E10
Introduction to Engineering

Industrial and Systems Engineering

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Industrial & Systems Engineering

An Introduction via Examples

- What is Industrial Engineering (IE)?
- What is Systems Engineering (SE)?
- An Early and Modern Example about Manufacturing: Car Assembly
- A Modern Example about the Service Industry: Disneyland
- A Modern Example about the truck manufacturing company
- ISE and ISE Curriculum at SJSU
- Current Multidisciplinary Research into Efficient and Safer Large-truck Freight Operations

What is Industrial Engineering?

- Electrical Engineering – to engineer an electrical product or system.
- Computer Engineering – to engineer a computer or a system of networked computers.
- Industrial Engineering?
  - To engineer an industry?? No.
  - To engineer an industrial product or system (efficiently and effectively): for manufactured goods or services, originally
  - To engineer a product or system for industry, the military, government, education, etc.
  - **Efficiency** and **Quality** Engineering!!

What is Systems Engineering?

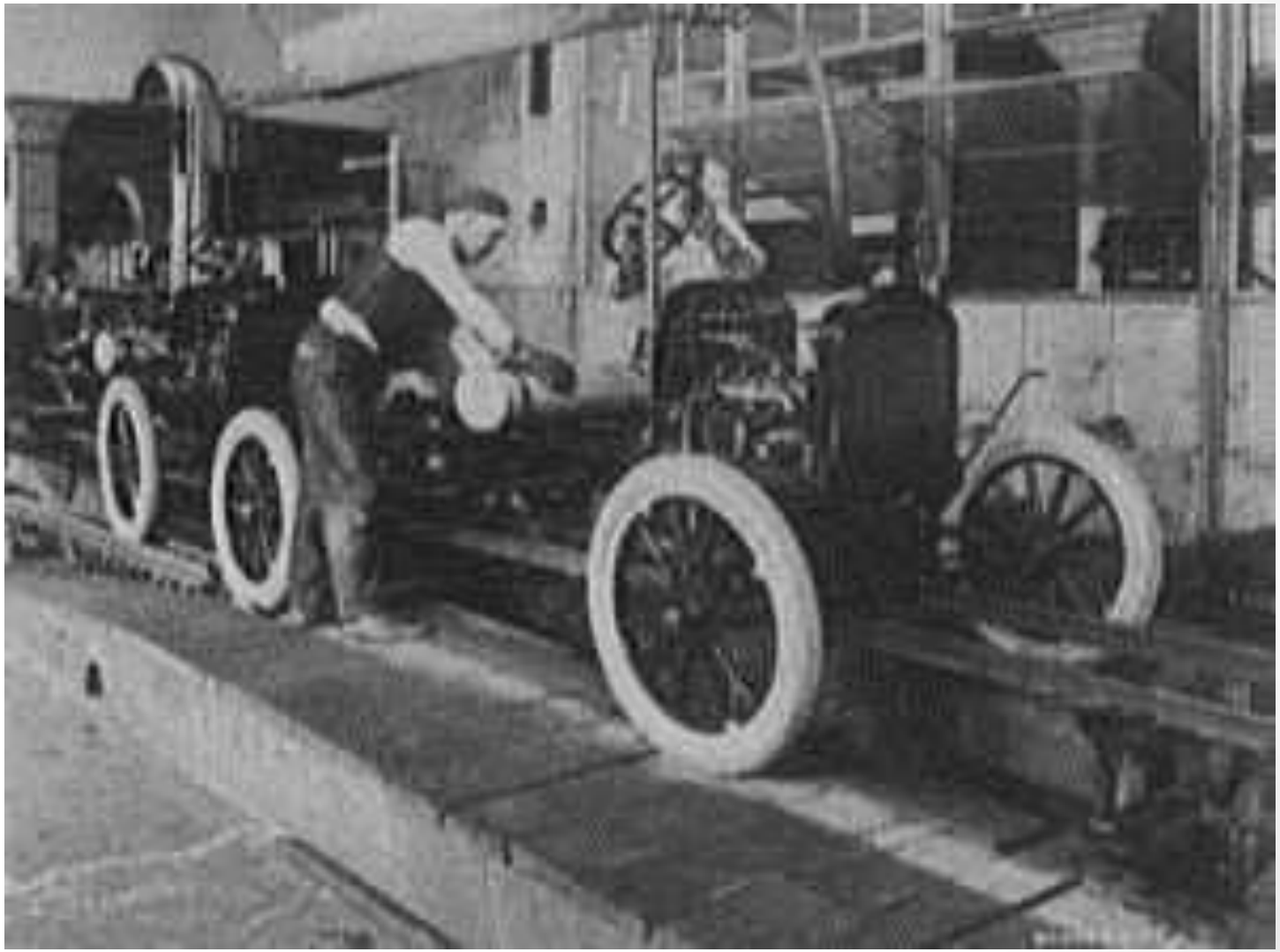
- To engineer a system, with efficiency and quality
- All Types of Systems:
  - Aviation Systems, including Air Traffic Control Systems
  - Telecommunication and Computer Systems
  - Airline Reservation Systems
  - Software and Database systems
  - Highway Systems
  - Manufacturing Systems, e.g., the Toyota Production System (TPS)
  - …..

An Early and Modern Example about Manufacturing:

Car Assembly

- The original "work cell" assembly method
- Henry Ford's idea of assembly line, following the efficiency innovations in cattle slaughtering
- Many innovations for higher efficiency and better quality, including robotics
- The Toyota Production System (TPS), practiced at The New United Motor Manufacturing Incorporated (NUMMI) in Fremont, California (and elsewhere)

Early Moving Assembly Line at Ford



A Glimpse of a Car Assembly Line

Robots at Work in Car Assembly

Robots at Work in Car Assembly

A Modern Car "Assembly Line" VW Phaeton in Dresden

A Modern Example about the Service Industry: Disneyland

- Simple “Take-a-Number” virtual waiting lines at a hospital, to avoid patience discomfort or enable rest
- The recent implementation of “Take-a-Number” virtual lines at California’s DMVs and recent acceptance of appointments via the Internet
- Why can’t Disneyland use this simple idea? What may be the unintended consequences?

A Modern Example about the Service Industry: Disneyland (Cont'd)

- Disneyland first estimated wait time for the customers and displayed it at each attraction.
- Disneyland then displayed the estimated wait times at the entrance and other strategic locations, for better planning by the customers.
- Disneyland recently implemented its version of the "Take-a-Number" system: the "FastPass".
- Better customer satisfaction, and higher revenue too, at the restaurants and gift shops, etc.!

FastPass

Disneyland – Splash Mountain

FastPass Machine

Disneyland – Splash Mountain

FastPass Ticket

Disneyland – Splash Mountain

A Leading Truck Manufacturing Plant in U.S.

- **Goal:** Double the amount of truck they manufactured in a day, by optimizing their resources while maintaining excellence in quality
- One of the objectives of the study was
  - To know the precise amount of time spent on non value adding tasks at each truck assembly station, in order to optimize their operation
- Required to evaluate 70 assembly workers

Beyond the Stopwatch

- Work measurement studies often use stop watches to collect task times
- Difficulty
  - Hold the stopwatch and write the information at the same time
  - The results are not accurate
  - Data collection not easy

ng
ion.

State-of-the-Art Software

- UmtPlus™: The highest quality work measurement tool that leverages handheld computers
- This software developed by Laubrass, facilitates and optimizes the data collection process
- Just need to click on the appropriate icon and your time is logged
- Easy to use
- Truck company customized to suit their needs

Results

- Two hours of training in using UmtPlus to collect the necessary data
- Evaluated 70 workers in just three days
- Once the tasks have been accurately timed on the PDA the results are uploaded to the computer without having to do any data entry
- Employees prefer to see the PDAs rather than a stop watch

Industrial & Systems Engineering

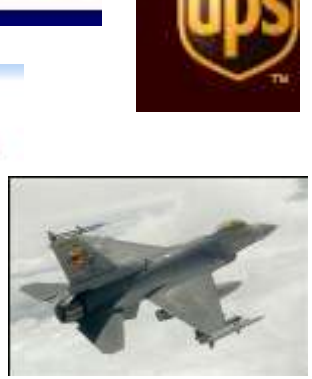
- ISE UG program ranked 3rd in the Nation according to US News
- Approx 55 Undergraduate students
- Very active IIE student chapter
- 165+ Graduate students (MS ISE [110] & MS Human Factors/Ergonomics [55])
- Current FTES 125, and approximately 60-65% graduate FTES
- 4 Full time faculty
  - **Dr. Dessouky → Undergraduate Advisor**
  - **Dr. Tsao → Grad Advisor**
  - **Dr. Freund → HF/E Program Director**
  - **Dr. Minnie Patel → Assessment**
- ISE Faculty experience in manufacturing, healthcare, civil aviation, transportation, supply chain engineering, biometrics, process control
- Research funding from NASA, PATH, MTI, NSF, IBM etc.
- Very good co-op and employment record

ISE empowers its students to better the world…

- ISE students learn how to:
  - improve quality of products and services
  - minimize costs
  - improve security
  - reduce risk of injury
  - minimize delays
  - improve accommodation for the disabled
  - improve quality of work life of employees
  - improve service to customers
  - reduce human errors
  - improve on-time performance

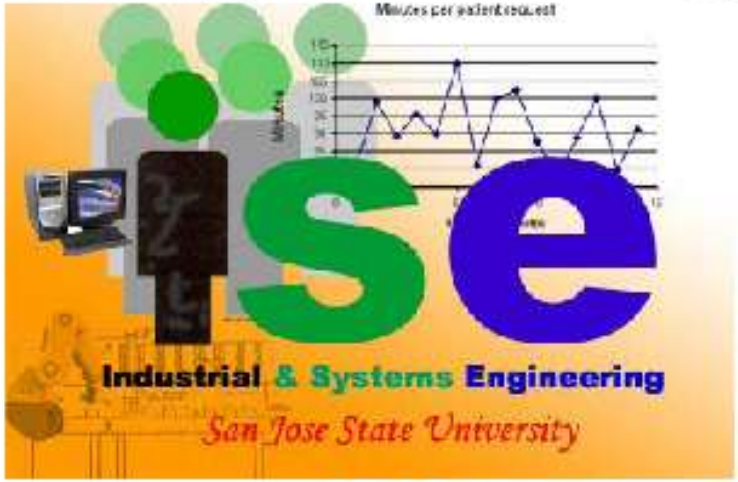
...through innovative applications in many types of organizations:

- Manufacturing
- Computers
- Semiconductors
- Biomedical Device
- Consulting
- Hospitals
- Restaurant chains
- Hotel chains
- Airlines and airports
- Government agencies
- Armed forces
- Worldwide distribution and delivery companies
- Entertainment companies and retail chains



Industrial & Systems Engineering

Management



Products,
Processes,
& Services

The Essential *Linking* Profession

What do ISE's do?

Production planning and scheduling
Inventory management
Supplier reliability management
Quality improvement
Facility planning and layout
Resource planning and scheduling
Equipment selection
Minimizing scrap and waste
Optimization to minimize costs
Line balancing
Measure productivity
Supply Chain Management
Health Systems design
Decision Science
Quality engineering
Operations research
Simulation modeling
Design methods and procedures
Analyze operations
Specify automation systems
Ergonomics / Human Factors
Work measurement

Where do ISE's work?

Manufacturing
Consulting
Hospitals
Restaurant chains
Hotel chains
Airlines, airports
Government
Armed Forces
Distribution
Entertainment Venues
Retail chains

What are some jobs that ISE's fill?

Industrial Engineer
Systems Engineer
Management Engineer
Quality Engineer
Production Engineer
Logistics Planner
Supply Chain Manager
Plant Manager
VP Manufacturing
Director of Planning
Process Engineer
Product Manager
Manufacturing Engineer
Management Consultant
Ergonomist
Human Factors Engineer
Reliability Engineer
Methods Engineer
Coordinator of Process Improvement
Director of Engineering

Find out more about how you can become an Essential Link!
Visit the SJSU ISE Department web site at: www.engr.sjsu.edu/ise
Watch the streaming video, and find out more about
Industrial and Systems Engineering in your future
or, contact the ISE Department at San Jose State University today: (408) 924-3301
or email to: ise@ email.sjsu.edu

San José State
UNIVERSITY

ISE Undergraduate Curriculum

Ranked 3rd in the USA* 2009-10

Enterprise Operations

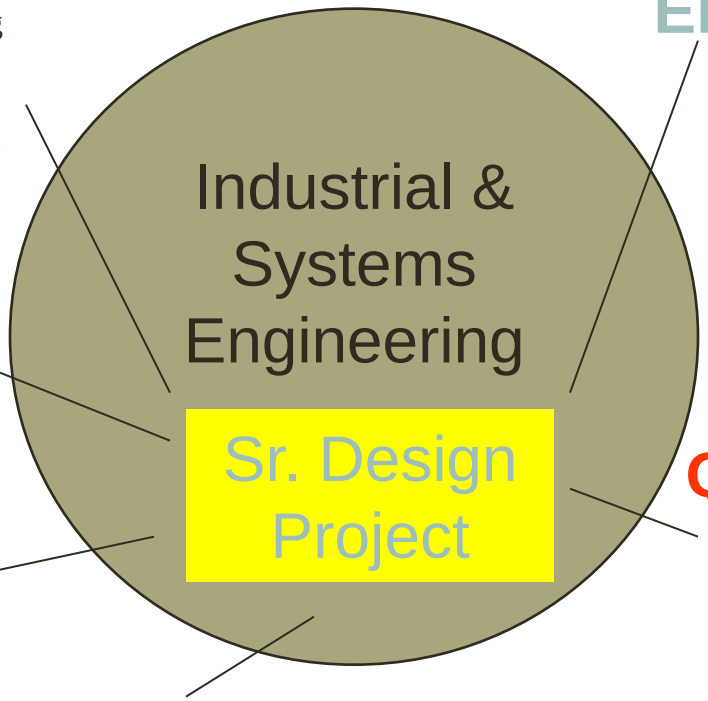
ISE 155 Supply Chain Engineering
ISE 140 Opns Plng & Control
ISE 142 Services Engineering
ISE 115 Computer Integrated Mfg

Eng. Breadth

Engr 10 Problem Solving
ME 20 Design & Graphics
CmpE 30
MatE 25 Intro to Materials
EE 98 Circuits
Cmp E 131 Software Engrg

Eng. Management

ISE 105 Intr Systems Engrg
ISE 102 Engrg Economics
ISE 151 Engrg Mgmt



Math Modeling

ISE 130 Statistics
ISE 167 Simulation
ISE 170 Operations Research

Quality Control

ISE 131 Quality Control
ISE 135 Design of Expts
ISE 196R Reliability

Human Component

ISE 112 Occ Hlth Engrg
ISE 114 Safety Engineering
ISE 120 Work Methods & Measurement
ISE 164 Human Computer Interaction

***U.S. NEWS among colleges and Universities without doctoral degrees.**

Multidisciplinary Research: Efficient and Safer Large-truck Operations

- Proven US oil reserve: 22 billion barrels
- Daily US consumption: 21 million barrels
- “Desperate” need for fuel efficiency
- Public transportation for passengers, but how about freight transportation?
- Longer Combination Vehicles (LCVs) for higher fuel efficiency: 5.4 MPG for a 40,000-lb “straight truck” and 4.6 MPG for a 140,000-lb “turnpike double”

Efficient and Safer Large-truck Operations

- LCV for higher productivity: tractor utilization, driver utilization and speed of freight movement
- But, only 20 states allow such operations.
- California does not allow them. Why?
- Safety hazard and damage to roadway
- A major source: “off-tracking”
- Innovative concept: Automated Trailer Steering, for virtual elimination of off-tracking [Rangavajhula & Tsao]
- Multidisciplinary research: mechanical engineering, electrical engineering, electrical engineering, industrial engineering, economics, public policy, etc.

Industrial & Systems Engineering

- Questions?
- Comments? You are the customer, and the product too.

Plant location

Meaning-the establishment of an industry at a particular place.

It is of 2 types-

1. Localization /centralization-means concentration of similar type of industries at some particular place. E.g. textile in Mumbai.
2. Delocalization /Decentralization-means spreading of similar type of industries at different places. E.g. banking industries.

Factors affecting location & site decisions

1. Availability of raw material
2. Nearness to the potential market
3. Near to the source of operating requirements like electricity, disposal of waste, drainage facilities.
4. Supply of labor
5. Transport & communication facilities
6. Integration with other group of companies
7. Suitability of land & climate
8. Availability of housing, other amenities & services
9. Local building & planning regulations
10. Safety requirements
11. Others like low interest on loans, special grants, living standards

selection of the site for the factory

Known as location analysis where firstly some geographical area is selected & from that area a particular site is selected for the establishment of the plant.

Methods for the evaluation of plant location-

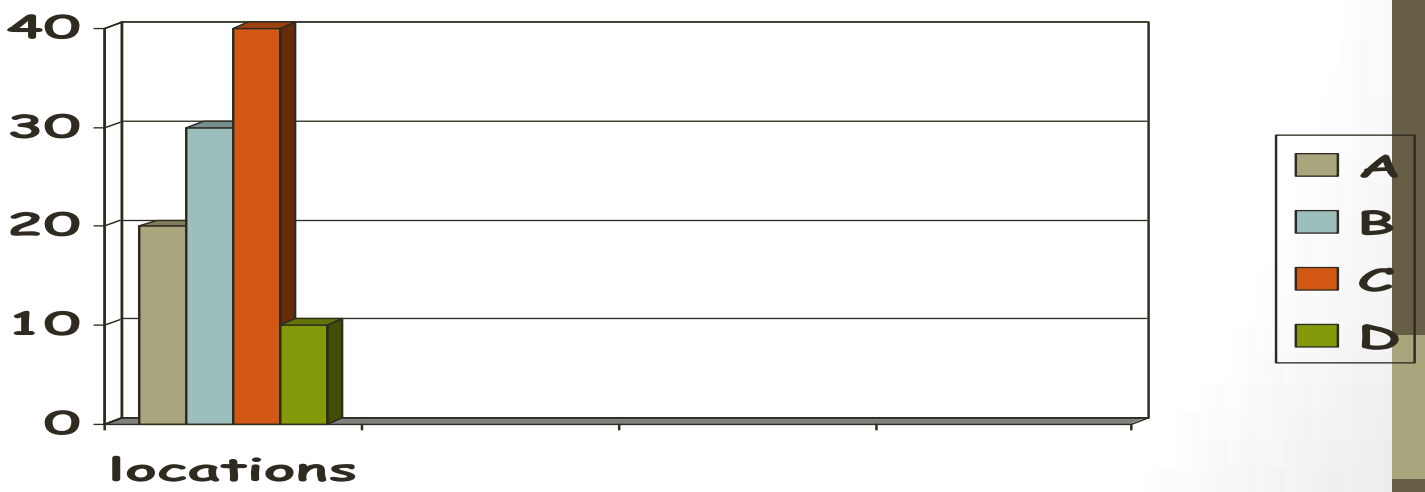
1. Involving quantitative factors-

a. Comparative cost chart, b. dimensional analysis.

2. Comparison of qualitative factors.

Comparative cost chart

Is appropriate where the location problem concerns the placement of a single plant. This is based on location cost summary chart. A comparative chart of total costs involved in setting up a plant of desired size is prepared.



The total cost is represented by the height of column for each location. we select a location for which total cost is minimum.

The cost summary chart has advantage of clarity in presentation. but analysis is restricted to certain specified factors only.

- Least cost centre analysis-

Here transportation cost associated with various location alternatives is considered.

Limitation of these techniques-

1.Choice of plant location assumed to be entirely dependent upon minimization of operational costs.

2.Operational costs are assumed to be linearly related to distance involved.

Dimensional analysis

It involves

1. calculation of the relative merits or cost ratios for each of the factors,
2. giving each of the cost factor an appropriate weightage by means of an index to which the cost ratio is raised
3. & multiplying these weighted ratios in order to arrive at a figure on the relative merits of alternative sites.

Let Cm1,Cm2,Cm3,…..Cmz are the costs associated with site M for various cost factors. Cn1,Cn2,Cn3,…….Cnz are of site N.W1,W2,W3,…….Wz are weightage for various factors.

Merit of location M=(Cm1)W1*(Cm2)W2*…(Cmz)Wz

Merit of location N=(Cn1)W1*(Cn2)W2*…(Cnz)Wz

Relative merits of sites M & N are-

$$\frac{\text{merit of M}}{\text{merit of N}}$$

If this value is > 1, then select site M & vice-versa.

Advantages- it compares both subjective & objective factors & gives a quantitative figure.

Comparison of qualitative factors.

- These are the factors to which cost values can't be assigned. Like lack of good schools, community attitude. These can be termed as good or excellent.

factors	Location A	Location B
labor	adequate	excellent
relation	good	Very good
education	Good	Very good

Clearly location B appears to be better one.

Ranking & weight method

1. Various locations are ranked acc. To their contribution
2. Various factors are assigned weights acc. To their importance
3. Weights are then multiplied with rank assigned
4. Total of these products for each location is calculated
5. Location having max. total is then selected.

- Advantages &disadvantages of urban, rural & sub-urban sites for a plant-

urban	rural	Sub-urban
Better transportation	More water	Planned industrial
Large labor supply	Cheaper land	Larger area
Big local market	Lower taxes	
Easy finance	Few ordinances	
Municipal services		
Better civil attitude	Labor stability	

Backward area & industrial policy

- In the facilities location problems, the industrial policies of the governments are very important inputs in the overall consideration. In India, the industrial development of backward areas for balanced regional development of the country has always been emphasized. This has been attempted mainly through:

1. Licensing policy (practice of leasing a legally protected property to another party)
2. Location of public sector projects
3. Investment subsidy (money granted by the State to keep down the price of commodities)
4. Concessional finance (by IDBI, IFCI , ICICI)
5. Concession on income tax import duty etc and
6. Setting up of industrial estates (property consisting of much land)

Backward area & industrial policy contd.

All the districts in the country have been classified into four categories:

A. No industry districts,
B. Moderately backward districts
C. Least backward districts, and
D. Non-backward districts

The A, B, and C categories are eligible for subsidy on investment in fixed assets in an industrial unit, as given below:

Category	Percent Subsidy	Maximum Limit Per unit
A	25	Rs 25 lakh
B	15	Rs15 lakh
C	10	Rs 10 lakh
D	not eligible for subsidy	

Global locations

World-wide locations are called global locations.

E.g. MNC's are setting up their branches in India & Indian companies are extending their operations in other countries like -

USA, EUROPE , CHINA.

virtual proximity – Social networking at a distance .with the advances in telecommunications technology , a firm can be in virtual proximity to its customers.

Virtual Factory

Many firms based in USA and UK—in the service sector and in the manufacturing sector—often outsource part of their business processes to foreign locations such as India. Thus, instead of one's own operations, a firm could use its business associates' operations facilities. In a way, the Indian BPO firm is that foreign-based company's 'virtual service factory'. So, one's business associate's operations facilities is called virtual factory.

REASONS FOR A FOREIGN LOCATION

1. Reaching the Customer -One obvious reason for locating a facility abroad is that of capturing a share of the market expanding worldwide.
2. Other Tangible Reasons-

- ✓ The host country may have/offer substantial tax advantages compared to the home country.
- ✓ The costs of manufacturing and/or running operations may be substantially less in that foreign country. This may be due to
  - Low labor cost
  - Low raw material cost
  - Better availability of inputs
- ✓ The co. may overcome the tariff (table of fixed charges) barriers by setting up a manufacturing plant in foreign country rather than exporting the items to that country.

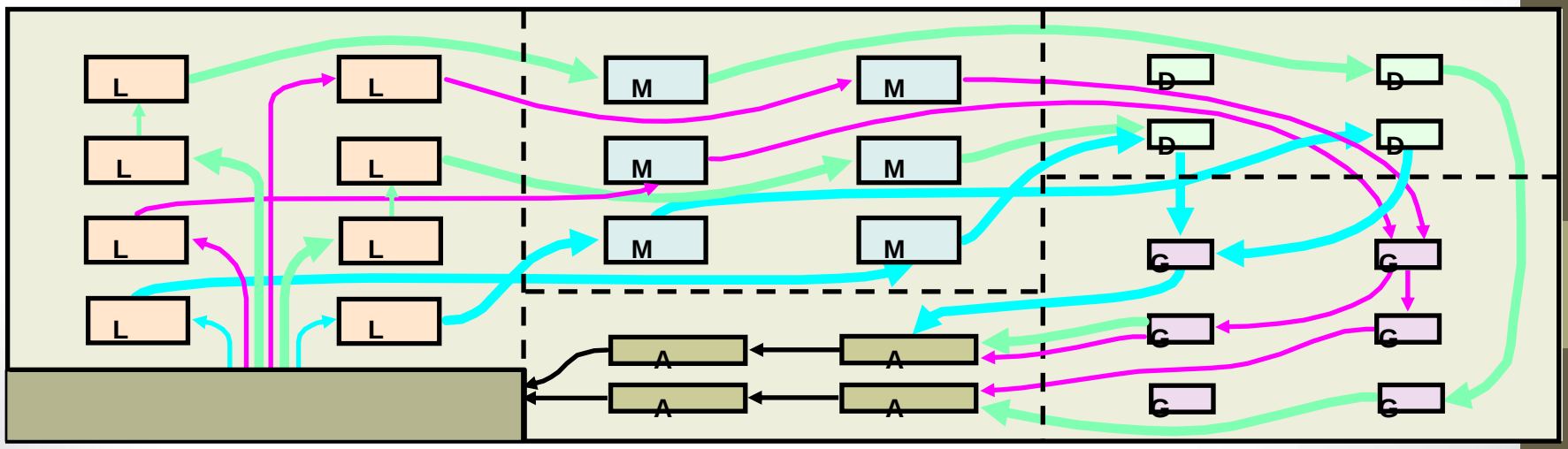
3. Intangible reasons-

- ✓ Customer-related reasons-
  - firm's customer may feel secure that firm is more accessible.
  - Firm may be able to give a personal touch.
  - Firm may understand customer's requirements better.
  - It may discover other potential customers in abroad.
- ✓ Organizational learning related reasons
  - Firm can learn advanced technology
  - Firm can learn from its customers abroad
  - It can also learn from its competitors operating in abroad.
  - It may also learn from its suppliers abroad.

Plant layout

- Meaning-

Plant layout is the physical arrangement of industrial facilities. It involves the allocation of space & the arrangement of equipment in such a manner that overall operating costs are minimized.



Objectives of plant layout

- An efficient layout can be instrumental in the accomplishment of the following objectives-

1. Economies in materials, facilitate manufacturing process & handling of semi-finished & finished goods.
2. Proper & efficient utilization of available floor space.
3. To avoid congestion & bottlenecks.
4. Provision of better supervision & control of operations.

Objectives of plant layout cont.

5. Careful planning to avoid frequent changes in layout which may result in undue increase in cost of production.
6. To provide adequate safety to the workers from accidents.
7. To meet the quality & capacity requirements in the most economical manner.
8. Provision of medical facilities & cafeteria at suitable & convenient places.
9. To provide efficient material handling system.
10. To suggest the improvements in production process & work methods.

Principles of plant layout

1. Principle of integration (of 5M's)
2. Principle of minimum distance
3. Principle of cubic space utilization(both horizontal & vertical space).
4. Principle of flow(must be forward no backtracking)
5. Principle of maximum flexibility
6. Principle of safety, security & satisfaction
7. Principle of minimum handling.

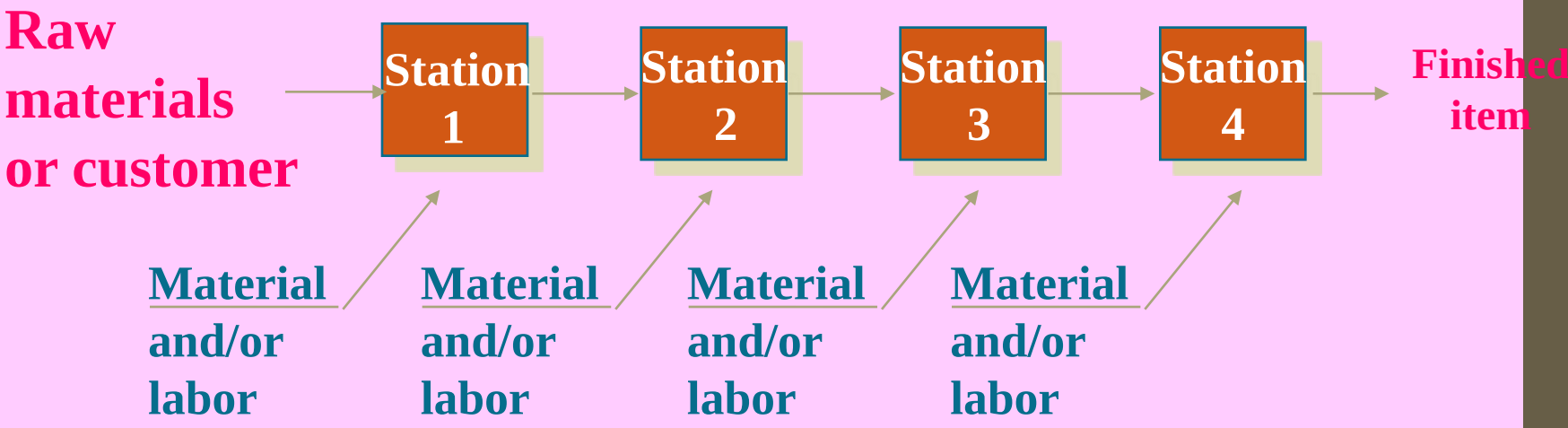
Types of plant layout

1. Product layout
2. Process layout
3. Fixed Position/ Stationary layout

Product layout-

- Layout that uses standardized processing operations to achieve smooth, rapid, high-volume flow
- Here machines are arranged acc. To the needs of product & in the same sequence as the operations are necessary for manufacture. E.g. ‘back office’ of services such as **banks and insurance companies.**

Product Layout



Used for Repetitive or Continuous Processing

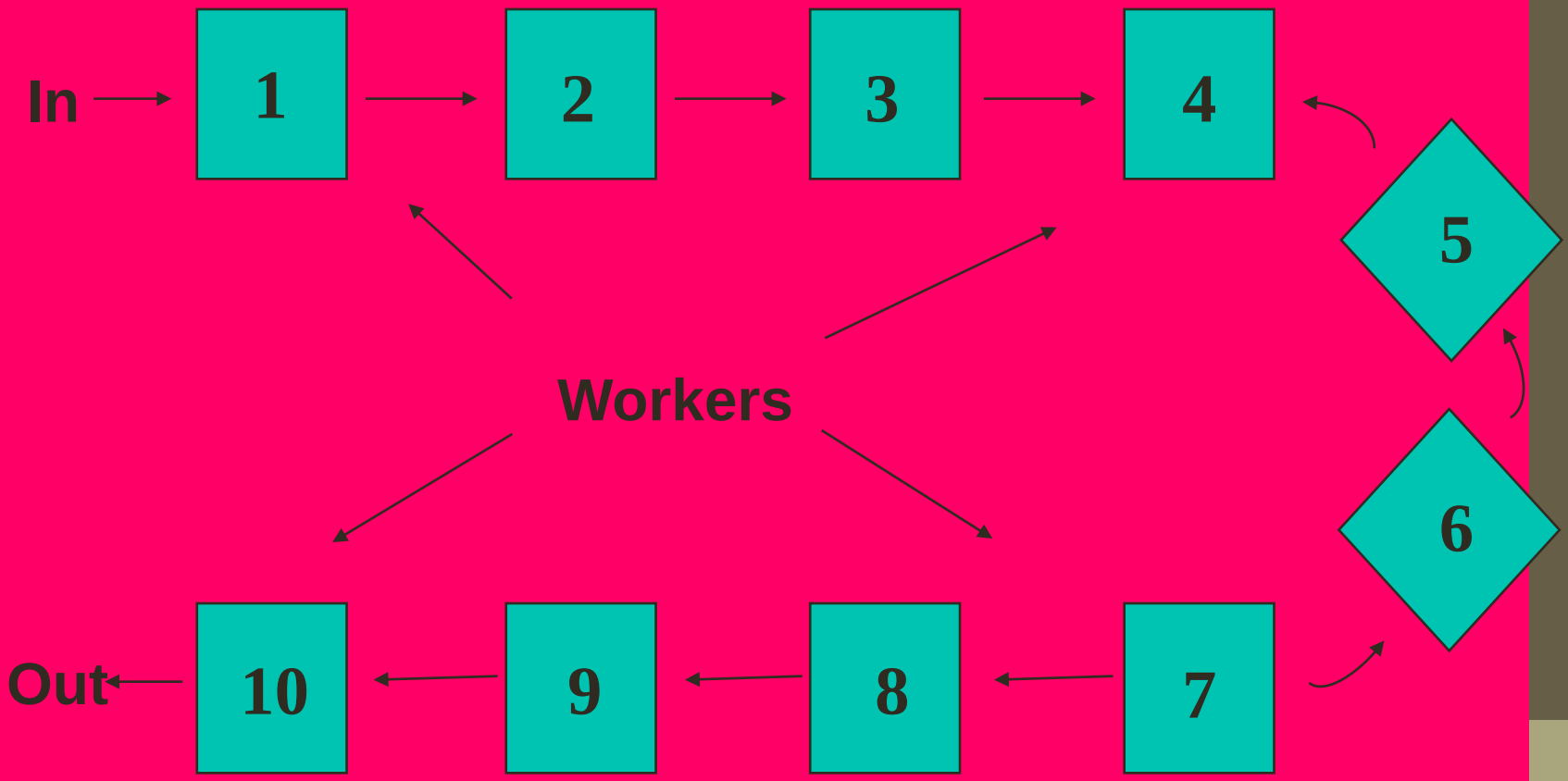
Advantages of Product Layout

1. High rate of output
2. Low unit cost
3. Labor specialization
4. Low material handling cost
5. High utilization of labor and equipment
6. Established routing and scheduling
7. Short processing time

Disadvantages of Product Layout

1. Creates dull, repetitive jobs
2. Poorly skilled workers may not maintain equipment or quality of output
3. Fairly inflexible to changes in volume
4. Highly susceptible to shutdowns
5. Needs preventive maintenance
6. Require large capital investment

A U-Shaped Production Line

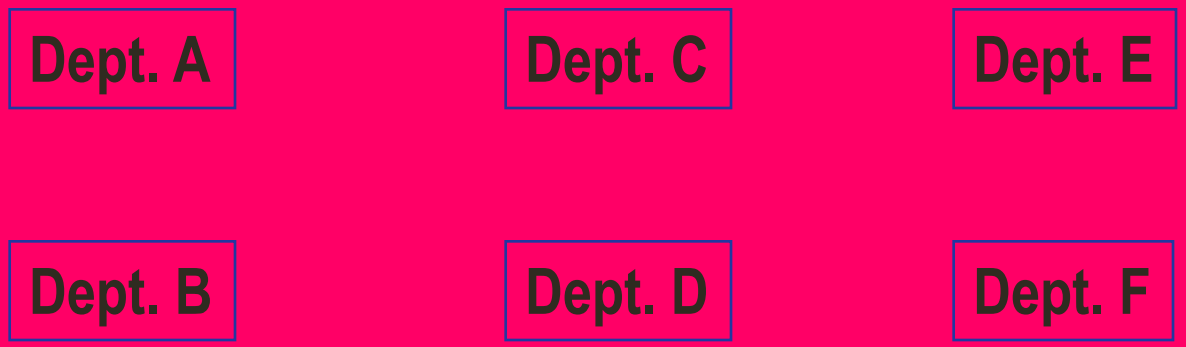


Process layout-

- Layout that can handle varied processing requirements
- Here all machines performing similar type of operations are grouped together at one location in the process layout. Thus here facilities are grouped together acc. To their functions. E.g. all drilling machines are located at one place known as drilling section.

Process Layout

Process Layout
(functional)



Used for Intermittent processing
Job Shop or Batch

Product Layout

Product Layout
(sequential)

Used for Repetitive Processing
Repetitive or Continuous

Advantages of Process Layouts

1. Can handle a variety of processing requirements
2. Machines breakdown doesn’t result in shutdown.
3. Equipment used is less costly
4. Wide flexibility in production facilities.
5. Each production unit of system works independently.
6. High utilization of facilities
7. Variety makes the job interesting.

Disadvantages of Process Layouts

1. In-process inventory costs can be high
2. Challenging routing and scheduling
3. Equipment utilization rates are low
4. Material handling is slow and inefficient & is more.
5. More space is required
6. Longer processing time
7. Back tracking may occur.

Comparison of product & process layout

factors	Product layout	Process layout
1. nature	Sequence of facilities	Similar aregp2gether
2. Machines utilization	Not to full capacity	Better utilization
3. product	standardized	diversified
4. Processing time	less	more
5. Material handling	less	more
6. inventory	High WIP	Low WIP
7. breakdown	Can't tolerate	Can tolerate
8. Production centre	simple	complex
9.flexibilty	low	high
10. floor space	Requires less	more
11. investment	high	low

Stationary layout- Layout in which the product or project remains stationary, and workers, materials, and equipment are moved as needed. E.g. construction of DAMS.

The product, because of its size and/or weight, remains in one location and processes are brought to it.

Factors affecting plant layout

1. **Nature of product-** e.g. some products need air-conditioned plants.
2. **Size of output-**

- For bulk-product/line layout
- For small-functional layout

3. **Nature of manufacturing system-**

- For intermittent-functional layout
- For continuous-product/line layout

4. **Localization of plant-** e.g. there will be different transportation arrangement if site is located near railway line.
5. **Machines or equipment-** e.g. heavy machines need stationary layout
6. Climatic conditions, need of light, temperature also affect design of layout.

CRAFT: COMPUTER PROGRAM TO SOLVE PROCESS LAYOUT PROBLEMS

CRAFT- Computerized Relative Allocation of Facilities Technique

A CRAFT program basically has the following elements:

1. It reads the load summary (the number of loads carried between pairs of departments), the costs per unit load per unit distance for the handling of materials between various pairs of departments.
2. It computes the centres of the departments and computes the various inter-departmental distances.
3. On the basis of the above it computes the total material handling costs per unit period for the layout.

4. It makes paired and/or three-way exchanges between the different departmental locations so as to produce a valid and improved layout pattern. The improvement is in terms of reducing the total material handling costs.

5. The computer prints out the scaled layout pattern and the corresponding cost.

The ultimate aim of the CRAFT program is to minimize the material handling costs for the entire plant.

Capacity Planning

- Capacity is the upper limit or ceiling on the load that an operating unit can handle.
- The basic questions in capacity handling are:
  - What kind of capacity is needed?
  - How much is needed?
  - When is it needed?

Types of Capacity

- Design capacity
  - maximum output rate or service capacity an operation, process, or facility is designed for
- Effective capacity
  - Design capacity minus allowances such as personal time, maintenance, and scrap
- Actual output
  - rate of output actually achieved--cannot exceed effective capacity.

Efficiency and Utilization

$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}}$$

$$\text{Utilization} = \frac{\text{Actual output}}{\text{Design capacity}}$$

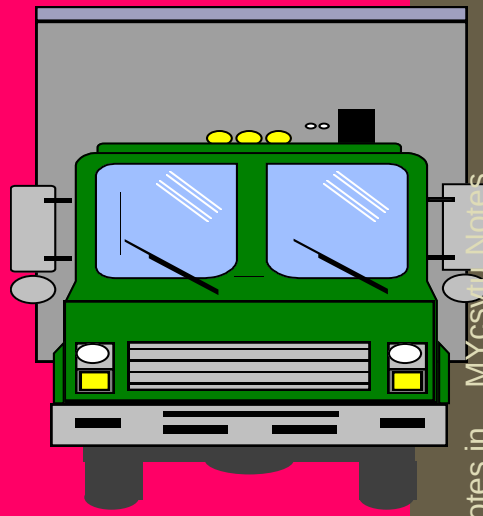
Both measures expressed as percentages

Efficiency/Utilization Example

Design capacity = 50 trucks/day

Effective capacity = 40 trucks/day

Actual output = 36 units/day



$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}} = \frac{36 \text{ units/day}}{40 \text{ units/ day}} = 90\%$$

$$\text{Utilization} = \frac{\text{Actual output}}{\text{Design capacity}} = \frac{36 \text{ units/day}}{50 \text{ units/day}} = 72\%$$

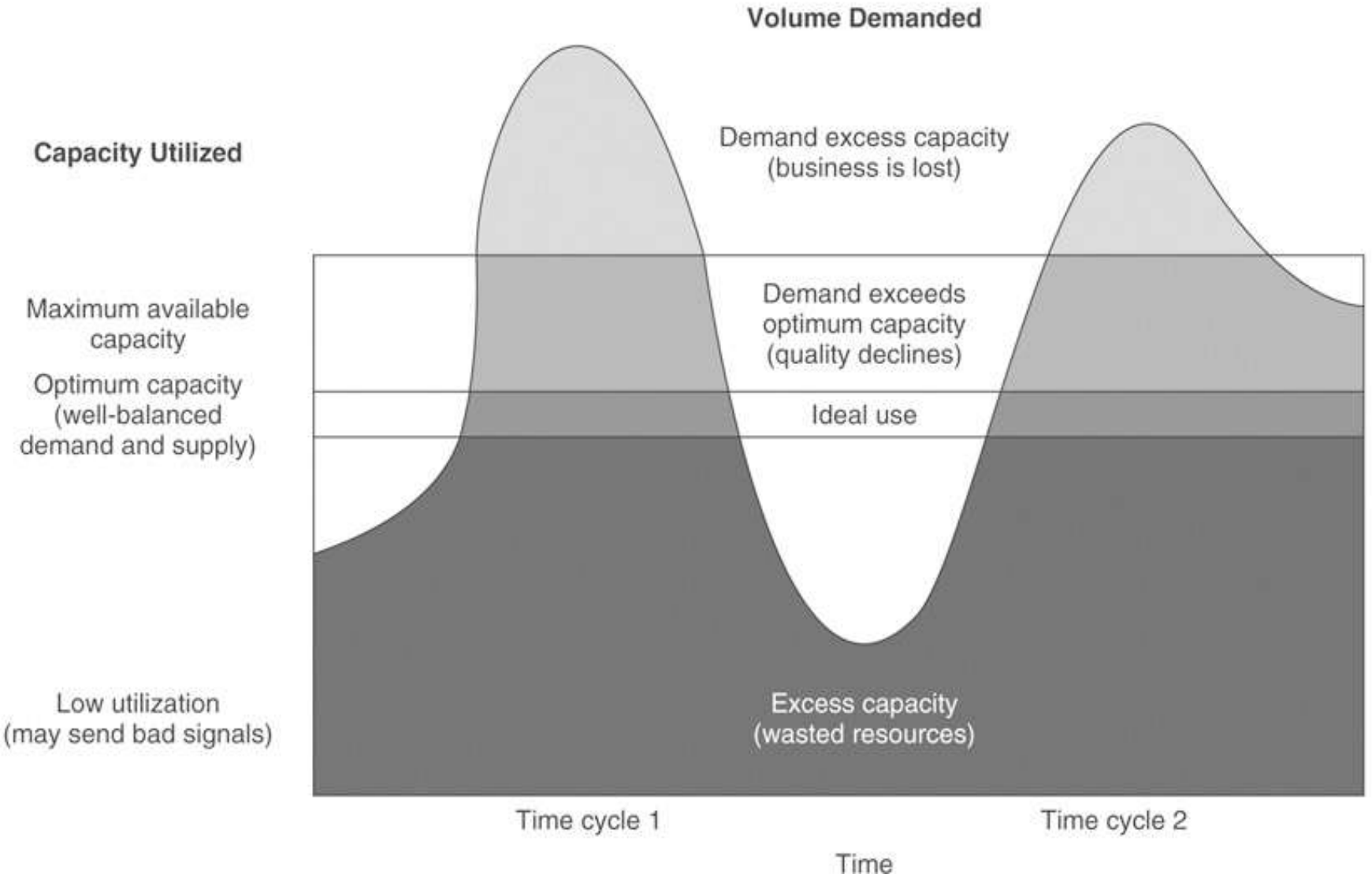
Objectives of capacity planning

1. To satisfy the future demand of products without any shortage
2. To find the optimal capacity of the facility so that the sum of costs of under-capacity & over- capacity is the minimum.
3. To keep the initial investment in the facility as low as possible to achieve lower break-even volume
4. Investment in facility capacity are long-term & can't be reversed easily.

Variations in Demand Relative to Capacity

FIGURE 15.1 Variations in Demand Relative to Capacity

Source: Reprinted from C. Lovelock and J. Wirtz, *Services Marketing: People, Technology, Strategy* (Upper Saddle River, NJ: Pearson Prentice Hall, 2007), chap. 9, p. 261. Reprinted by permission of Pearson Prentice Hall.



Determinants of Effective Capacity

- Facilities
- Product and service factors
- Process factors
- Human factors
- Operational factors
- Supply chain factors
- External factors

Steps for Capacity Planning

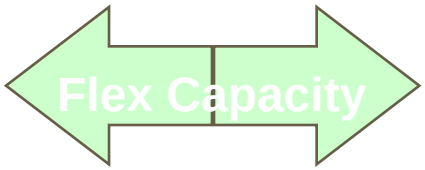
1. Estimate future capacity requirements
2. Evaluate existing capacity
3. Identify alternatives
4. Conduct financial analysis
5. Assess key qualitative issues
6. Select one alternative
7. Implement alternative chosen
8. Monitor results

Strategies for Shifting Demand to Match Capacity

- Use signage to communicate busy days and times
- Offer incentives to customers for usage during non-peak times
- Take care of loyal or regular customers first
- Advertise peak usage times and benefits of non-peak use
- Charge full price for the service--no discounts

- Use sales and advertising to increase business from current market segments
- Modify the service offering to appeal to new market segments
- Offer discounts or price reductions
- Modify hours of operation
- Bring the service to the customer

Strategies for Flexing Capacity to Match Demand

Demand Too High  Demand Too Low

- Stretch time, labor, facilities and equipment
- Cross-train employees
- Hire part-time employees
- Request overtime work from employees
- Rent or share facilities
- Rent or share equipment
- Subcontract or outsource activities

- Perform maintenance renovations
- Schedule vacations
- Schedule employee training
- Lay off employees

Production planning & control

- Production planning implies formulation, co-ordination & determination of activities in a manufacturing system necessary for the accomplishment of desired objectives
- Production control is the process of maintaining a balance between various activities evolves during production planning providing most effective & efficient utilization of resources.

Objectives of PPC

1. Determining the nature & magnitude of various input factors to manufacture desired output.
2. To co-ordinate labor, machines in the most economic manner
3. Setting targets & checking these against performance.
4. Ensuring smooth flow of material by eliminating bottlenecks if any
5. Utilization of under employed resources
6. To produce desired output of right quality & quantity at right time.

Importance of time horizon

Depending on the time horizon, the plan is of 3 types-

- Long-term Planning: Strategic Planning – normally more than an year's time.
- Medium-term Planning: Aggregate Planning – up to an year's time.
- Short-term Planning: Routine Planning – monthly/weekly.

Dovetailing (fit together) of Plans-

Shorter-range plans are always made within the framework of the longer-range plans**.** Production planning as it is generally understood, is really the intermediate-range and short-range plan. That is why. production planning is said to follow from the marketing plan. The production plan is the translation of the market demands into production orders. The market demands have to be matched with the production capacities

Need for Detailed Plans-

At a gross level, one must balance the gross demand into gross level availability of resources in machine-hours or man-hours, etc. **At the detailed level** one needs to balance the requirements of individual products with the availability of individual machines/equipments and labor of different skill categories.

Centralization & decentralization-

concentrate of authority (esp. administration) at a single centre & transfer (power etc.) from central to local authority.

AGGREGATE PLANNING DEFINED

- **Aggregate Planning may be defined as 'Intermediate Planning' which is normally done for a period of up to one year's time. The word 'Aggregate' symbolizes that the planning is done at the broadest level.**

AGGREGATE PLANNING PROCESS –

1. Sales forecast for each product: the quantities to be sold in each time period (weeks, months, or quarters) over the planning horizon (6–18 months)
2. Total all the individual product or service forecasts into one aggregate demand

3. Transform the aggregate demand for each time period into production resource requirements (workers, materials, machines, etc.)
4. Develop alternative resource plans to support the cumulative aggregate demand and compute the cost for each.
5. Select the best alternative which satisfies aggregate demand and best meets the organization's objectives

Goals for aggregate planning-

there are number of goals to be satisfied –

- ✓ It has to provide the overall levels of output, inventory and backlogs
- ✓ Proper utilization of the plant capacity.
- ✓ The aggregate plan should be consistent with the company's goals and policies regarding its employee
- ✓ Make sure enough capacity available to satisfy expected demand

Assembly line balancing

The sequence of machines & equipments arranged to produce the desired product is called assembly lines.

The amount produced by machine depends on

1. No. of operations performed on machine
2. Time required for each operation

There can be a situation that different machines may produce varying amount of product during same period. This property is known as unbalanced assembly line

Example of ALB

machine	Operation no.	Time required to perform operation/unit	Units processed by machine in 1 hr.
A	1	15 min.	60/15=4 units
B	2	20 min.	60/20=3 units
C	3	30 min.	60/30=2 units

Clearly, assembly line is unbalanced.

Alternatively if in system we arrange 3 machines of type A, 4 of B & 6 of C, then output/hr. will

machine	No. of machines	Operation no.	Time required to perform operation/unit	Units processed by machine in 1 hr.
A	3	1	15 min.	3*60/15=12 units
B	4	2	20 min.	4*60/20=12 units
C	6	3	30 min.	6*60/30=12 units

Such type of arrangement is called balanced assembly/production line.

To balance the production line by increasing the machines may not be in the interest of organization due to increased capital investment.

So another method is to increase the working hours for machines. E.g.

machine	Operation no.	Time required to perform operation/ unit	Time required for each machine shift	Units processed by machine in 1 hr.
A	1	15 min.	1 hr.	60/15=4 units
B	2	20 min.	1hr. 20 min.	80/20=4 units
C	3	30 min.	2 hrs	120/30=4 units

Production planning procedures

It can be divided in 3 parts-

1. Routing
2. Scheduling
3. Loading

Routing-

It means determination of path or route over which each piece is to travel in being transformed from raw-material into finished product.

In general routing consists of seven decisions, namely

1. Whether to make/buy
2. The form & shape of material
3. Division of work to be done into operations
4. The choice of machines on which each operation should be done.
5. The sequence in which operations are to be performed
6. The division of operations into work elements
7. The choice of special tooling.

Advantages of routing

1. Efficient use of resources
2. Reduction in manufacturing costs
3. Improvement in quantity & quality of output
4. Provides a basis for scheduling & loading.

Scheduling- it means

1. A description of when & where each operation is to be executed.
2. Establishment of timetable at which to begin/ complete each operation.

Objectives of scheduling-

1. Items are delivered on due date
2. Production cost is minimum
3. To minimize idle time of machines
4. To prevent unbalanced allocation of time among various departments

Types of schedules-

1. **Operations schedule-** determine total time required to do a piece of work with given machine
2. **Master schedule-** is a list showing how many of each item to make in each period of time in future.

Scheduling devices

1. Gantt charts- portrays planned production & actual performance over a period of time. It is a rectangular chart divided by horizontal & vertical lines.
2. PERT & CPM method- job is first broken in basic elements & network is constructed which is then analyzed to prepare schedule.
3. The Run Out approach

Productivity

- Productivity
  - A measure of the effective use of resources, usually expressed as the ratio of output to input

$$\text{Productivity} = \frac{\text{Outputs}}{\text{Inputs}}$$

All Productivity measures

- Productivity = $\frac{\text{Number of units of output}}{\text{Number of persons employed to produce that output}}$

- Productivity= $\frac{\text{no. of units produced}}{\text{no. of man-hours worked}}$

- Productivity= $\frac{\text{output at standard price}}{\text{Amount of wages paid in order to produce that output}}$

- Capital productivity = $\frac{\text{Value Added}}{\text{Capital employed}}$

- Capital Productivity= $\frac{\text{Total sales in Rupees}}{\text{Depreciation of capital assets}}$

- MULTI FACTOR PRODUCTIVITY = $\frac{\text{Production at standard price}}{\text{Labor + materials + overhead + k (capital invested)}}$

where, labor, materials overhead and capital constitute all the input factors

Methods to increase productivity

1. By increasing output, keeping input constant
2. By decreasing inputs for same output
3. By Better utilization of resources
4. By using efficient & effective methods of working
5. By using good layouts
6. By reducing material handling
7. By selecting new technology
8. By proper maintenance
9. By good working conditions to workers
10. By good incentive schemes
11. By better quality of purchase
12. By Training to employees
13. Be customer oriented.
14. Assign right people for right jobs.
15. Keep things simple

Difference between efficiency & effectiveness-

factors	efficiency	effectiveness
Objective:	To produce quantity and quality	To enhance the value to the customer and, therefore, to the society.
Goal:	To improve the process and/or the product	To determine the right direction for the organization and the value that needs lo be generated.
Questions:	*How* to perform a task (whether in production, marketing or any other area)	*Why* to perform something and, so. *what* to perform.
Satisfaction Measure:	Is everything running well?"	-Are we aiming right?"

- BUSINESS PROCESS REENGINEERING-

Business Process Reengineering is about revamping or overhauling the existing processes and redesigning them from a clean slate, in order to achieve significant improvements in critical measures of performance.

Benchmarking-

1. Internal
2. Competitive
3. Functional
4. generic