Chapter 2 - Product Design & Process Selection

Production & Operations Management

Product & Service Design

- The process of deciding on the unique characteristics of a company's product & service offerings
- Serves to define a company's customer base, image, competition and future growth

SCOPE: PRODUCT DESIGN

- **Meaning of product design**

"Product design is the translation of intellectual wisdom, requirements of the entrepreneurs, or needs of the consumers, etc. into a specific product."

Product design

- **Product design is the process of creating a new product to be sold by a business to its customers. A very broad concept it is essentially the efficient and effective generation and development of ideas through a process that leads to new products.**

Product design

- **In a systematic approach product designers conceptualize and evaluate ideas turning them into tangible inventions and products. The product designer's role is to combine art science and technology to create new products that other people can use**

Product design

- **Their evolving role has been facilitated by digital tools that now allow designers to communicate, visualize, analyze and actually produce tangible ideas in a way that would have taken greater manpower in the past.**

Product design

- **Product design is sometimes confused with industrial design and has recently become a broad term inclusive of service software and physical product design. Industrial design is concerned with bringing artistic form and usability usually associated with craft design and ergonomics together to mass-produce goods**

Products versus Services

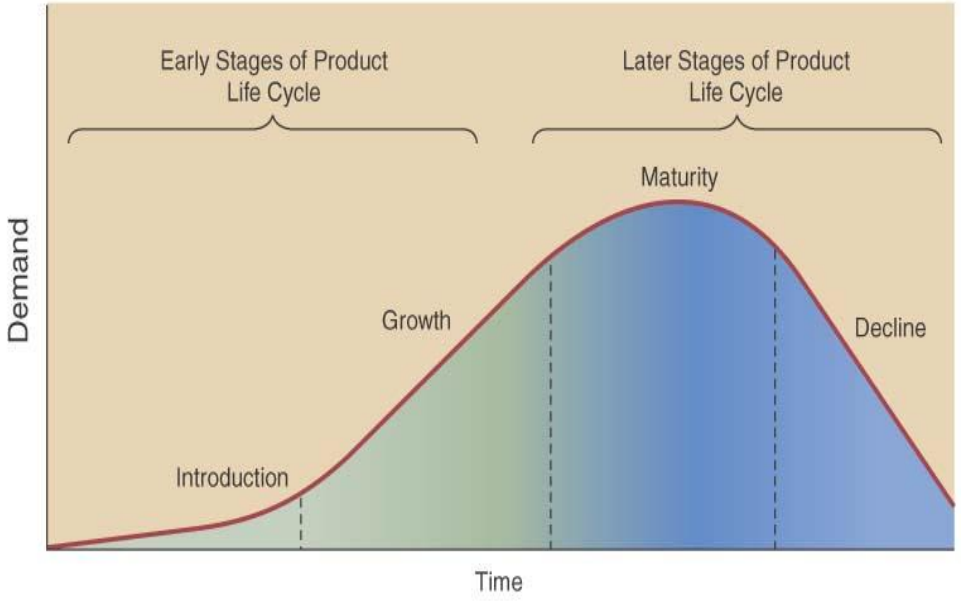
- Products:
  - Tangible offerings
  - Dimensions, materials, tolerances & performance standards
- Services:
  - Intangible offerings
  - Physical elements + sensory, esthetic, & psychological benefits

Strategic Importance

- Products & service offerings must support the company's business strategy by satisfying the target customers' needs & preferences
- If not, the company will lose its customer base and its market position will erode

Product Life Cycle

- **Product life cycle stages**
  - **Introduction**
  - **Growth**
  - **Maturity**
  - **Decline**
- **Facility & process investment depends on life cycle**



Steps in Product Design

- Idea Development:
  - A need is identified & a product idea to satisfy it is put together
- Product Screening:
  - Initial ideas are evaluated for difficulty & likelihood of success
- Preliminary Design & Testing
  - Market testing & prototype development
- Final Design
  - Product & service characteristics are set

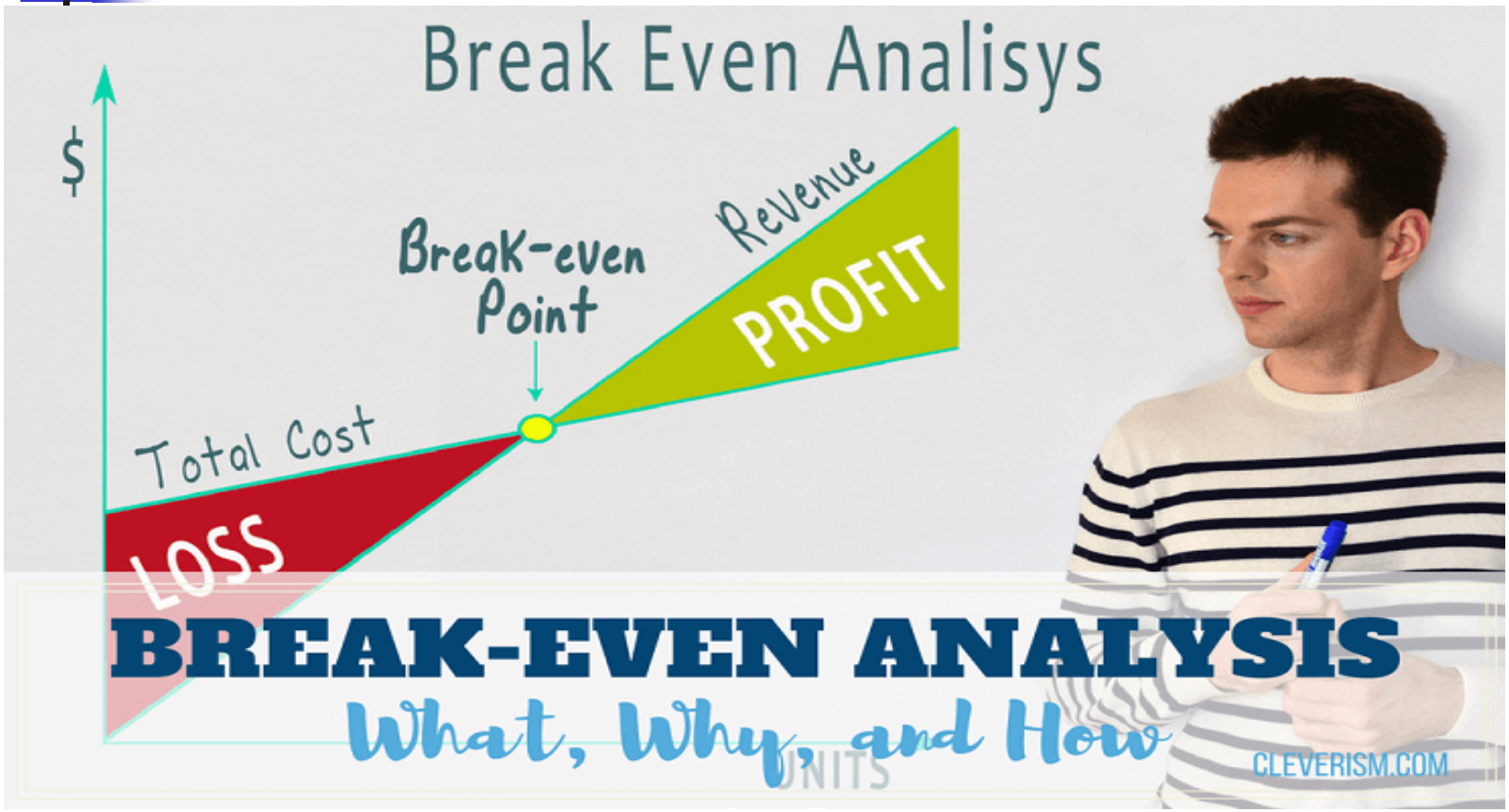
Idea Development

- Existing & target customers
  - Customer surveys & focus groups
- Benchmarking
  - Studying "best in class" companies from your industry or others and comparing their practices & performance to your own
- Reverse engineering
  - Disassembling a competitor's product & analyzing its design characteristics & how it was made
- Suppliers, employees and technical advances

Product Screening

- Operations:
  - Are production requirements consistent with existing capacity?
  - Are the necessary labor skills & raw materials available?
- Marketing:
  - How large is the market niche?
  - What is the long-term potential for the product?
- Finance:
  - What is the expected return on investment?

BREAK-EVEN ANALYSIS



Break-Even Analysis

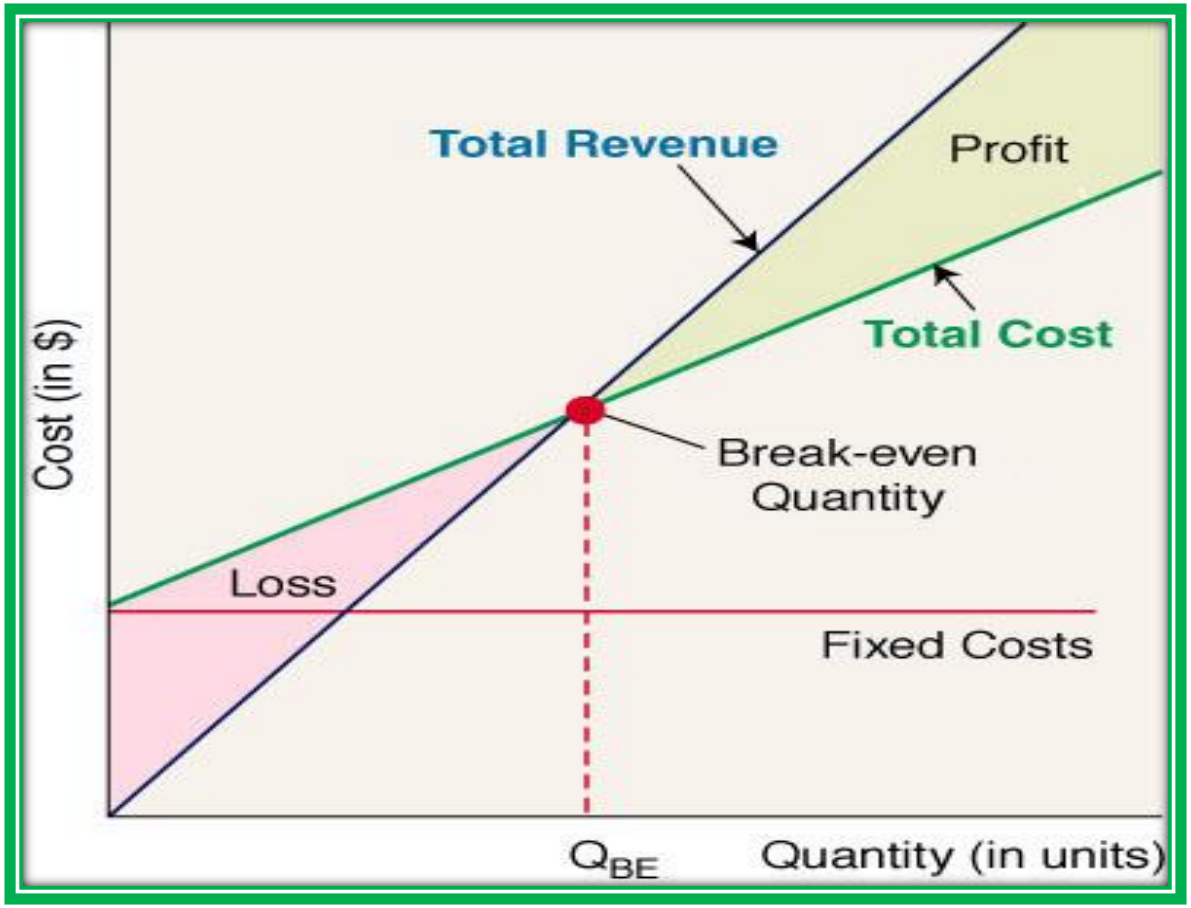
Break-Even Analysis

- **Break-even analysis is a technique widely used by production management and management accountants. It is based on categorizing production costs between those which are "variable" (costs that change when the production output changes) and those that are "fixed" (costs not directly related to the volume of production).**

Break-Even Analysis

- Total variable and fixed costs are compared with sales revenue in order to determine the level of sales volume, sales value or production at which the business makes neither a profit nor a loss (the "break-even point").

Break-Even Analysis



Break-Even Analysis

Break Even Point

$$\text{Break Even Point in Units} = \frac{\text{Fixed Costs}}{\text{Sales Price per Unit - Variable Cost per Unit}}$$

Break-Even Analysis

Since the price per unit minus the variable costs of product is the definition of the contribution margin per unit, you can simply rephrase the equation by dividing the fixed costs by the contribution margin

Break-Even Analysis

Break Even Point

$$\text{Break Even Point in Units} = \frac{\text{Fixed Costs}}{\text{Contribution Margin per Unit}}$$

Break-Even Analysis

This computes the total number of units that must be sold in order for the company to generate enough revenues to cover all of its expenses. Now we can take that concept and translate it into sales dollars.

The break-even formula in sales dollars is calculated by multiplying the price of each unit by the answer from our first equation.

Break-Even Analysis

Break Even Point

Break Even Point in Dollars = Sales Price per Unit x Break Even Point in Units

Break-Even Analysis

This will give us the total dollar amount in sales that will we need to achieve in order to have zero loss and zero profit. Now we can take this concept a step further and compute the total number of units that need to be sold in order to achieve a certain level profitability with out break-even calculator.

Break-Even Analysis

First we take the desired dollar amount of profit and divide it by the contribution margin per unit. The computation of the number of units we need to sell in order to produce the profit without taking in consideration the fixed costs. Now we must add back in the break-even point number of units. Here's what it looks like

Break-Even Analysis

Break Even Analysis

$$\text{\# of Units To Produce the Desired Profit} = \frac{\text{Desired Profit in Dollars}}{\text{Contribution Margin per Unit}} + \text{Break Even \# of Units}$$

BEP **Example**

Let's take a look at an example of each of these formulas. Barbara is the managerial accountant in charge of a large furniture factory's production lines and supply chains. She isn't sure the current year's couch models are going to turn a profit and what to measure the number of units they will have to produce and sell in order to cover their expenses and make at $500,000 in profit. Here are the production stats.

- **Total fixed costs: $500,000**
- **Variable costs per unit: $300**
- **Sale price per unit: $500**
- **Desired profits: $200,000**

BEP **Example**

First we need to calculate the break-even point per unit, so we will divide the $500,000 of fixed costs by the $200 contribution margin per unit ($500 – $300).

Break Even Point

$$\text{2500 Units} = \frac{\$500{,}000}{\$500 - \$300}$$

BEP **Example**

As you can see, the Barbara's factory will have to sell at least 2,500 units in order to cover it's fixed and variable costs. Anything it sells after the 2,500 mark will go straight to the CM (Contribution Margin) since the fixed costs are already covered.

BEP **Example**

Next, Barbara can translate the number of units into total sales dollars by multiplying the 2,500 units by the total sales price for each unit of $500.

Break Even Point		
$1,250,000	=	2,500 units x $500 per unit

BEP **Example**

- **Now Barbara can go back to the board and say that the company must sell at least 2,500 units or the equivalent of $1,250,000 in sales before any profits are realized. She can also take it a step further and use a break-even point calculator to compute the total number of units that must be produced in order to meet her $200,000 profitability goal by dividing the $200,000 desired profit by the contribution margin then adding the total number of break-even point units.**

BEP **Example**

Break Even Analysis

$$3{,}500 \text{ Units} = \frac{\$200{,}000}{\$500 - \$300} + 2{,}500 \text{ Units}$$

BEP Example & Analysis

As you can see there are many different ways to use this concept. Production managers and executives have to be keenly aware of their level of sales and how close they are to covering fixed and variable costs at all times. That's why they constantly try to change elements in the formulas reduce the number of units need to produce and increase profitability.

Advantages of BE Analysis

- Assists in establishing prices of products.
- Assists in analysing the impact that volume has on short-term profits.
- Assists in focusing on the impact that changes in costs(variable and fixed) have on profits.
- Assists in analysing how the mix of products affects profits

Limitations of BEA

- It assumes fixed cost, variable cost and sales volume behave in a linear manner. However, some overhead costs may be stepped in nature. The straight sales volume line and total cost line tent to curve beyond certain level of production.
- It is assumed that all production is sold. The breakeven chart does not take the changes in stock level into account.
- It can provides information for small and relatively simple companies that produce same product. It is not useful for the companies multiple products

Break-Even Analysis

- Total cost = fixed costs + variable costs (quantity):

$$TC = F + (VC)Q$$

- Revenue = selling price (quantity)

$$R = (SP)Q$$

- Break-even point is where total costs = revenue:

$$TC = R \quad or \quad F + (VC)Q = (SP)Q$$

$$or \quad Q = \frac{F}{SP - VC}$$

Break-Even Analysis Example

- A firm estimates that the fixed cost of producing a line of footwear is $52,000 with a $9 variable cost for each pair produced. They want to know:
  - If each pair sells for $25, how many pairs must they sell to break-even?
  - If they sell 4000 pairs at $25 each, how much money will they make?

Example Solved

- Break-even point:

$$Q = \frac{F}{SP - VC} = \frac{\$52{,}000}{\$25 - \$9} = 3250\ pairs$$

- Profit = total revenue – total costs

$$P = (SP)Q - (F + (VC)Q)$$
$$= (\$25)4000 - (\$52{,}000 + (\$9)4000)$$
$$= \$12{,}000$$

Preliminary Design & Testing

- General performance characteristics are translated into technical specifications
- Prototypes/Samples are built & tested (maybe offered for sale on a small scale)
- Bugs are worked out & designs are refined

Final Design

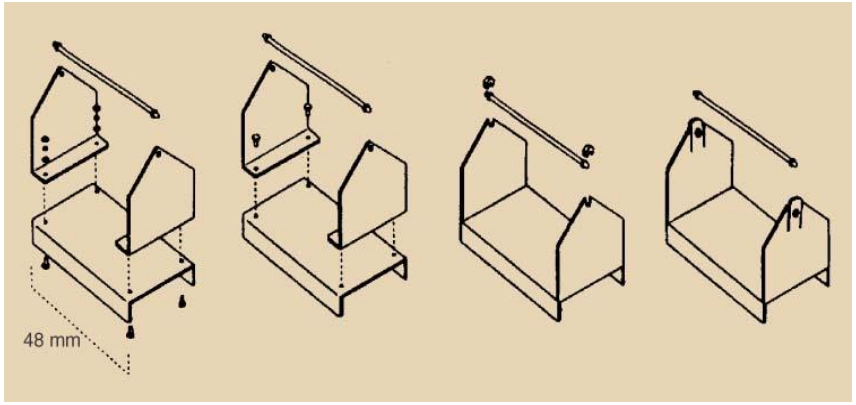
- Specifications are set & then used to:
  - Develop processing and service delivery instructions
  - Guide equipment selection
  - Outline jobs to be performed
  - Negotiate contracts with suppliers and distributors

Other Design factors

- Design for Manufacture
- Product Life Cycle
- Concurrent Engineering

Design for Manufacture (DMF)

- **Minimize parts**
- **Design parts for multiply applications**
- **Use modular design**
- **Avoid tools**
- **Simplify operations**



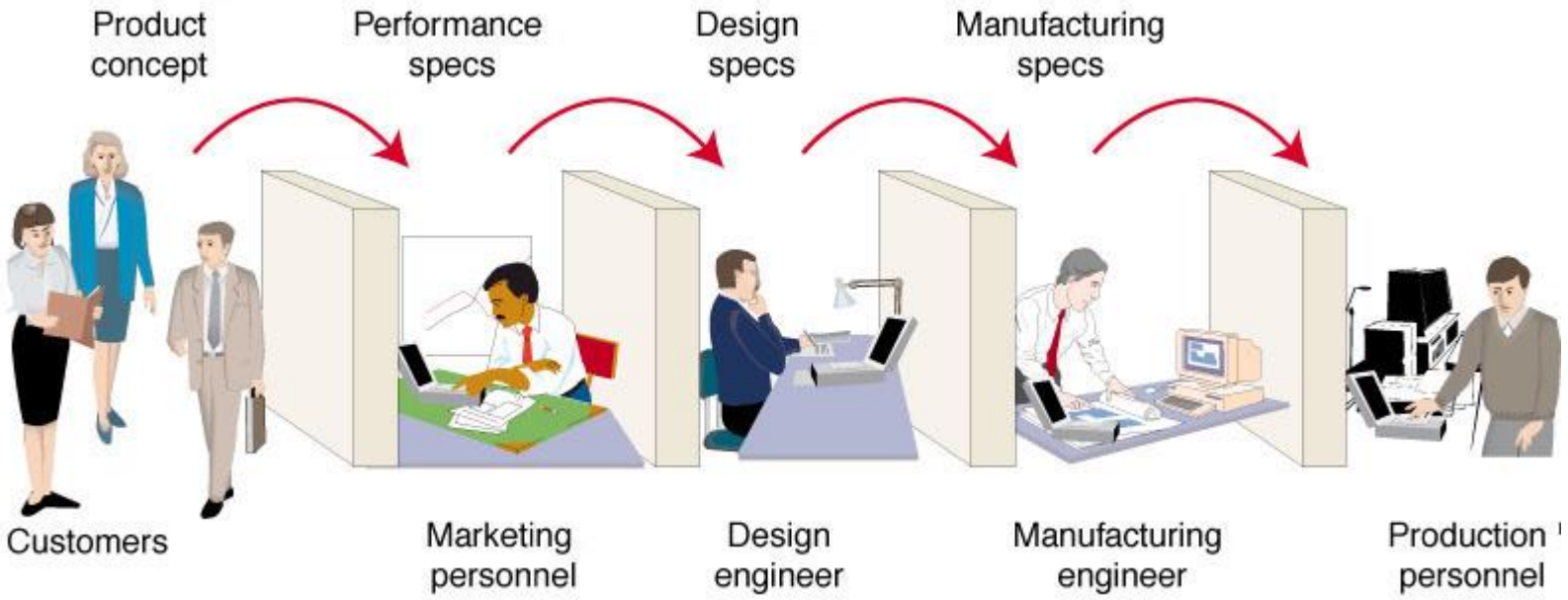
DFM Benefits

- Lower costs:
  - Lower inventories (fewer, standardized components)
  - Less labor required (simpler flows, easier tasks)
- Higher quality:
  - Simple, easy-to-make products means fewer opportunities to make mistakes

Concurrent /Parallel Engineering

- A design approach that uses multifunctional teams to simultaneously design the product & process
- Replaces a traditional 'over-the-wall' approach where one group does their part & then hands off the design to the next group

Sequential Design



Concurrent Engineering

Concurrent Engineering Benefits

- Representatives from the different groups can better consider trade-offs in cost & design choices as each decision is being made
- Development time is reduced due to less rework (traditionally, groups would argue with earlier decisions & try to get them changed)
- Emphasis is on problem-solving (not placing blame on the 'other group' for mistakes)

Process Selection

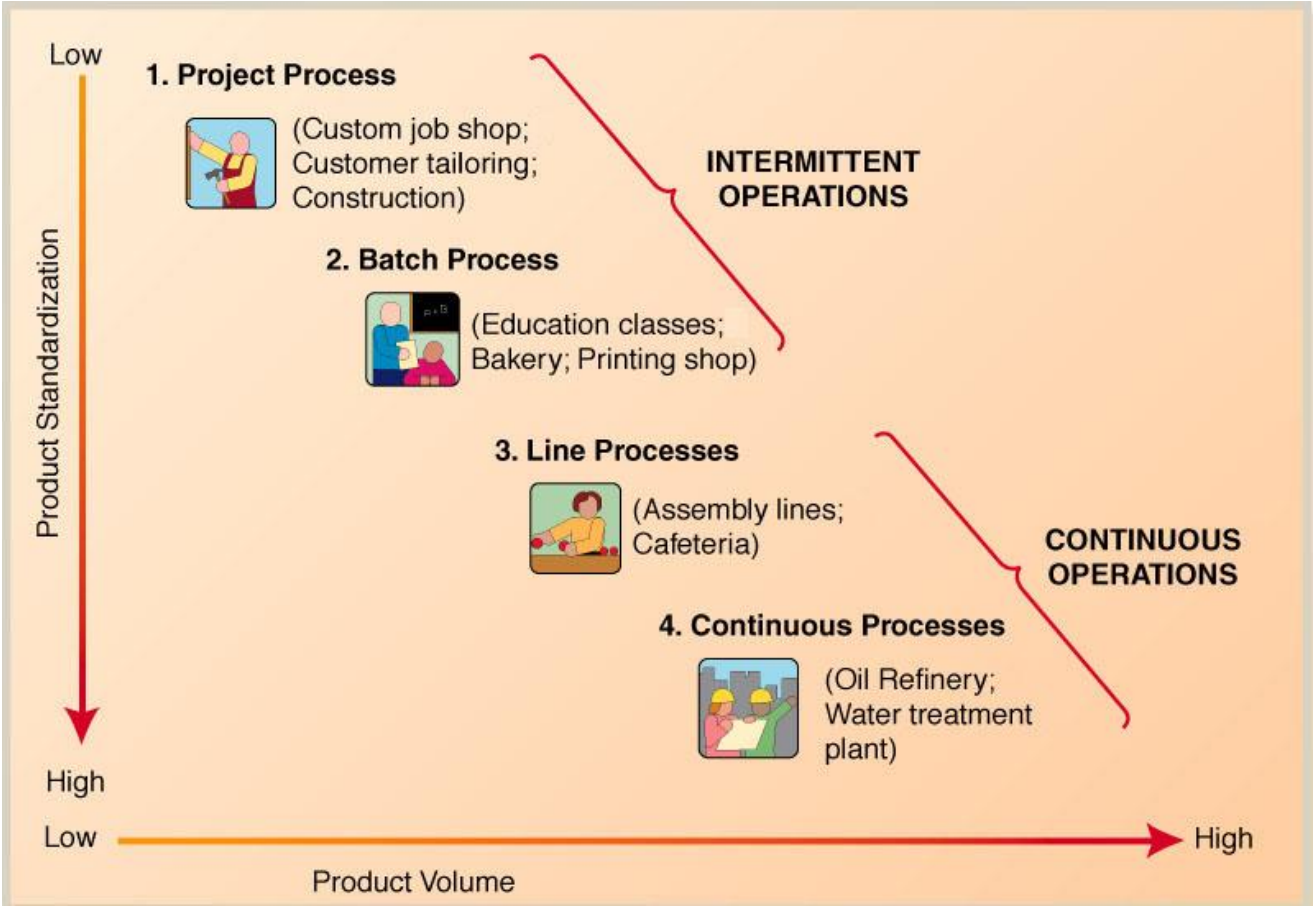
- **Process selection is based on five considerations**
  - Type of process; range from intermittent to continuous
  - Degree of vertical integration
  - Flexibility of resources
  - Mix between capital & human resources
  - Degree of customer contact

- **Process types can be:**
  - Project Process
  - Batch Process
  - Line Process
  - Continuous Process

Types of Processes

- Intermittent operations:
  - Capable of producing a large variety of product designs in relatively low volumes
- Continuous operations:
  - Capable of producing one (or a few) standardized designs in very high volumes

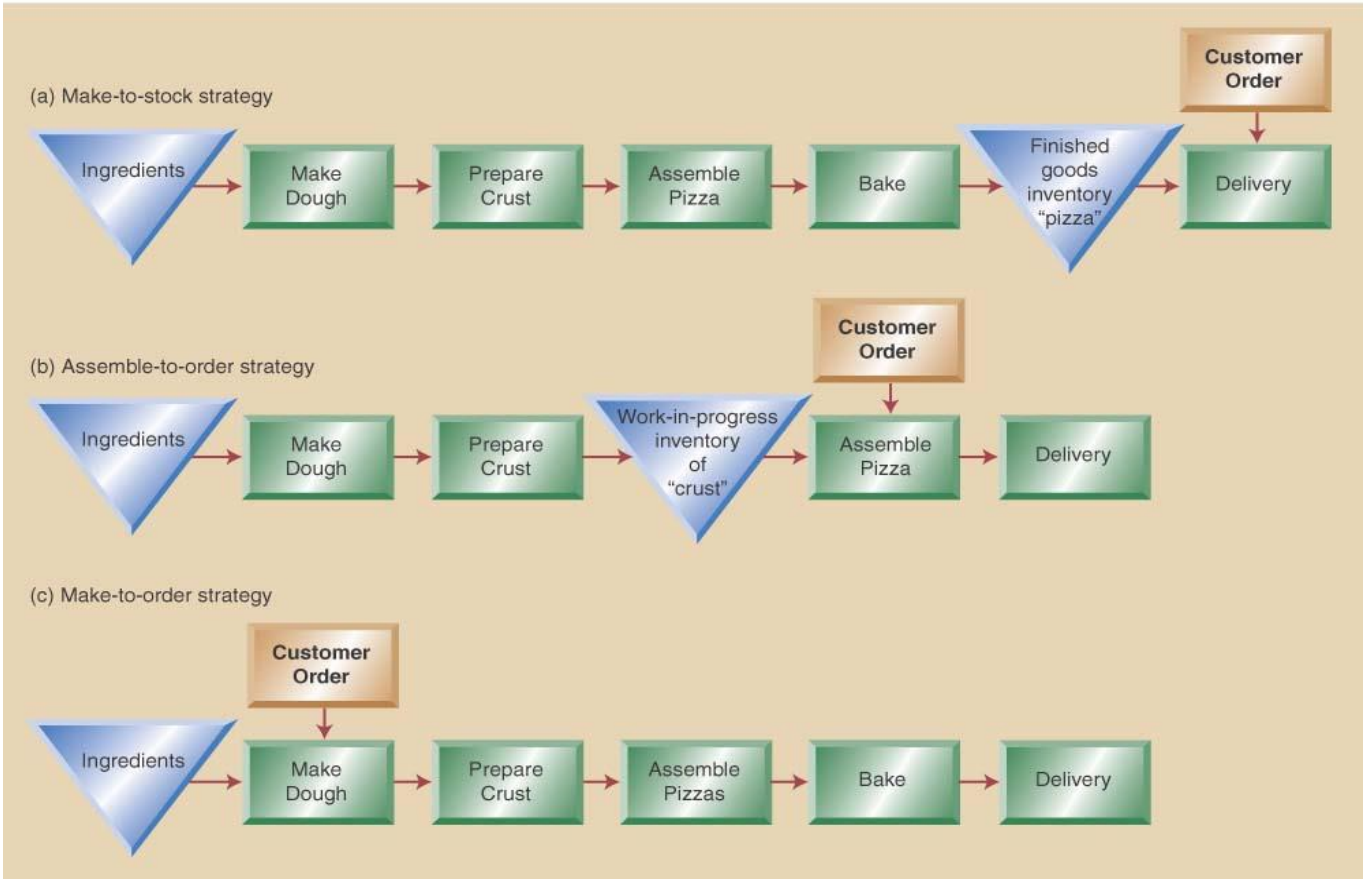
Continuum of Process Types



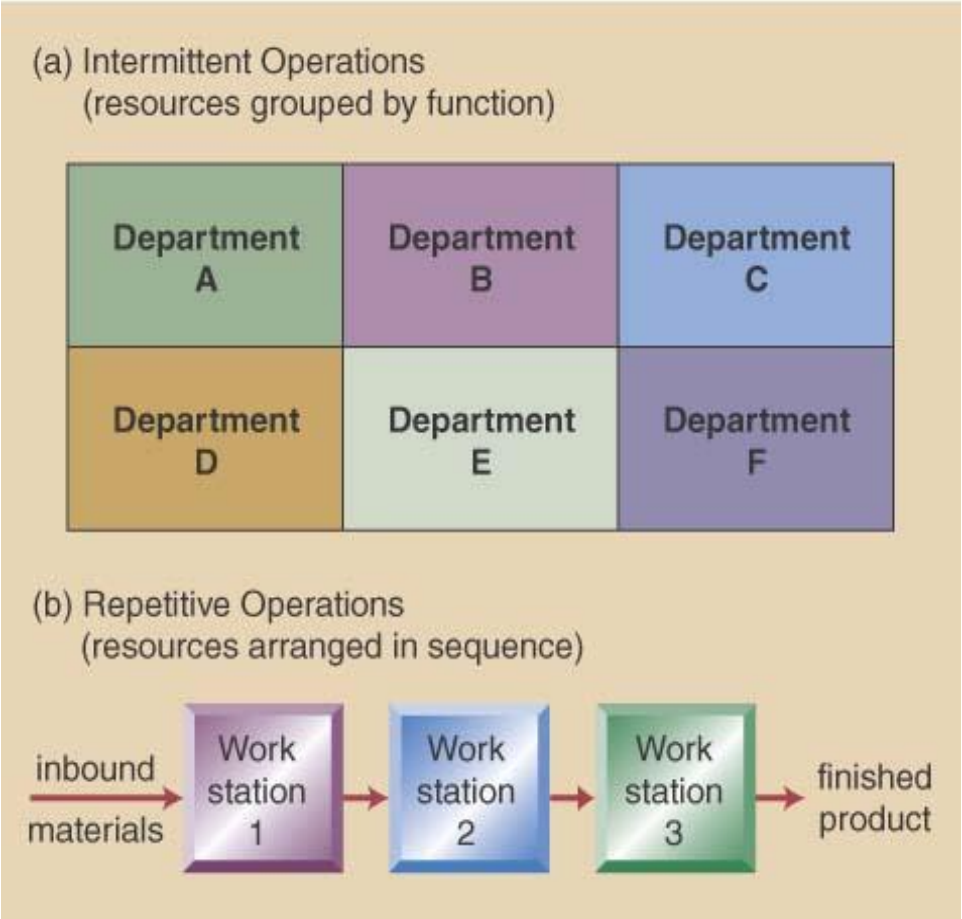
Differences between Intermittent and Continuous Operations

Decision	Intermittent	Continuous
Product Variety	Large	Small
Degree of Standardization	Low	High
Path through Facility	Varied pattern	Line Flow
Critical Resource	Labor	Equipment
Importance of Work Skills	High	Low
Type of Equipment	General Purpose	Specialized
Degree of Automation	Low	High
Throughput Time	Longer	Shorter
Work-in-Process Inventory	More	Less

Product Strategies and Process Choice



Process Selection Facility Layout



Process Technologies

- Automation
- Automated Material Handling:
  - Automated guided vehicles (AGV)
  - Automated storage & retrieval systems (AS/RS)
- Computer-Aided Design (CAD) software
- Robotics & Numerically-Controlled (NC) equipment
- Flexible Manufacturing Systems (FMS)
- Computer-Integrated Manufacturing (CIM)

Service Design

Approaches to Service Design:

- Substitute Technology for People
- Get the Customer Involved
- Provide High Level of Customer Attention