EASTERN INTERNATIONAL
UNIVERSITY
School of Engineering

ENGINEERING ECONOMY

Lecturer: Thach Dung Chinh
Email: chinh.thach@eiu.edu.vn
MB: 0978104193

Chapter 4 . Operational Strategy

Outline:

1. Capacity analysis
2. Location strategies
3. Human resource
4. Layout strategies

Capacity

- The throughput, or the number of units a facility can hold, receive, store, or produce in a period of time
- Determines fixed costs
- Determines if demand will be satisfied
- Three time horizons

Planning Over a Time Horizon

Options for Adjusting Capacity

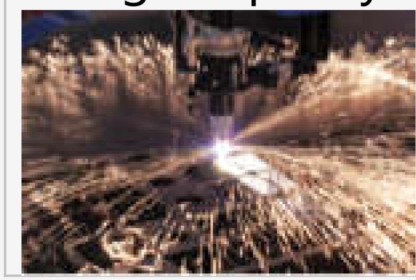
Time Horizon	Modify capacity	Use capacity
Long-range planning	Design new production processes Add (or sell existing) long-lead-time equipment Acquire or sell facilities Acquire competitors	*
Intermediate-range planning (aggregate planning)	Subcontract Add or sell equipment Add or reduce shifts	Build or use inventory More or improved training Add or reduce personnel
Short-range planning (scheduling)	*	Schedule jobs Schedule personnel Allocate machinery

* Difficult to adjust capacity as limited options exist

Design and Effective Capacity

- **Design capacity** is the maximum theoretical output of a system
  - Normally expressed as a rate
- **Effective capacity** is the capacity a firm expects to achieve given current operating constraints
  - Often lower than design capacity

Design and Effective Capacity

[redacted]	Capacity Measurements	
MEASURE	**DEFINITION**	**EXAMPLE**
Design capacity 	Ideal conditions exist during the time that the system is available	Machines at ***Frito-Lay*** are designed to produce 1,000 bags of chips/hr., and the plant operates 16 hrs./day. **Design Capacity = 1,000 bags/hr. × 16 hrs.** **= 16,000 bags/day**

Design and Effective Capacity

[redacted] Capacity Measurements

MEASURE	DEFINITION	EXAMPLE
Effective capacity 	Design capacity minus lost output because of *planned* resource unavailability (e.g., preventive maintenance, machine setups/changeovers, changes in product mix, scheduled breaks)	***Frito-Lay*** loses 3 hours of output per day (= 0.5 hrs./day on preventive maintenance, 1 hr./day on employee breaks, and 1.5 hrs./day setting up machines for different products). **Effective Capacity** **= 16,000 bags/day – (1,000 bags/hr.)(3 hrs./day)** **= 16,000 bags/day – 3,000 bags/day** **= 13,000 bags/day**

Design and Effective Capacity

[redacted]	Capacity Measurements	
MEASURE	**DEFINITION**	**EXAMPLE**
Actual output 	Effective capacity minus lost output during *unplanned* resource idleness (e.g., absenteeism, machine breakdowns, unavailable parts, quality problems)	On average, machines at ***Frito-Lay*** are not running 1 hr./day due to late parts and machine breakdowns. **Actual Output** **= 13,000 bags/day – (1,000 bags/hr.)(1 hr./day)** **= 13,000 bags/day – 1,000 bags/day** **= 12,000 bags/day**

Solve this

An executive conference center has the physical ability to handle 1,100 participants. However, conference management personnel believe that only 1,000 participants can be handled effectively for most events. The last event, although forecasted to have 1,000 participants, resulted in the attendance of only 950 participants. ***What is design, effective capacity and actual output?***

Answers

- Design Capacity = 1,100 participants
- Effective Capacity = 1,000 participants
- Actual Output = 950 participants

Utilization and Efficiency

Utilization is the percent of design capacity actually achieved

Utilization = Actual output/Design capacity

Efficiency is the percent of effective capacity actually achieved

Efficiency = Actual output/Effective capacity

DETERMINING CAPACITY UTILIZATION AND EFFICIENCY

Example 1

Sara James Bakery has a plant for processing *Deluxe* breakfast rolls and wants to better understand its capability. Last week the facility produced 148,000 rolls. The effective capacity is 175,000 rolls. The production line operates 7 days per week, with three 8-hour shifts per day. The line was designed to process the nut-filled, cinnamon-flavored *Deluxe* roll at a rate of 1,200 per hour. Determine the design capacity, utilization, and efficiency for this plant when producing this *Deluxe* roll.

Design Capacity

Bakery Example

Design Capacity

Actual production last week = 148,000 rolls
Effective capacity = 175,000 rolls
Design capacity = 1,200 rolls per hour
Bakery operates 7 days/week, 3 - 8 hour shifts

Design capacity = (7 x 3 x 8) x (1,200) = 201,600 rolls

Utilization

Bakery Example

Utilization

Actual production last week = 148,000 rolls
Effective capacity = 175,000 rolls
Design capacity = 1,200 rolls per hour
Bakery operates 7 days/week, 3 - 8 hour shifts

Design capacity = (7 x 3 x 8) x (1,200) = 201,600 rolls

Utilization = 148,000/201,600 = 73.4%

Efficiency

Bakery Example

Efficiency

Actual production last week = 148,000 rolls
Effective capacity = 175,000 rolls
Design capacity = 1,200 rolls per hour
Bakery operates 7 days/week, 3 - 8 hour shifts

Design capacity = (7 x 3 x 8) x (1,200) = 201,600 rolls

Utilization = 148,000/201,600 = 73.4%

Efficiency = 148,000/175,000 = 84.6%

EXPANDING CAPACITY

Example 2: The manager of **Sara James Bakery** now needs to increase production of the increas- ingly popular *Deluxe* roll. To meet this demand, she will be adding a second production line. The second line has the same design capacity (201,600) and effective capacity (175,000) as the first line; however, new workers will be operating the second line. Quality problems and other inefficiencies stemming from the inexperienced workers are expected to reduce output on the second line to 130,000 (compared to 148,000 on the first). The utilization and efficiency were 73.4% and 84.6%, respectively, on the first line. Determine the new utilization and efficiency for the *Deluxe* roll operation after adding the second line.

Design Capacity

Bakery Example

Design Capacity

Actual production last week = 148,000 rolls
Effective capacity = 175,000 rolls
Design capacity = 201,600 rolls per line
Efficiency = 84.6%
Expected output of new line = 130,000 rolls

Design capacity = 201,600 x 2 = 403,200 rolls

Effective Capacity

Bakery Example

Effective Capacity

Actual production last week = 148,000 rolls
Effective capacity = 175,000 rolls
Design capacity = 201,600 rolls per line
Efficiency = 84.6%
Expected output of new line = 130,000 rolls

Design capacity = 201,600 x 2 = 403,200 rolls

Effective capacity = 175,000 x 2 = 350,000 rolls

Actual Output

Bakery Example

Actual Output

Actual production last week = 148,000 rolls
Effective capacity = 175,000 rolls
Design capacity = 201,600 rolls per line
Efficiency = 84.6%
Expected output of new line = 130,000 rolls

Design capacity = 201,600 x 2 = 403,200 rolls

Effective capacity = 175,000 x 2 = 350,000 rolls

Actual output = 148,000 + 130,000 = 278,000 rolls

Utilization Efficiency

Bakery Example

Actual production last week = 148,000 rolls
Effective capacity = 175,000 rolls
Design capacity = 201,600 rolls per line
Efficiency = 84.6%

Expected output of new line = 130,000 rolls

Design capacity = 201,600 x 2 = 403,200 rolls

Effective capacity = 175,000 x 2 = 350,000 rolls

Actual output = 148,000 + 130,000 = 278,000 rolls

Utilization = 278,000/403,200 = 68.95%

Efficiency = 278,000/350,000 = 79.43%

Solve this

An executive conference center has the physical ability to handle 1,100 participants. However, conference management personnel believe that only 1,000 participants can be handled effectively for most events. The last event, although forecasted to have 1,000 participants, resulted in the attendance of only 950 participants. ***What are the utilization and efficiency of the conference facility?***

Answers

- Design Capacity = 1,100 participants
- Effective Capacity = 1,000 participants
- Actual Output = 950 participants
- Utilization = 86.4%
- Efficiency = 95.0%

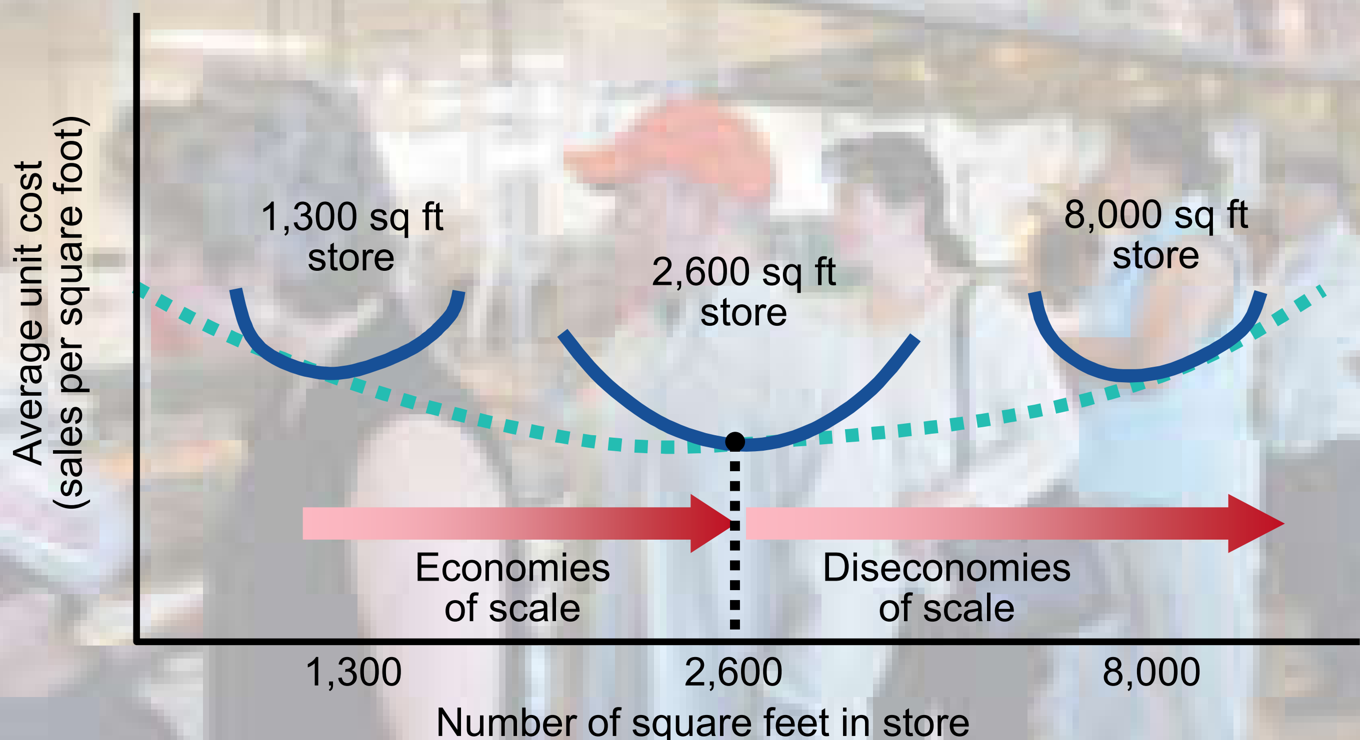
Capacity and Strategy

- Capacity decisions impact all 10 decisions of operations management as well as other functional areas of the organization
- Capacity decisions must be integrated into the organization’s mission and strategy

Capacity Considerations

1. Forecast demand accurately
2. Match technology increments and sales volume
3. Find the optimum operating size (volume)
4. Build for change

Economies and Diseconomies of Scale

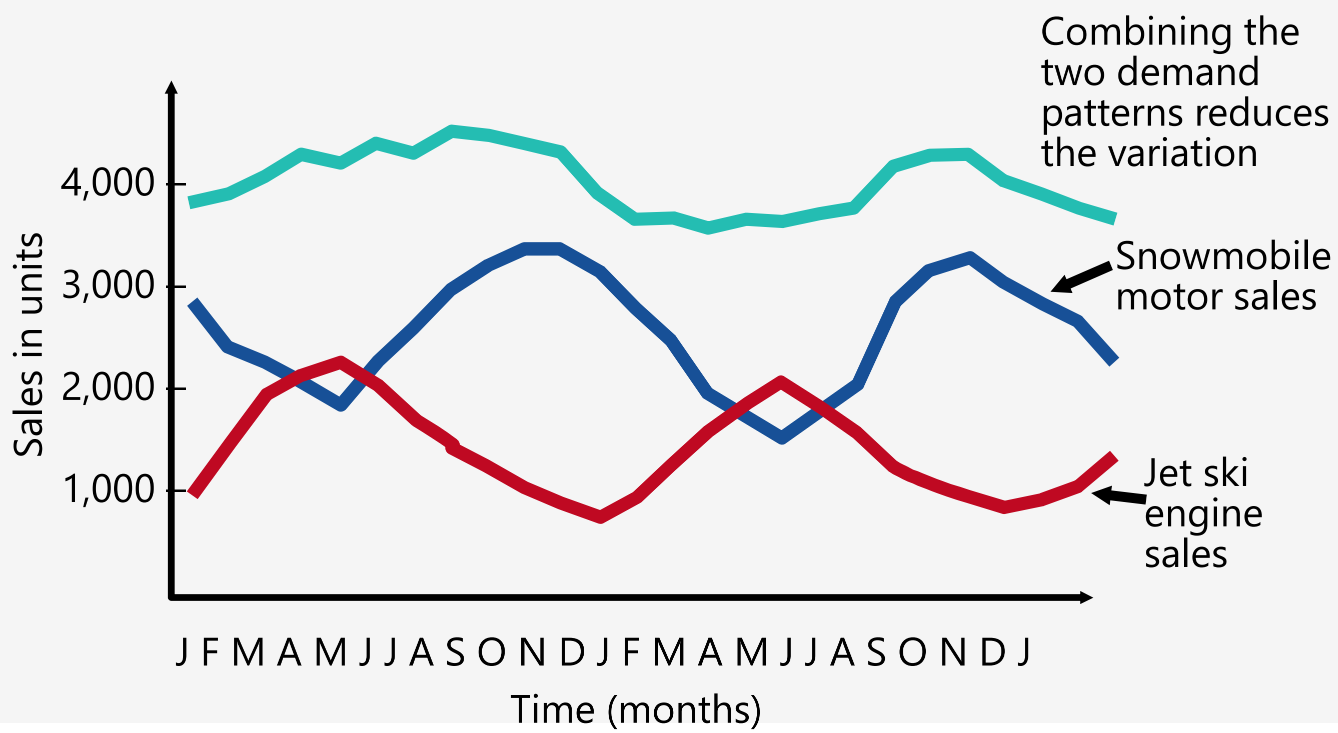


   S7 - 25

Managing Demand

- Demand exceeds capacity
  - Curtail demand by raising prices, scheduling longer lead times
  - Long-term solution is to increase capacity
- Capacity exceeds demand
  - Stimulate market
  - Product changes
- Adjusting to seasonal demands
  - Produce products with complementary demand patterns

Complementary Demand Patterns

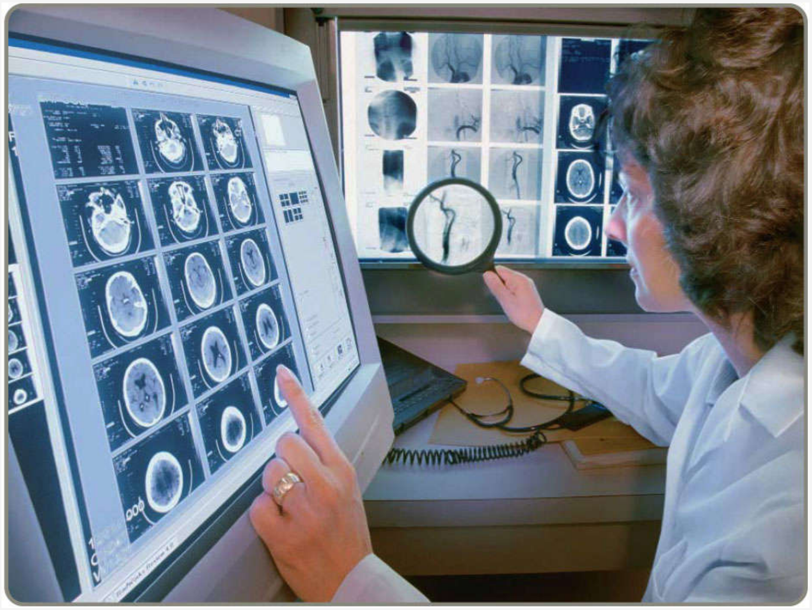


Tactics for Matching Capacity to Demand

1. Making staffing changes
2. Adjusting equipment
   - Purchasing additional machinery
   - Selling or leasing out existing equipment
3. Improving processes to increase throughput
4. Redesigning products to facilitate more throughput
5. Adding process flexibility to meet changing product preferences
6. Closing facilities

Service-Sector Demand and Capacity Management

- Demand management
  - Appointment; reservations; first-come, first-served rule (FCFS rule)
- Capacity management
  - Full time, temporary, part-time staff

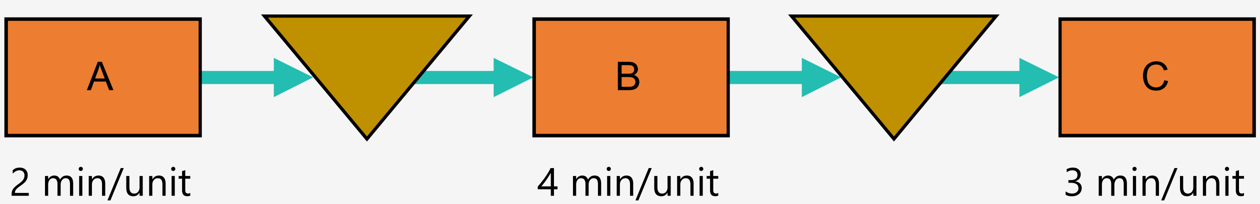


Bottleneck Analysis and the Theory of Constraints

- Each work area can have its own unique capacity
- **Capacity analysis** determines the throughput capacity of workstations in a system
- A **bottleneck** is a limiting factor or constraint
  - A bottleneck has the lowest effective capacity in a system
- The time to produce a unit or a specified batch size is the **process time**

Bottleneck Analysis and the Theory of Constraints

- The **bottleneck time** is the time of the slowest workstation (the one that takes the longest) in a production system
- The **throughput time** is the time it takes a unit to go through production from start to end, *with no waiting*

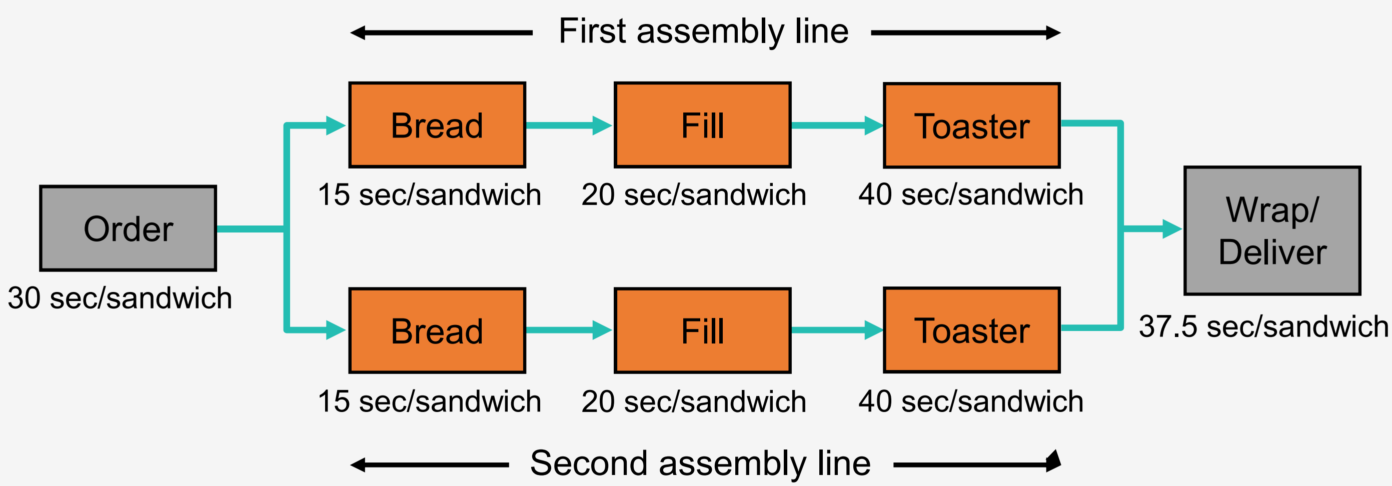


CAPACITY ANALYSIS WITH PARALLEL PROCESSES

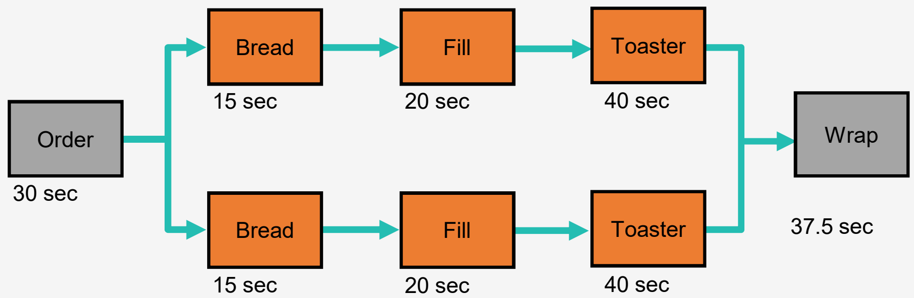
Example 3: ***Howard Kraye's*** sandwich shop provides healthy sandwiches for customers. Howard has two identical sandwich assembly lines. A customer first places an order, which takes 30 seconds. The order is then sent to one of the two assembly lines. Each assembly line has two workers and three operations: (1) assembly worker 1 retrieves and cuts the bread (15 seconds/sandwich), (2) assembly worker 2 adds ingredients and places the sandwich onto the toaster conveyor belt (20 seconds/sandwich), and (3) the toaster heats the sandwich (40 seconds/sandwich). Finally, another employee wraps the heated sandwich coming out of the toaster and delivers it to the customer (37.5 seconds/sandwich). A flowchart of the process is shown below. ***Howard*** wants to determine the bottleneck time and throughput time of this process.

Capacity Analysis

- Two identical sandwich lines
- Lines have two workers and three operations
- All completed sandwiches are wrapped

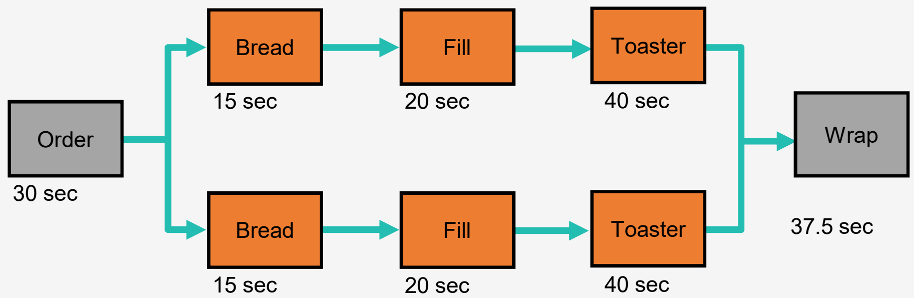


Capacity Analysis



- The two lines are identical, so parallel processing can occur
- At 40 seconds, the toaster has the longest processing time and is the bottleneck for each line
- At 40 seconds for two sandwiches, the bottleneck time of the combined lines = 20 seconds
- At 37.5 seconds, wrapping and delivery is the bottleneck for the entire operation

Capacity Analysis



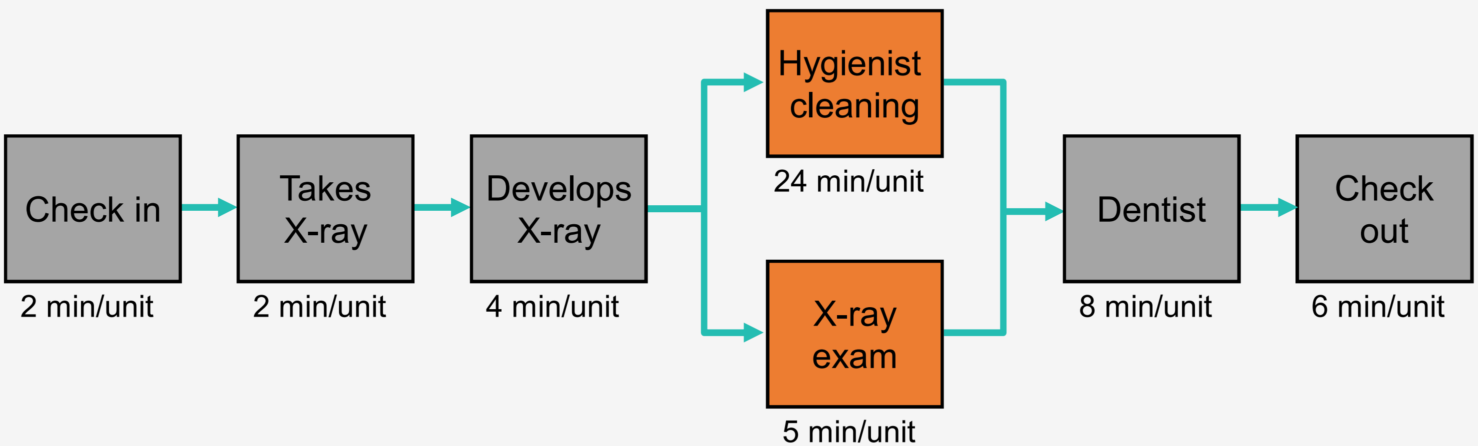
- Capacity per hour is 3,600 seconds/37.5 seconds/sandwich = 96 sandwiches per hour
- Throughput time is 30 + 15 + 20 + 40 + 37.5 = 142.5 seconds

CAPACITY ANALYSIS WITH SIMULTANEOUS PROCESSES

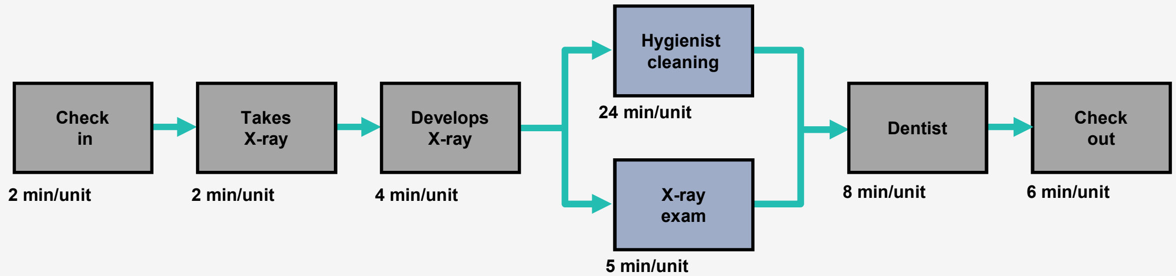
Example 4: ***Dr. Cynthia Knott's*** dentistry practice has been cleaning customers' teeth for decades. The process for a basic dental cleaning is relatively straightforward: (1) the customer checks in (2 minutes); (2) a lab technician takes and develops X-rays (2 and 4 minutes, respectively); (3) the dentist processes and examines the X-rays (5 minutes) while the hygienist cleans the teeth (24 minutes); (4) the dentist meets with the patient to poke at a few teeth, explain the X-ray results, and tell the patient to floss more often (8 minutes); and (5) the customer pays and books her next appointment (6 minutes). A flowchart of the customer visit is shown below. ***Dr. Knott*** wants to determine the *bottleneck time* and *throughput time* of this process.

Capacity Analysis

- Standard process for cleaning teeth
- Cleaning and examining X-rays can happen simultaneously



Capacity Analysis



- All possible paths must be compared
- Bottleneck is the hygienist at 24 minutes
- Hourly capacity is 60/24 = 2.5 patients
- X-ray exam path is 2 + 2 + 4 + 5 + 8 + 6 = 27 minutes
- Cleaning path is 2 + 2 + 4 + 24 + 8 + 6 = 46 minutes
- Longest path involves the hygienist cleaning the teeth, patient should complete in 46 minutes

Theory of Constraints

Five-step process for recognizing and managing limitations

Step 1: Identify the constraints

Step 2: Develop a plan for overcoming the constraints

Step 3: Focus resources on accomplishing Step 2

Step 4: Reduce the effects of constraints by offloading work or expanding capability

Step 5: Once overcome, go back to Step 1 and find new constraints

Bottleneck Management

1. Release work orders to the system at the pace of set by the bottleneck's capacity
2. Lost time at the bottleneck represents lost capacity for the whole system
3. Increasing the capacity of a nonbottleneck station is a mirage
4. Increasing the capacity of a bottleneck increases the capacity of the whole system

Applying Expected Monetary Value (EMV) and Capacity Decisions

Assign probability values to states of nature to determine expected value

EMV APPLIED TO CAPACITY DECISION

Example 5: *Southern Hospital Supplies, a company that makes hospital gowns, is considering capacity expansion.* Southern's major alternatives are to do nothing, build a small plant, build a medium plant, or build a large plant. The new facility would produce a new type of gown, and currently the po- tential or marketability for this product is unknown. If a large plant is built and a favorable market exists, a profit of $100,000 could be realized. An unfavorable market would yield a $90,000 loss. However, a medium plant would earn a $60,000 profit with a favorable market. A $10,000 loss would result from an unfavorable market. A small plant, on the other hand, would return $40,000 with favorable market conditions and lose only $5,000 in an unfavorable market. Of course, there is always the option of doing nothing. Recent market research indicates that there is a .4 probability of a favorable market, which means that there is also a .6 probability of an unfavorable market. With this information, the alternative that will result in the highest expected monetary value (EMV) can be selected.

EMV Applied to Capacity Decision

- Southern Hospital Supplies capacity expansion

EMV (large plant) = (.4)($100,000) + (.6)(–$90,000)
= –$14,000

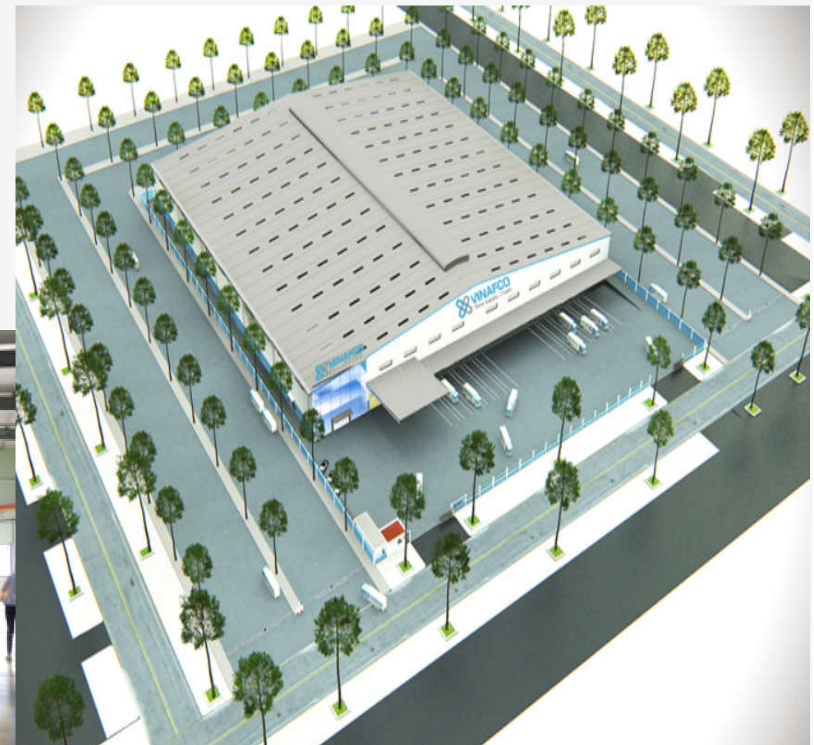
EMV (medium plant) = (.4)($60,000) + (.6)(–$10,000)
= +$18,000

EMV (small plant) = (.4)($40,000) + (.6)(–$5,000)
= +$13,000

EMV (do nothing) = $0

2. Location Strategies

The objective of location strategy is to maximize the benefit of location to the firm



2. Location Strategies

- One of the most important decisions a firm makes
- Increasingly global in nature
- Significant impact on fixed and variable costs
- Decisions made relatively infrequently
- The objective is to maximize the benefit of location to the firm

2. Location Strategies

Location and Costs

- Location decisions based on low cost require careful consideration
- Once management is committed to a specific location, many costs are firmly in place and difficult to reduce
- Determining optimal facility location is a good investment

2. Location Strategies

Location and Innovation

- ❖ Cost is not always the most important aspect of a strategic decision
- ❖ Four key attributes when strategy is based on innovation
  - ❑ High-quality and specialized inputs
  - ❑ An environment that encourages investment and local rivalry
  - ❑ A sophisticated local market
  - ❑ Local presence of related and supporting industries

2. Location Strategies

Location Decisions

- ❖ Long-term decisions
- ❖ Decisions made infrequently
- ❖ Decision greatly affects both fixed and variable costs
- ❖ Once committed to a location, many resource and cost issues are difficult to change

Location Decisions

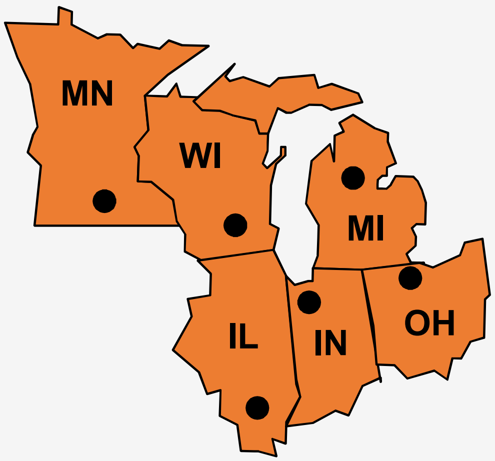
Country Decision

Key Success Factors

1. **Political risks, government rules, attitudes, incentives**
2. **Cultural and economic issues**
3. **Location of markets**
4. **Labor talent, attitudes, productivity, costs**
5. **Availability of supplies, communications, energy**
6. **Exchange rates and currency risks**

Location Decisions

Region/ Community Decision

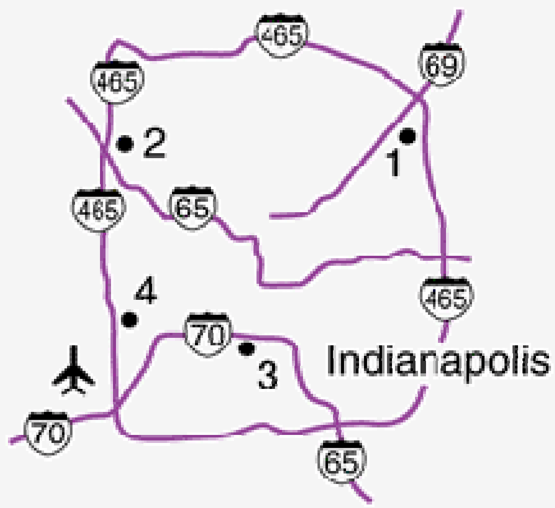


Key Success Factors

1. Corporate desires
2. Attractiveness of region
3. Labor availability and costs
4. Costs and availability of utilities
5. Environmental regulations
6. Government incentives and fiscal policies
7. Proximity to raw materials and customers
8. Land/construction costs

Location Decisions

Site Decision



Key Success Factors

1. **Site size and cost**
2. **Air, rail, highway, and waterway systems**
3. **Zoning restrictions**
4. **Proximity of services/ supplies needed**
5. **Environmental impact issues**

Factors That Affect Location Decisions

Example 6:

If Otis Elevator pays $70 per day with 60 units produced per day in South Carolina, it will spend less on labor than at a Mexican plant that pays $25 per day with production of 20 units per day

Factors That Affect Location Decisions

Labor productivity

- **Wage rates are not the only cost**
- **Lower productivity may increase total cost**

$$\frac{\text{Labor cost per day}}{\text{Productivity (units per day)}} = \text{Labor cost per unit}$$

Case 1: South Carolina plant

$$\frac{\$70}{60 \text{ units}} = \$1.17 \text{ per unit}$$

Case 2: Juarez, Mexico, plant:

$$\frac{\$25}{20 \text{ units}} = \$1.25 \text{ per unit}$$

Factors That Affect Location Decisions

Exchange rates and currency risks

- Can have a significant impact on costs
- Rates change over time

Costs

- Tangible - easily measured costs such as utilities, labor, materials, taxes
- Intangible - less easy to quantify and include education, public transportation, community, quality-of-life

Factors That Affect Location Decisions

Political risk, values, and culture

- National, state, local governments attitudes toward private and intellectual property, zoning, pollution, employment stability may be in flux
- Worker attitudes towards turnover, unions, absenteeism
- Globally cultures have different attitudes towards punctuality, legal, and ethical issues

Factors That Affect Location Decisions

Proximity to markets

- Very important to services
- JIT (just in time) systems or high transportation costs may make it important to manufacturers

Proximity to suppliers

- Perishable goods, high transportation costs, bulky products

Factors That Affect Location Decisions

Proximity to competitors

- Called clustering
- Often driven by resources such as natural, information, capital, talent
- Found in both manufacturing and service industries

The Factor-Rating Method

Six steps in the method

1. Develop a list of relevant factors called key success factors
2. Assign a weight to each factor
3. Develop a scale for each factor
4. Score each location for each factor
5. Multiply score by weights for each factor for each location
6. Recommend the location with the highest point score

The Factor-Rating Method

Example 7: *A business needs to choose a location to build a factory. Through preliminary research, two potential locations have been identified in provinces A and B. According to experts, the weights and scores for the factors of these two locations are given in the following table.*

Key Success Factor	**Weight**	**Scores**	
		Location A	Location B
Labor availability and attitude	0.25	70	60
People-to-car ratio	0.05	50	60
Per capita income	0.1	85	80
Tax structure	0.39	75	70
Education and health	0.21	60	70

Use the weighted scoring method to compare these two locations and determine which one to choose.

The Factor-Rating Method

Solution:

Factor	Weight	Weighted Scores	
		Location A	Location B
Labor availability and attitude	0.25	0.25x70=17.5	0.25x60=15
People-to-car ratio	0.05	0.05x50=2.6	0.05x60=3
Per capita income	0.1	0.1x85=8.5	0.1x80=8
Tax structure	0.39	0.39x75=29.3	0.39x70=27.3
Education and health	0.21	0.21x60=12.6	0.21x70=14.7
Total	**1.0**	**70.4**	**68**

Locational Cost–Volume Analysis

The three steps to locational cost–volume analysis are as follows:

1. Determine the fixed and variable cost for each location.

2. Plot the costs for each location, with costs on the vertical axis of the graph and annual volume on the horizontal axis.

3. Select the location that has the lowest total cost for the expected production volume

Locational Cost–Volume Analysis

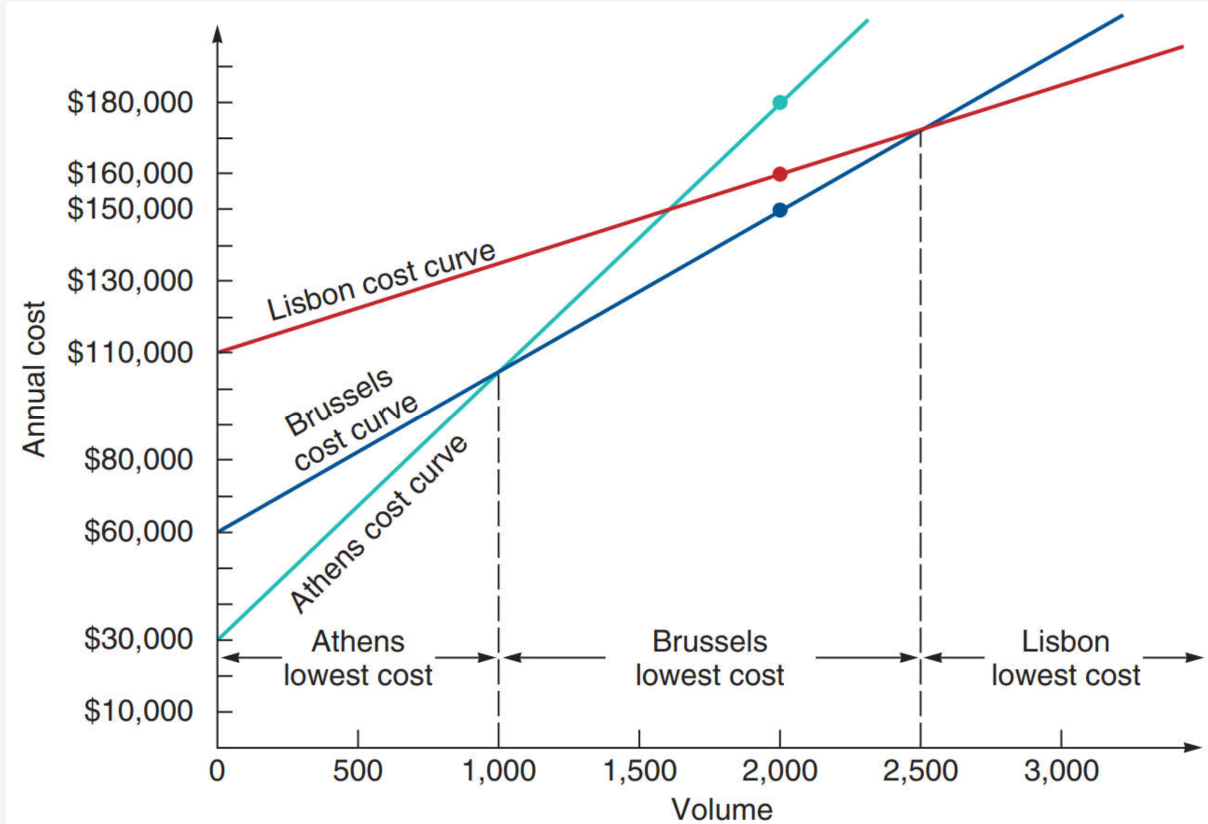
Example 8: Esmail Mohebbi, owner of European Ignitions Manufacturing, needs to expand his capacity. He is con- sidering three locations-Athens, Brussels, and Lisbon-for a new plant. The company wishes to find the most economical location for an expected volume of 2,000 units per year.

APPROACH

Mohebbi conducts locational cost-volume analysis. To do so, he determines that fixed costs per year at the sites are $30,000, $60,000, and $110,000, respectively; and variable costs are $75 per unit, $45 per unit, and $25 per unit, respectively. The expected selling price of each ignition system produced is $120.

Locational Cost–Volume Analysis

Solution: For each of the three locations, Mohebbi can plot the fixed costs (those at a volume of zero units) and the total cost (fixed costs + variable costs).



Locational Cost–Volume Analysis

For Athens:

Total cost = \$30,000+ \$75(2,000)=\$180,000

For Brussels:

Total cost = \$60,000 +\$45(2,000)=\$150,000

For Lisbon:

Total cost = \$110,000+ \$25(2,000) =\$160,000

With an expected volume of 2,000 units per year, Brussels provides the lowest cost location. The expected profit is:

Total revenue - Total cost = \$120(2,000) - \$150,000 = \$90,000 per year

Locational Cost–Volume Analysis

The crossover point for Athens and Brussels is:

$$30{,}000 + 75(x) = 60{,}000 + 45(x)$$

$$30(x) = 30{,}000$$

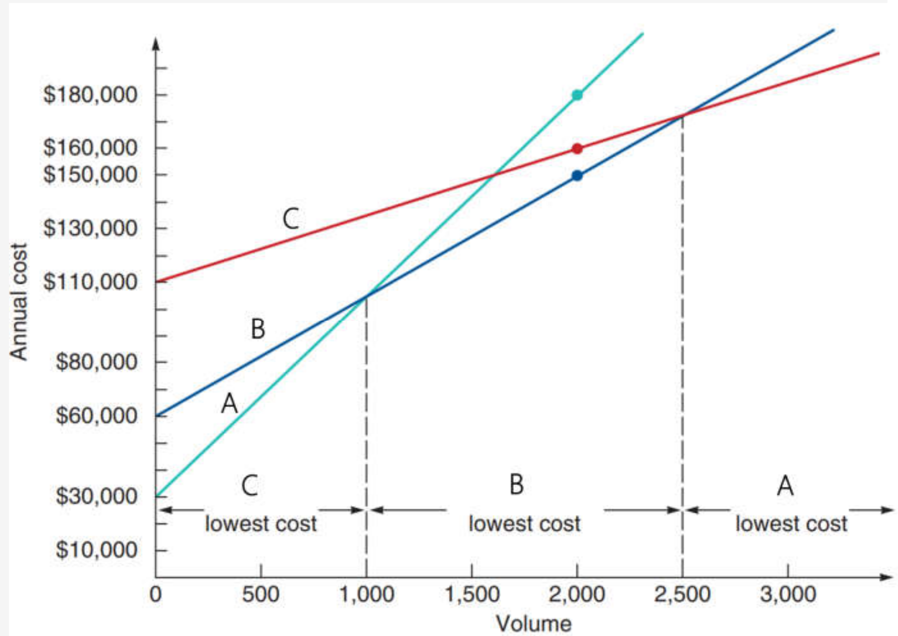
$$x = 1{,}000$$

and the crossover point for Brussels and Lisbon is:

$$60{,}000 + 45(x) = 110{,}000 + 25(x)$$

$$20(x) = 50{,}000$$

$$x = 2{,}500$$



- For a volume of less than 1,000, Athens would be preferred.
- For a volume greater than 2,500, Lisbon would yield the greatest profit.

Center-of-Gravity Method

The center-of-gravity method is a mathematical technique used for finding the location of a distribution center that will minimize distribution costs.

$$\text{x-coordinate of the center of gravity} = \frac{\sum_i x_i Q_i}{\sum_i Q_i}$$

$$\text{y-coordinate of the center of gravity} = \frac{\sum_i y_i Q_i}{\sum_i Q_i}$$

where *x*

i = *x*-coordinate of location *i*

y_i = *y*-coordinate of location *i*

Q_i = Quantity of goods moved to or from location *i*

Center-of-Gravity Method

Example 9: Quain's Discount Department Stores, a chain of four large Target-type outlets, has store locations in Chicago, Pittsburgh, New York, and Atlanta; they are currently being supplied out of an old and inad- equate warehouse in Pittsburgh, the site of the chain's first store. The firm wants to find some “central” location in which to build a new warehouse.

Quain's will apply the center-of-gravity method. It gathers data on demand rates at each outlet.

STORE LOCATION	NUMBER OF CONTAINERS SHIPPED PER MONTH
Chicago	2,000
Pittsburgh	1,000
New York	1,000
Atlanta	2,000

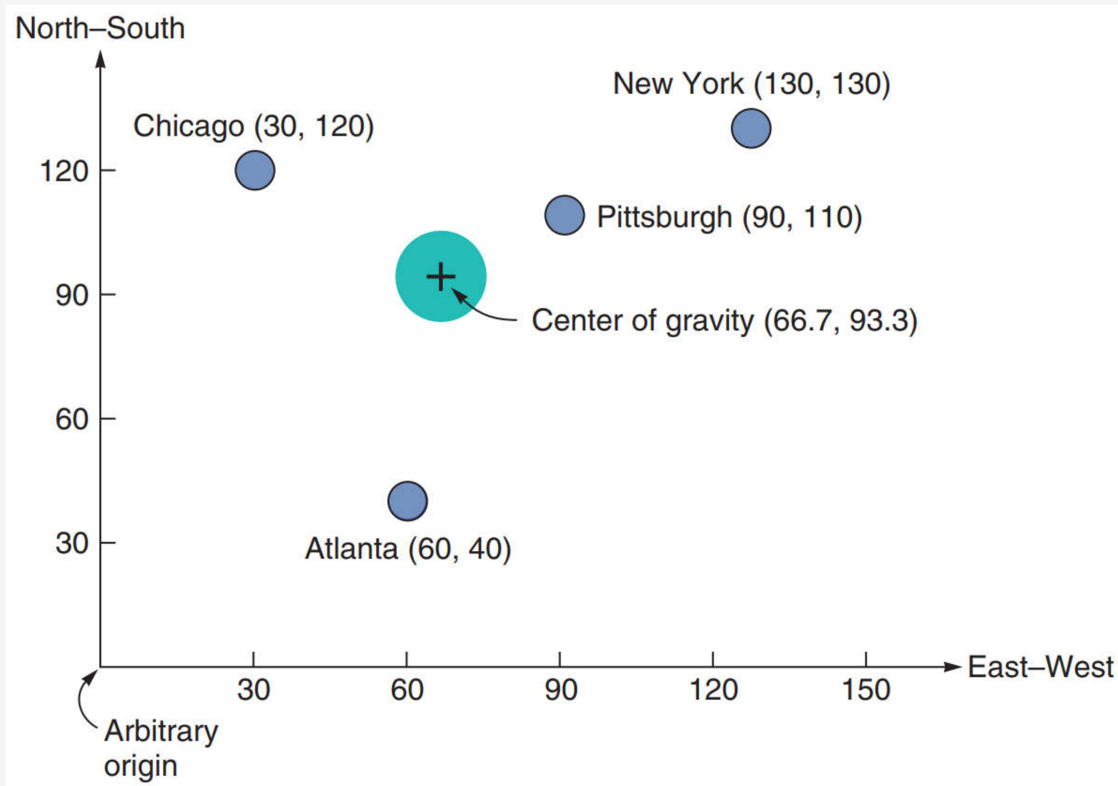
Center-of-Gravity Method

Location 1 is Chicago

$X_1 = 30$

$y_1 = 120$

$Q_1 = 2{,}000$



Center-of-Gravity Method

Solution:

x-coordinate of the center of gravity:

$$= \frac{(30x2000 + (90x1000) + (130x1000) + (60x2000)}{2000 + 1000 + 1000 + 2000} = 66.7$$

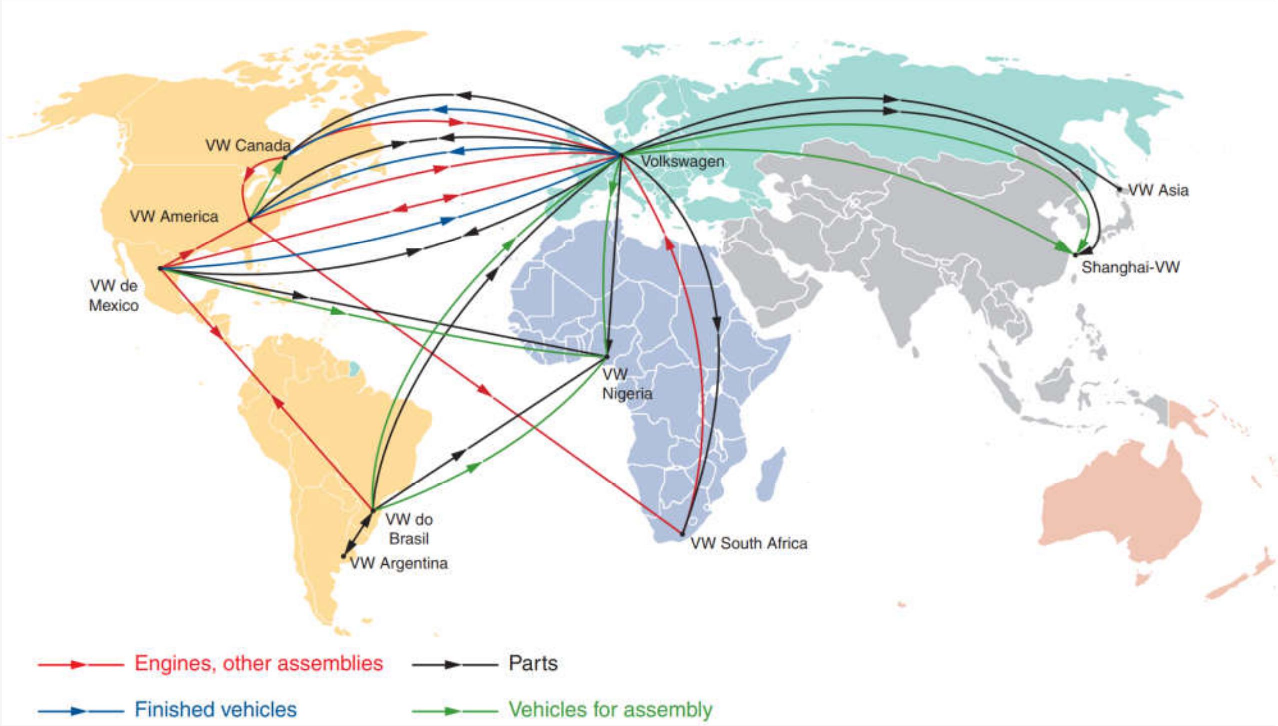
y-coordinate of the center of gravity:

$$= \frac{(120x2000 + (110x1000) + (130x1000) + (40x2000)}{2000 + 1000 + 1000 + 2000} = 93.3$$

This location (66.7, 93.3) is shown by the crosshairs

Transportation Model

The objective of the transportation model is to determine the best pattern of shipments from several points of supply (sources) to several points of demand (destinations) so as to minimize total production and transportation costs



Service Location Strategy

1. Purchasing power of customer-drawing area
2. Service and image compatibility with demographics of the customer-drawing area
3. Competition in the area
4. Quality of the competition
5. Uniqueness of the firm’s and competitors’ locations
6. Physical qualities of facilities and neighboring businesses
7. Operating policies of the firm
8. Quality of management

3. Human Resource Planning

Definition:

HRP is the process of determining future employee needs and deciding steps or strategies to achieve those needs for the purpose of accomplishing organization goals and objectives.

3. Human Resource Planning

Significance of HRP:

- To determine future employee needs
- To utilize HR more efficiency and effectively
- To control employee cost
- To develop high talent employees
- To formulate and implement strategic plans

3. Human Resource Planning

To determine future employee needs

- An organization wants to know future employee needs.
- What type of employees are needed?
- How many employees are needed for the next month or next year?
- To get answers for the two questions correctly it is essential to do HRP. Without doing HRP the organization will not be able to determine employee needs for future.

3. Human Resource Planning

To utilize HR more efficiently and effectively

Careful analysis of all Human Resource Management (HRM) activities shows that their effectiveness and efficiency, which results in increased productivity, depends on HRP

3. Human Resource Planning

To control employee cost

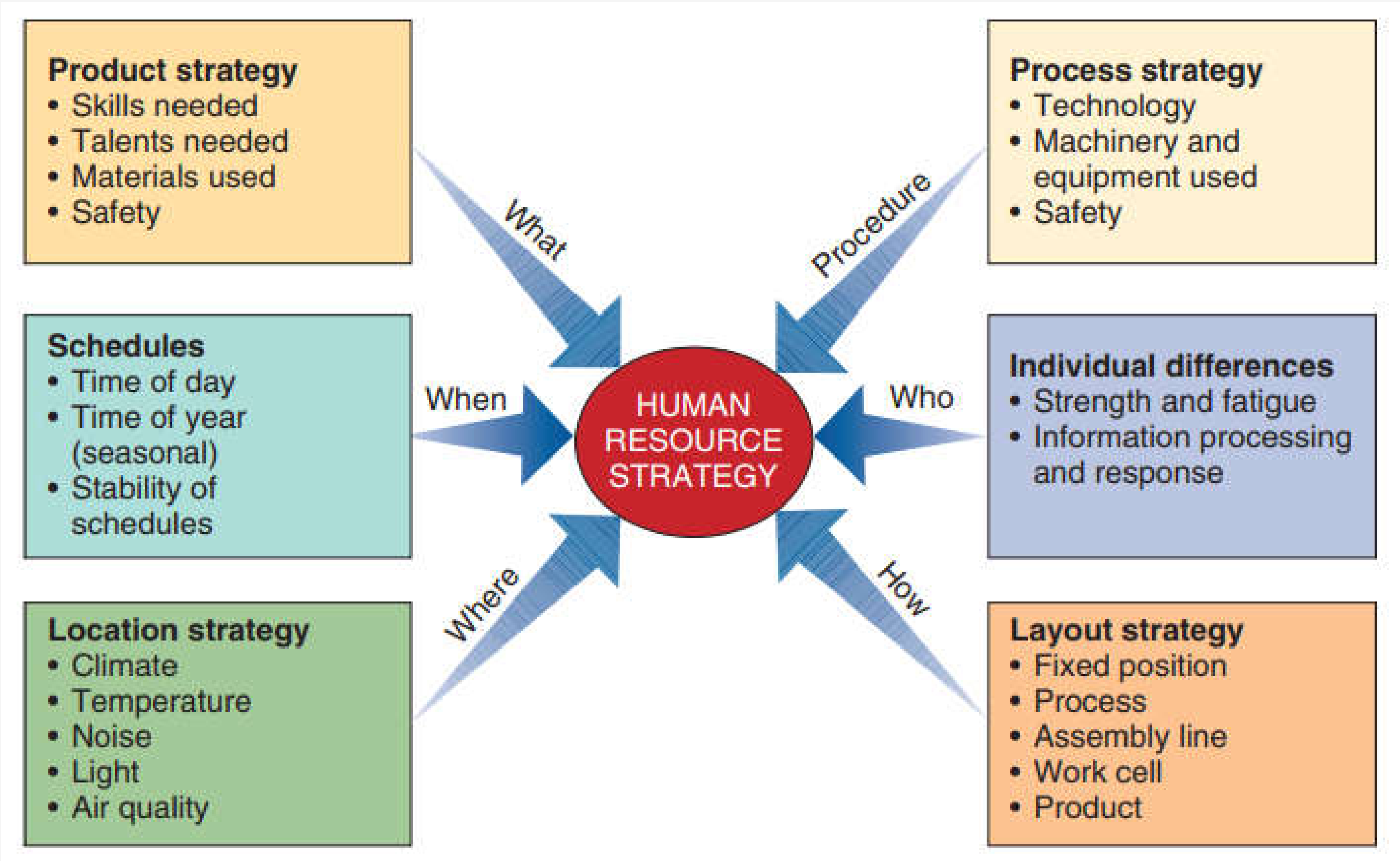
Through HRP it is possible to know in advance employee surpluses or shortages which may occur in future. Hence it is possible for the organization to get prepared in advance in order to prevent from occurring surpluses or shortage of employees.

3. Human Resource Planning

To develop high talent employees

Generally there is a scarcity of highly competent/ talented employees in the market. The lead time that is required to procure, train and develop such employees is long. Successful HRP provides an adequate lead time for the procurement, training and development of such employees.

3. Human Resource Planning



3. Human Resource Planning

Process of HRP

1. Forecast future demand for HR
2. Estimate HR supply
3. Compare forecast demand with estimated supply
4. Develop strategies to be taken
5. Assess HRP effort

Feedback

Process of HRP

1. Forecasting Demand for HR

Forecasting demand for human resources involves estimating the types and numbers of employees needed for future

Process of HRP

Factors affecting future demand for HR

- Demand for the product
- Goals and strategic plans of the organization
- Production methods
- Retirements
- Resignations
- Deaths
- Leave of absence
- Termination
- External factors

Process of HRP

2. Estimate HR supply

- Internal Supply

Internal supply consists of current employees who can be promoted and transferred to meet forecast needs or fill job vacancies which are in the staffing table.

- External supply

External supply consist of people who are working for other organizations in industries and job seekers who are unemployed. They are the people who are in the employee market.

Process of HRP

3. Compare forecast demand with estimated supply

Calculation of Net employee Requirement

Job No.	Job title	Forecast Demand	Estimated Supply	Net Employee Requirement
O03	Assistant Operation Manager	01	00	-01
O07	Production Supervisor	02	02	00
F01	Finance Manger	01	01	00
F05	Management Trainee (Fin)	01	00	-01
M04	Sales Engineer	07	02	-05
H03	HR executive	02	01	-01
A05	Driver	01	03	+02
---------------	-----------------------------	------------	----------------	------------------------
	Total	Xxx	Xxx	Xxx

Process of HRP

4. Develop strategies to be taken

Strategies in surplus conditions:

- Hiring freeze
- Attrition (Voluntary departures)
- Encouragement of leaves of absence
- Early retirement on voluntary basis
- Reduction of reward expenditure
- Lay off
- Formal outplacement facilities
- Termination

Process of HRP

- Have current employees work overtime
- Sub contract work to other firms
- Provide opportunities for learners for a period of time
- Hire part- time employees
- Hire casual employees
- Hire temporary employees
- Hire permanent full-time employees
- Capital substitution

Process of HRP

5. Assess HRP effort

HRP effort has to be assessed in order to determine its impact on accomplishing organizational goals and objectives.

4. Layout strategies

The Strategic Importance of Layout Decisions

Layout design must consider how to achieve the following:

- ❑ Higher utilization of space, equipment, and people
- ❑ Improved flow of information, materials, and people
- ❑ Improved employee morale and safer working conditions
- ❑ Improved customer/client interaction
- ❑ Flexibility (whatever the layout is now, it will need to change)

4. Layout strategies

Types of Layout

1. Office layout
2. Retail layout
3. Warehouse layout
4. Fixed-position layout
5. Process-oriented layout
6. Work-cell layout
7. Product-oriented layout

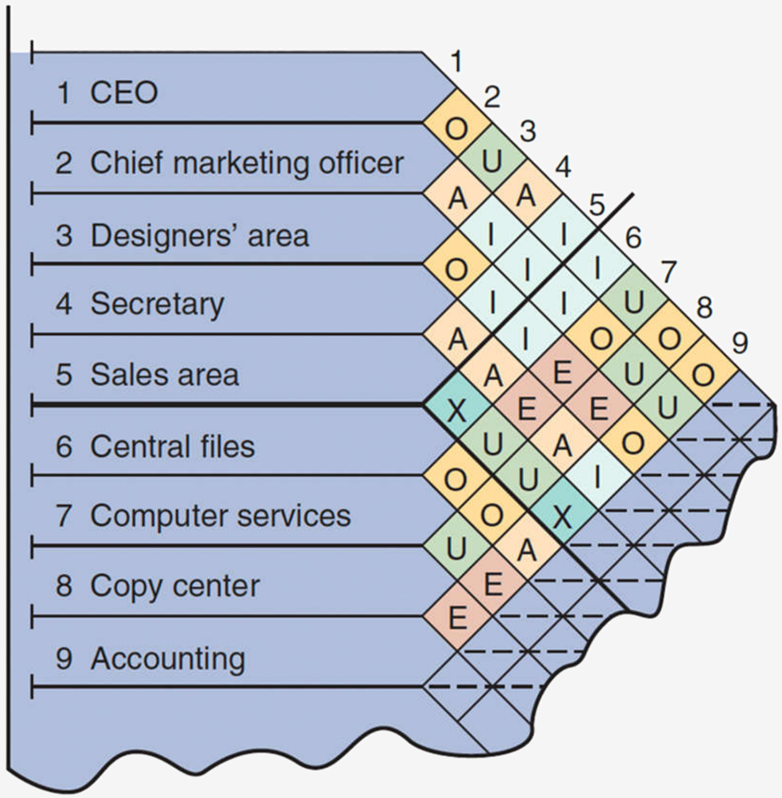
Office Layout

Positions workers, their equipment, and spaces/offices to provide for movement of information

- Grouping of workers, their equipment, and spaces to provide comfort, safety, and movement of information
- Movement of information is main distinction
- Typically in state of flux due to frequent technological changes

Office Layout

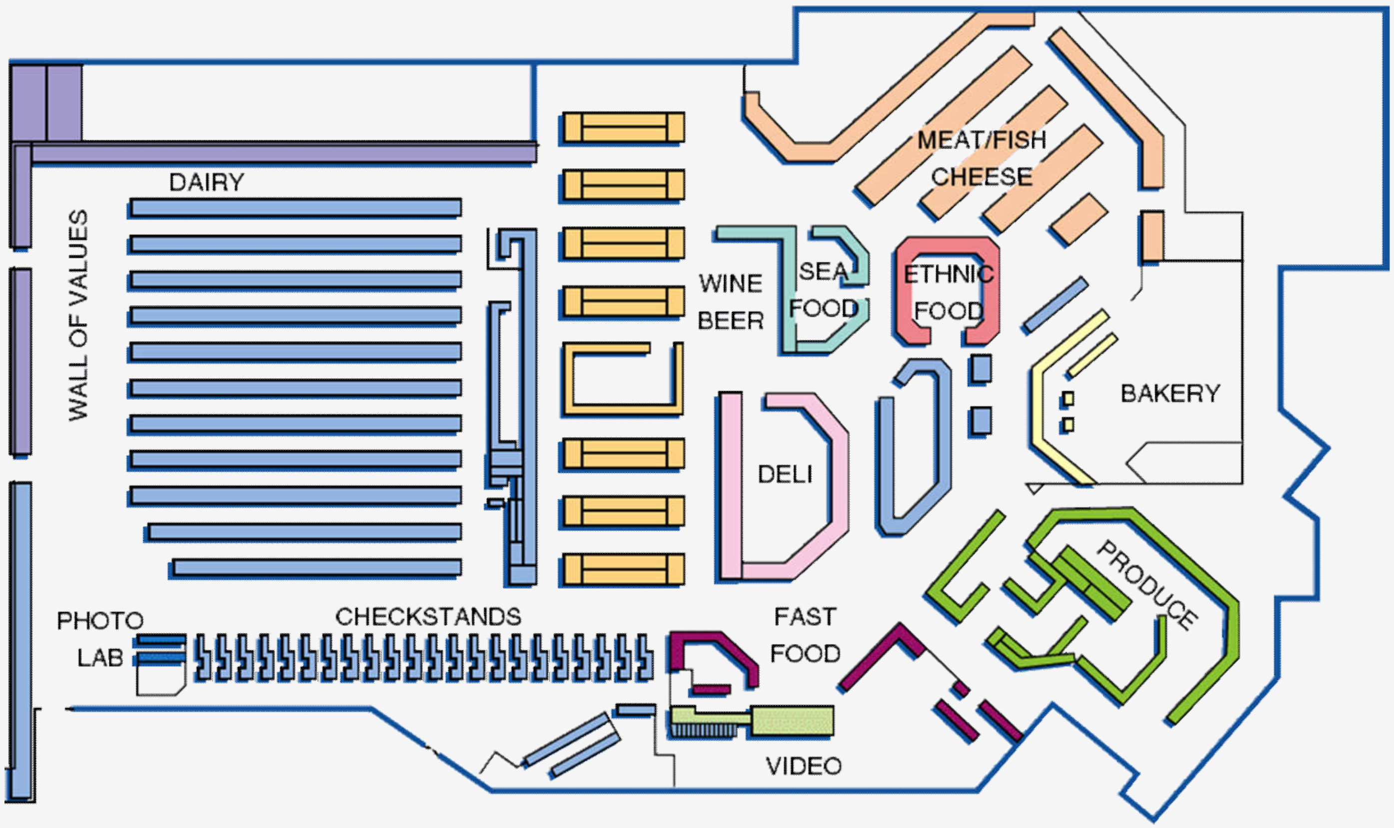
Relationship Chart



Value	CLOSENESS
A	Absolutely necessary
E	Especially important
I	Important
O	Ordinary OK
U	Unimportant
X	Not desirable

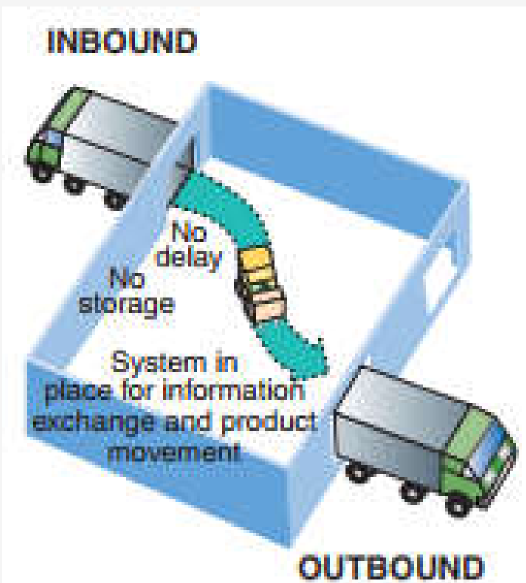
Retail Layout

- Objective is to maximize profitability per square foot of floor space
- Sales and profitability vary directly with customer exposure



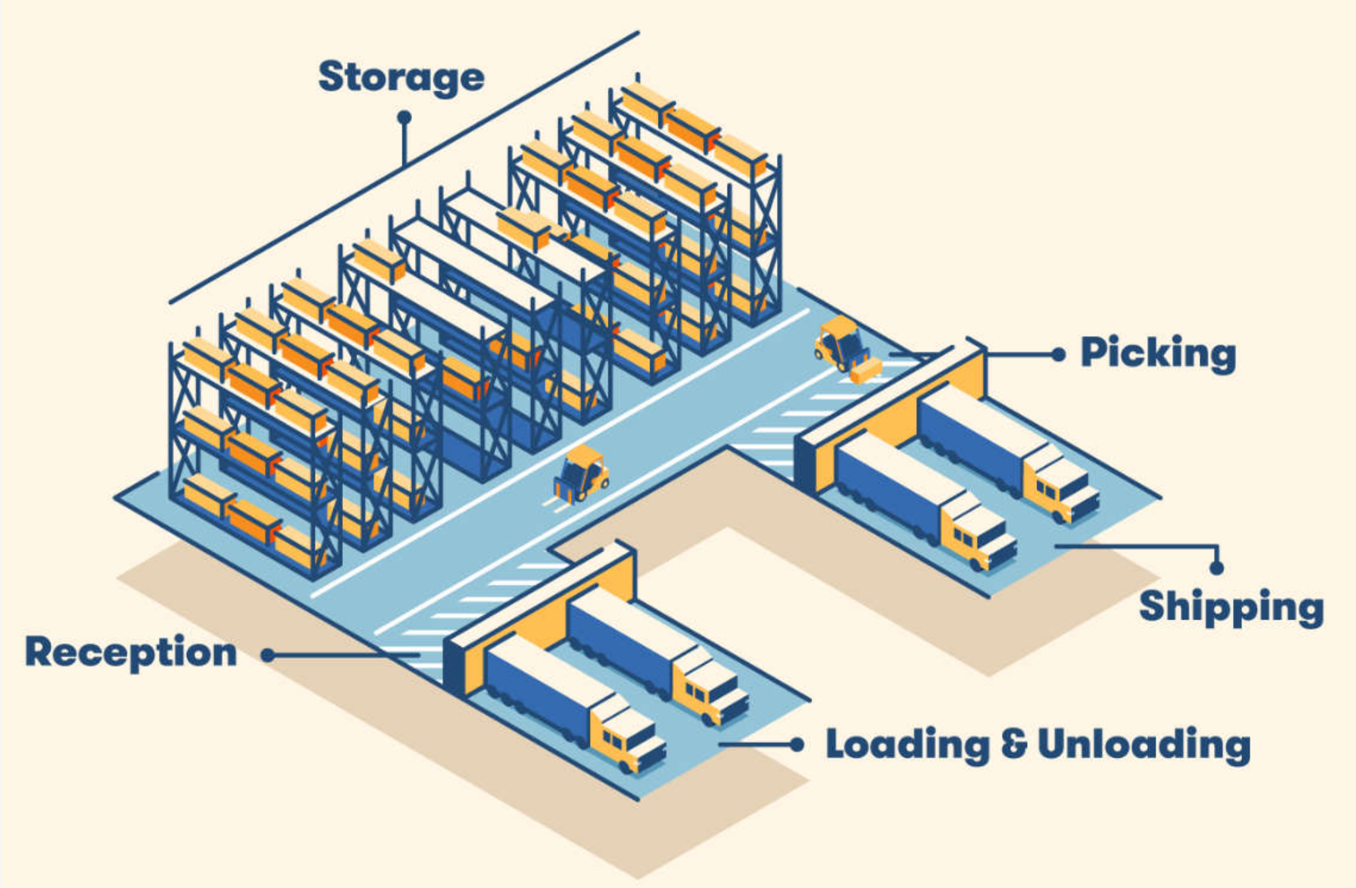
Warehouse and Storage Layouts

- Objective is to optimize trade-offs between handling costs and costs associated with warehouse space



- Maximize the total “cube” of the warehouse – utilize its full volume while maintaining low material handling costs

Warehouse and Storage Layouts



Fixed-Position Layout

Some manufacturing and construction plants use this type of layout, by arranging work to locate products in fixed locations and transport workers, materials, machinery, and other items to the site. product manufacturing sector.

Example 10: Airplane carriers, missiles, ships, road and bridge construction...

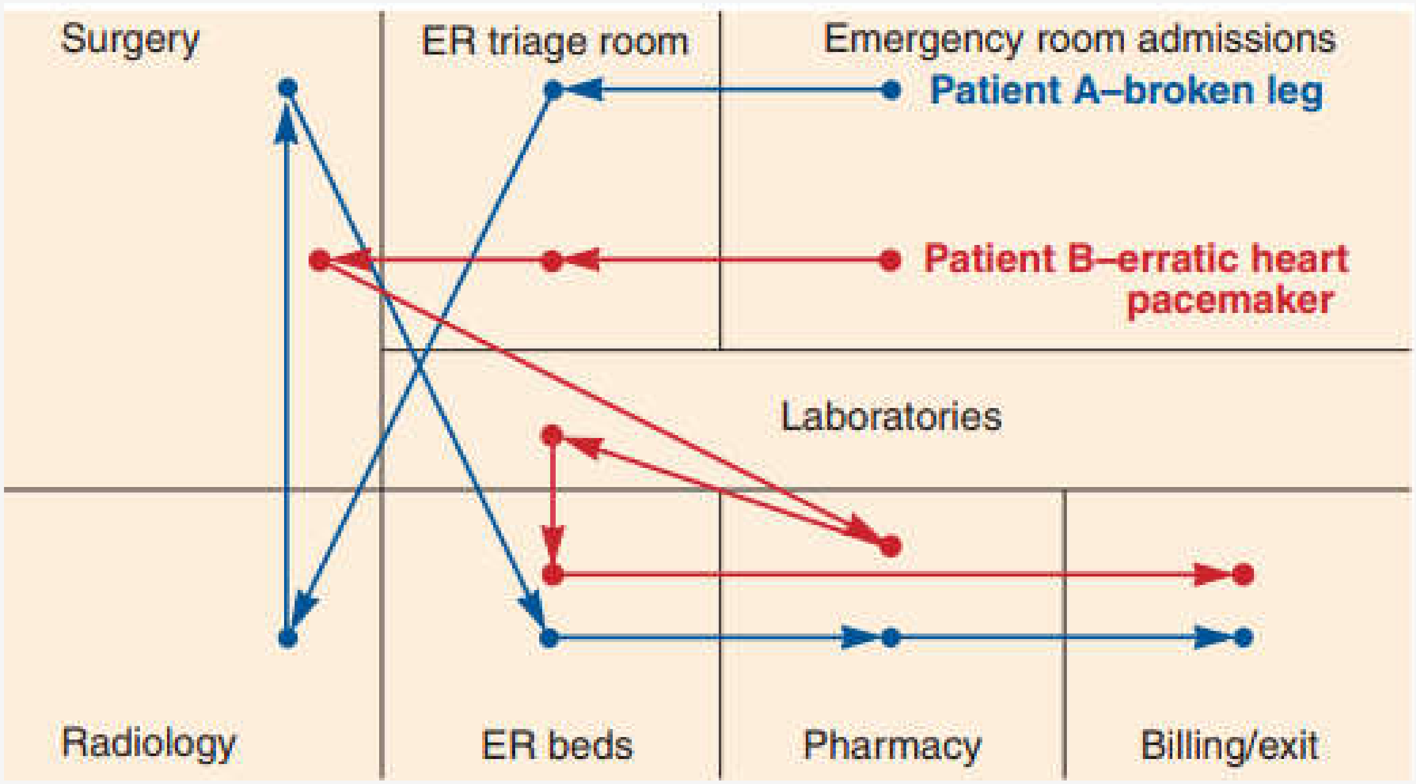
This type of layout is applied when the product is very bulky, heavy, and easily damaged. The goal of manufacturers is to minimize shipping volume.

Process-oriented layout

To conduct design according to the process, it is necessary to collect and analyze the following main information:

- The purpose of the production layout set by the enterprise
- The list, location, and size of parts, workplaces, and factories need to be arranged
- Determine the relationship between parts
- Projected future jobs across workplaces
- Distance between locations and cost per unit of distance to move product between departments
- List of special elements such as heavy equipment and foundation structural requirements.
- Total investment capital for production arrangement

Process-oriented layout



Process-oriented layout

Quantitative method (Minimize cost or travel distance)

Important criteria for design are transportation costs or distance between parts. The total cost of shipping the product is quantified according to the formula

$$\text{Minimize cost} = \sum_{i=1}^{n} \sum_{j=1}^{n} X_{ij} C_{ij}$$

Where
n = total number of work centers or departments
i, j = individual departments
X_{ij} = number of loads moved from department i to department j
C_{ij} = cost to move a load between department i and department j

Process-oriented layout

Methods of implementation

- Determine the initial trial layout plan for businesses that need a new layout
- Improve to have a better plan (use the plan as the initial trial solution
- Apply the above formula to calculate the total cost for the initial or current solution
- Improve the original solution to form a new layout plan. Calculate the total cost of this layout and compare it with the original plan.

Process-oriented layout

Exercise 11: A workshop with premises 18m long and 12m wide is arranged into 6 parts of equal size and 6mx6m according to the following diagram.

I	II	III
IV	V	VI

- Transportation cost of 1 unit of goods between 2 adjacent departments - 1 USD
- Shipping cost of 1 unit of goods between 2 non-adjacent departments - 2 USD
- The volume of goods transported between departments is given in the following table

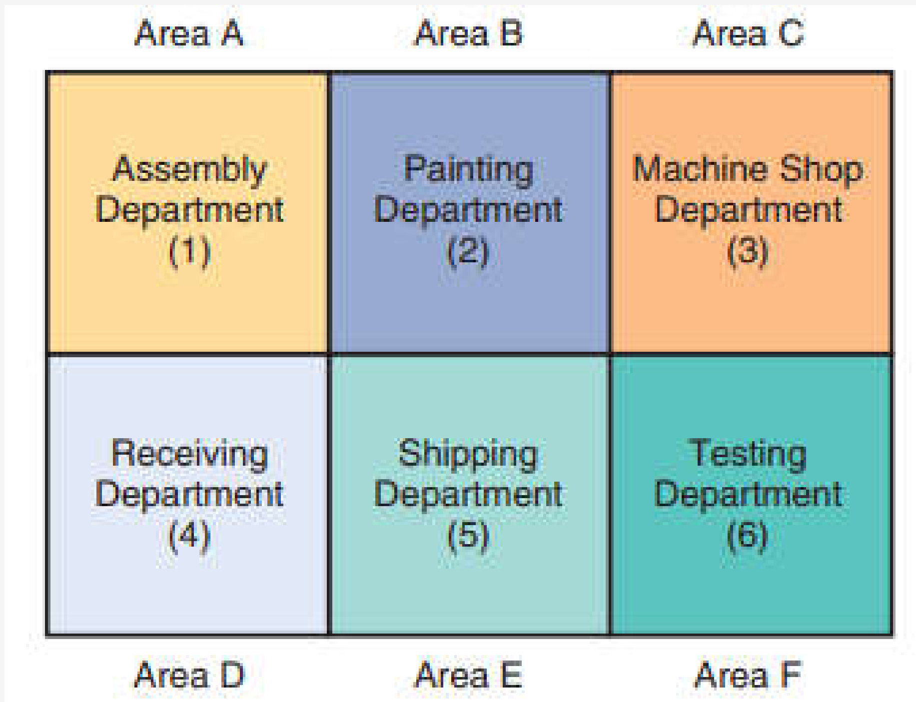
Number of loads per week

Department	Assembly (1)	Painting (2)	Machine Shop (3)	Receiving (4)	Shipping (5)	Testing (6)
Assembly (1)		50	100	0	0	20
Painting (2)			30	50	10	0
Machine Shop (3)				20	0	100
Receiving (4)					50	0
Shipping (5)						0
Testing (6)						

Consider whether the arrangement of parts is reasonable.

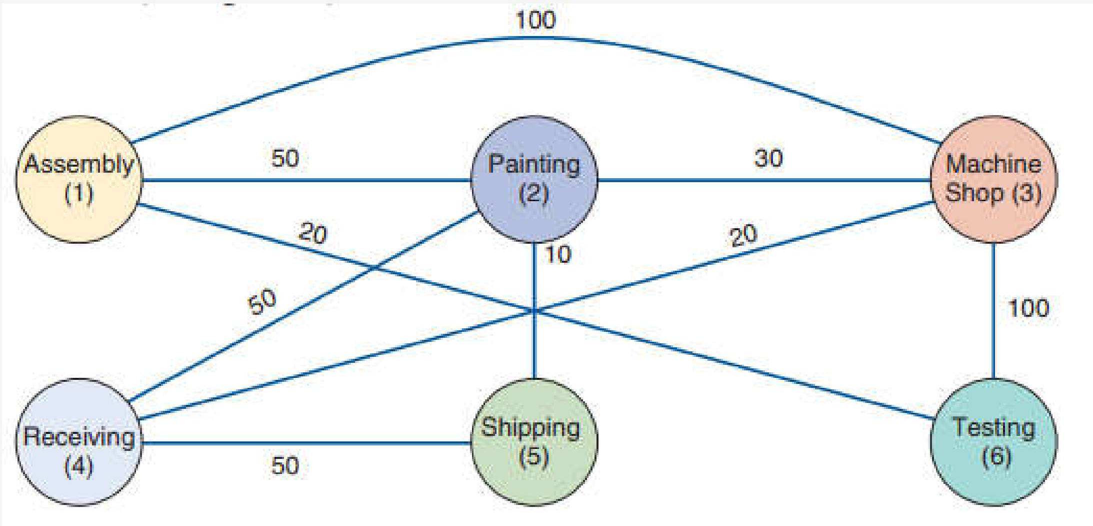
Solution

- Determine the space requirements for each department



Solution

- Develop an initial schematic diagram

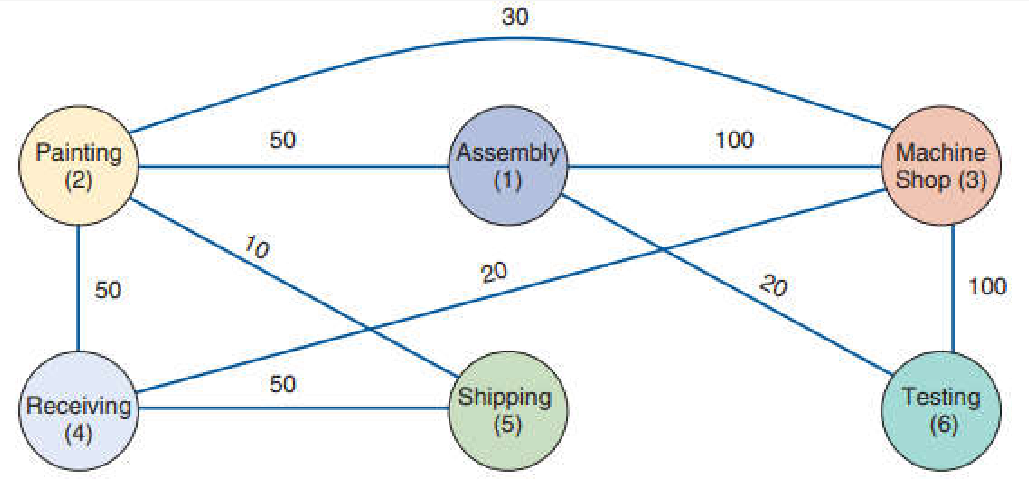


- Determine the cost of this layout

$$Cost(1) = (50x1) + (100x2) + (20x2) + (30x1) + (50x1) + (10x1) + (20x2) + (100x1) + (50x1) = 570 \text{ USD}$$

Solution

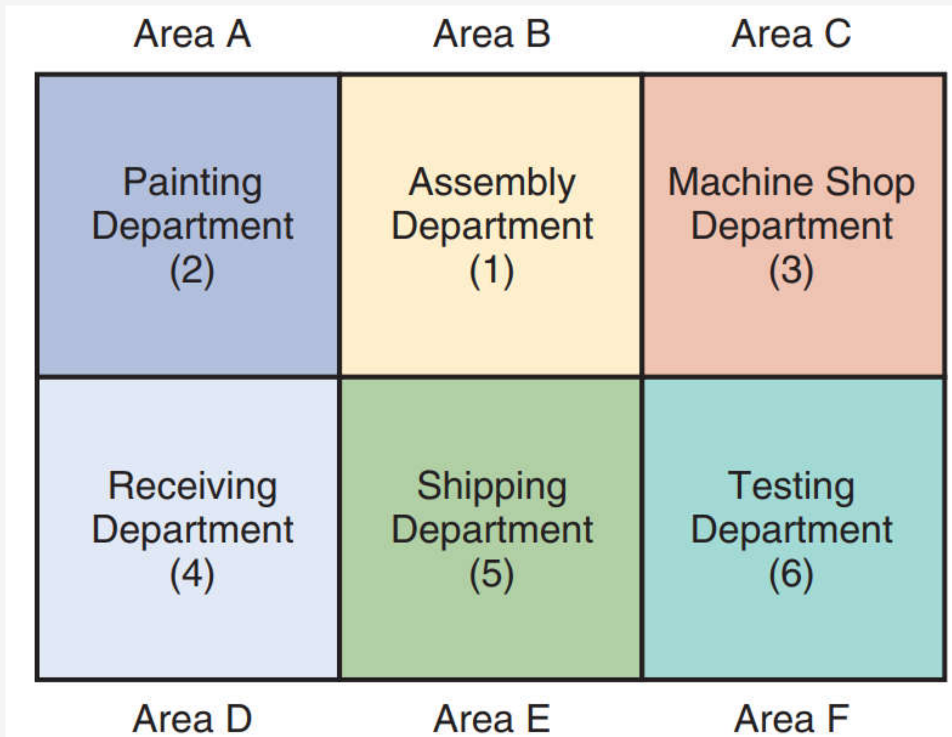
- Try to improve the layout



$$Cost(2) = (50x1) + (100x1) + (20x1) + (30x2) + (50x1) + (10x1) + (20x2) + (100x1) + (50x1) = 480 \text{ USD}$$

Solution

- Prepare a detailed plan



Work Cell

An arrangement of machines and personnel that focuses on making a single product or family of related products.

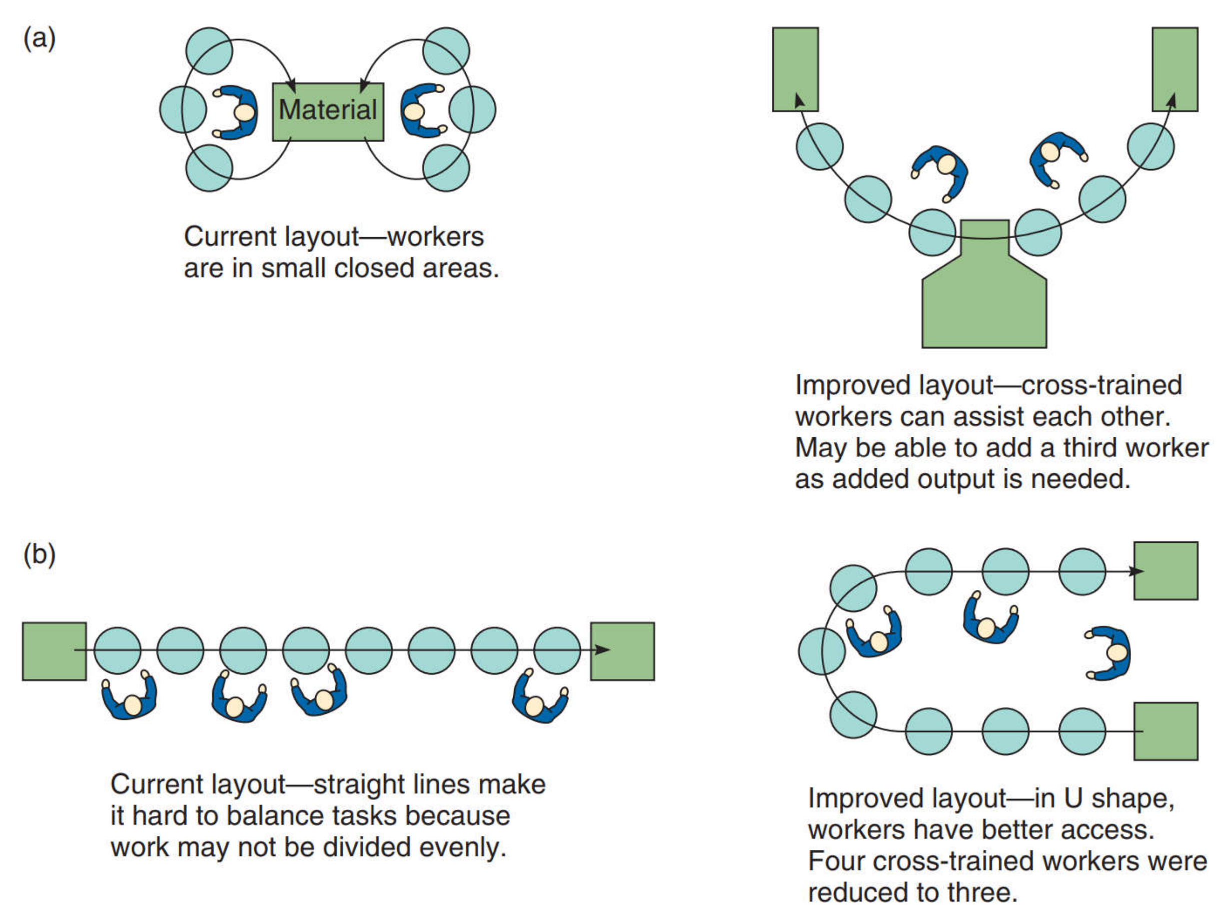
1. *Reduced work-in-process inventory*
2. *Less floor space*
3. *Reduced raw material and finished goods inventories*
4. *Reduced direct labor cost*
5. *Heightened sense of employee*
6. *Increased equipment and machinery utilization*
7. *Reduced investment in machinery and equipment*

Work Cell

Requirements of Work Cells

- Identification of families of products
- A high level of training, flexibility and empowerment of employees
- Being self-contained, with its own equipment and resources
- Test (poka-yoke) at each station in the cell

Work Cell



(a)
Material
Current layout—workers are in small closed areas.
Improved layout—cross-trained workers can assist each other. May be able to add a third worker as added output is needed.
(b)
Current layout—straight lines make it hard to balance tasks because work may not be divided evenly.
Improved layout—in U shape, workers have better access. Four cross-trained workers were reduced to three.

Work Cell

Staffing and Balancing Work Cells

- Once the work cell has the appropriate equipment located in the proper sequence, the next task is to staff and balance the cell. Efficient production in a work cell requires appropriate staffing.
- This involves two steps. First, determine the takt time, 2 which is the pace (frequency) of production units necessary (time per unit) to meet customer orders:
- **Takt time** = Total work time available/Units required to satisfy customer demand
  Second, determine the number of operators required. This requires dividing the total operation time in the work cell by the takt time:
  Workers required = *Total operation time required/Takt time*

Work Cell

Exercise 12:

Stephen Hall's company in Dayton makes auto mirrors. The major customer is the Honda plant nearby. Honda expects 600 mirrors delivered daily, and the work cell producing the mirrors is scheduled for 8 hours. Hall wants to determine the takt time and the number of workers required.

Work Cell

SOLUTION

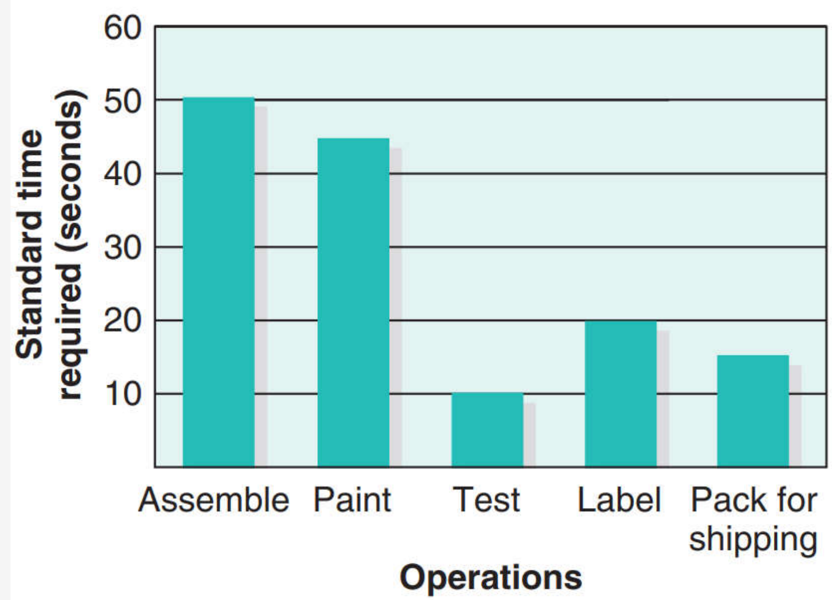
Takt time = (8 hours × 60 minutes)/600 units= 480/600 = 0.8 minute = 48 seconds

Therefore, the customer requirement is one mirror every 48 seconds.

The work balance chart in Figure shows that 5 operations are necessary, for a total operation time of 140 seconds:

Workers required = Total operation time required/Takt time

=(50+45 + 10 +20 + 15)/48 = 140/48= 2.92



To produce one unit every 48 seconds will require 2.92 people. With three operators this work cell will be producing one unit each 46.67 seconds (140 seconds/3 employees = 46.67) and 617 units per day (480 minutes available × 60 seconds/46.67 seconds for each unit = 617).

Product-oriented layout

Product-oriented layouts are organized around products or families of similar high-volume, low-variety products

The assumptions are that:

1. Volume is adequate for high equipment utilization
2. Product demand is stable enough to justify high investment in specialized equipment
3. Product is standardized or approaching a phase of its life cycle that justifies investment in specialized equipment
4. Supplies of raw materials and components are adequate and of uniform quality (adequately standardized) to ensure that they will work with the specialized equipment

Product-oriented layout

Two types of a product-oriented layout are *fabrication* and *assembly lines*

Product-oriented layout

The main advantages of product-oriented layout are:

1. The low variable cost per unit usually associated with high-volume, standardized products

2. Low material-handling costs

3. Reduced work-in-process inventories

4. Easier training and supervision

5. Rapid throughput

Product-oriented layout

The disadvantages of product layout are:

1. The high volume required because of the large investment needed to establish the process

2. Work stoppage at any one point can tie up the whole operation

3. The process flexibility necessary for a variety of products and production rates can be a challenge

Product-oriented layout

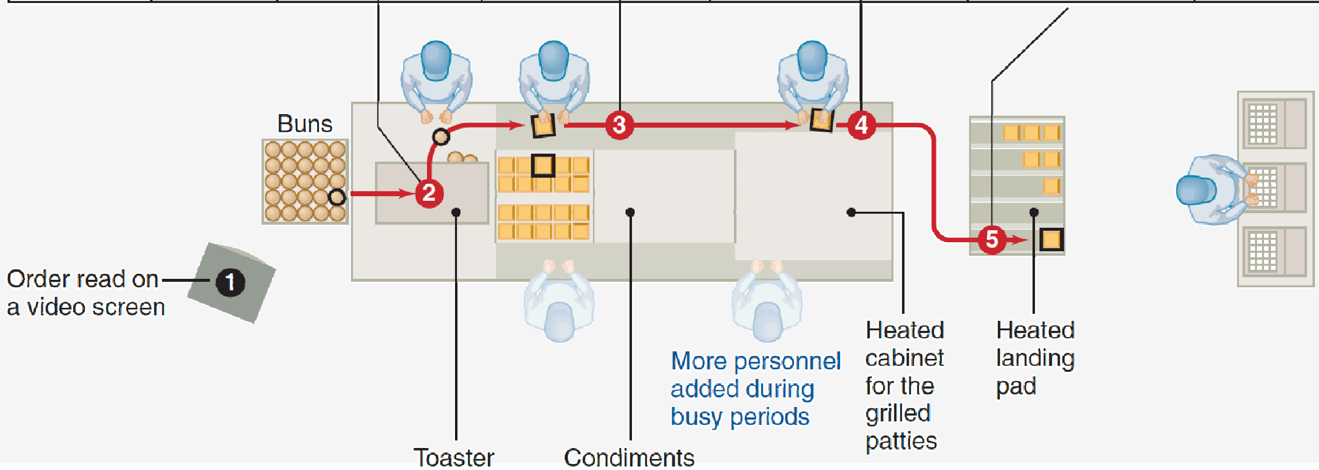
Assembly-Line Balancing

Line balancing is usually undertaken to minimize imbalance between machines or personnel while meeting a required output from the line

McDonald's

Assembly Line

Elapsed time	0:00	0:11	0:31	0:45		1:30
Task time (seconds)		11	20	14	0	45
Task	1. Order	2. Bun toasting	3. Assembly with condiments	4. Wrapping of patty with bun	5. Order picked up immediately to keep it fresh	6 Customer service (order and payment)



Product-oriented layout

Production line

Product-oriented layout

Principles of Equipment Arrangement in the Workshop

- ❑ Floor Arrangement: Arrange the line on one or multiple floors based on raw materials.
- ❑ Reduce types of transportation equipment.
- ❑ Spacing: Ensure adequate distance between devices and walls for operation, repair, and replacement.
- ❑ Cluster Similar Devices: Place devices with the same function together.

Product-oriented layout

- Grounding: All equipment must have a grounding system to avoid electrical build-up.
- Stair Safety: Stairs must have handrails; multi-story buildings need emergency stairs.
- Cover Moving Parts: Carefully cover moving parts of machines and equipment.
- Positioning by Weight: Heavy, vibrating machinery on the lower floor; light machines on the upper floor; tall machines in the middle; low machines near doors for ventilation and light.

Product-oriented layout

- Ventilation for Hot Equipment: Separate hot, dusty, and toxic equipment with walls or ensure good ventilation.
- Pressure Equipment Safety: Must have pressure gauges and safety valves.
- Observation Windows: Arrange observation windows facing out.
- Control System Height: Place control systems and levers at hand level (0.8-1.2m).
- Walkway Clearance: Maintain adequate distances for vertical and horizontal walkways, avoiding accidents and facilitating equipment replacement.

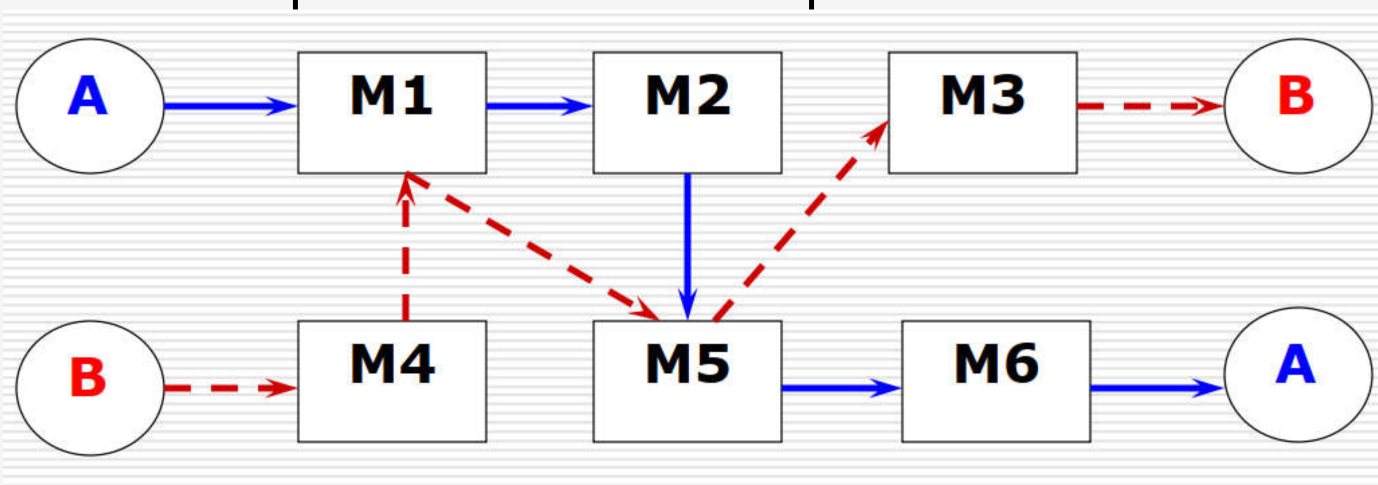
Product-oriented layout

- Minimum distance between two large devices: 1.8m (preferably 3-4m).
- Clear distance between rows of machines: over 1.8m (over 3m if vehicles pass through).
- Walking path: about 0.8-1m.
- Sunken Equipment: Deeply placed equipment like containers must have tight lids or walls 0.8m above the floor.
- Wall Clearance: Production lines must be at least 1.6m from the wall; input devices 2-3m from the wall.

Product-oriented layout

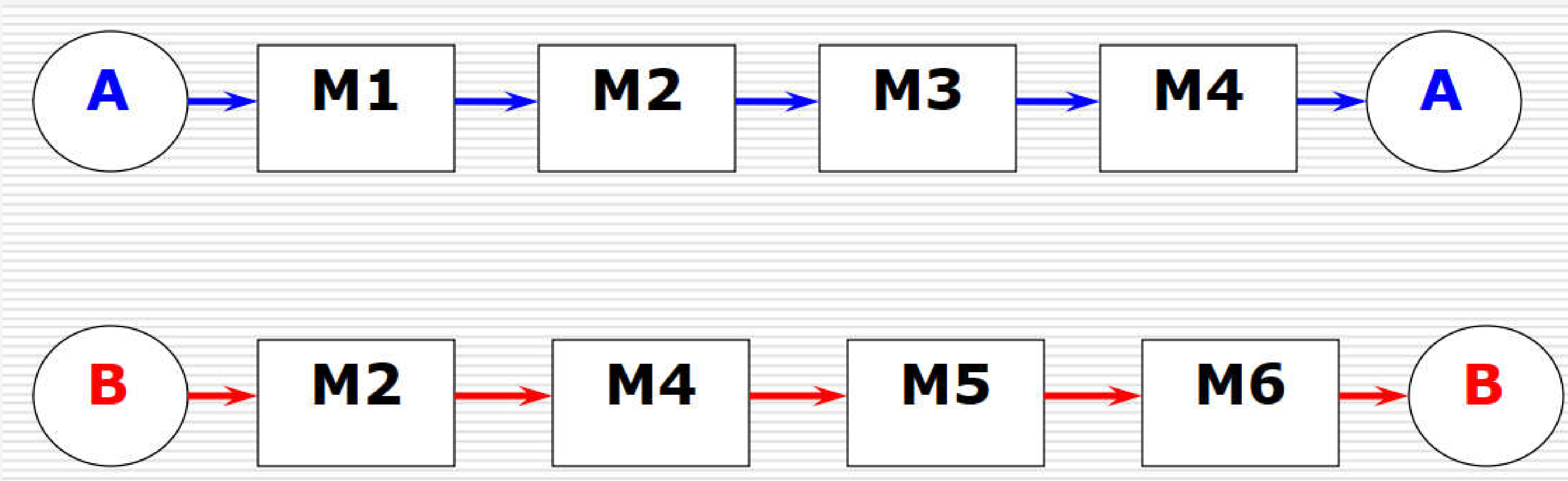
Types of layouts

- Arrange the premises according to the process
- Machines and jobs are grouped by function
- Products are moved from one work area to another depending on the individual requirements of each product



Product-oriented layout

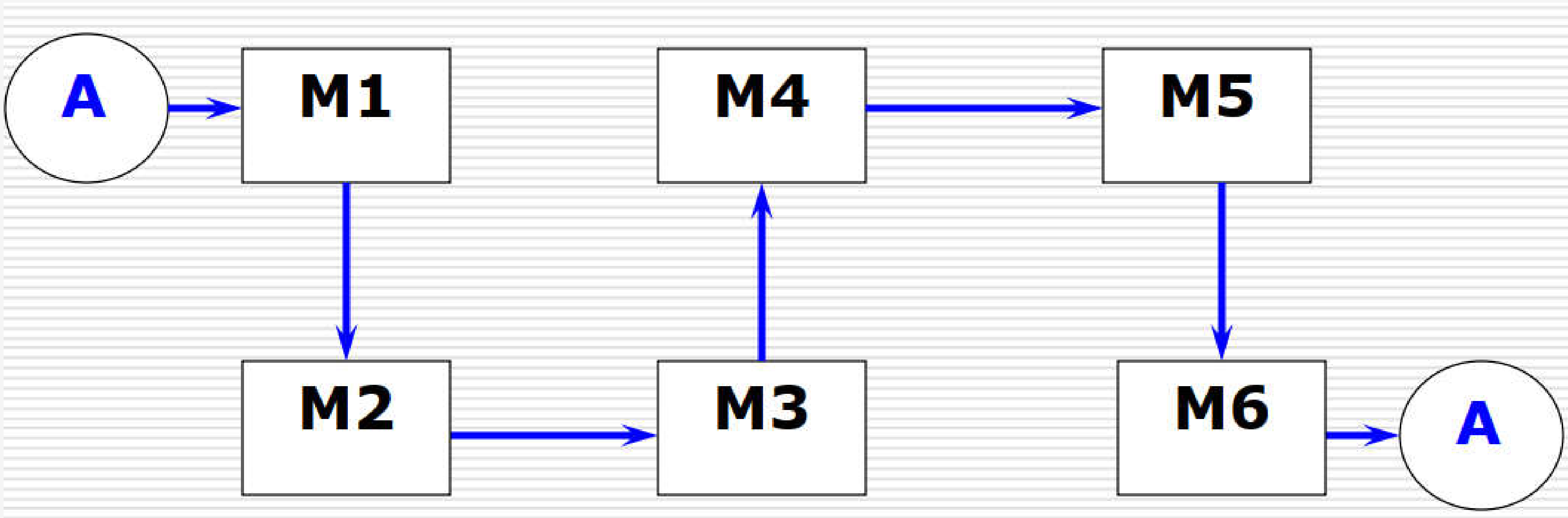
Straight line form



Applicable to short production lines with few equipment

Product-oriented layout

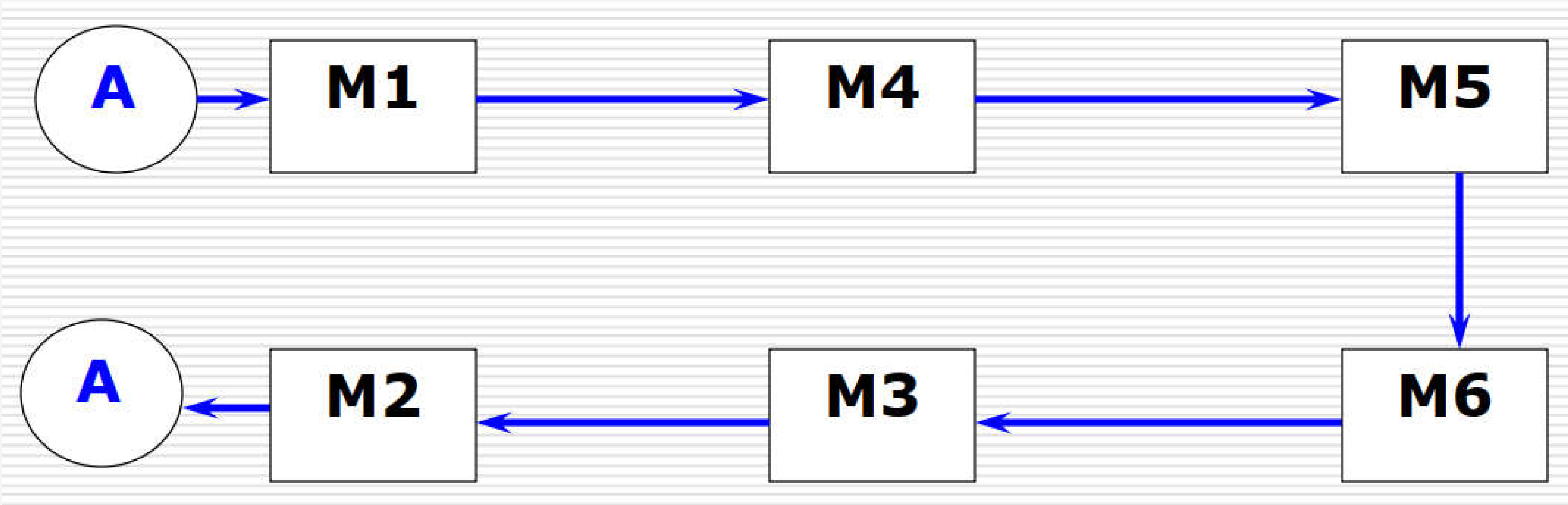
Zig-zag form



Applicable to longer production lines

Product-oriented layout

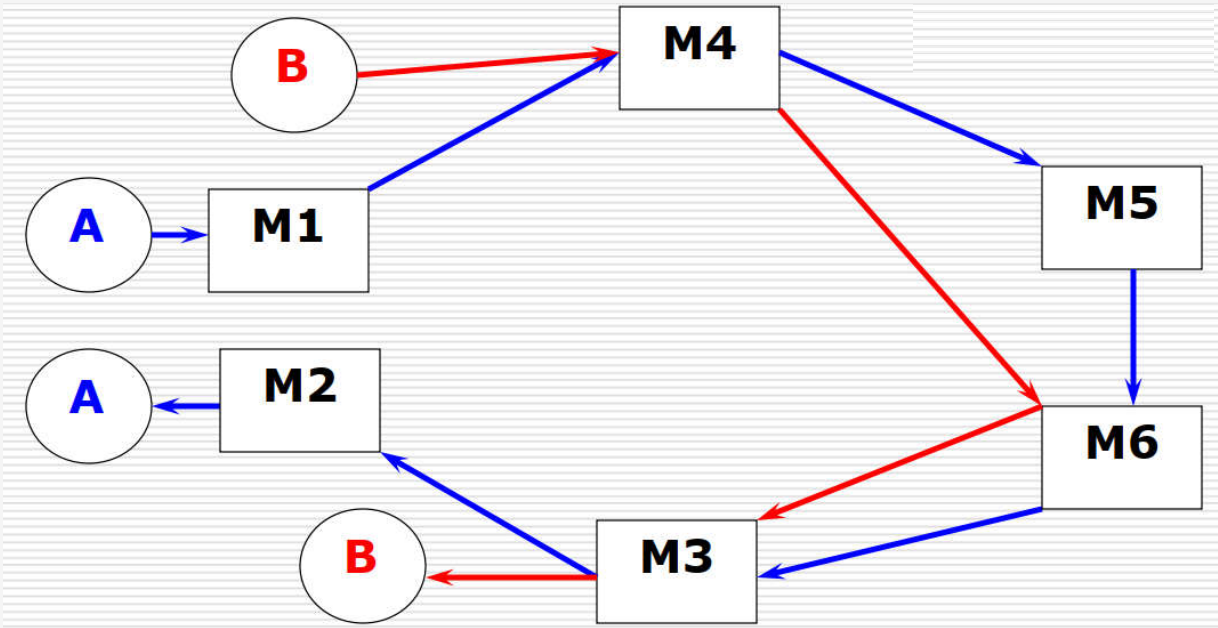
U-shaped



Applicable to longer lines, raw materials, and finished products enter and exit at the same place

Product-oriented layout

Round shape



Applicable to longer lines, raw materials, and finished products enter and exit at the same place

Product-oriented layout

This process involves three steps:

1. Take the units required (demand or production rate) per day and divide them into the productive time available per day (in minutes or seconds)

$$\text{Cycle time} = \frac{\text{Production time available per day}}{\text{Units required per day}}$$

Product-oriented layout

2. Calculate the theoretical minimum number of workstations

$$\text{Minimum number of workstations} = \frac{\sum_{i=1}^{n} \text{Time for task i}}{\text{Cycle time}}$$

where n is the number of assembly tasks

Product-oriented layout

3. Balance the line by assigning specific assembly tasks to each workstation

a. Identify a master list of tasks.

b. Eliminate those tasks that have been assigned.

c. Eliminate those tasks whose precedence relationship has not been satisfied.

d. Eliminate those tasks for which inadequate time is available at the workstation.

e. Line balancing

Product-oriented layout

The five choices

- Longest task time,
- Most following tasks,
- Ranked positional weight,
- Shortest task time
- Least number of following tasks

Product-oriented layout

4. Efficiency

- The first measure computes the *efficiency* of a line balance (machinery, equipment or labor)

$$\text{Efficiency} = \frac{\sum \text{Task times}}{(\text{Actual number of workstation}) \text{ x } (\text{Largest assigned cycle time})}$$

- The second measure computes the idle time for the line

Idle time = (Actual number of workstations × Largest assigned cycle time)-∑Task times

Product-oriented layout

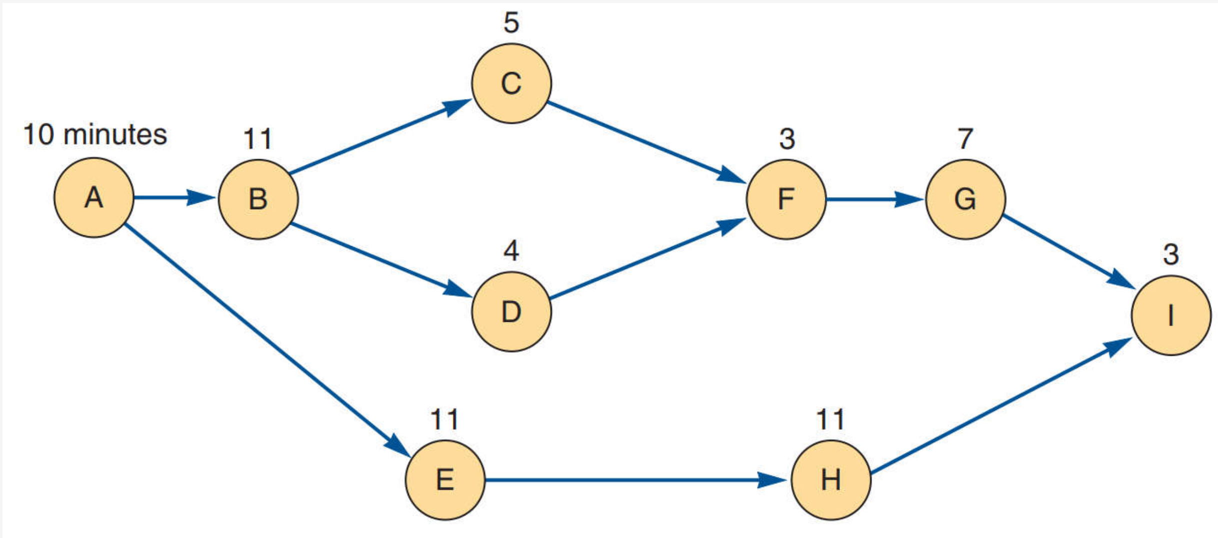
Example 13: The time to complete the assembly of product X is 65 minutes. Jobs have time and order of execution according to the following table

Task	Assembly time (minutes)	Task must follow task listed below
A	10	
B	11	After A
C	5	After B
D	4	After B
E	11	After A
F	3	After C,D
G	7	After E
H	11	After F
I	3	After G,H
Total time	65	

Required capacity: 40 products/day
Working time: 8 hours/day
Please arrange the premises to assemble 40 products/day.

Solution

Precedence diagram



$$\text{Cycle time} = \frac{8 \text{ hour x } 60 \text{ minutes}}{40 \text{ units}} = 12 \text{ minutes/unit}$$

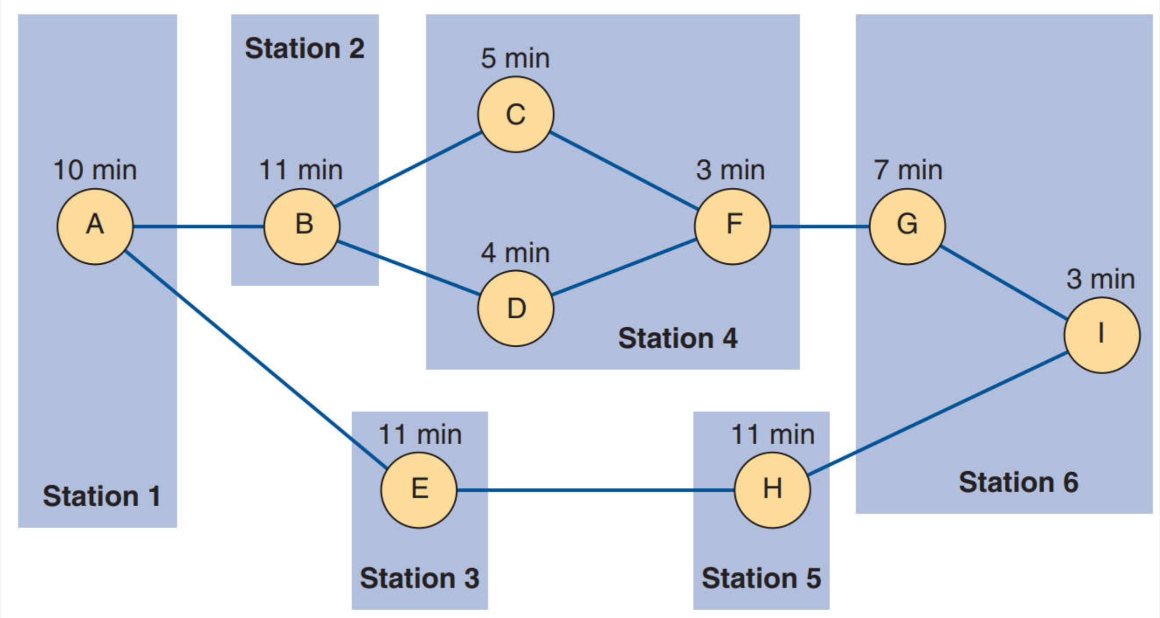
Solution

- Minimum number of workstation (N_{min})

$$\text{Minimum number of workstations} = \frac{\text{Total task time}}{\text{Cycle time}} = \frac{65}{12} = 5,42 \approx 6 \text{ station}$$

- Efficiency

$$E = \frac{65}{6x12} x100 = 90,3\%$$



Solution

- Idle time of each workstation:

Workstation	Task	Assembly time (minutes)	Total assembly time (minutes)	Cycle time	Idle time (minutes)
1	A	10	10	12	2
2	B	11	11	12	1
3	C	5	5	12	7
3	D	4	9	12	3
3	F	3	12	12	0
4	E	11	11	12	1
5	G	7	7	12	5
5	I	3	10	12	2
6	H	11	11	12	1

- Summary

Workstation	1	2	3	4	5	6
Task	A	B	C,D,F	E	G,I	H
Idle time	2	1	0	1	2	1

Thank you!