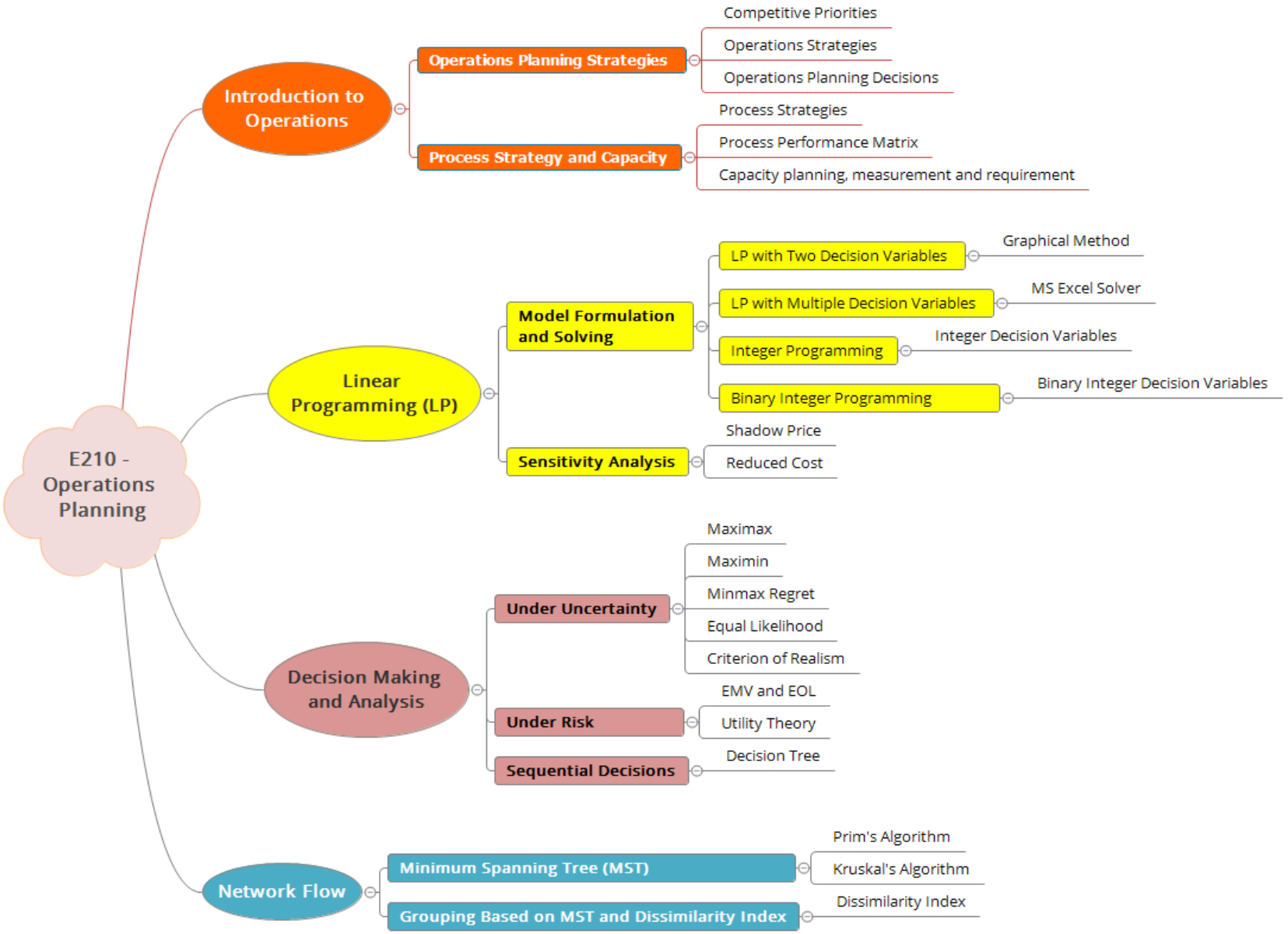
Lesson 02

The Cupcake Business Expansion

E210 – Operations Planning

SCHOOL OF ENGINEERING

E210 Operations Planning Topic Tree



Scenario – The Cupcake Business Expansion

- Amy currently runs a cupcake bakery outlet in Singapore. In addition to walk-in customers, the outlet also serves customers who order customized cupcakes (with specified designs, shapes, and sizes) through phone or online system.
- Amy's cupcake business is a huge success. She starts to receive orders from supermarkets in Singapore and Malaysia. The projected demand will be increased from 3,000 to 12,000 cupcakes per week including the additional supply to local and Malaysia supermarkets.
- With the significant increase in demand, Amy needs to expand her business through mass production of the cupcakes.

- She visited a famous cupcake production facility and amazed at the complex process and production line used in the production.
- There are significant differences between the mass production process and the process in her current outlet.

Scenario – Tasks of the day

Assume that you are a consultant helping Amy plan for her business expansion. Help her

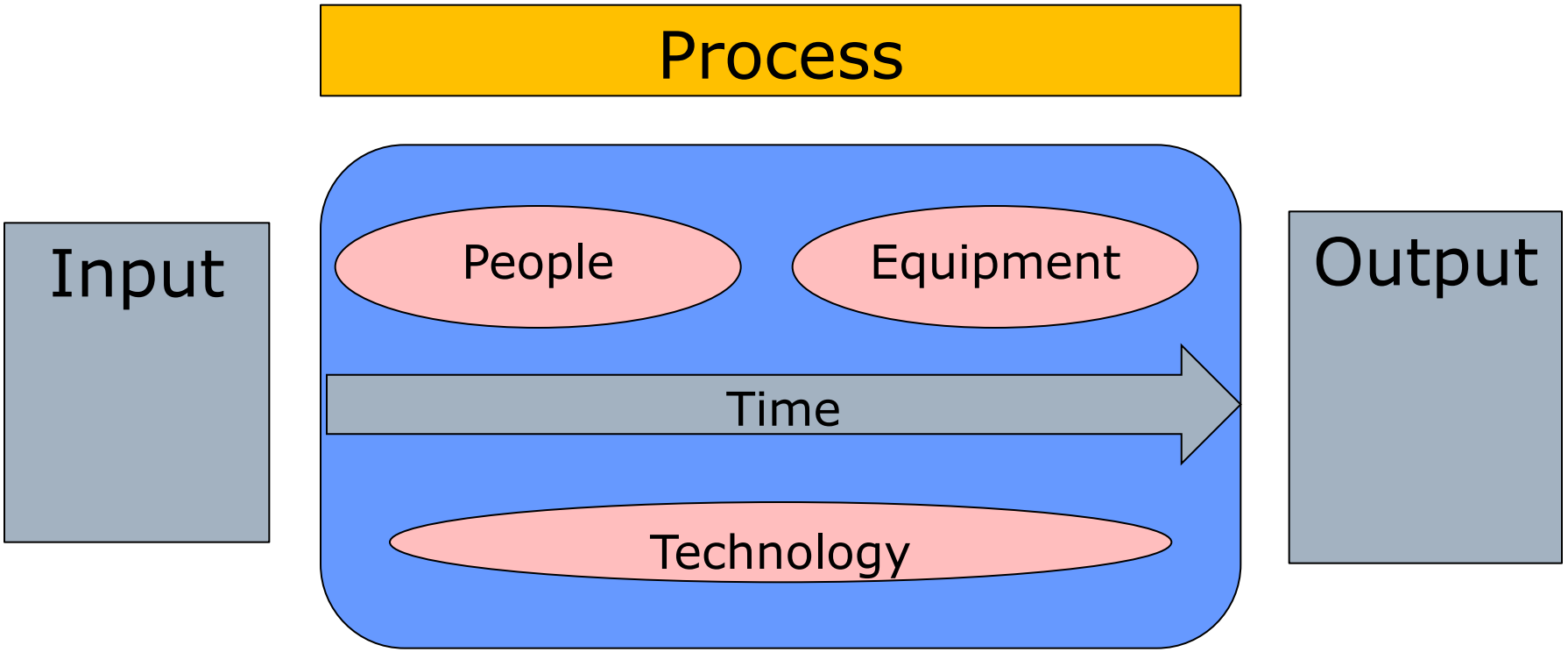
- Understand the cupcake production process and plot a simple process map.
- Identify performance metrics to measure process performance and evaluate the process performance through calculation of the performance metrics.
- Analyse the capacity utilization level and capacity utilization requirements.
- Find out more information regarding process strategies for the mass production of the cupcakes.

Scenario Definition Template

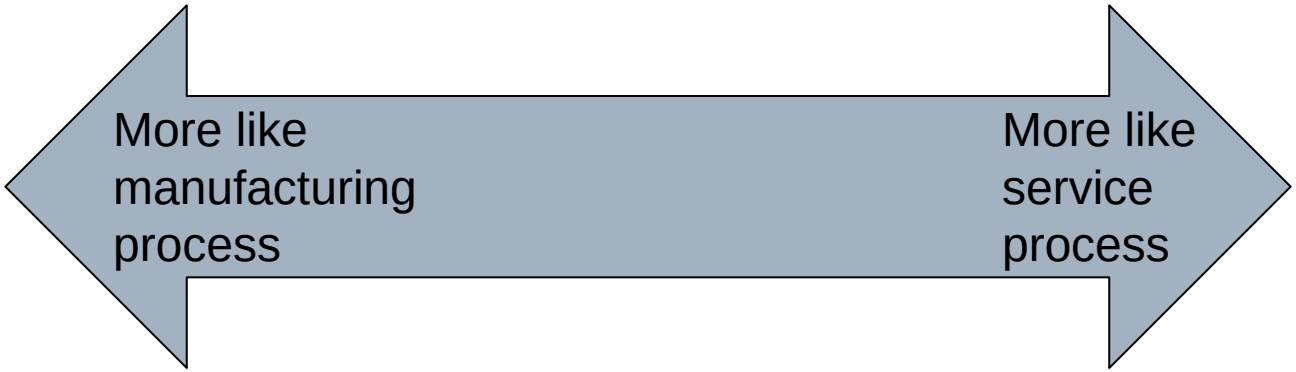
- What do we know?
- What do we not know?
- What do we need to find out?

What is a Process?

- Definition: A business process is a set of logically related tasks or activities performed to achieve a defined business outcome.



Manufacturing Vs Service Processes



- Physical, durable output
- Output can be stored
- Low customer contact
- Long lead time
- Capital intensive
- Quality easily measured

- Intangible, perishable output
- Output cannot be stored
- High customer contact
- Short lead time duration
- Labor intensive
- Quality not easily measured

Note:

- Manufacturers may provide services such as after-sales support.
- Many service providers such as healthcare providers and restaurants carry inventories and require investment in equipment.

Poll

1. Company ABC is a manufacturer of laptops. Which of the following about ABC's manufacturing process is true?
   a. Output can be stored
   b. Quality not easily measured
   c. High customer contact
   d. Labor intensive

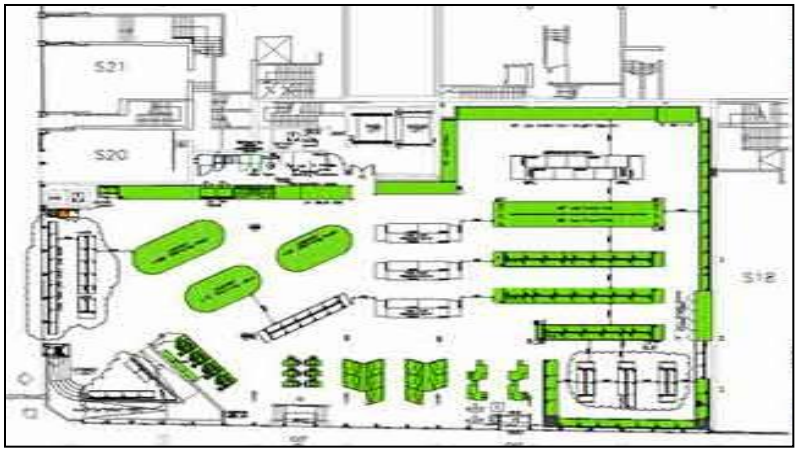
2. Which of the following about a hospital's service process is NOT true?
   a. Intangible, perishable output
   b. Labor intensive
   c. Long lead time
   d. Quality not easily measured

Process Strategy

- Process strategies are implemented to achieve competitive priorities in cost, quality, time and flexibility.
- Four basic process strategy decisions are:
  - Process structure
  - Customer involvement (for service process)
  - Resource flexibility
  - Capital intensity (i.e. level of automation)
- Process strategies determine the type, amount and allocation of resources (manpower, equipment, space, facility layout) to the process.

Process Structure

- Determines the process type relative to the kinds of resources needed and how the resources are organized.
- Process structure also determines the layout, which is the physical arrangement of operations created by various processes.



- The flow within a process can be represented in a flowchart or process map.

Manufacturing Process Structure

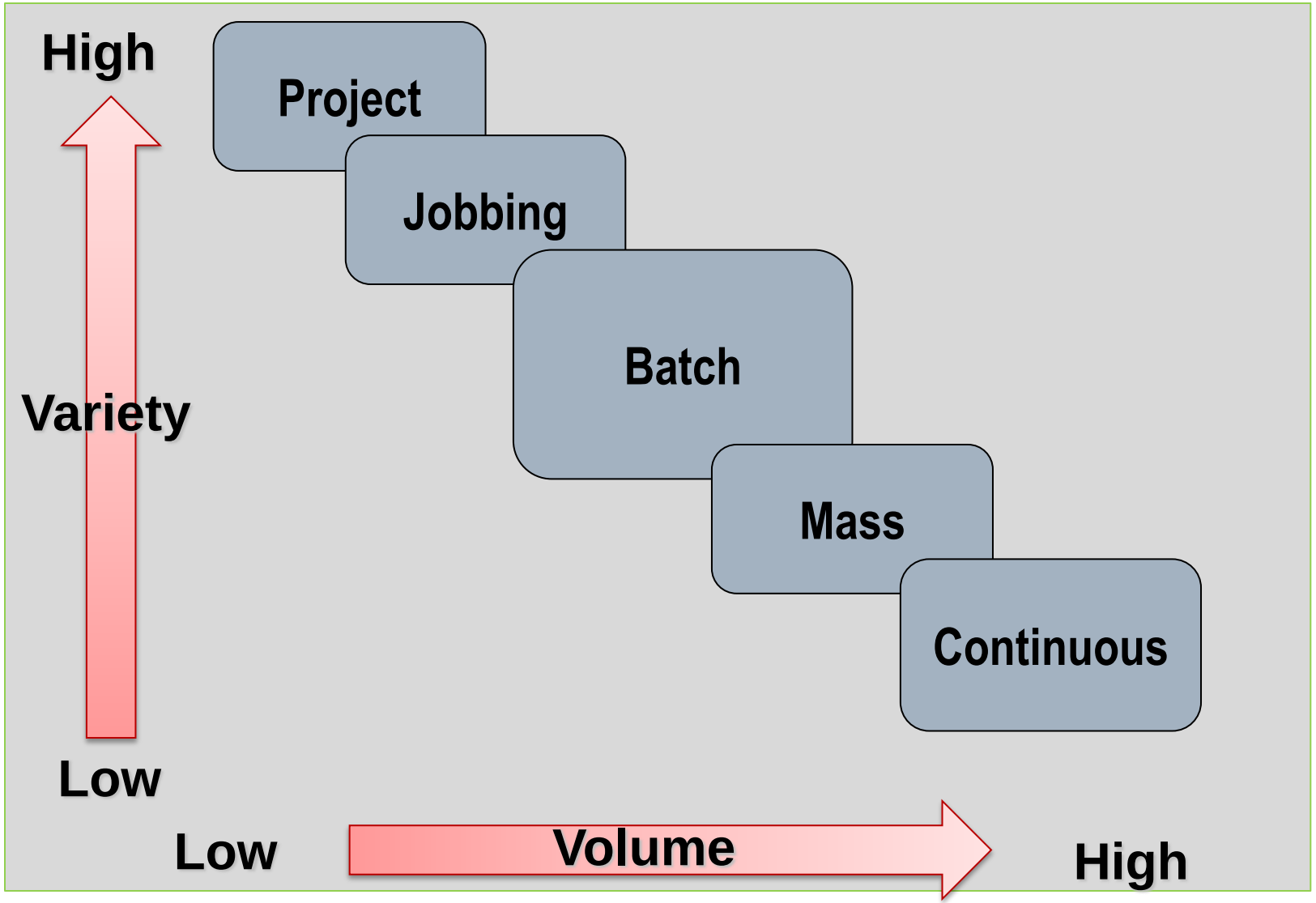
- Product-Process Matrix helps to determine the manufacturing process structure.

- The different types of process structures are Project, Jobbing/job shop, Batch process, Mass/Line and Continuous flow.

- Choice of process structure depends on the volume and variety of products to be made.

- If a process provides for customization and a wide variety of products, production volume will tend to be lower.

Manufacturing Process Matrix



Adopted from Operations Management Andrew Greasley

Manufacturing Process Matrix

- **Project processes -** used to make one-off products to a customer specification. E.g. Movie file production.
- **Jobbing / Job Shop processes –** high-variety and low volume products. Used to make one-off (or low volume) product to a customer specification. E.g. precision engineering job shop.
- **Batch processes –** Medium variety and medium volume. Cover a relatively wide range of volume and a variety of combinations. E.g. vehicle component assembly, clothing manufacturing, bakeries and magazines or books.
- **Mass/Line processes –** High-volume & low-variety. Movement of the product may be automated by using a conveyor system and the production process broken down into smaller, simpler tasks. E.g. automobile manufacturing, assembly of consumer products such as Televisions and computers.
- **Continuous processes –** Very high volume of a standard product. Use a large amount of equipment, which is specialized and dedicated to producing a single product with continuous flow. Such as oil refinery, electricity production.
- https://www.bing.com/videos/search?q=manufacturing+process+matrix&&view=detail&mid=9640DD1D815A5E32F2969640DD1D815A5E32F296&&FORM=VRDGAR

Think-Pair-Share

Answer the following questions through pair and group discussions:

1. What are the five basic types of manufacturing process structures?
2. What are the two factors determining the choice of process structures?
3. For each process structure type, give examples of products that are produced by the process.

1. Five basic manufacturing process structures:
   - Project processes, Jobbing / Job Shop processes, Batch processes, Mass/Line processes, Continuous processes;
2. The differentiating factors: product volume and variety
3. Examples for each process structure type:
   - Project processes: Movie file production.
   - Jobbing / Job Shop processes: precision engineering job shop.
   - Batch processes: vehicle component assembly, clothing manufacturing, etc.
   - Mass/Line processes: automobile manufacturing, assembly of consumer products such as Televisions and computers.
   - Continuous processes: oil refinery, electricity production.

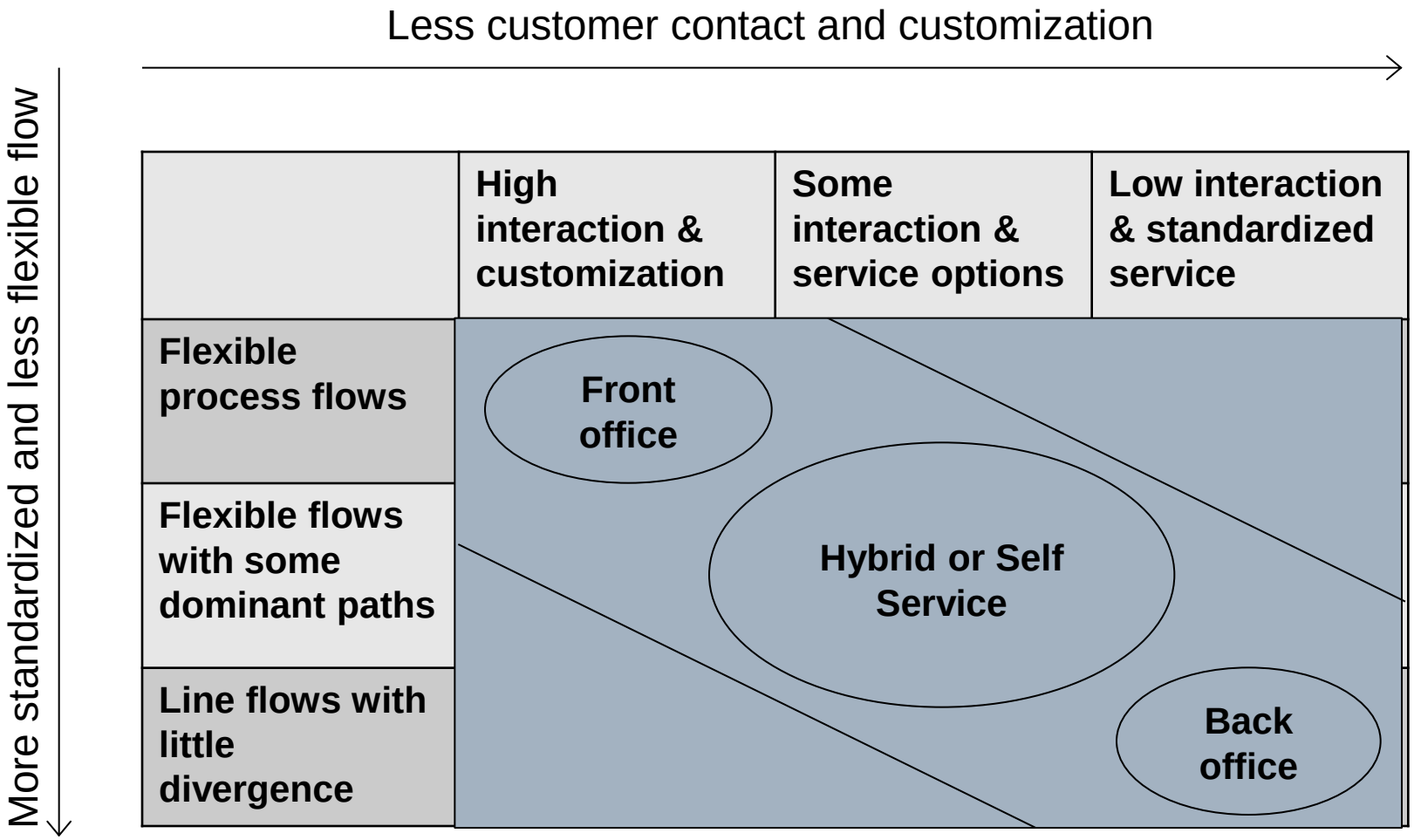
Service Process Structure

- Customer Contact Matrix helps to determine the service process structure.

- Structure of a Service Process depends on the amount and type of customer contact as well as the degree of service customization.

- Service processes can be broadly classified into these types:
  - Front office (or personal attention approach)
  - Back office (or production line approach)
  - Self service or Hybrid (mix of front and back office characteristics)

Customer Contact Matrix



Think-Pair-Share

Answer the following questions through pair and group discussions:

Referring to the Customer Contact Matrix.

1. What are the two factors determining the service process structures?
2. Give some examples of the 1) front office, 2) back office and 3) hybrid service process structure types and explain their differences.

1. Factors determining the service process structures

- The amount and type of customer contact
- The degree of service customization

2. Examples:

- Front office – luxury hotel check-in, luxury car purchase, doctor consultation
- Back office – preparation of financial reports, mail processing, credit application
- Hybrid – purchase via internet, restaurant service, vehicle servicing, and supermarket checkouts

Customer Involvement

- How much involvement should the customer have in the process?
- How many possible choices will the customer have?

Advantages of Customer Involvement	Disadvantages of Customer Involvement
Self service may mean lower cost	Disrupts process, making it less efficient
Some customers want to be in control and seek active participation	Greater need for interpersonal skills
Build closer relationship between customer and service provider	Quality measurements are harder
Foster collaboration as more information can be shared	Managing perceptions becomes more important

Resource Flexibility

- Workforce
  - A flexible workforce has different skills and is capable of handling multiple tasks.
  - When volume is low and process flows are divergent, a flexible workforce is preferred (so that one person is able to do different tasks).
  - More training and education is required for a flexible workforce.
  - Employment of temporary workers (who do not have the required skills-set) during seasonal periods may be an issue.
- Equipment
  - General purpose equipment is more flexible compared with specialized ones.
  - When volume is high and customization is low, specialized equipment is preferred and vice versa.

Capital Intensity

- High capital intensity means greater use of machinery and automation in processes.
- High volumes are needed to justify the large fixed cost brought about by investment in machines.
- Fixed automation (specialized machinery) is used in assembly line or continuous flow process.
- Flexible (or programmable) automation allows for some degree of customization in the output.
- Service processes where customer contact is not critical (e.g. online ticket booking) are often automated to save cost and provide customers with more choices.

One-minute Paper

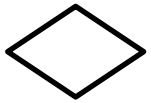
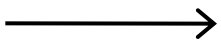
What are the four basic process strategy decisions? In one sentence, describe each of them.

- Process structure – determines how the process is organized relative to the kinds of resources needed (process type); how to make physical arrangement of the operations created from the process (process layout)
- Customer involvement – degree of customer involvement in the process; possible choices customers can have.
- Resource flexibility – can the manpower and equipment handle a wide variety of products, output levels, duties and functions?
- Capital intensity – level of use of machinery and automation in the process; the mix of equipment and human skills in a process.

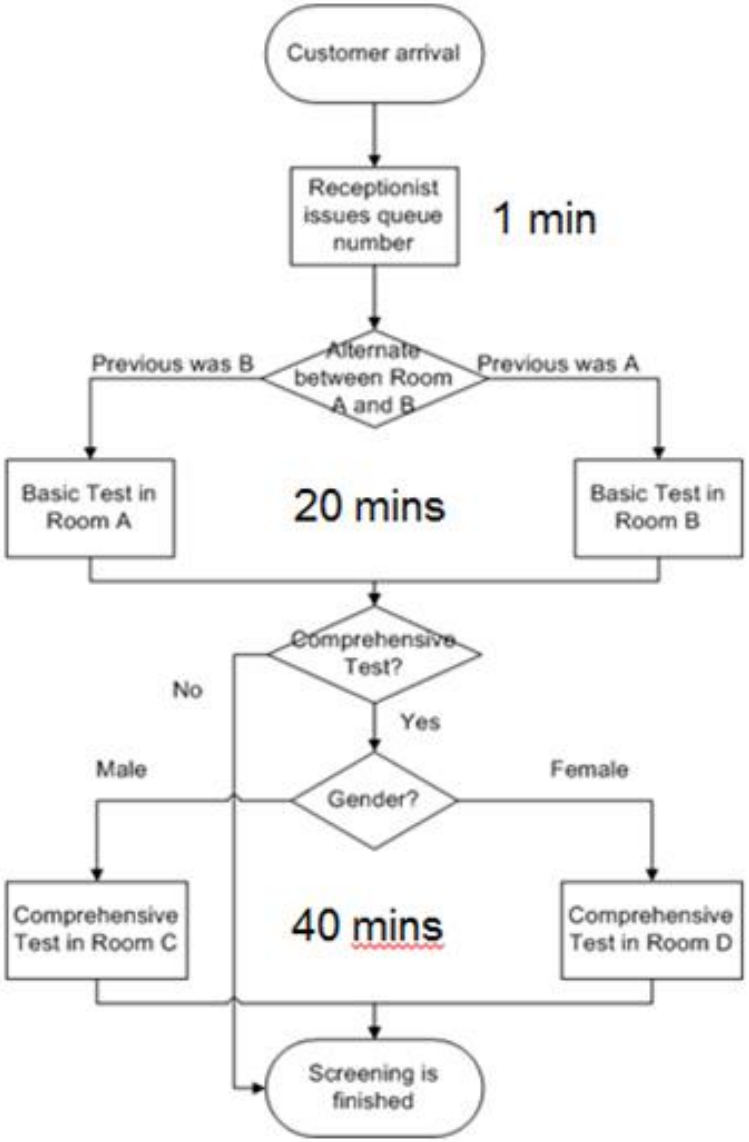
Process Map

- Also known as Process Flowchart.
- Shows how an entity (customer, product or information) flows through the process.
- The purpose is to create common understanding of the process and provides a baseline to measure improvement efforts.
- Appropriate level of detail should be shown:
  - Identify clear boundaries, starting and ending points
  - Keep it simple – leave out unnecessary details but include activities that are critical to process performance

Process Map (Basic Symbols)

Symbol	Meaning
	Process or Action Step
	Decision Point
	Start/End Point
	Direction of Flow

An Example of Process Map



Process Map of Clinic that provides Health Screening Services

Process Performance Metrics

- *Operation Time* = Setup time + Run (or Process) time
- *Flow Time* = Average time for a unit to move through the system (i.e. total process time + waiting time in process; also known as throughput time or lead time)
- *Cycle Time* = Average time between completion of units (Also the maximum time that a product is allowed at each workstation)
- *Throughput Rate* = 1 / Cycle time

  (Number of units produced per unit time)

Process Performance Metrics

- *Efficiency* = Actual output / Standard output
  (Standard output is the theoretical achievable throughput)

- *Productivity* = Output / Input
  (Actual measure is specific to business context)

- *Utilization* = Time utilized / Time available

- *Order Fulfilment Lead Time* = Total time taken to satisfy customer demand, from order placement to customer receipt

Performance Benchmarking

- It is often vital for companies to compare their business processes against others with similar processes.
- The aim is to understand and adopt the ‘best-in-class’ practices.
- For example
  - Civil authorities may publish data on punctuality of flights (for airliners) and mishandled baggage (airport services company).
  - Automotive manufacturers could compare performance in terms of total assembly hours per vehicle or number of cars produced per employee.

Think-Pair-Share

Share with your teammates two metrics you can use to measure a process' performance. Discuss the definition for each performance metric.

- *Operation Time* = Setup time + Run (or Process) time
- *Flow Time* = Average time for a unit to move through the system (i.e. total process time + waiting time in process; also known as throughput time or lead time)
- *Cycle Time* = Average time between completion of units (Also the maximum time that a product is allowed at each workstation)
- *Throughput Rate* = 1 / Cycle time
  (Number of units produced per unit time)
- Efficiency = Actual output / Standard output
  (Standard output is the theoretical achievable throughput)
- Productivity = Output / Input
  (Actual measure is specific to business context)
- Utilization = Time utilized / Time available
- Order Fulfilment Lead Time = Total time taken to satisfy customer demand, from order placement to customer receipt

Capacity

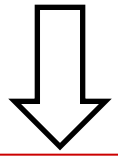
- Definition: Amount of output of a process or system attainable per time period.
- It measures the capability of worker, machine, work center, plant or organization to produce, process, receive or hold something.
- Capacity is measured differently at different functional areas of an organization.
- The aim of capacity planning is to match resource capability with demand level.

Capacity Planning

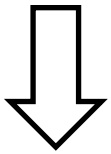
- Capacity planning is about making decisions on how much and what type of capacity are required.
- Long range (~more than one year)
  - Investments in new facilities and equipment that require top management's approval because of high capital intensity.
- Intermediate range (~ 6 to 18 months)
  - Examples are hiring, layoffs, new tools, minor equipment purchases and subcontracting.
- Short range (~ one month or less)
  - Related to daily or weekly scheduling activities. Examples are overtime, personnel transfers and temporary measures to increase/decrease capacity.

Systematic Approach to Long-term Capacity Planning

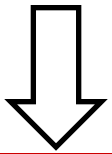
Forecast future capacity requirements



Identify gaps by comparing requirement with available capacity



Develop alternative plans for reducing gaps



Evaluate each alternative and select the best plan

Manufacturing vs Service Capacity Planning

Factor	Manufacturing	Service
Time	Inventory is used as buffer to satisfy future demand	Capacity must be available when there is a demand
Location	Products are delivered to retail stores or designated location	Services must be available where customers need them
Quality	Quality is controlled by manufacturing process and product design	Resource utilization directly affects service quality
Variability	Demand variability may be seasonal or affected by new product launches	Large demand variability as customer behavior is less predictable
Planning Strategy	Lead, Lag or match	(Usually) make changes in small increments

Capacity Decisions

- Type and Flexibility of Resources and their Capacity
  - Plant, process, workers, outsourcing capacity
- Desired Capacity Utilization Level
  - Often difficult but important decision to make for a service process or a manufacturing process with large demand variability
- Capacity Change Strategy
  - Timing of capacity change (lead, lag or straddle)
  - Size of capacity change

Measures of Capacity

- **<u>Output measures</u>:** suitable when a process generates a small variety of standard products or services at high volumes

  - E.g. Number of cars (produced) per day, number of invoices (processed) per week

- **<u>Input measures</u>:** suitable for low volume, flexible processes that generate a large variety of outputs

  - E.g. Number of machine hours per month in a furniture making factory, number of consultation hours per week

Examples of Measures of Capacity

Type of Organization	Measures of Capacity	
	Input	**Output**
Manufacturer	Machine hours per shift	Number of units produced per shift
Hospital	Number of beds	Number of patients treated per month
Airline	Number of planes or seats	Number of seat-kilometers flown
Restaurant	Number of seats	Number of customers served per busy period
Retailer	Area (space) of store	Sales dollars
Theatre	Number of seats	Number of customers visited per time period

Capacity Utilization

- Utilization is the degree to which a resource of an organization (asset or labour) is currently being used.

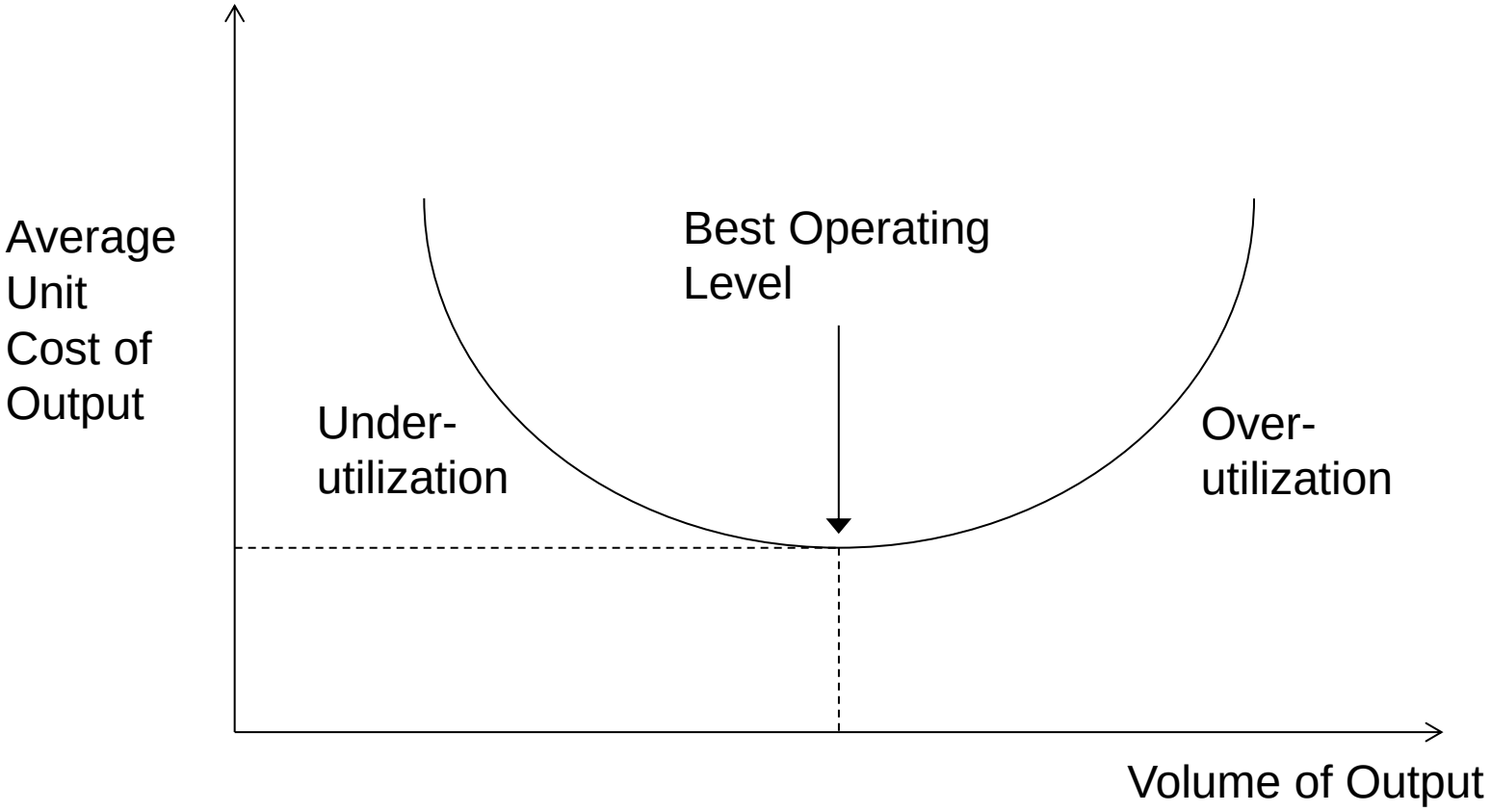
$$Capacity\ Utilization = \frac{Capacity\ Used}{Capacity\ Available}$$

- Capacity available can be measured in terms of:
  - Maximum Capacity (or design capacity) – theoretical capacity not taking into account machine setup time, downtime, worker absenteeism and other reasons.
  - Rated Capacity (or effective capacity) – the long-term achievable capacity of a resource or process. Possible to operate above the rated capacity for a short period of time (e.g. by overtime)

Desired Capacity Utilization

- Every organization or process has its own appropriate capacity utilization.
  - Too little capacity remaining means the output may be too slow or insufficient to satisfy demand.
  - Too much remaining means a need to cut prices, carry excess inventory or even cut capacity.
- If the average utilization has an upward trend and approaches 100%, it is usually a sign to increase capacity.
- For processes that are capital intensive and generate high volume output, utilization level should be high.
- Flexible processes or service capacity should have a lower level of utilization to handle uncertainty and inherent demand variability.

Economic Importance of Right Sizing Capacity (Best Operating Level)



- Best Operating Level is the **volume of output** (e.g. number of soft toys, number of patients etc.) at which the average **cost per unit** ($) is the lowest, usually at design or rated capacity.

Test Yourself: Capacity Utilization

Consider the case where a process utilizes a machine to produce an item.

1. Assume that there are 9 hours in each shift, and the machine operates on an average of 8 hours in one shift, what is the capacity utilization of the machine? What is the type of measure of capacity (Input or output) used?
2. If the process is able to produce 2000 items a month, and during the month of January, 1800 items are produced, what is the capacity utilization of the process? What is the type of measure of capacity (Input or output) used?

1. 8/9, input measure
2. 1800/2000 = 0.9, output measure

Calculate Capacity Requirements

- Capacity requirements may be calculated as number of input units required for a resource type

$$\text{Capacity Requirement} = \frac{Processing\ hours\ required\ per\ year}{Hours\ available\ per\ year}$$

Where

Processing hours = demand forecast for the year x processing time per unit

Hours available = hours available from a single capacity unit after factoring the desired utilization level

E.g. If the desired utilization is 80% for a piece of equipment, the hours available for an 8-hour shift will be 0.8 x 8 = 6.4 hours

Note

Time unit in calculation can be any relevant period other than 'per year'

Test Yourself: Capacity Requirements

Consider the process where a machine is used to produce widgets. Assume that the desired capacity utilization level for the machine is 85%, how many units of the machine are required if the processing hours required each month is 650? Assume that the company operates 25 days in a month at a 12-hour shift a day.

Capacity requirement

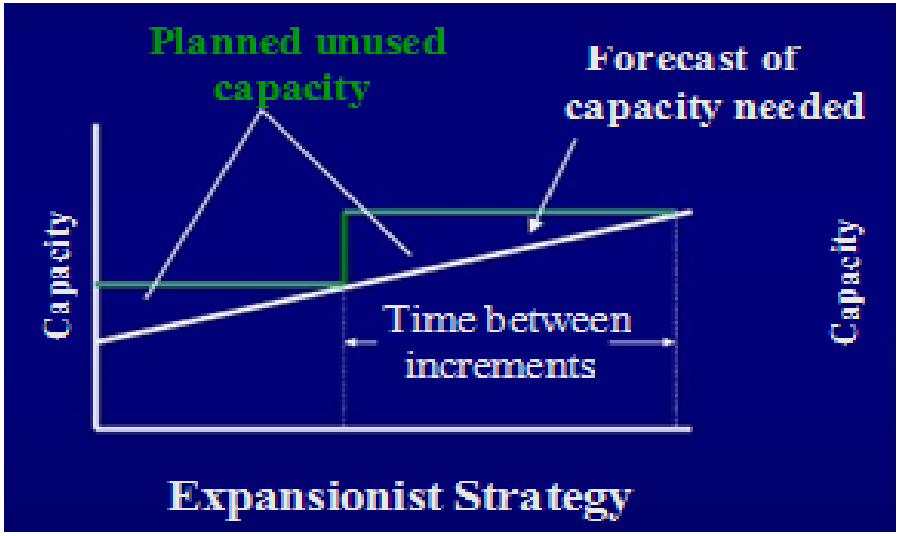
= Processing hours required per month / hours available per month

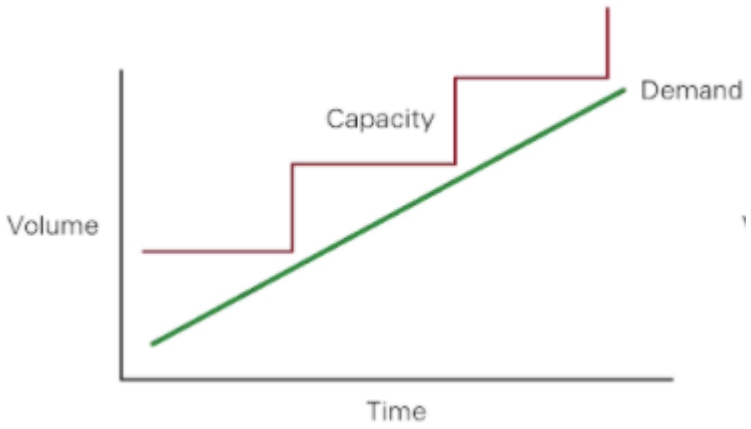
= 650 / (12*25*0.85)

= 2.55 ~ 3 machines

Capacity Change Strategy

A Capacity Lead (or Expansionist) Strategy

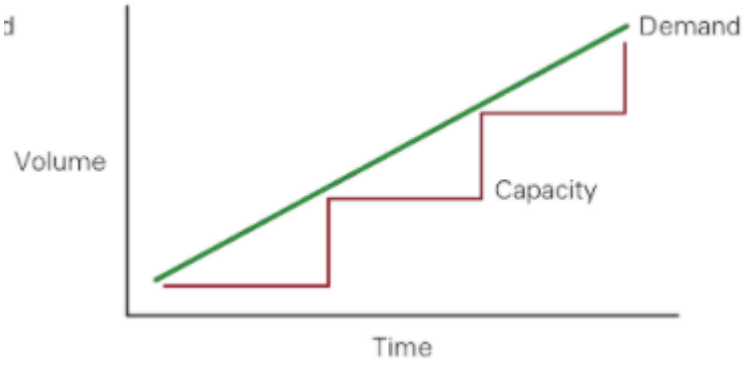




- Advantages: Ahead of competitors, meet demand for hot new product/service, overbuilding is cheaper and less disruptive compared with making frequent small changes.
- Disadvantages:
  - Demand may change or emergence of new technology.
  - More expensive to commit to a larger expansion.

Capacity Change Strategy

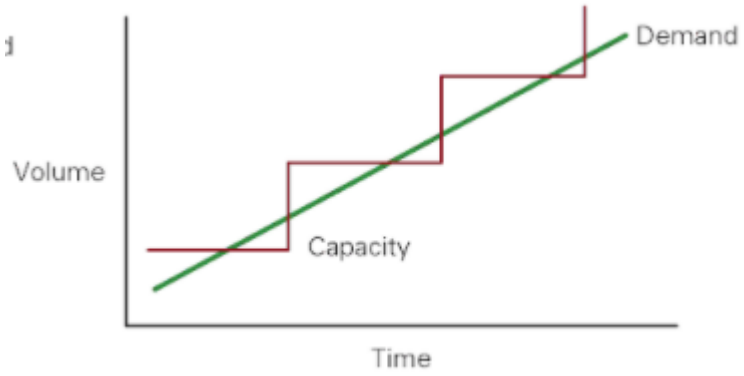
A Capacity Lag (or Wait-and-see) Strategy



- Advantages: Reduced risk of overbuilding, better productivity through higher utilization, lower capital investment, appropriate for mature products/services.
- Disadvantages:
  - Unable to meet demand surge, lagging behind competitors.
  - Short term options required to meet demand. E.g.: Overtime, outsource, lease equipment/ space, employ temporary workers.

Capacity Change Strategy

A Capacity Straddle Strategy



- Advantages: The capacity additions try to match with demand as closely as possible.
- Disadvantages:
  - There will be short periods of over- and under-resource utilization.
  - When capacity is above the demand curve, the company has excess capacity; when it is below, there is a shortage of capacity to meet demand.

One-minute Paper

What are the three capacity change strategies? Give one advantage for each strategy.

Capacity change strategies:

- A capacity lead (or expansionist) strategy
- A capacity lag (or wait-and-see) strategy
- A capacity straddle strategy

Advantage:

- Expansionist: Ahead of competitors, meet demand for hot new product/service, overbuilding is cheaper and less disruptive compared with making frequent small changes
- Wait-and-see: Reduced risk of overbuilding, better productivity through higher utilization, lower capital investment, appropriate for mature products/services
- Straddle: The capacity additions try to match with demand as closely as possible

Learning Objectives

At the end of the lesson, students should be able to:

- Define the four process strategy decisions and describe the considerations behind each decision.
- Identify and describe the differences between manufacturing and service processes and the way capacity planning is done.
- Define and measure the common process matrices.
- Define and measure capacity.
- Calculate the capacity utilization and capacity requirement.
- Explain capacity change strategies with respect to timing and size of expansion by organizations.

Overview of E210 Operation Planning Module