



# Chapter 1- Introduction

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# Remember the Tucker!

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The Tucker automobile of the late 1940s stands out as one of the most celebrated failures in the annals of American business. With its aerodynamic sheet metal, rear-mounted engine, and a Cyclops headlight that turned in tandem with the steering wheel, the prototype “Tucker 48” shown to the public in 1947 generated quite a bit of excitement. But the Tucker 48 never made it into mass production. Only 51 models were produced, all largely fabricated by hand at tremendous expense.



# Remember the Tucker!

<http://www.hfmgv.org/exhibits/showroom/1948/tucker.html>

Existing equipment and processes were not capable of executing the relatively sophisticated design of the Tucker 48 on a large scale. Thus the Tucker 48 provides an object lesson in the need to design for manufacturing (DFM). DFM is part of the *concurrent engineering* movement that blossomed in the 1980s. DFM stresses the need to incorporate the perspective of manufacturing engineering into the earliest stages of product design.

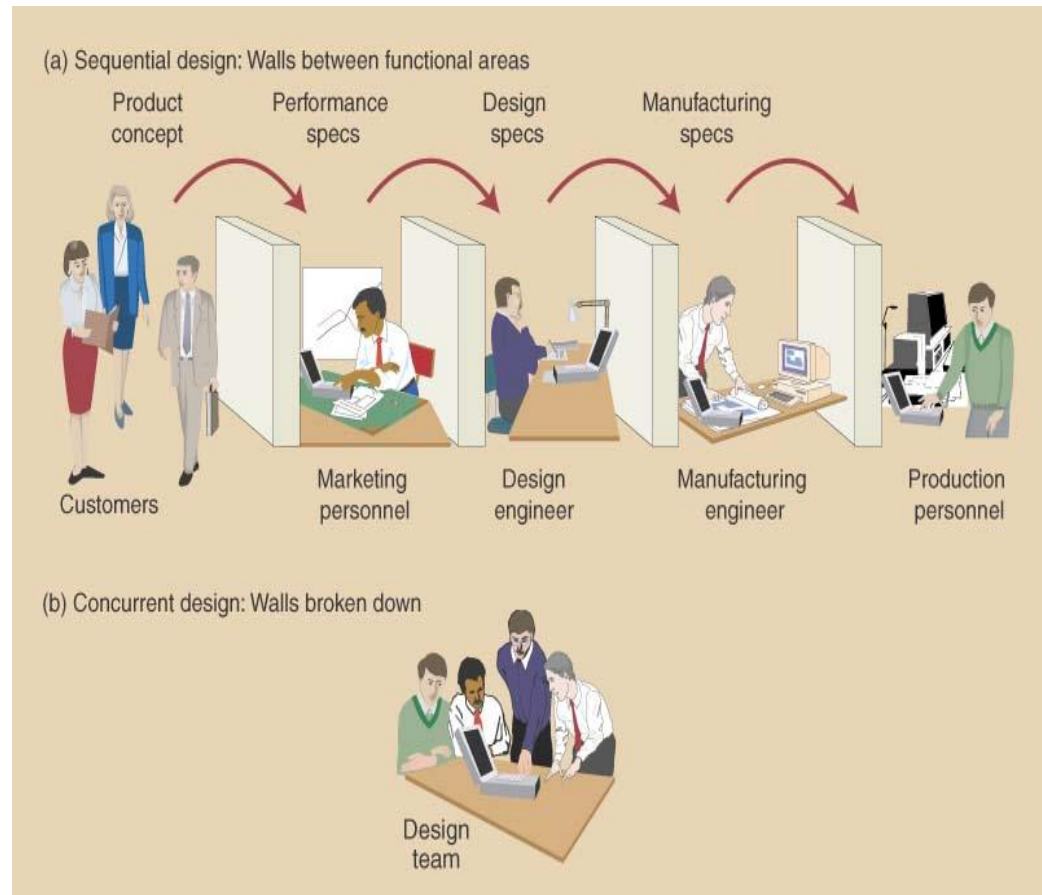
# Concurrent Engineering

## Old “over-the-wall” sequential products design process

- Each function did its work and passed it to the next function

## Improved Concurrent Engineering process

- All functions form a design team that develops specifications, involves customers early, solves potential problems, reduces costs, & shortens time to market





# Product Design & Process Selection - defined

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Product design – the process of defining all of the companies product characteristics

- Product design must support product manufacturability (the ease with which a product can be made)
- Product design defines a product's characteristics of:
  - appearance,
  - materials,
  - dimensions,
  - tolerances, and
  - performance standards.

Process Selection – the development of the process necessary to produce the designed product.



# The Product Design Process

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**Idea development:** all products begin with an idea whether from:

- customers,
- competitors or
- suppliers

**Reverse engineering:** buying a competitor's product



# Product Design Process

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- Idea developments selection affects
  - Product quality
  - Product cost
  - Customer satisfaction
  - Overall **manufacturability** – the ease with which the product can be made



# The Product Design Process

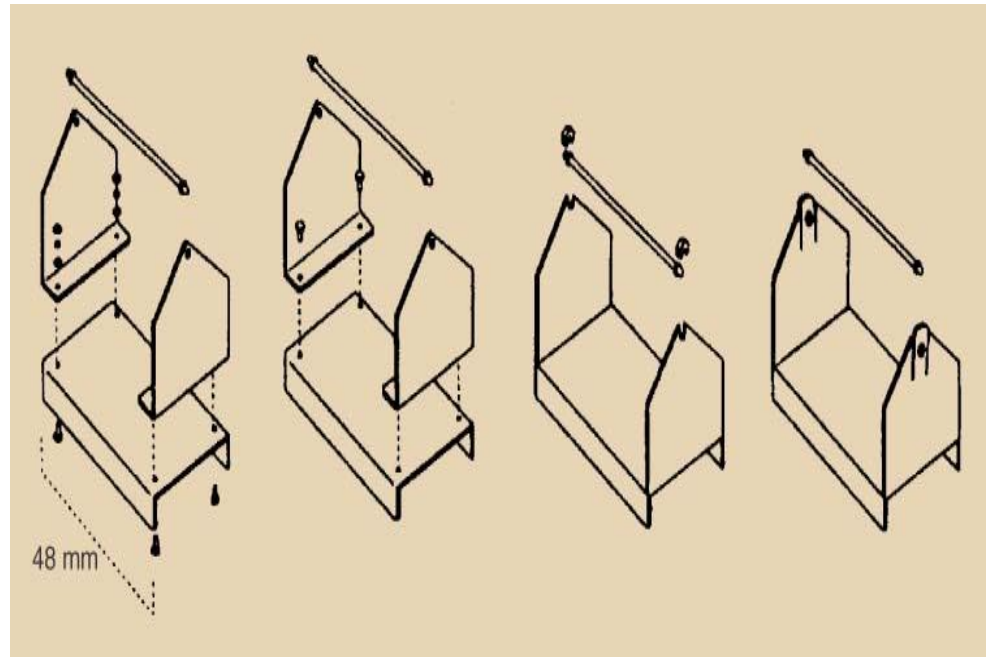
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- Step 1 - Idea Development - Someone thinks of a need and a product/service design to satisfy it: customers, marketing, engineering, competitors, benchmarking, reverse engineering
- Step 2 - Product Screening - Every business needs a formal/structured evaluation process: fit with facility and labor skills, size of market, contribution margin, break-even analysis, return on sales
- Step 3 – Preliminary Design and Testing - Technical specifications are developed, prototypes built, testing starts
- Step 4 – Final Design - Final design based on test results, facility, equipment, material, & labor skills defined, suppliers identified



# Design for Manufacturing (DFM)

- **Guidelines to produce a product easily and profitably**
  - **Simplification - Minimize parts**
  - **Standardization**
    - **Design parts for multiply applications**
  - **Use modular design**
  - **Simplify operations**





# Product Screening Tool – Break-Even Analysis con't

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- Break-even analysis considers two functions of Q
  - Total cost – sum of fixed and variable cost

$$\text{Total cost} = F + (VC) * Q$$

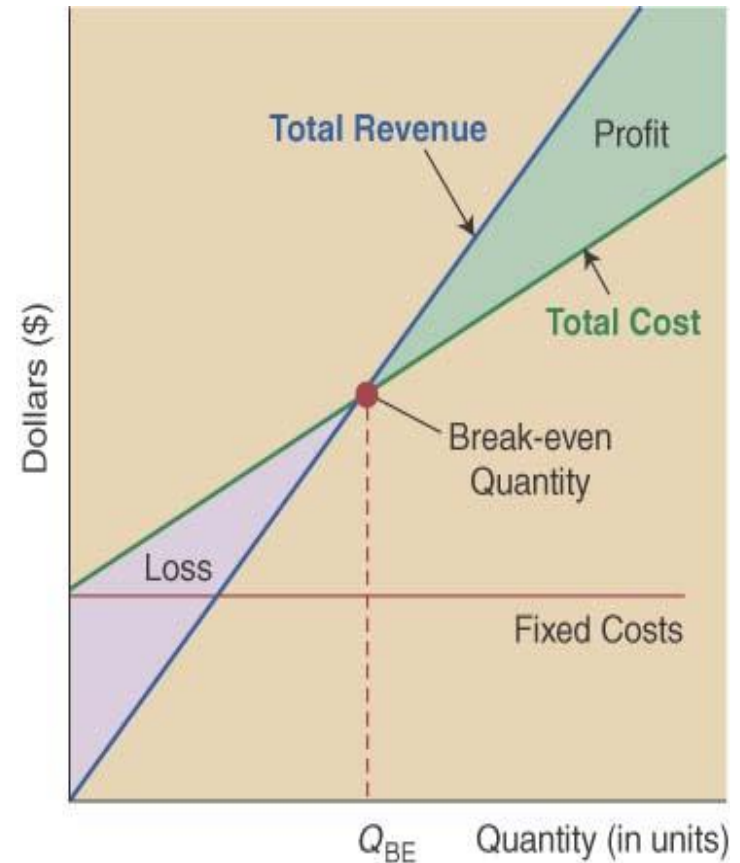
- Revenue – amount of money brought in from sales

$$\text{Revenue} = (SP) * Q$$

Q = number of units sold

# Break-Even Analysis: Graphical Approach

- Compute quantity of goods that must be sold to break-even
- Compute total revenue at an assumed selling price
- Compute fixed cost and variable cost for several quantities
- Plot the total revenue line and the total cost line
- Intersection is break-even
- Sensitivity analysis can be done to examine changes in all of the assumptions made





# Product Screening Tool – Break-Even Analysis

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- Computes the quantity of goods company needs to sell to cover its costs

$$Q_{BE} = F / (SP - VC)$$

- $Q_{BE}$  – Break even quantity
- $F$  – Fixed costs
- $SP$  – selling price/unit
- $VC$  – Variable cost



# Break-Even Example:

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A company is planning to establish a chain of movie theaters. It estimates that each new theater will cost approximately \$1 Million. The theaters will hold 500 people and will have 4 showings each day with average ticket prices at \$8. They estimate that concession sales will average \$2 per patron. The variable costs in labor and material are estimated to be \$6 per patron. They will be open 300 days each year. What must average occupancy be to break-even?



# Break-Even Example Calculations

## ■ Break-Even Point

Total revenues = Total costs @ break-even point Q

Selling price\*Q = Fixed cost + variable cost\*Q

$$(\$8 + \$2)Q = \$1,000,000 + \$6*Q$$

$$Q = \mathbf{250,000 \text{ patrons (42\% occupancy)}}$$

## ■ What is the gross profit if they sell 300,000 tickets

Profit = Total Revenue – Total Costs

$$P = \$10*300,000 - (1,000,000 + \$6*300,000)$$

$$P = \mathbf{\$200,000}$$

## ■ If concessions only average \$.50/patron, what is break-even Q now? (sensitivity analysis)

$$(\$8.50)Q = 1,000,000 - \$6*Q$$

$$Q = \mathbf{400,000 \text{ patrons (67\% occupancy)}}$$



# Is Breakeven Analysis **really** in use?

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- [http://www.businessweek.com/magazine/content/06\\_44/b4007026.htm?chan=search](http://www.businessweek.com/magazine/content/06_44/b4007026.htm?chan=search)



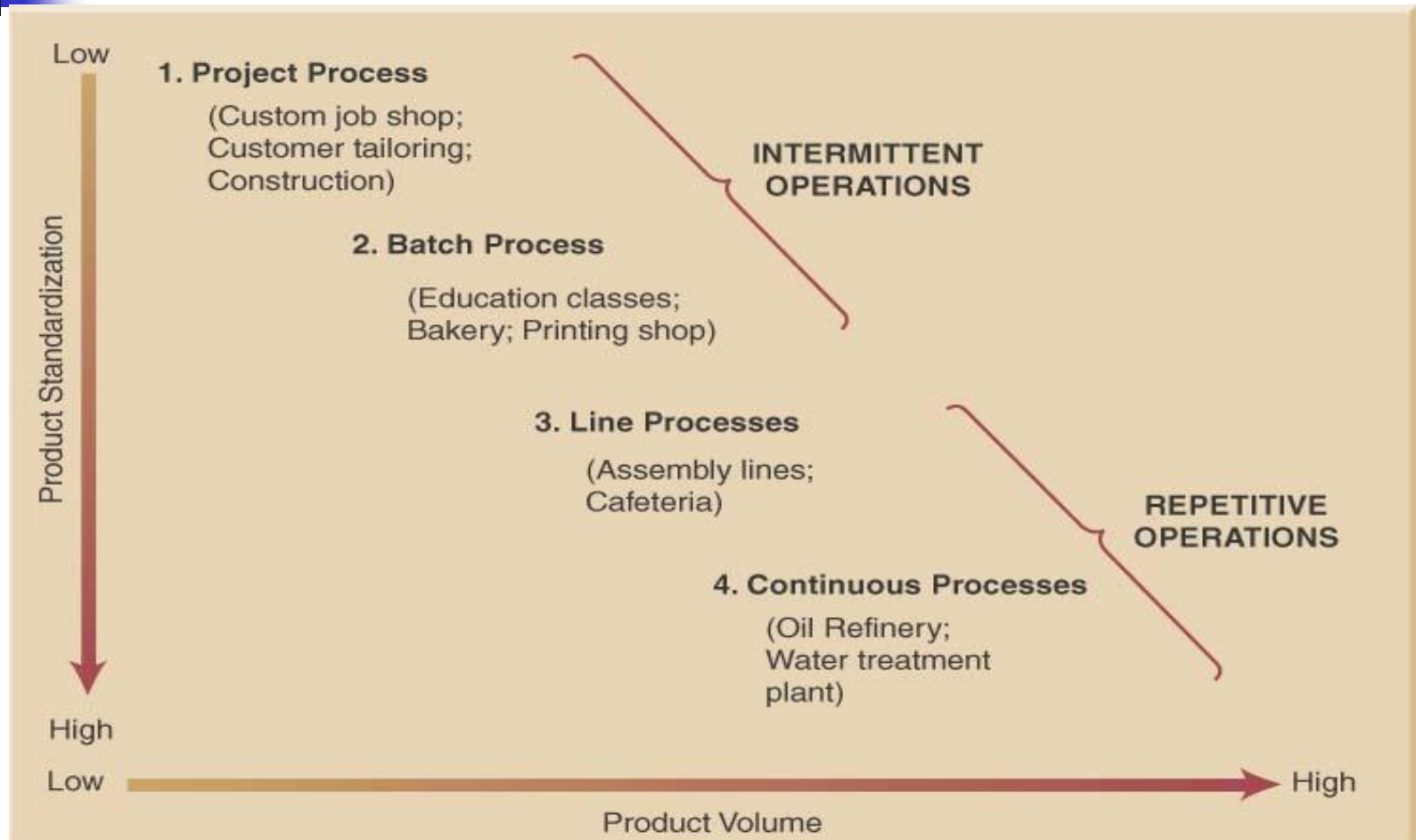
# Process Selection

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- Product design considerations must include the process
- Intermittent processes:
  - Processes used to produce a variety of products with different processing requirements in lower volumes. (such as healthcare facility)
- Repetitive processes:
  - Processes used to produce one or a few standardized products in high volume. (such as a cafeteria, or car wash)



# Product-Process Grid





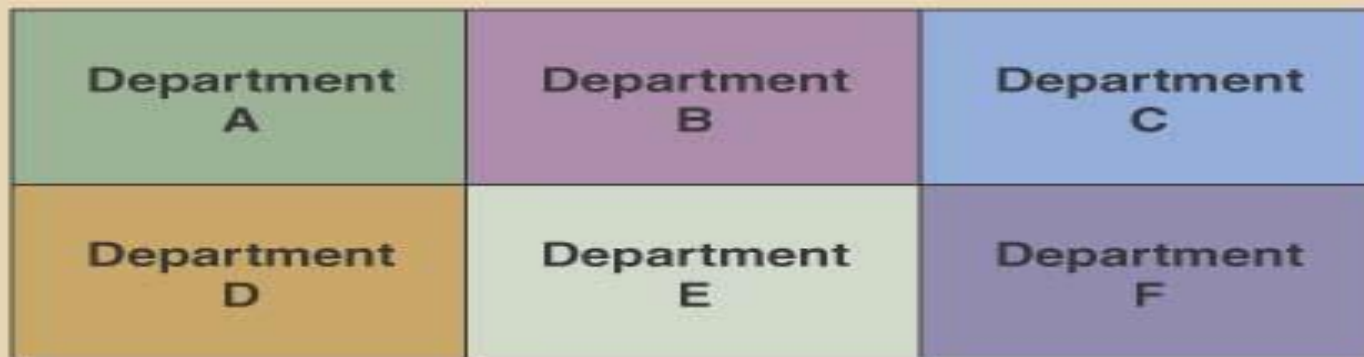
# Process Types

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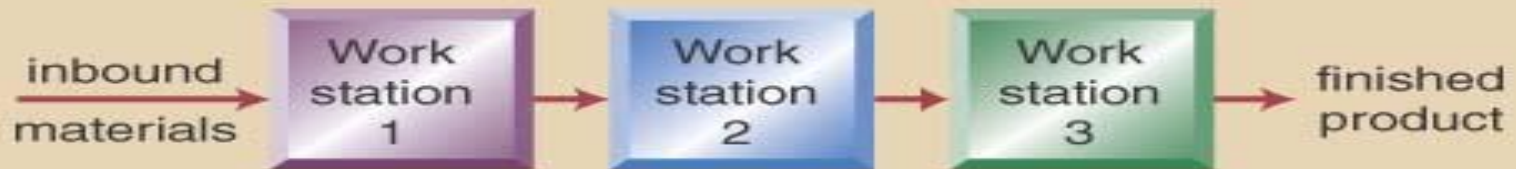
- Process types can be:
  - Project process – make a one-at-a-time product exactly to customer specifications
  - Batch process – small quantities of product in groups or batches based on customer orders or specifications
  - Line process – large quantities of a standard product
  - Continuous process – very high volumes of a fully standard product
- Process types exist on a continuum

# Intermittent VS. Repetitive Facility Layouts

(a) Intermittent Operations  
(resources grouped by function)



(b) Repetitive Operations  
(resources arranged in sequence)





# Process Selection Considerations

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- **Process selection is based on five principal considerations**
  1. Product-Process Grid
  2. Degree of vertical integration
  3. Flexibility of resources
  4. Mix between capital & human resources
  5. Degree of customer contact



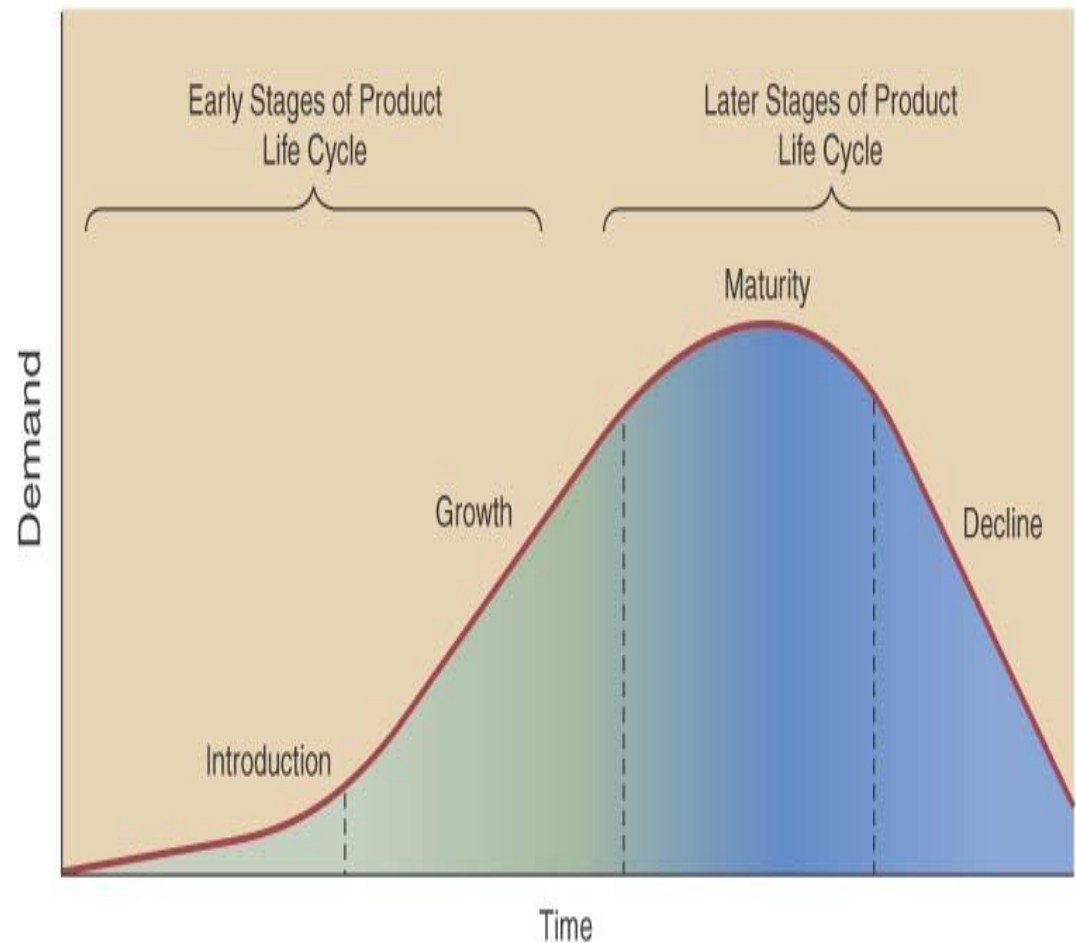
# Process Decisions-Vertical Integration & Make or Buy

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- **Vertical integration refers to the degree a firm chooses to do processes itself- raw material to sales**
  - Backward Integration means moving closer to primary operations
  - Forward Integration means moving closer to customers
- **A firm's *Make-or-Buy* choices should be based on the following considerations:**
  - Strategic impact
  - Available capacity
  - Expertise
  - Quality considerations
  - Speed
  - $\text{Cost (fixed cost + variable cost)}_{\text{make}} = \text{Cost (fixed cost + Variable cost)}_{\text{buy}}$  **[see Ch 4]**
- **Business are trending toward less backward integration, more outsourcing**

# Product Life Cycle also affects decisions

- **Product life cycle – series of changing product demand**
- **Consider product life cycle stages**
  - **Introduction**
  - **Growth**
  - **Maturity**
  - **Decline**
- **Facility & process investment depends on life cycle**



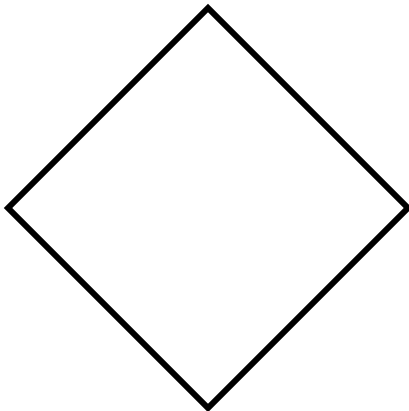
# Flowchart Symbols for Process Design

## Purpose and Examples



Tasks or operations

Examples: Giving an admission ticket to a customer, installing a engine in a car, etc.

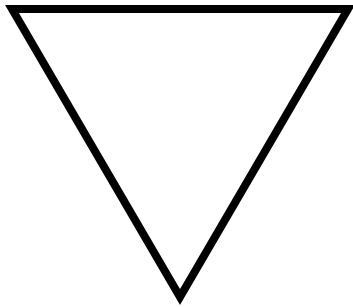


Decision Points

Examples: How much change should be given to a customer, which wrench should be used, etc.

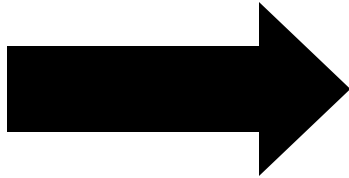
# Flowchart Symbols for Process Design

## Purpose and Examples



Storage areas or  
queues

Examples: Sheds,  
lines of people waiting  
for a service, etc.



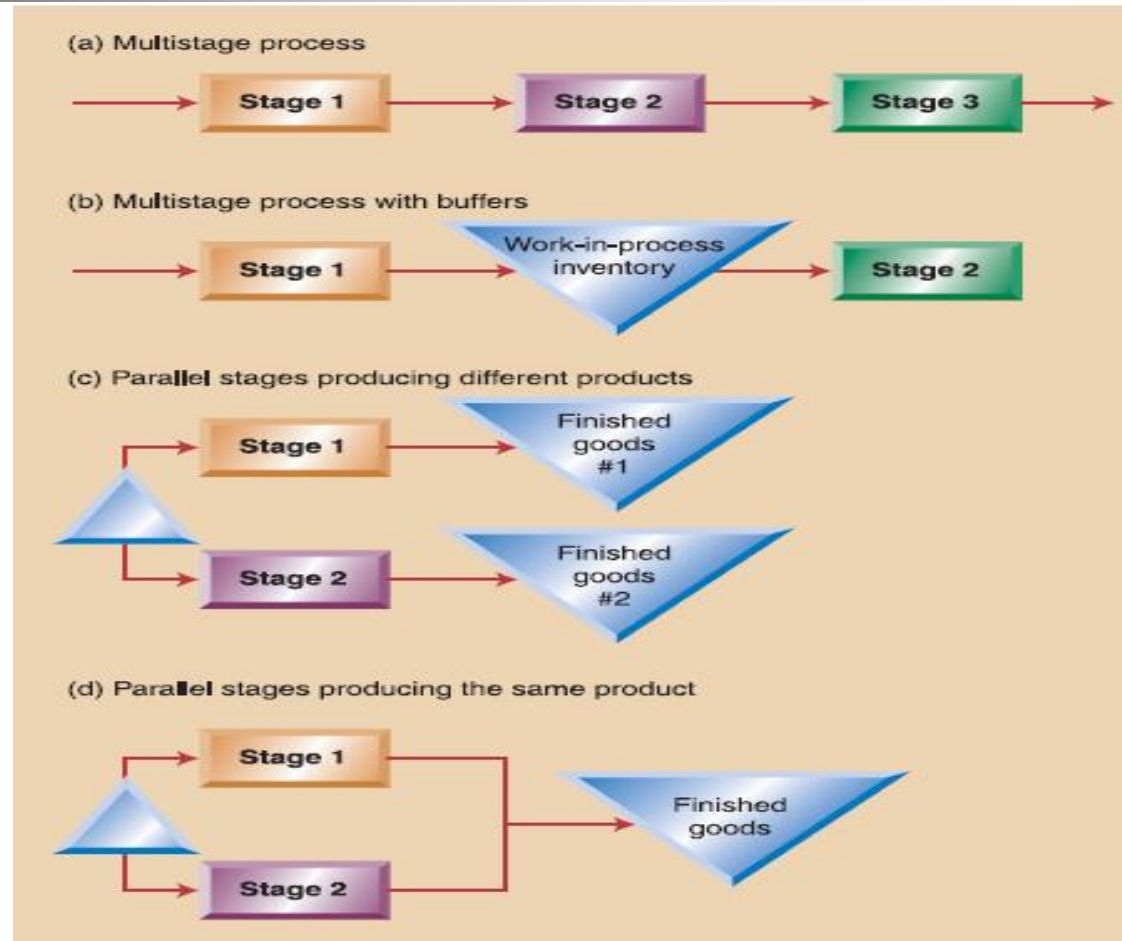
Flows of  
materials or  
customers

Examples: Customers  
moving to a seat,  
mechanic getting a  
tool, etc.



# Process Improvement

Often stages in the production process can be performed in parallel, as shown here in (c) and (d). The two stages can produce different products (c) or the same product (d).





# Process Performance Metrics

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## **Process performance metrics – defined:**

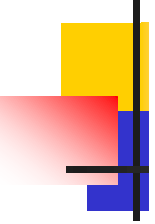
Measurement of different process characteristics that tell us how a process is performing

- Determining if a process is functioning properly is required
- Determination requires measuring performance



# Process Performance Metrics

Measure	Definition
1. Throughput time	Average amount of time product takes to move through the system.
2. Process velocity = $\frac{\text{Throughput time}}{\text{Value-added time}}$	A measure of wasted time in the system.
3. Productivity = $\frac{\text{Output}}{\text{Input}}$	A measure of how well a company uses its resources.
4. Utilization = $\frac{\text{Time a resource used}}{\text{Time a resource available}}$	The proportion of time a resource is actually used.
5. Efficiency = $\frac{\text{Actual output}}{\text{Standard output}}$	Measures performance relative to a standard.



**Metrics Example:** At Zelle's Dry Cleaning, it takes an average of 3 ½ hours to dry clean & press a shirt, with value-added time estimated at 110 min. Workers are paid for a 7-hour workday but work 5 ½ hr/day, accounting for breaks and lunch. Zelle's completes 25 shirts per day, while the industry standard is 28 for a comparable facility.

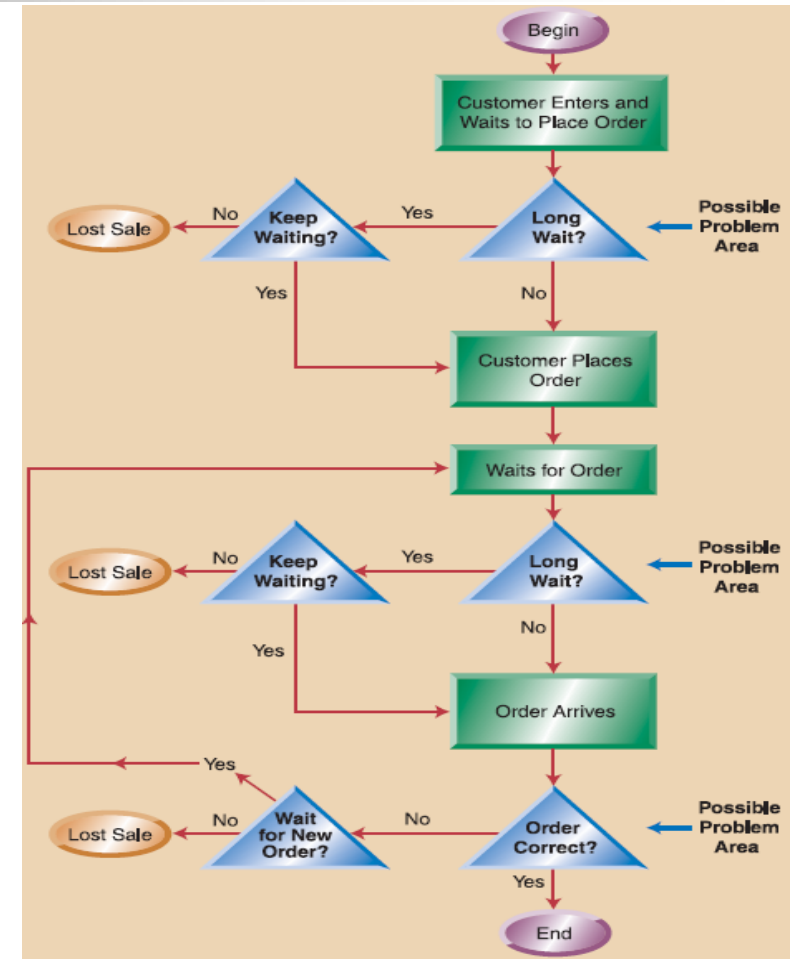
$$\begin{aligned}\text{Process Velocity} &= (\text{Throughput Time})/(\text{Value-added time}) \\ &= (210 \text{ minutes/shirt})/(110 \text{ minutes/shirt}) = \mathbf{1.90}\end{aligned}$$

$$\begin{aligned}\text{Labor Utilization} &= (\text{Time in Use})/(\text{Time Available}) \\ &= (5 \frac{1}{2} \text{ hr})/(7 \text{ hr}) = .786 \text{ or } \mathbf{78.6\%}\end{aligned}$$

$$\begin{aligned}\text{Efficiency} &= (\text{Actual Output})/(\text{Standard Output}) \\ &= (25 \text{ shirts/day})/(28 \text{ shirts/day}) = .89 \text{ or } \mathbf{89\%}\end{aligned}$$

# Throughput Time

A basic process performance metric is **throughput time**. A lower throughput time means that more products can move through the system. One goal of process improvement is to reduce *throughput time*.





# Linking Product Design & Process Selection

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- Product design and process selection are directly linked
- Type of product selected defines type of operation required
- Type of operation available defines broader organizational aspects such as
  - Equipment required
  - Facility arrangement
  - Organizational structure



# Linking Product Design & Process Selection con't

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## Impact of Product Life Cycle:

Intermittent and repetitive operations typically focus on producing products in different stages of the product life cycle. Intermittent is best for early in product life; repetitive is better for later when demand is more predictable.



# Linking Product Design & Process Selection, con't

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- Impact of Competitive Priorities:  
Intermittent operations are typically less competitive on cost than repetitive operations. (Think “off the rack” vs. custom tailored clothing.)





# Linking Design & Process Selection: Summary

- **Organizational Decisions appropriate for different types of operations**

Decision	Intermittent Operations	Repetitive Operations
Product design	Early stage of product life cycle	Later stage of product life cycle
Competitive priorities	Delivery, flexibility, and quality	Cost and quality
Facility layout	Resources grouped by function	Resources arranged in a line
Product strategy	Make-to-order/assemble-to-order	Make-to-stock
Vertical integration	Low	High

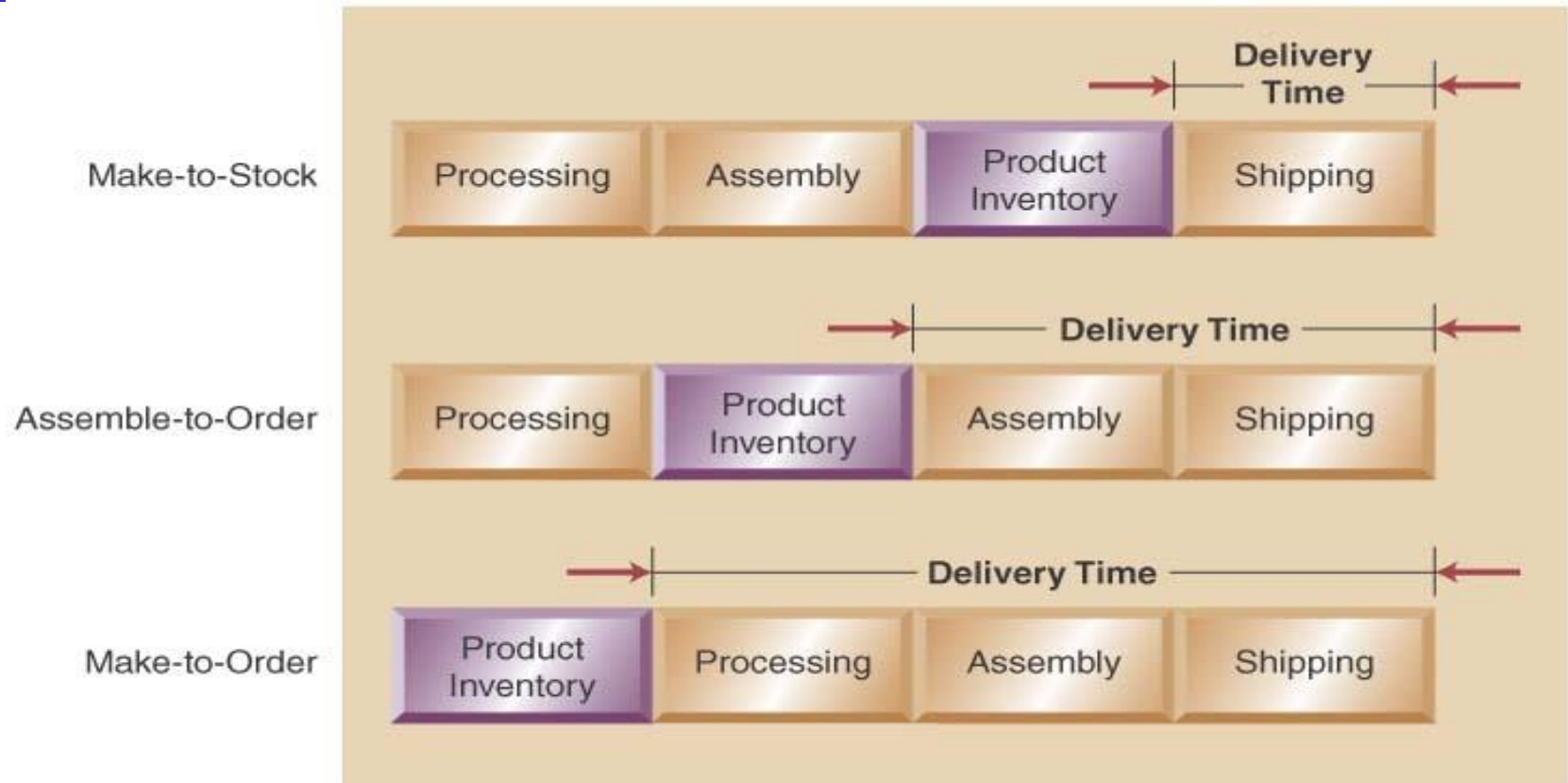


# Product and Service **Strategy**

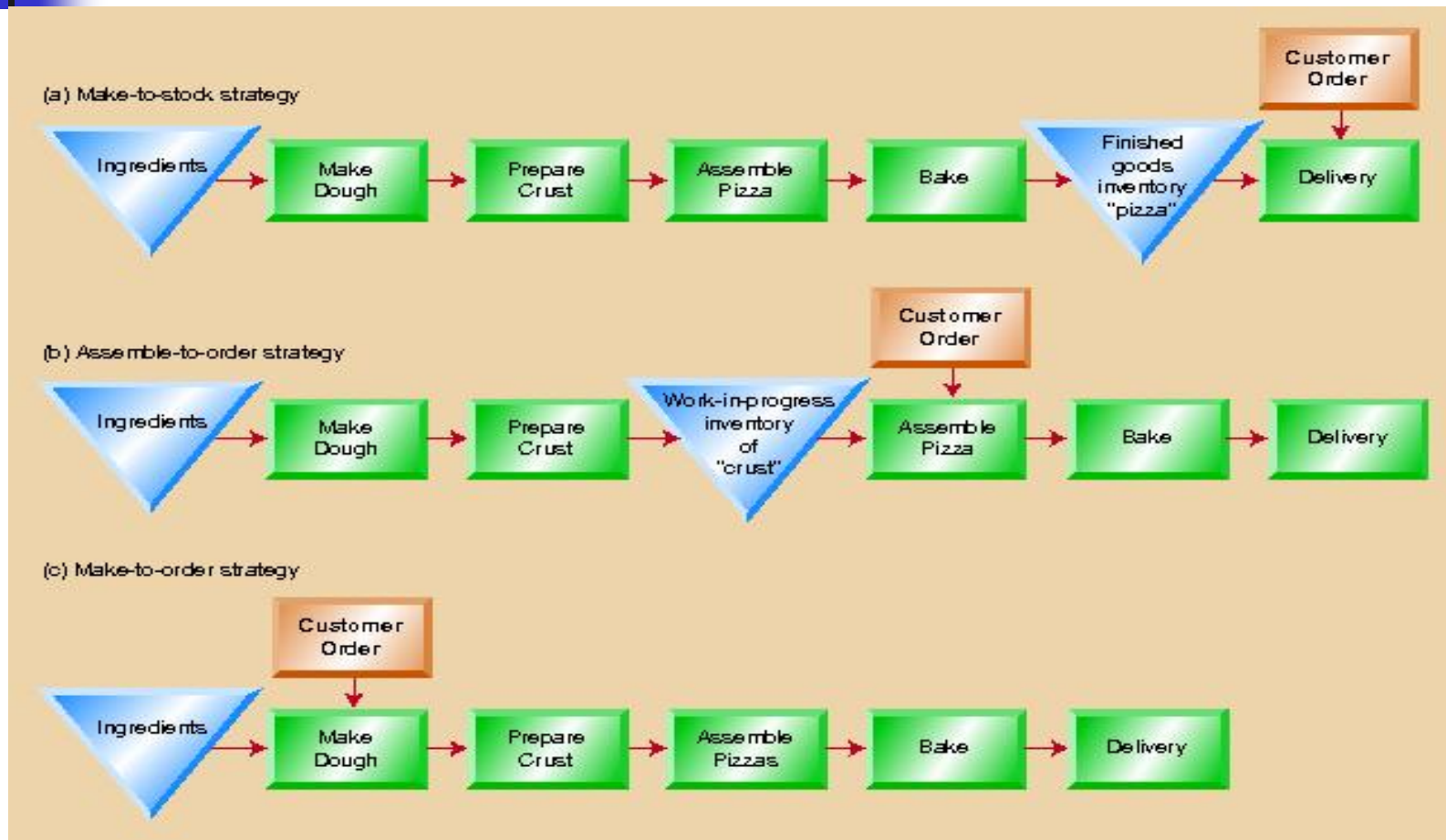
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- Type of operation is directly related to product and service strategy
- Three basic strategies include
  - Make-to-stock; in anticipation of demand
  - Assemble-to-order; built from standard components on order
  - Make-to-order; produce to customer specification at time of order

# Product and Service Strategy Options



# Flowchart for Different Product Strategies at Antonio's Pizzeria





# Technology Decisions

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## Information Technology

- Simplify first then apply appropriate technology
  - ERP, GPS, RFID
  - Automation
  - Automated Material Handling: Automated guided vehicles (AGV), Automated storage & retrieval systems (AS/RS)
  - Flexible Manufacturing Systems (FMS)
  - Robotics & Numerically-Controlled (NC) equipment



# E-manufacturing

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- Web-based environment creates numerous business opportunities to include;
  - Product design collaboration
  - Process design collaboration
- Computer-aided design – uses computer graphics to design new products
- Computer-integrated manufacturing – integration of product design, process planning, and manufacturing using an integrated computer system



# Design of Services

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- Service design is unique in that the service and entire service concept are being designed
  - must define both the service and concept
    - Physical elements, aesthetic & psychological benefits  
e.g. promptness, friendliness, ambiance
  - Product and service design must match the needs and preferences of the targeted customer group



# Designing Services vs Products?

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- Services are different from manufacturing as they;
  - Produce intangible products
  - Involve a high degree of customer contact
- Type of service is classified according to degree of customer contact



# Service Design Matrix

## ■ Service Characteristics

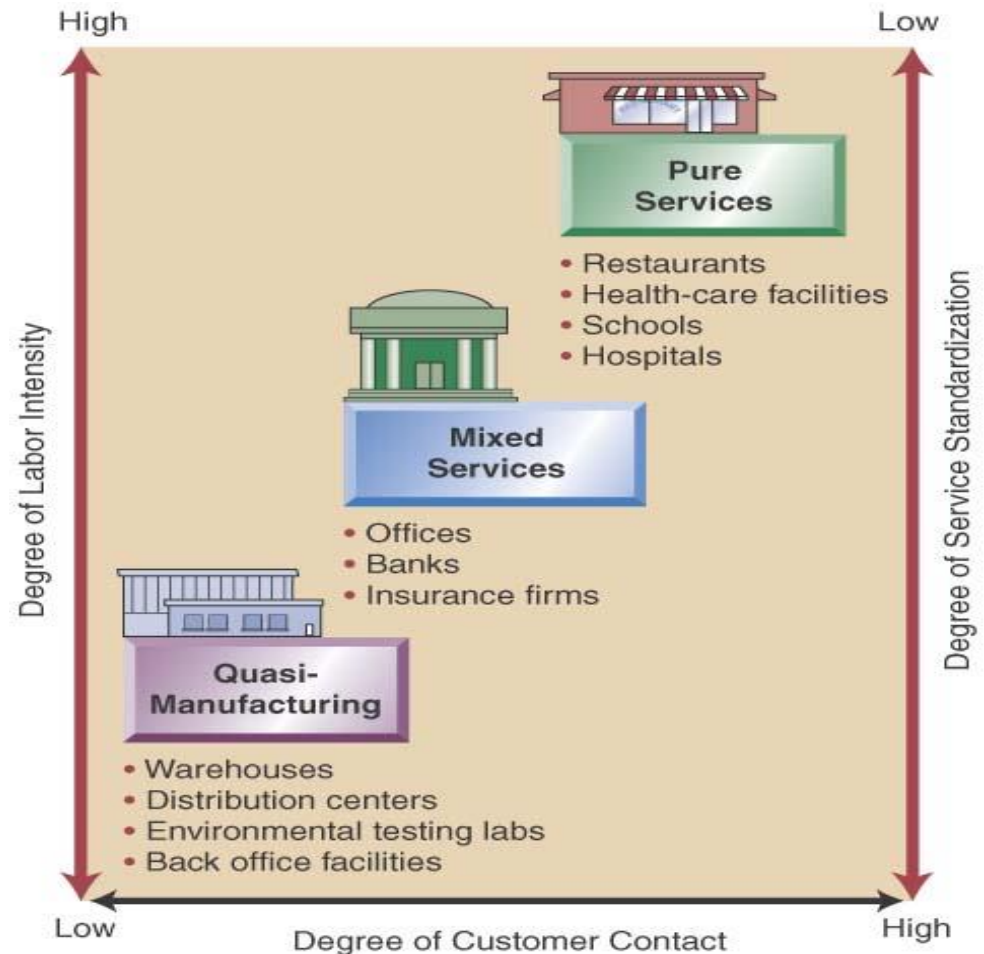
- Pure services
- Quasi-Manufacturing
- Mixed services

## ■ Service Package

- The physical goods
- The sensual benefits
- The psychological benefits

## ■ Differing designs

- Substitute technology for people
- Get customer involved
- High customer attention





# How Services Can Learn from Manufacturing

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[http://www.businessweek.com/magazine/content/05\\_34/b3948443.htm?chan=search](http://www.businessweek.com/magazine/content/05_34/b3948443.htm?chan=search)



# Manufacturing Crisis?

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- [http://www.businessweek.com/magazine/content/09\\_38/b4147046115750.htm](http://www.businessweek.com/magazine/content/09_38/b4147046115750.htm)



# Remanufacturing

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Uses components of old products in the production of new ones and has:

- Environmental benefits
- Cost benefits

Good for:

- Computers, televisions, automobiles



# Product Design and Process Selection Across the Organization

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- Strategic and financial of product design and process selection mandates operations work closely across the organization
  - Marketing is impacted by product that is produced
  - Finance is integral to the product design and process selection issues due to frequent large financial outlays



# Product Design and Process Selection Across the Organization – con't

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- Strategic and financial of product design and process selection mandates operations work closely across the organization
  - Information services has to be developed to match the needs of the production process
  - Human resources provides important input to the process selection decisions for staffing needs



# Review of Learning Objectives

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- Define product design and explain its strategic impact on organizations
- Describe steps to develop a product design
- Using break-even analysis as a tool in selecting between alternative products
- Identify different types of processes and explain their characteristics



## Review of Learning Objectives – con't

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- Understand how to use a process flowchart
- Understand how to use process performance metrics
- Understand current technology advancements and how they impact process and product design
- Understand issues impacting the design of service operations





# Chapter 3 Highlights

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- Product design is the process of deciding on the unique characteristics and features of a company's product  
Process selection is the development of the process necessary to produce the product being designed.
- Steps in product include idea generation, product screening, preliminary design and testing, and final design
- Break-even analysis is a tool used to compute the amount of goods that have to be sold just to cover costs.
- Production processes can be divided into two broad categories: intermittent and repetitive operation project to batch to line to continuous



# Chapter 1 Highlights con't

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- Product design and process selection decisions are linked
- Process flow charts is used for viewing the flow of the processes involved in producing the
- Different types of technologies can significantly enhance product and process design. These include automation, automated material handling devices, CAD, NC, FMS, and CIM
- Designing services have more complexities than manufacturing, because service produce an intangible product and typically have a high degree of customer contact.