt with) in a particular period of time
- Another definition...
  - 'maximum level of value-adding activity in a period'
- but not universal (e.g. other texts use 'resource' as capacity)

# How capacity is defined?

- *Capacity as a function of circumstances & assumptions*

- Often involves aggregation over multiple products/services
    - E.g. hotel: room nights/month irrespective of room type
    - MS cinema: seats/month irrespective of screen seating

- And relevant only to a particular time horizon
    - long term: substantial changes possible
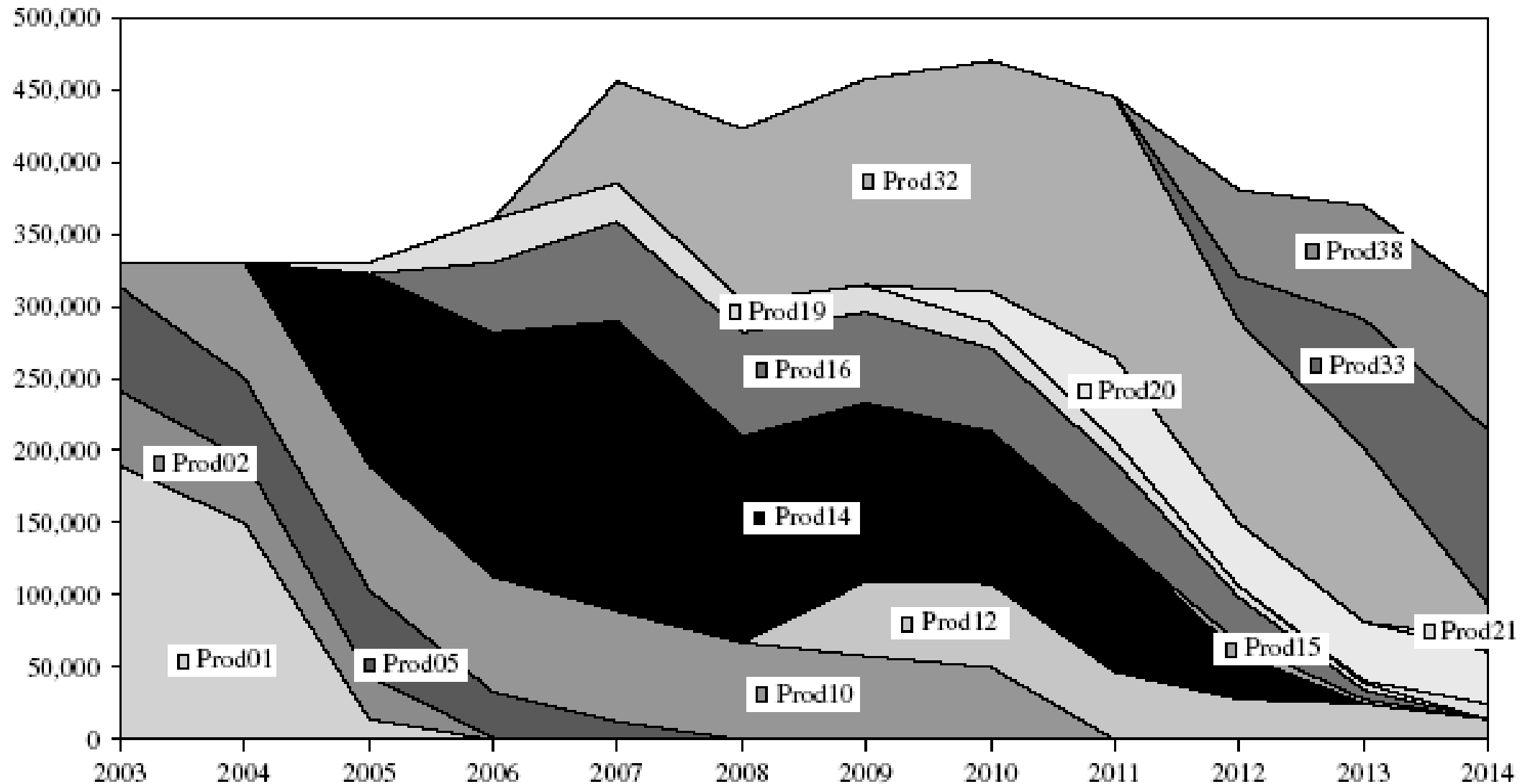    - short term: only marginal changes possible

# Capacity of the University?



- Number of lecture rooms, labs or offices

- Number of faculty or staff

- Number of students who can graduate per year

- Amount of research output can be published per quarter

# BMW load plan



Fleischmann, B., Ferber, S. & Henrich, P. (2006). Strategic Planning of BMW's Global Production Network. Interfaces, 36, 194-208

# How capacity is defined?

- *Capacity as an illusion*
- Theoretical capacity never achievable
- Usually distinguish 'planned' & 'avoidable' losses

# Example: A road repair team

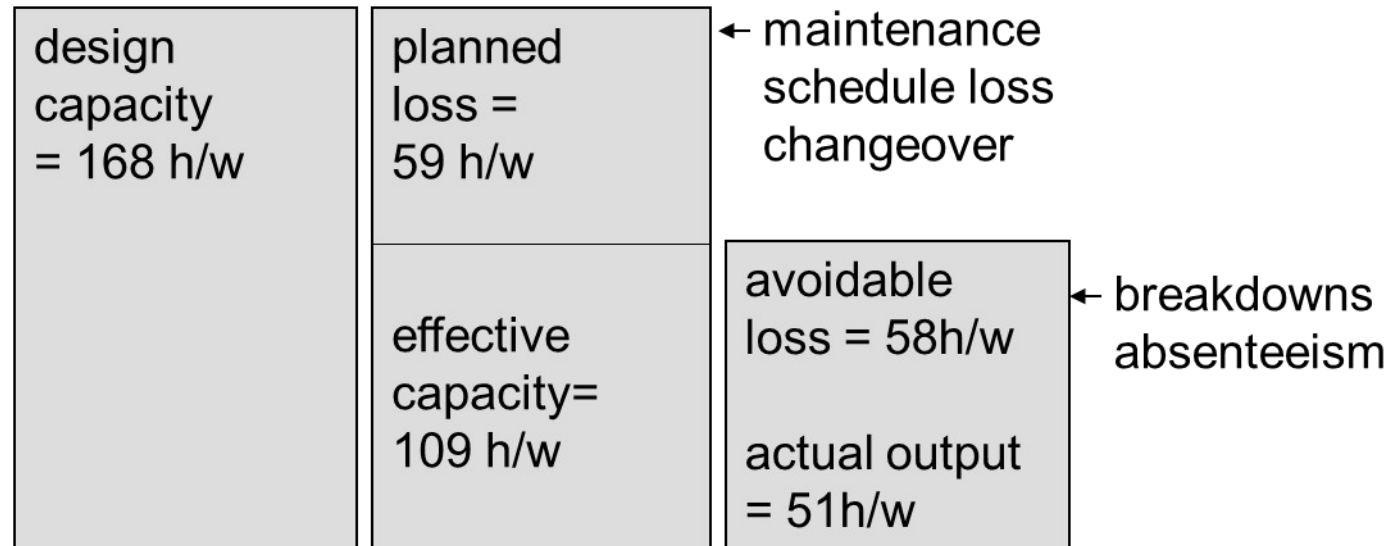# Quiz: Determine the road repair team's capacity (approx.)

**7:00-8:00**         Pick up van from depot, drive to other district

**8:00-9:15**         Every Monday "toolbox talk" with safety instructions

**9:15-9:50**         Pick up work orders for day

**9:50-11:15**        Leave depot, queue at tarmac plant, pick up tarmac, Drive to site of first defect.

**11:15-11:30**       Arrive at site and find work orders unclear. Another crew with different equipment has same work orders. Phone inspector and wait for instructions. Have breakfast.

**11:30-11:45**       Inspector arrives and points out defects.

**11:45-13:00**       Work on first patch

**13:00-13:15**       Work on small second patch

**13:15-13:30**       Move van and equipment to the location of the third patch

**13:30-14:30**       Work on third patch, then pack up equipment

**14:30-15:30**       Drive van back to depot in other district. Clean equipment, tidy up van and dispose of leftover tarmac and rubble

- In the 'working hours':

- fill in vibration exposure records, driver's book and other paperwork

- talk to 3 residents about work and discuss other defects

- find parking spaces for van, take water breaks

A. 8 hours 30 minutes
B. 2 hours 30 minutes
C. 1 hour 30 minutes
D. Indeterminable: It is clear the team is not interested in work

# How capacity is defined?

- *Capacity as an illusion*
- Theoretical capacity never achievable
- Usually distinguish 'planned' & 'avoidable' losses

| design capacity = 168 h/w | planned loss = 59 h/w | ← maintenance schedule loss changeover |
| | effective capacity= 109 h/w | avoidable loss = 58h/w ← breakdowns absenteeism<br><br>actual output = 51h/w |

# How capacity is defined

| design capacity = 168 h/w | planned loss = 59 h/w<br><br>effective capacity= 109 h/w | avoidable loss = 58h/w<br><br>actual output = 51h/w |
|---|---|---|

- This leads to two measures of capacity use…

- Utilization = actual output / design capacity
    - = 51/168 = .30

- Efficiency = actual output / effective capacity
    - = 51/109 = .47


- Finite utilization & efficiency is true of *all* systems

- Since all require maintenance & renewal and all are subject to random events

# Quiz

The utilization of university lecture theatres is about 60%. What is the efficiency if design capacity is 60 000 lecture theatre hours and effective capacity is 40 000 lecture theatre hours?

A. 0.6

B. It depends on attendance

C. 0.8

D. 0.9

# How **demand** is responded to
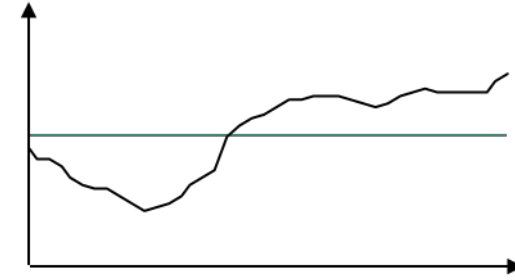
- ***Level* capacity planning**
- ignore demand fluctuations, operate buffer inventory
- Pluses
  - stability of employment
  - simplicity
  - predictability
- *Minuses*
  - *financing need (inventory, warehousing etc)*
  - *deterioration/obsolescence problems*
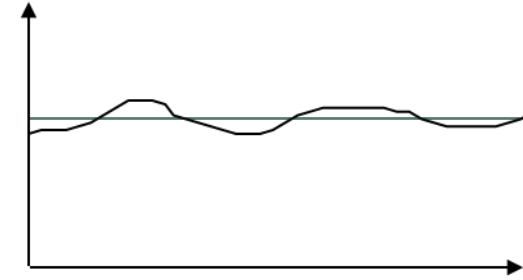
How **demand** is responded to



- ***Chase demand* planning**

- match by adjusting capacity

- pluses
  - limits storage need
  - avoids deterioration problems

- minuses
  - managing unstable employment
  - difficulty in *ad hoc* resourcing
  - high levels of physical capacity needed
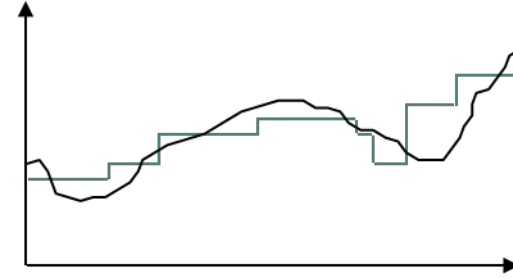
How **demand** is responded to

- Which industry is thought to have the highest proportion of casual labour in order to practice a chase demand strategy?

A. Agriculture

B. Financial services

C. Catering and hospitality
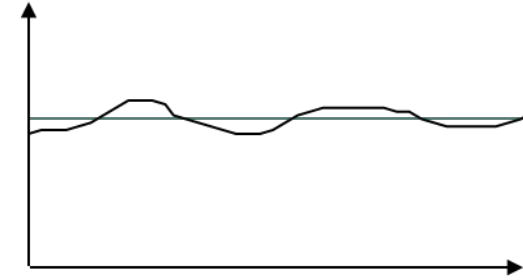
D. Higher education

# How **demand** is responded to

*Manage demand* planning

- reduce demand fluctuation – price differentials (surge pricing)
- discounts when demand low, premium prices when backlog
- diversify product or service
- Constraining customer access

How **demand** is responded to

*Mixed* plans

- all of the above eg...

- skim off peaks by premium prices / discounts

- increase/decrease capacity occasionally

- take advantage of 'natural wastage'

- allow some inventories

# Questions

Thank you