

Operations and Supply Management



REPRESENTATIVE CONTENT SAMPLE

Study Map

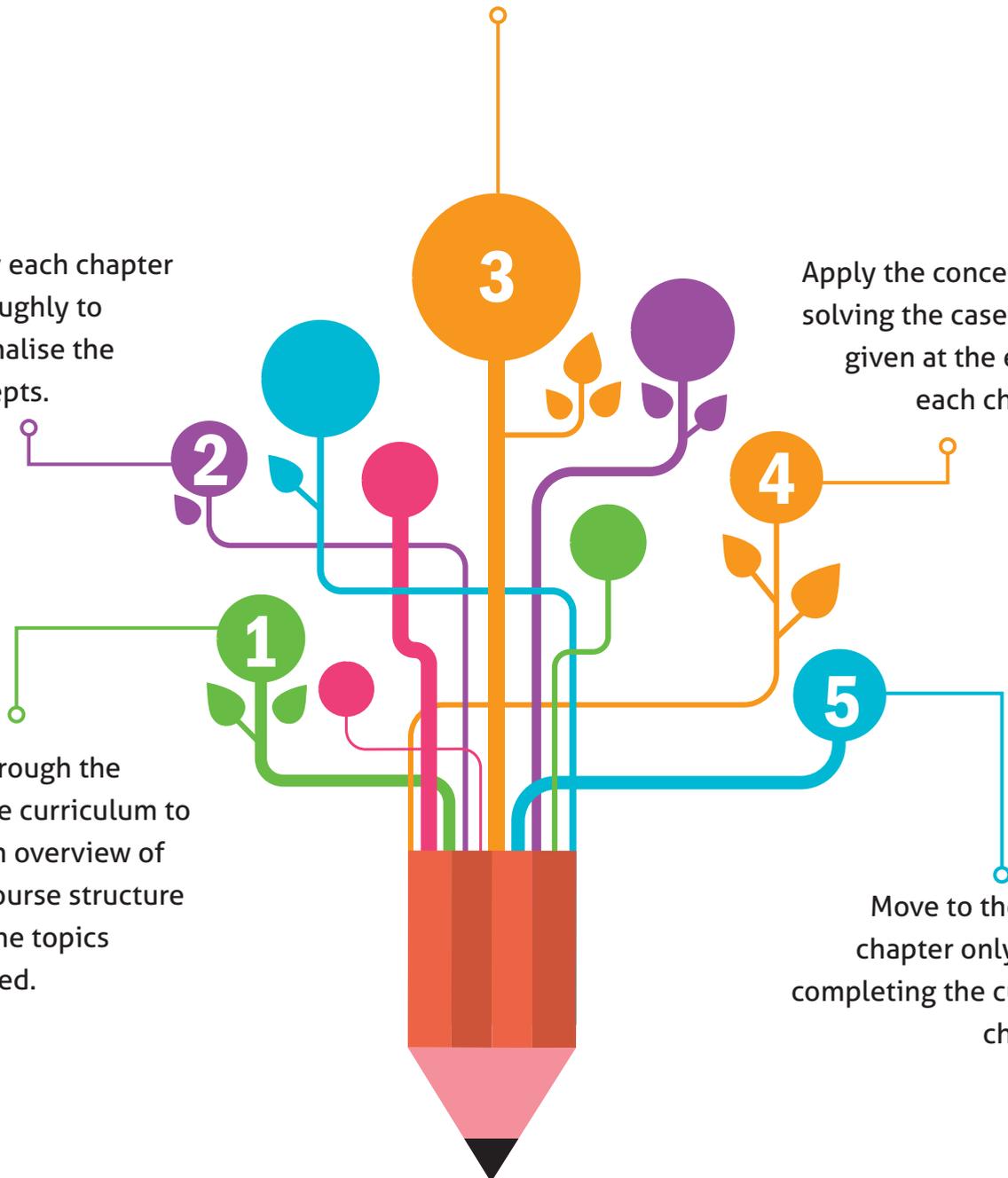
Assess your learning
by attempting
exercises and activities
given in each chapter.

Study each chapter
thoroughly to
internalise the
concepts.

Apply the concepts by
solving the case study
given at the end of
each chapter.

Go through the
course curriculum to
get an overview of
the course structure
and the topics
covered.

Move to the next
chapter only after
completing the current
chapter.



FACILITY LOCATION AND LAYOUT

Structure

Learning Objectives

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 - 3.1.2 Factors Affecting Facility Location Decisions
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LEARNING OBJECTIVES

After studying this chapter, you will be able to:

- ▶▶ Explain the concept of facility location
- ▶▶ Discuss factors affecting facility location decisions
- ▶▶ Explain the procedures and techniques for selecting facility location
- ▶▶ Explain the concept of facility layout
- ▶▶ List the types of facility layouts
- ▶▶ Describe service facility layouts



Introduction

In the previous chapter, you studied product and process design and how product development process takes place in any organisation. A process is a group of related tasks with specific inputs and outputs. No product/service can be made without a process and no process can exist without at least one product/service. In other words, a product is the final output of a process.

For a manufacturer, a product is a result of various processes or operations. It is the manufacturer who determines processes and operations which are deployed to create the product. Thus, processes depict an organisation's overall approach to physically produce products and services.

In this chapter, let us discuss in detail about Facility location and layout. Facility location determines where a facility (plant) should be located for maximum effectiveness of various processes and operations. Selecting a location for a facility is one of the biggest challenges faced by an organisation. This is because a facility can provide a competitive advantage by enabling and leveraging the latest process concepts. Facilities affect both quality and productivity as they determine how much and how fast goods can be produced, how efficiently workers can perform, how difficult it is to automate a system, and how responsive is the system to the changes in the product/service design or demand quantity. Therefore, it is important for an organisation to conduct thorough planning before selecting a facility location.

Selecting a suitable location ensures consistent supply of raw materials and labour, proper utilisation of production capacity, and reduction in production and operations costs. An ideal facility location may not, by itself, guarantee success, but it certainly contributes to the smooth and efficient functioning of an organisation. A poor location of the facility, on the other hand, may lead to huge financial losses for the organisation. Hence, it is essential to exercise utmost care while selecting a facility location. Once a mistake is made in selecting a facility location, it becomes extremely difficult and costly to correct it, especially in the case of large facilities.

Apart from a location, an effective facility layout is another factor that contributes to production efficiency. A facility layout is all about the arrangement of activities, processes, departments, workstations, aisles, storage areas and common areas within a facility in a way that helps maintain a quick flow of materials at the minimum handling cost. Hence, you can say that a facility should be properly laid out. A well-designed facility layout helps an organisation to make efficient utilisation of available floor space and labour, reduce accidents, and enhance its productivity.

In this chapter, you will study the concept of facility location and the factors affecting it. You will also understand the procedures and techniques for selecting a facility location. Next, the chapter will explain the concept and objectives of a facility layout. The chapter will also acquaint you with different types of facility layouts and the process of designing such layouts. At the end, you will study different service facility layouts.

3.1 Concept of Facility Location

Facility location may be defined as a place where the facility will be set up for producing goods or services. The need for location selection may arise under any of the following conditions:

- a. When a business is newly started.
- b. When the existing business unit has outgrown its original facilities and expansion is not possible; hence a new location has to be found.
- c. When the volume of business or the extent of market necessitates the establishment of branches.
- d. When the lease expires and the landlord does not renew the lease.
- e. Other social or economic reasons such as inadequate labour supply, shifting of the market, etc.

Regardless of the reason, while selecting a new facility location, an organisation has to take some interrelated decisions, such as the scale of operation, the technology to be adopted, and the location of the facility. This is because selecting a suitable location is important as it decides the fate of a business. A good location may reduce the cost of production and distribution to a considerable extent. For example, the cost of procuring raw materials would be lesser for an organisation located near the sources of raw materials as compared to that of an organisation located at a distant place. Similarly, an organisation that is located near the market would be able to launch its products in the market more quickly than an organisation located in a remote area. Reduction in the cost of production and distribution helps in improving the competitive strength or profit margin of the business.

Identifying a suitable location for a business is critical to any organisation as it involves the investment of a large sum of money. Any inaccuracy in the selection of a facility location may lead to huge losses for an organisation. Once established, the location cannot be changed frequently as it incurs huge costs. Therefore, it is important for the organisation to select an appropriate facility location in the first place.

3.1.1 Need for Facility Location Planning

As discussed earlier, selecting an appropriate facility location is the most important decision for any organisation to ensure the success of its business. However, selecting a facility location is not an easy task. It requires careful planning of factors that may influence a facility location.

Facility location planning is also required for providing a cost benefit to the organisation. The location planning should help in reducing the transportation cost for the organisation. This ultimately helps in decreasing the cost of production and generating cost advantage for the organisation.

Facility location planning is also needed to identify proximity to the sources of raw materials and transportation facilities. A facility should ideally be located at a place where raw materials are available. This is necessary for maintaining continuity in the production process. Moreover, proper transportation facilities

help manufacturers/suppliers distribute their products to retailers in a short time at the minimum possible cost. A sturdy facility location planning helps the organisation in judging all these aspects accurately.

Facility location planning should also take into account the possible impact of political and social changes on business functioning. Political and social changes are external factors, which are beyond the control of an organisation. For example, political changes may involve changes in economic policies of the government, which may make the existing location unattractive for doing business. Thus, the organisation should consider all such factors that may lead to change in the facility location.

3.1.2 | Factors Affecting Facility Location Decisions

While selecting a facility location, an organisation should consider various factors that may have significant impact on its performance. These factors are explained below:

- **Availability of power:** Power is essential to move the wheels of an industry. Coal, electricity, oil and natural gas are the sources of power. In the case of iron and steel industries, where coal is the basic source of power, the facility should be located near coal mines. For example, in India, steel plants are located in mineral-rich areas, such as Jharkhand, Bengal, Chhattisgarh and Orissa.
- **Transportation:** While selecting a facility location, an organisation considers the places where favourable modes of transportation are available. Transportation amenities are essential for bringing raw materials and labour to the facility and carrying the finished goods to the market. A place which is well connected by rail, road and sea is ideal for a facility location.
- **Suitability of climate:** The climate of a place has its own importance in the selection of facility location because there are certain industries, which require particular climatic conditions for survival. For example, humid climate is required for cotton textiles and jute industries. This is the reason why many cotton industries are located in Mumbai and Kolkata.
- **Government policy:** The influence of government policies and programmes on facility location is apparent in every country. For example, environmental policies of the government, trade permits, fees, etc. may or may not work in favour of a facility location. Sometimes the government provides some tax benefits for starting a business in rural areas. This may also affect the selection of facility location as organisations may get encouraged to start their business units in remote areas.
- **Competition between states:** States compete with each other to attract new industries by offering various benefits such as investment subsidies and sales tax exemptions to new units. These incentives may not be of substantial benefit for large facilities. However, for small and medium facilities, incentives do matter. The owners of these facilities certainly consider state incentives while selecting a region for facility location.
- **Availability of labour:** Despite mechanisation and automation, the importance of labour in the industrial domain has not been lost completely. Other than fully automated facilities, labour is essential for production and it should be available at a reasonable rate.

- **Civic amenities for workers:** Besides good working conditions, employees require certain civic and recreation amenities such as clubs, theatres, schools, hospitals, parks, etc. Easy accessibility to these amenities also affects the selection of facility location.
- **Existence of complementary and competing industries:** The existence of complementary industries at a location selected by an organisation also proves to be an advantage. This is because an industrial unit in association with other industrial units can get the following benefits:
 - An industrial unit in collaboration with other similar units can secure materials on better terms than it can do it all by itself. Concentration of similar establishments at one place helps increase the variety of materials that can be offered by suppliers.
 - Concentration of similar industries at one place improves the labour market for both the employer and the employee.
- **Finance and research amenities:** Adequate capital is essential for the successful working of an organisation. A place with an opportunity of raising capital attracts new industries. This is particularly true in developing countries where capital is not uniformly distributed throughout the country.
- **Availability of water and fire-fighting facilities:** Some industries require plenty of water for their working. These industries include fertiliser units, rayon manufacturing units, absorbent cotton manufacturing units, leather tanneries, bleaching and dyeing units, and screen printing units. These units must be located in places where water is available in abundance.



ACTIVITY

Identify the factors that affect the location of a steel plant in India. Prepare a presentation on it.

3.1.3 | Procedures and Techniques for Selecting Facility Location

Facility location choices can be critically important for organisations as they have a profound impact on its supply chain. An organisation follows certain steps to make a correct location choice. These steps are shown in Figure 3.1:

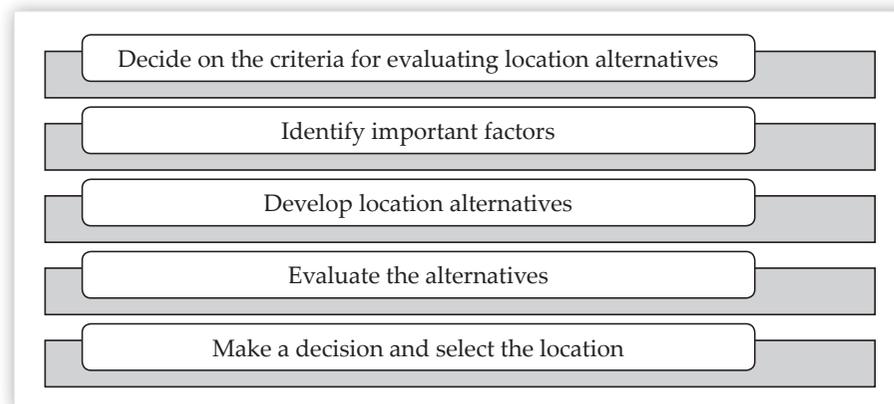


FIGURE 3.1: Steps Involved in Making Location Choice

Let us discuss these steps in detail.

1. **Decide on the criteria for evaluating location alternatives:** Location criteria involve distinctive location factors that have a critical impact on the organisation's strategic goals. In other words, these criteria relate to strategic goals of an organisation like low cost, convenience to attract market share, etc. An organisation has to evaluate its entire supply chain network to decide on the criteria that a new facility location must fulfil.
2. **Identify important factors:** Next, based on the evaluation criteria, an organisation needs to identify and weigh the factors that may affect location decisions. These factors include proximity to customers and suppliers, labour costs, transportation costs, and so on. Apart from this, management should also divide factors as dominant or secondary to determine their importance. You have already studied these factors in detail in the previous section.
3. **Develop location alternatives:** This step involves considering alternative locations for establishing a new facility. Identification of location alternatives involves the following sub-steps:
 - a. Identify the country or countries for location
 - b. Identify a general region for a location
 - c. Identify a small number of community alternatives
 - d. Identify specific sites among the community alternatives
4. **Evaluate the alternatives:** For evaluating alternative sites, an organisation collects data regarding the sites from location consultants, state development agencies, city and country planning departments, chambers of commerce, electric power companies, banks, etc. After that, the collected data is analysed on the basis of quantitative and qualitative factors. The quantitative factors can be measured in terms of money, time and distance. Sales, labour and transportation costs, etc. are some quantitative factors. On the other hand, qualitative factors cannot be measured in these terms. Community attitude, environmental factors and quality of work life come under qualitative factors.
5. **Make a decision and select the location:** After evaluating various potential site alternatives, the site with the highest weighted score is selected for establishing the new facility.

Techniques for Selecting Sites

Facility location decision is a crucial decision made by an organisation. This decision is influenced by multiple factors which you have already studied in the previous chapter. An organisation starts with collecting information on different factors. This information is then processed using different quantitative techniques or models. There is no single model that is suitable for all types of firms and for all facility location decisions. Following are some main techniques used in making location decisions.

- **Location rating factor technique:** In this technique, first of all an organisation needs to identify the factors that influence its location decision. Next, each factor is provided a weight between '0' to '1' according to the level of importance,

where '0' denotes least important and '1' denotes most important. Table 3.1 shows an example of how a typical factor rating looks like:

TABLE 3.1: Example of Rating Factors

Factor	Weight	Subjective Score (01-100)		
		Location 1	Location 2	Location 3
Factor -1	0.35	72	82	79
Factor -2	0.25	74	79	90
Factor -3	0.30	98	45	67
Factor -4	0.10	70	73	75
Total Score	1.0	80.10	69.25	77.75

Here, location 1 will be selected as it gets the highest score.

A subjective score is assigned (usually between 0 and 100) to each factor based on its attractiveness compared with other locations, and the weighted scores are summed. Next, the factors are assigned a subject score between '0' to '100' to denote their relative attractiveness in different locations. Lastly, the weighted scores of these factors are summed to determine the final score of a location. Decisions typically will not be made based solely on these ratings, but they provide a good way to organise and rank factors.

- **Centre-of-gravity technique:** This technique emphasises on transportation cost in the determination of facility location. Transportation cost mainly depends on distance, weight of merchandise and the time required for transportation. Centre-of-gravity maps various supplier locations on a Cartesian plane and suggests a central facility location with respect to the locations of suppliers. Figure 3.2 shows the output of a typical centre-of-gravity analysis:

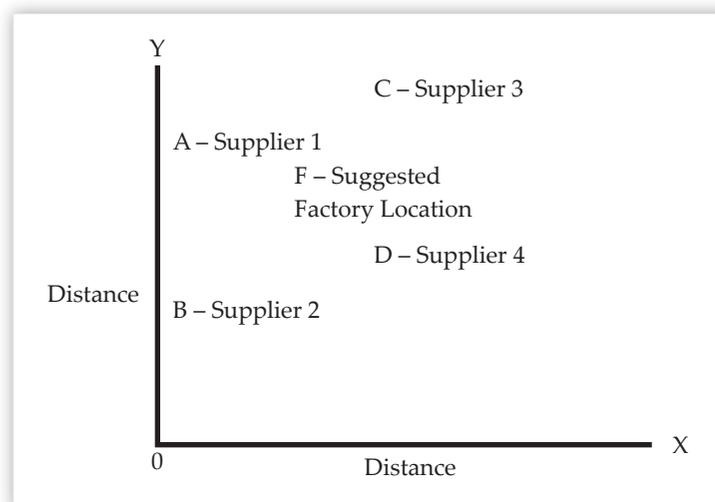


FIGURE 3.2: Centre-of-Gravity in Facility Location

In the figure, 4 suppliers (A, B, C and D) of an organisation have been mapped on a Cartesian plane. On the basis of the locations of the suppliers, facility location (F) has been suggested.

- **Transportation technique:** In simple words, the transportation technique evaluates multiple transportation routes of shipping goods from multiple origins to multiple destinations and finds or develops the least cost route. The technique is often used in determining facility locations for evaluating transportation costs of routes by selecting different facility locations. In the transportation technique, multiple facility locations fits are identified and their relative transportation costs are calculated. Finally, the location that is related to the lowest cost routes is selected.



**CHECK
YOUR PROGRESS**

1. The place where the facility is set for producing goods or services is called _____.
2. Selecting a facility location is a permanent decision made by any organisation. (True/False)
3. Which of the following factors affects the facility location decision?
 - a. Availability of power
 - b. Transport facilities
 - c. Government policy
 - d. All of these
4. Secondary factors are very important as they have a strong impact on cost or sales. (True/False)
5. The _____ factors can be measured in terms of money, time and distance.
6. Transportation cost mainly depends on distance, weight of merchandise, and the time of the required for transportation. (True/False)

3.2 Concept of Facility Layout

After the location of a facility is identified, the next important step is the placement of machinery in that facility. Apart from this, other elements like stores, inspection area, maintenance area, washrooms and other utilities also form the basic requirements of a facility, for which suitable places are needed in the facility. Facility layout may be defined as the arrangement of machinery, equipment, and other amenities in a facility, which should ensure a smooth movement of materials. A good deal of expertise is used by the top management of organisations to secure a proper layout for the new or existing facility. The use of expertise is necessary because there is no set pattern of layout for all facilities.

For example, a layout suitable for a processing industry may not be suitable for a job industry. Similarly, a layout suitable for a small-sized facility will not be suitable for a bigger facility. Likewise, a layout fit for a facility located on a flat terrain will not be suitable for a facility located on an uneven terrain. Moreover, the initial layout is almost never final or permanent. Changes do take place in product design, production methods and the size of the facility.

According to **Moore**, facility layout is the plan of or the act of planning an optimum arrangement of facilities, including personnel, operating equipment, storage space, material handling equipment, and all other supporting services along with the design of the best structure to contain these facilities.

According to **Knowles and Thomson**, *facility layout involves*:

1. *Planning and arranging manufacturing machinery, equipment, and services for the first time in completely new plants*
2. *The improvements in layouts already in use in order to introduce new methods and improvements in manufacturing procedures*

3.2.1 | Objectives of an Effective Facility Layout

As discussed earlier, an organisation needs to have a proper facility layout to carry out its production processes smoothly. An effective facility layout strives to achieve the following objectives:

- **Minimum material handling:** It implies that in an effective facility layout, machines and equipment are arranged in such a manner that minimum handling is required. This ultimately reduces material handling costs of an organisation.
- **Elimination of bottlenecks:** It states that a proper facility layout reduces bottlenecks that are caused by insufficient storage and machine capacity. These bottlenecks lead to various issues such as congestion, production delays, improper utilisation of floor space and accidents. An organisation can prevent these issues by having a suitable facility layout.
- **Shorter production cycles:** It implies that an effective facility layout shortens production cycles by reducing the time spent on each production activity.
- **Reduction in production delays:** A facility layout plays a significant role in the timely execution of different activities by reducing the causes of production delays. Such causes include shortage of space, long distance movement of materials and spoiled work.
- **Improved quality control:** It implies that a facility layout provides a platform for effective supervision of materials in an organisation. A good layout facilitates inspection at various stages of production. Thus, it ensures that the output generated is as per the desired quality.
- **Efficient utilisation of labour:** It implies that an efficient facility layout arranges each individual operation in such a way that the time of each worker is utilised effectively.
- **Improved employee morale:** An employee would be enthusiastic and cheerful if the working environment of an organisation is positive. A proper facility layout increases employee morale by ensuring:
 - Better working environment
 - Increased earnings
 - Reduced number of accidents
 - Better employee facilities

3.2.2 | Types of Facility Layouts

A facility layout differs from one organisation to another, depending on their requirements. Based on the requirements of different organisations, there can be different types of facility layouts, as shown in Figure 3.3:

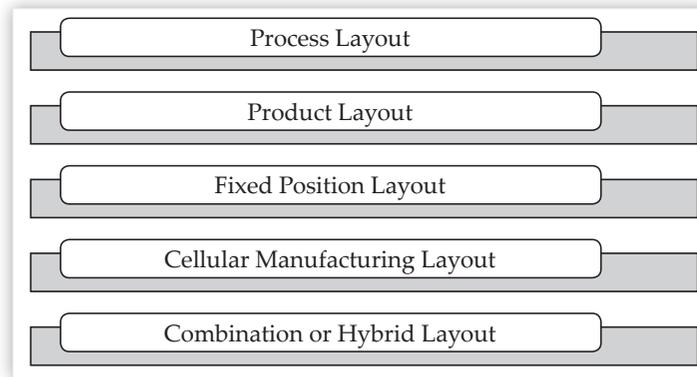


FIGURE 3.3: Types of Layout

Let us discuss these different types of layouts one by one.

Process Layout

Process layout, also called functional layout or batch production layout, is characterised by the grouping together of similar machines, based upon their operational characteristics. For example, machines engaged in drilling work may be installed in the drilling area, casting machines in the casting area, etc. Similarly there would be a heat treatment department, a painting department, a machining department, etc., where similar machines would be installed in the facilities that follow the process layout. Figure 3.4 shows a process layout:

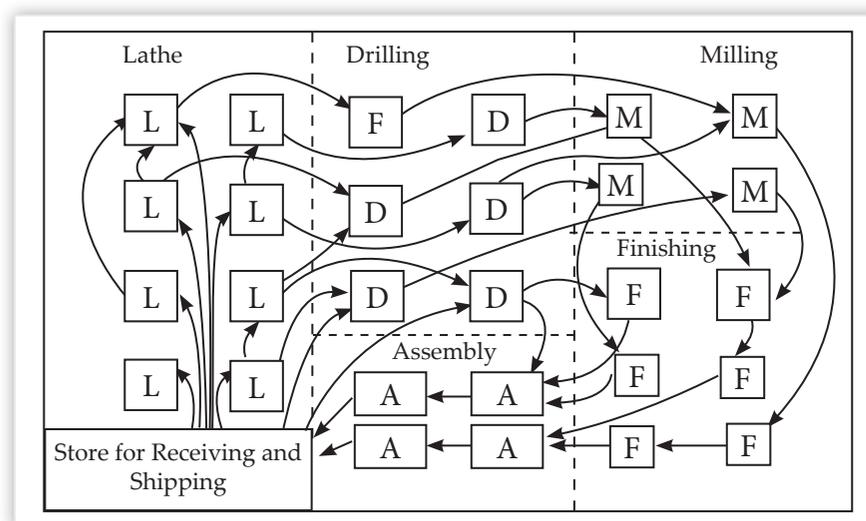


FIGURE 3.4: A Process Layout

Source: <http://www.transtutors.com/homework-help/industrial-management/plant-layout/process-layout.aspx>

In the process layout, partly finished goods wait for treatment in every department, just as commuters wait for buses in a city. Machines in each department cater to a particular product allotted to them. These machines are, therefore, called general purpose machines. This type of layout is best suited for the intermittent type of production, which is a method of manufacturing several different products using the same production line.

Product Layout

In product layout, also called straight line layout, machinery is arranged in one line as per the sequence of production operations. Materials are fed into the first machine and finished products come out of the last machine. It is a feast for the eyes to watch the way sugarcane, fed at one end of the mill, comes out as sugar at the other end. Figure 3.5 shows a product layout:

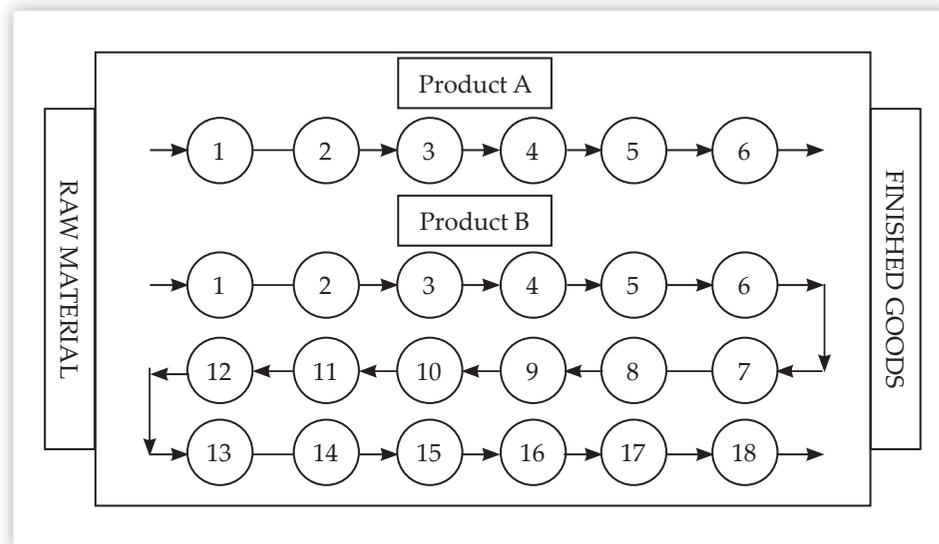


FIGURE 3.5: A Product Layout

Source: <http://sumitshrivastva.blogspot.in/2012/03/industrial-engineering-facilities.html>

An organisation using the product layout should consider the following points while grouping different machines:

- All machines and equipment should be arranged in a sequence as required in production operations.
- Two different lines should not coincide with each other.

Following are the advantages of the product layout:

- Requires minimum material handling cost
- Reduces bottlenecks in the production process
- Provides a better control of the production process

- Reduces manufacturing time
- Requires minimum inspection

The product layout is beneficial for chemical, paper, sugar, rubber, refineries, and cement industries. The product layout has disadvantages too. These limitations are discussed below:

- Provides lesser flexibility
- Requires large amounts of investments for arranging and grouping different machines
- Requires execution of individual incentive schemes, which may be difficult for an organisation
- Lacks specialised supervision

Fixed Position Layout

This type of facility layout is used to assemble products that are too large, heavy or fragile to move to a location for completion. In the fixed position layout, machinery, men, as well as other pieces of material, are brought to the location where the product is to be assembled. The movement of men and machines is preferable to that of products because the cost of moving the former would be less than the cost of moving products that are bulky. Figure 3.6 shows a fixed position layout:

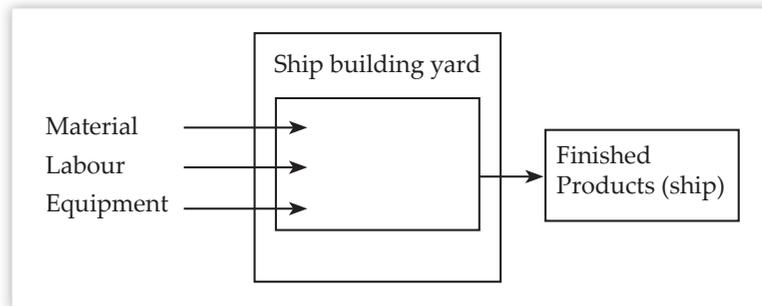


FIGURE 3.6: A Fixed Position Layout

Source: <http://debashish-ie.blogspot.in/2013/01/plant-location-and-layout.html>

Also known as fixed location layout, this type of layout is used in the manufacturing of bulky and heavy products such as locomotives, ships, boilers, aircraft, and generators. The construction of a building requires the fixed location layout because men, cement, sand, bricks, steel, wood, etc. are taken to the site of the construction.

Cellular Manufacturing Layout

In Cellular Manufacturing (CM) layout, machines are grouped into cells, which function somewhat like a product layout in a larger shop or a process layout. Each

cell in the CM layout is formed to produce a single part family, that is, a few parts with common characteristics. Figure 3.7 shows a CM layout:

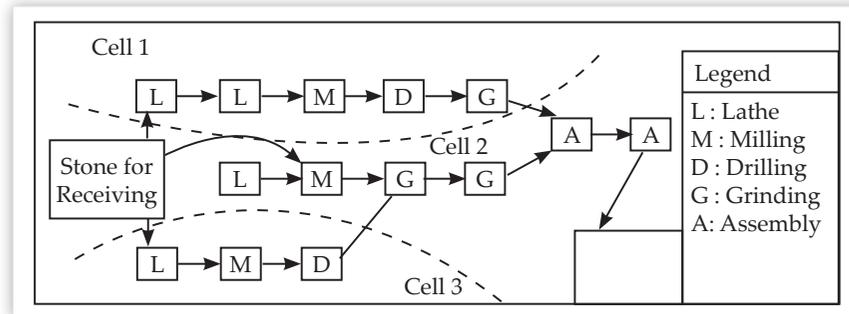


FIGURE 3.7: A CM Layout

Source: <http://www.transtutors.com/homework-help/industrial-management/plant-layout/cellular-layout.aspx>

CM layout helps in increasing the overall performance of a process by lowering production costs and improving on-time delivery. Some other benefits of CM layouts are:

- Lowers work-in-process inventories
- Reduces material handling costs
- Shortens flow times in production
- Simplifies production planning (materials and labour)
- Improves the overall quality

Combination or Hybrid Layout

It is difficult to use the principles of product layout, process layout, or fixed location layout in facilities that involve fabrication of parts and assembly. Fabrication tends to employ the process layout, while assembly areas often employ the product layout. For example, in soap manufacturing plants, the machinery that manufactures soap is arranged on the product-line principle, but allied services, such as heating, power house, and water treatment plant are arranged on a functional basis. Figure 3.8 shows a combination or hybrid layout:

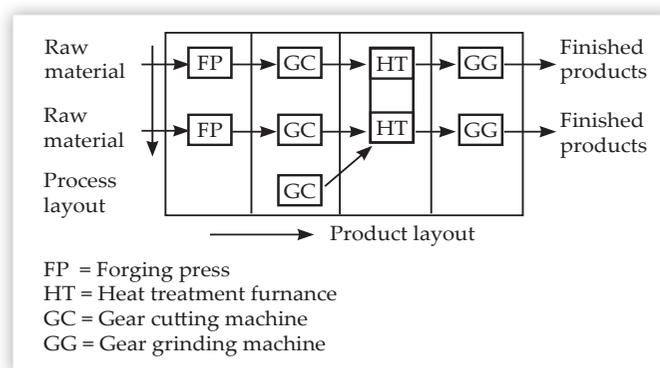


FIGURE 3.8: A Combination or Hybrid Layout

Source: <http://www.expertsmind.com/questions/combined-layout-30127312.aspx>



ACTIVITY

Using the Internet, identify at least five manufacturing facilities that use the combination or hybrid layout. Prepare a note based on your study.

3.2.3 | Factors Affecting a Facility Layout

The layout of a facility may be influenced by the placement of materials, machinery and men. Other factors such as the type of product, workers, industry, and management policies also influence this layout. Let us discuss how these factors influence the facility layout:

- **Materials:** Every facility should buy raw materials when they are readily and cheaply available. These materials should be stored properly and moved through production centres efficiently for manual or mechanical operations or chemical processing. Storage and movement of raw materials require properly placed storage rooms, smooth movement of materials and adequate handling of equipment.
- **Product:** The type of product, i.e., whether the product is heavy or light, big or small, liquid or solid, and its position in relation to the facility location also influences the facility layout. In majority of cases, the product moves from one work station to another. In some cases, such as manufacturing of locomotives and shipbuilding, the product is stationary but men and machinery are moved to the product.
- **Machinery:** Production happens from a combination and manipulation of men, material and machines. These elements may be combined in various ratios and ways in the course of the production activity.
- **Type of industry:** The type of industry and the method of its manufacturing process exercise a significant influence on the facility layout. Industries in this context may be broadly classified into two types, which are:
 - **Intermittent industries:** Intermittent industries manufacture different components on different machines and assemble them to get the end-products; for example, the tailoring industry.
 - **Continuous industries:** In continuous industries, goods are produced continuously. There is no irregularity in the production system. Goods are produced on a large scale and for stocking; for example, the food industry.
- **Management policies:** Management policies significantly influence the facility layout. Some management policies are as follows:
 - Volume of production and provision for expansion
 - Extent of automation
 - Making or buying a particular component
 - Desire for rapid delivery of goods to customers
 - Purchasing policy

3.2.4 | Prerequisites for Developing a Facility Layout

A facility layout exerts major influence on the overall efficiency and effectiveness of an organisation. Different organisational activities, such as production, administration, and storage are greatly affected by the facility layout. Therefore, an organisation should conduct proper planning and analysis of its various activities before developing its facility layout. Following are some prerequisites for developing a proper facility layout:

- **Developing process charts:** A process chart is the graphical representation of production activities performed by an organisation. Process charts facilitate a systematic analysis and demonstration of the entire production process. These charts are further classified into two categories, namely operation process chart and flow process chart.
- **Making process flow diagrams:** A process flow diagram represents the movement of materials on a floor layout. These diagrams help an organisation in avoiding needless material movement and rearranging facility operations.
- **Developing machine data cards:** A machine data card helps in developing equipment layout (pieces of equipment layout in relation to everything including the persons using them) by providing information related to power and materials handling requirements and capacity and dimensions of different machines.
- **Visualising the layout:** It represents the most common technique that is deployed for layout planning. It involves creating duplication of machines and equipment and arranging them in two- or three-dimensional plans for determining the effectiveness of a layout.

3.2.5 | Process of Facility Layout Designing

Designing a facility layout requires a systematic approach. It constitutes the following four steps:

1. **Information gathering:** This step includes the following points:
 - a. Determine what will be produced
 - b. Determine how much will be produced
 - c. Determine what components will be made or purchased
 - d. Determine the required operations
 - e. Determine the sequence of operations
 - f. Set time standards for each operation
2. **Production and material flow analysis:** This is the second step of designing a facility layout. This includes the following points:
 - a. Determine the facility rate, which is denoted by R
 - b. Determine the number of machines
 - c. Balance the production lines
 - d. Study the flow requirement
 - e. Determine the activity relationships
 - f. Layout each workstation

3. **Support services:** This step includes the following points in designing a facility layout:
 - a. Identify the needs for personal and facility services
 - b. Identify office needs
 - c. Develop total space requirements
 - d. Select material handling equipment
 - e. Identify the area
 - f. Develop the plot plan and building shape
4. **Implementation and evaluation:** This is the last step of designing a facility layout. It includes the following points:
 - a. Construct a master plan
 - b. Seek the input required for the facility layout
 - c. Seek approvals
 - d. Install
 - e. Start up
 - f. Follow up

3.2.6 | Techniques for Designing a Facility Layout

Now that you have studied the process of designing a facility layout, let us observe the techniques that are used in the facility layout designing process. A facility layout can only be effective if a proper technique is used for designing the same. A facility layout can be designed using various techniques. Let us discuss two main techniques of designing a facility layout.

Block Diagramming

The block diagram can be prepared by following the steps given below:

1. Analyse the unit load summary that provides information about the average number of unit loads moved between different departments of an organisation.
2. Calculate the composite movements (back-and-forth movement) of the unit load between the departments and rank them from the highest movement to the lowest movement.
3. Place the trial layouts, which are designed using the ranking between departments, on a grid. This grid represents the relative distance between the departments.

Richard Muther's Systematic Layout Planning (SLP)

In this technique, a grid displays the ratings of the relative importance of the distance between different departments of an organisation. This grid is also called 'closeness rating chart'. In this chart, the rating for department A relative to department B is similar to the rating of department B to department A. Closeness ratings are given to departments in the form of codes, which depict the desired

closeness of the departments according to the relative strength of their closeness. The codes in the closeness rating chart are as follows:

- A – Absolutely necessary
- E – Very important
- I – Important
- O – Ordinary importance
- U – Unimportant
- X – Undesirable

Closeness ratings are provided to the departments based on the following factors:

- Usage of similar equipment or facilities or similar work performed by different departments
- Sharing of the same personnel, records and communication by the departments
- Sequence of workflow in the departments
- Unsafe or unpleasant conditions in the departments

The rating given in the closeness rating chart is also called qualitative ranking. The closeness rating chart can be used for creating a block diagram as well as for checking the effectiveness of the layout design prepared by using other techniques.

Apart from the abovementioned techniques, load distance analysis and line balancing are also used for designing the facility layout.

3.2.7 | New Approaches to Layout Design

Nowadays, organisations are following various approaches to designing and evaluating their facility layout. Application of digital techniques is being increasingly used in layout design. Let us discuss some of these techniques in detail.

Computerised Relative Allocation of Facilities Technique (CRAFT)

CRAFT is one of the oldest and simplest methods used for layout engineering. Armour and Buffa developed this technique. CRAFT requires the following types of data to be used as input for layout engineering:

- Total floor space available
- Details of space required by each work centre
- Relation between flow and cost for all work stations
- Layout of the initial stage

Automated Layout Design Program (ALDEP)

ALDEP is a computer algorithm that is used to develop a layout design by using data related to facilities. The algorithm places different departments of an organisation in the layout. After placing these departments in the layout, a score is calculated. This score is the sum of the closeness rating values of different departments. This

process is repeated until the maximum score is obtained. The layout that has the maximum score is implemented. The data required for this algorithm is as follows:

- Ratio between the length and width of different departments
- Relationship (REL) charts that are used to specify the relationship between different departments
- Location of fixed departments

Computerised Relationship Layout Planning (CORELAP)

CORELAP refers to the layout engineering algorithm developed by R.C. Lee. This algorithm places the most critical department of an organisation in the middle of the layout. After that, the department that is closest to the already placed department is placed. The designing of the layout using this algorithm begins from the centre. The final score of the layout is calculated by considering the closeness values of different departments. The data required for this algorithm is as follows:

- Number of departments and their area
- Closeness relationship among different departments as indicated in the REL chart
- Scale of output

3.2.8 | Revision of a Current Layout

As pointed out earlier, a good facility layout involves not only the designing and installing of the layout but also encompasses the revision of the existing layout. Revisions ranging from minor alterations to complete dismantling of the existing structure and installation of a new layout become necessary from time to time to increase and maintain the operating efficiency of the facility. Generally speaking, the following developments necessitate the revision of the existing layout:

- **Expansion:** Expansion is a natural feature of an industrial establishment. A facility may expand in one of the following ways:
 - Increase in the output of the existing product
 - Introduction of a new product in the same line
 - Diversification of the lines of activity

To cater to the ever-increasing demand for its products, a facility may increase its capacity by installing a few more machines of the type already in operation or by adding machines of new designs and higher capacity. In such cases, the installation of new machinery will pose the same problems to the layout engineer as the designing and installation of a new layout does. If capacity expansion is sought to be achieved by adding a few more machines of the type which are already in operation, the problem becomes simple for the layout planner.

Expansion may also be achieved by introducing a new product in the same line. The sale of the existing product might decline because of tough competition in the market. A new product, of a better quality and bigger size, may be introduced to offset the loss, using the same line of production.

- **Technological advancement:** Due to industrial research, new products, novel use of existing products and materials, new machinery and sources of energy have been and are being discovered. Some technological advancement are as follows:

- Replacement of labour by machines
- Development in fuel and energy
- Development in processes
- Development in materials
- Improvement in product design
- Advancement in information technology

Technological advancements affect facility and equipment directly and indirectly. The layout of the facility must be revised to accommodate such advancements.

- **Improvement of the layout:** Every layout requires reviewing at certain time intervals to make necessary modifications to the layout. In perfectly laid-out facilities, there is always a scope of improvement for the overall betterment.



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7. _____ is all about the arrangement of physical facilities in a way that helps maintain a quick flow of materials at the minimum handling cost.
8. The use of expertise is necessary in deciding facility layout as there is a set pattern of layout for all facilities. (True/False)
9. Which of the following is not an objective of an effective facility layout?
 - a. Maximum material handling
 - b. Elimination of bottlenecks
 - c. Shorter production cycles
 - d. Reduction in production delays
10. An effective facility layout shortens production cycles. (True/False)
11. _____ is a layout wherein machinery is arranged in a line as per the sequence of production operations.
12. A layout in which movement of men, materials, and machines is at their minimum is called _____.
13. In which of the following layouts, machines are grouped into cells that work similar to a product layout in a larger shop or process layout?
 - a. Product layout
 - b. Fixed position layout
 - c. Cellular manufacturing layout
 - d. Hybrid layout
14. Which of the following is the first step of designing a facility layout?
 - a. Production and material flow analysis
 - b. Support services
 - c. Information gathering
 - d. Implementation and evaluation

3.3 Service Facility Layouts

The objectives of service facility layouts differ from those of manufacturing facility layouts. This is because a manufacturing facility aims to make on-time delivery of products to customers, whereas customers come to a service facility to receive services. Therefore, customers usually prefer a service facility that is close to them, especially when the service delivery process requires considerable customer contact. For example, if you are hungry, you would prefer to go to a restaurant near you.

There may be times when a service facility becomes over-crowded due to high footfalls. In such a case, it is difficult for the service provider to deliver services as per customers' expectations. A service layout focuses on efficient circulation of customer traffic through a facility. Thus, a service facility layout should provide easy entrance to the facility. Apart from this, systematic parking arrangements and well-designed walkways are also important elements of a service facility layout. Service facility layouts are often categorised under three heads, which are:

- **Product layout:** This type of layout is used only in cases where services are organised in a sequence. In other words, the product layout is applied if a customer and work follow a similar sequence, such as in car wash or cafeteria line.
- **Process layout:** These layouts are highly common in service facilities as they successfully deal with the varied customer processing requirements. For example, hospitals, retail stores, and banks use the process layout for their service facilities.
- **Fixed position layout:** In this type of service layout, materials, labour and equipment are brought to the customer's place. This layout is used in services like appliance repair, landscaping, home remodelling, etc.

3.3.1 Types of Service Facility Layouts

In any service facility layout design, the degree of customer contact and customisation are given high priority. In cases where both customer contact and customisation are high, such as in hospitals, the service layout would support high labour content and flexible equipment. Here the role of both the service provider and the customer is the maximum and therefore, the layout is designed in a flexible manner to support the highly customised needs of customers. If customisation is high, but customer contact is low, as in the case of tailoring, the layout can be designed to support workers and equipment.

Now, if customer contact is high but customisation is low, as in case of retail stores, the role of service providers becomes low, which encourages self-service system. In such a case, the layout design must focus on customer's ease of obtaining services. If both the degree of customisation and customer contact are low, as in a brick factory, the core service and customers can be separated. In this type of layout, achieving a high degree of efficiency in operations is very easy as products are not customised as per the customer's demand. Highly standardised services that involve zero customisation may lend themselves to automation, for example,

ATM machines, online banking, web services, etc. In this type of services, the role of service provider becomes negligible. However, customer contact remains high. Let discuss some service facility layouts.

Warehouse and Storage Layouts

The layouts of warehouse and storage facilities are designed by considering the frequency of order. Items that are ordered frequently are placed near the facility entrance. However, items that are not ordered frequently are placed at the rear of the facility. Apart from this, correlation between two merchandises is also important while designing a layout for a warehouse and storage facility. For example, if item A is usually ordered with item B, both the items should be placed together to reduce the cost and time to retrieve them. In addition, number and width of aisles, truck loading and unloading, height of storage racks, periodic cycle to count the stored items, etc. are also considered before designing the layouts of warehouse and storage facilities.

Retail Layouts

A retail store layout refers to a systematic arrangement of merchandise groups within a store. A well-planned retail store layout provides a description of the size and location of each department of the store, fixture locations, and traffic patterns. It also helps consumers find products of their choice in a short time. Let us discuss different types of retail store layouts:

- **Grid layout:** This kind of layout enables consumers to easily locate products on their shopping list. This layout consists of parallel aisles, and merchandise is kept on the shelves on both sides of the aisles. The grid layout reduces the time of consumers spent in searching the desired merchandise. This type of retail store layout is usually followed by conventional grocery stores, supermarkets and medical stores. Figure 3.9 shows a grid layout:

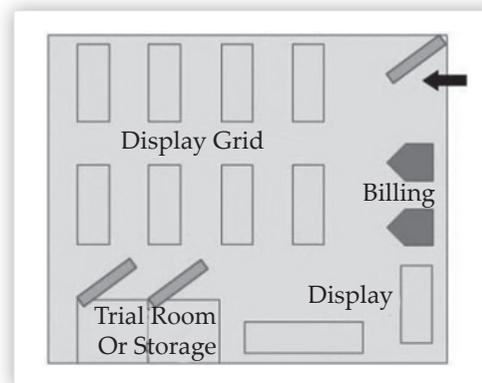


FIGURE 3.9: A Grid Layout

Source: TutorialsPoint

- **Free-form layout:** It is also called boutique layout. This type of layout is generally used by luxury or specialty stores. This layout provides relaxed shopping atmosphere to consumers as they have no defined traffic pattern. The free-flow layout follows an asymmetric pattern of aisles. However, this layout

is not suitable for stores having a large number of products. It is appropriate for the same type of merchandise like apparel. Figure 3.10 shows a free-form layout:

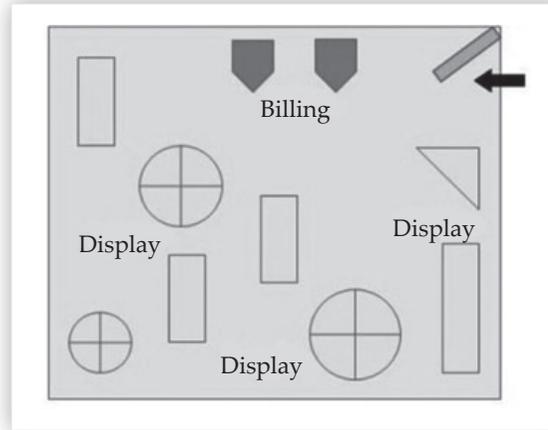


FIGURE 3.10: A Free-form Layout

Source: TutorialsPoint

- **Loop layout:** It is also known as race track layout. It makes loops throughout the store usually in the shape of circles, squares or rectangles. It provides an entertaining shopping experience and encourages impulse buying behaviour. Consumers are expected to navigate through specific paths to visit as many sections/departments as possible. In this layout, differentiation between departments is based on materials and colours used in accordance with the store’s decor. Figure 3.11 shows a loop layout:

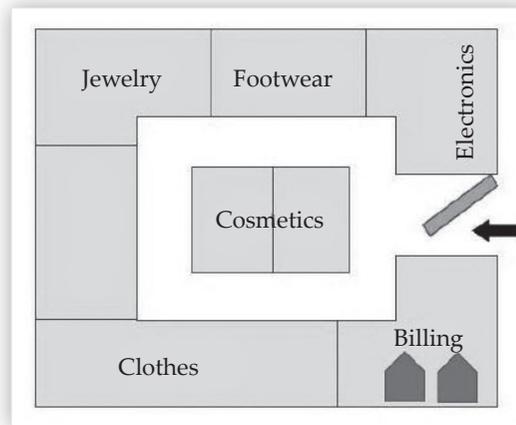


FIGURE 3.11: A Loop Layout

Source: TutorialsPoint

- **Spine layout:** It is a combination of the grid, loop and free-form layouts. The spine layout usually begins with a single main aisle running from the front to the back of the store and transporting consumers in both the directions. On either side of the spine, merchandise departments spread toward side walls. This kind of layout is generally used by medium-sized specialty stores that

occupy the space ranging from 2,000-10,000 square feet. Figure 3.12 shows a spine layout:

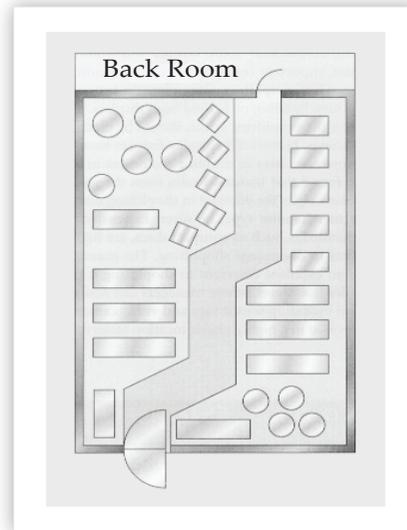


FIGURE 3.12: A Spine Layout

Source: Emaze

Office Layouts

Designing of office layouts is witnessing revolutionary changes as paperwork is now replaced with different modes of electronic communications. Today, office layouts focus more on creating an image of openness. Low-rise partitions are preferred between departments to facilitate easy communication among workers. Figure 3.13 shows a modern office layout:



FIGURE 3.13: An Office Layout

Source: StrongProject



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15. _____ layout is also called boutique layout.
16. Appliance repair, landscaping and home remodelling come under which type of service facility layout?
 - a. Product layout
 - b. Fixed position layout
 - c. Process layout
 - d. None of these
17. If customisation is high but customer contact is low, the layout can be designed to support workers and equipment. (True/False)

3.4

Chapter at a Glance

- A facility location may be defined as the place where a facility will be set up for producing goods or services.
- Selection of a suitable facility location is important as it decides the fate of a business. A good location may reduce the cost of production and distribution to a considerable extent.
- Once established, a location cannot be changed frequently as it incurs huge costs.
- Facility location factors can be divided into dominant and secondary factors.
- Factors that affect facility location decisions include:
 - Availability of power
 - Transport facilities
 - Suitability of climate
 - Government policy
 - Competition between states
 - Availability of labour
 - Civic amenities for workers
 - Existence of complementary and competing industries
 - Finance and research facilities
 - Availability of water and fire-fighting facilities
 - Momentum of an early start
- To make a correct location choice, an organisation follows the steps given below:
 1. Decide on the criteria for evaluating location alternatives
 2. Identify important factors

3. Develop location alternatives
 4. Evaluate the alternatives
 5. Make a decision and select the location
- There is no single model that is suitable for all types of firms and for all facility location decisions. Mainly, the following techniques are used in making location decisions:
 - Location rating factor technique
 - Centre-of-gravity technique
 - Transportation technique
 - A facility layout is defined as the arrangement of machinery, equipment and other amenities in a facility to ensure the smooth movement of materials.
 - An effective facility layout strives to achieve:
 - Minimum material handling
 - Elimination of bottlenecks
 - Shorter production cycles
 - Reduction in production delays
 - Improved quality control
 - Efficient utilisation of labour
 - Improved employee morale
 - Different types of facility layouts are:
 - Process layout
 - Product layout
 - Fixed position layout
 - Cellular manufacturing layout
 - Combination or hybrid layout
 - Revisions ranging from minor alterations to complete dismantling of the existing structure and installation of a new layout become necessary from time to time to increase and maintain the operating efficiency of a facility.
 - The objectives of service facility layouts differ from those of manufacturing facility layouts. This is because a service operation aims to organise all activities and processes to deliver services to customers.

3.5 Key Terms

- **Capacity:** A facility's maximum productive capability, usually expressed as the volume of output per period of time.
- **Diversification:** A process of entering into a field of business, which is new in terms of market or technology, or both.

- **Intermittent process:** A process in which raw materials are converted into components or parts for stock and they are combined according to customer orders.
- **Layout:** Physical location or configuration of a department or a work station.
- **Manufacturing:** A generic term used for the process of producing or assembling goods by hands or machines for sale to others.

3.6

Case Study: Offshore Manufacturing Location Decision at BMW



Source: www.bmwusfactory.com

Location decisions require careful analysis as they have long-lasting effects, particularly in offshore operations. Effective offshore location decisions have two features: (1) they are good for the organisation, and (2) they are good for the society where the facility is located.

Established in 1917 and headquartered in Munich, Germany, Bavarian Motor Works (BMW), is a manufacturer of world's most premium brands, such as BMW, MINI and Rolls-Royce motor cars. BMW was facing a need to find an offshore manufacturing site as it frequently required to deal in international markets. BMW finally selected Spartanburg, South Carolina as its offshore manufacturing site. Let us study why BMW found Spartanburg, South Carolina, a suitable location for establishing a new plant.

After realising the need for an offshore manufacturing site, BMW followed a 'blank page' approach to compile a list of 250 potential facility sites worldwide. The company analysed various factors before selecting the plant site. These factors included the proximity of the location to a large market segment for BMW's automobiles, labour climate in each country, geographical requirements and government policies of each country.

Considering the complex nature of the automotive manufacturing process, the construction of a facility largely depended on the availability of technologically

capable workforce. As the cost of training a single worker in the automotive industry ranges from \$10,000 to \$20,000; evaluating the labour climate of each prospective country was specifically critical. The company also needed to analyse geographical factors as thousands of automobile parts needed to be delivered from both domestic and foreign suppliers. Therefore, in order to keep the supply chain cost low, the new location required to have sufficient highway/interstate access. In addition, proximity to the port was also necessary to ensure easy transportation of both supplies and finished goods. Apart from all these, the final factor was government related policies. BMW was looking for a 'business friendly' location, where it could make concessions on various subjects, such as infrastructure improvements, tax abatements, employee screening and education programmes. The company also wanted to develop a mutually beneficial relationship between BMW and the local community through a coordinated improvement effort.

After three and a half years of the search process, the analysts at BMW trimmed the list of 250 potential facility sites down to 10 workable options. Among 10 alternatives, BMW finally selected Spartanburg, South Carolina as its new facility site and decided to build a new two-million-square-foot facility at that location. The final decision was taken after a careful evaluation of the aforementioned selection criteria and Spartanburg's environment.

The government policies at South Carolina were flexible enough to address the needs set forth by BMW. The South Carolina government agreed to acquire 500 acres of land necessary to build the facility, improve highway infrastructure around the facility, lengthen the runway and modernise the Spartanburg airport terminal. In addition, the government also agreed to provide tax incentives and property tax relief. It helped the company to establish an employee screening and training programme so that the right mix of workers could be hired for jobs.



Source: autoworkforce.org

The location also proved to be a good one from the viewpoint of community benefits. The BMW facility, which started in 1994, saw subsequent expansion in December 2013 with an investment of \$6.3 billion. Today, South Carolina's BMW Manufacturing Corporation is a part of BMW Group's global manufacturing network. It is BMW's largest plant in the world and employs more than 8,000 people to manufacture the X3 and X5 Sports Activity Vehicle, the X4 Sports Activity Coupe, the X5 xDrive35d fuel-efficient vehicle and the X6 Sports Activity Coupe.

In addition, supply chain activities carried by this facility have created more than 31,000 jobs in South Carolina with the help of huge investments.

The plant produces 450,000 vehicles annually, which is more than any of the BMW factories in Germany. According to Ludwig Willisch, the CEO of BMW of North America, “We are very fortunate that years ago, the company decided to go to the United States and build a plant at a time when everyone was withdrawing. It was not only a brave move, but it shows how right the move was. It is a big, important footprint for us. Overall, selecting Spartanburg, South Carolina was a success story all around as it helped BMW in reaping rewards in terms of business growth and community improvements.”

Questions

1. Why was the selection of a suitable location so important for BMW?

(Hint: The selection of a suitable location is important as it decides the fate of the business. A good location may reduce the cost of production and distribution to a considerable extent. BMW was looking for a ‘business friendly’ location, where it could get concessions on various issues, such as infrastructure improvements, tax abatements, employee screening and education programmes.)

2. Discuss the impact of government policies and programmes on the selection of BMW facility location.

(Hint: The government policies at South Carolina were flexible enough to address the needs set forth by BMW. The South Carolina government agreed to acquire 500 acres of land necessary to build the facility, improve highway infrastructure around the facility, lengthen the runway and modernise the Spartanburg airport terminal. In addition, the government also agreed to provide tax incentives and property tax relief to the company.)

3.7 Exercise

1. What is the concept of facility location? Discuss.
2. Explain the factors that affect facility location decisions.
3. Discuss various techniques of location analysis.
4. Explain the concept of facility layout.
5. What are the various types of facility layouts?
6. Why do service facility layouts have different objectives than manufacturing facility layouts?

3.8 Answers for Check Your Progress

Topic	Q. No.	Answer
Concept of Facility Location	1.	facility location
	2.	True
	3.	d. All of these
	4.	False
	5.	quantitative
	6.	True
Concept of Facility Layout	7.	Facility layout
	8.	False
	9.	a. Maximum material handling
	10.	True
	11.	Product layout
	12.	fixed position layout
	13.	c. Cellular manufacturing layout
	14.	c. Information gathering
Service Facility Layouts	15.	Free-form
	16.	b. Fixed position layout
	17.	True

3.9 Suggested Books and e-References

Books

- Heizer, J. & Render, B. (2001). Operations management (1st ed.). Upper Saddle River, N.J.: Prentice Hall.
- Slack, N., Chambers, S., & Johnston, R. (2010). Operations management (1st ed.). Harlow, England: Financial Times Prentice Hall.
- Stevenson, W. (2005). Operations management (1st ed.). Boston: McGraw-Hill.

e-References

- Facilities Layout. (2017). Boundless. Retrieved 21 April 2017, from <https://www.boundless.com/business/textbooks/boundless-business-textbook/operations-management-10/planning-for-operations-73/facilities-layout-348-6985/>
- Facility Layout – Objectives, Design and Factors Affecting the Layout. (2017). Managementstudyguide.com. Retrieved 21 April 2017, from <http://www.managementstudyguide.com/facility-layout.htm>
- Facility Layout and Design. (2017). Inc.com. Retrieved 21 April 2017, from <http://www.inc.com/encyclopedia/facility-layout-and-design.html>

FACILITY LOCATION AND LAYOUT

- Facility Location – Factors Influencing the Location. (2017). Managementstudyguide.com. Retrieved 21 April 2017, from <https://www.managementstudyguide.com/facility-location.htm>
- Service Layout – Plant Location and Layout - Production And Operations Management Tutorial | Wisdom Jobs. (2017). Wisdom Jobs. Retrieved 21 April 2017, from <https://www.wisdomjobs.com/e-university/production-and-operations-management-tutorial-295/service-layout-9558.html>
- Seven Key Factors to a Facility Location. (2017). Smallbusiness.chron.com. Retrieved 21 April 2017, from <http://smallbusiness.chron.com/seven-key-factors-facility-location-33442.html>



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