Chapter 4
Facilities Location and Layout
Introduction

• **A facility** is something built or established to serve a purpose.

• **Facilities management** is a location decision for that facility and the composition or **internal layout** of the facility once located.
Strategic Importance

- Facility location is important only if the location of other resources is important.
  - If location of a workforce, an inventory, and a capacity isn’t important, the facility can be anywhere
  - True of information-oriented services

- The larger the facility, the more it costs to maintain (power bills, tax bills...)

- Facility location decisions are more subjective than other resource decisions.
Facility Location Decisions
Locating a New Business

Businesses tend to locate facilities near inputs when:

- **Raw materials** are costly to transport
- Required skilled labor is scarce, found in certain places
- High-volume manufacturers with products that are relatively inexpensive to ship tend to base location on lower labor costs (for example, clothing manufacturers)

Closer markets/customers when:

- **Products** are expensive to transport (bricks, beverages)
- Providing better service (response time, dependability, flexibility...)

Other factors are considered, such as quality of life, climate, closest to a large city, potential for an expansion.
Facility Location Decisions
Relocating an Existing Business

Relocation decisions are made for several reasons.

- **Financial reasons**
- Changes in Availability of inputs
- Can no longer afford a lease
  - May need to relocate to same geographic area to avoid losing employees or customers.
Facility Location Decisions
Choosing a Location for Business Expansion

- Expand current facility, or build a new, bigger one.
  - Comparison of the costs of expanding and building
  - Consider lack of opportunities because of old facility limitations
    - New technologies more easily integrated into a new building

- Keep current facility and build a new one
  - Supervision and control issues when management needs to be two places at once
  - Can lead to competitive advantages such as opening up new markets
Facility Location Decisions

In general, location decisions

- Long-term decisions
- Difficult to reverse
- Affect fixed & variable costs
  - Transportation cost
    - As much as 25% of product price
  - Other costs: Taxes, wages, rent etc.
The location decision usually is made in two stages:

1. **The general location** must be determined, and
2. **The exact site** must be selected from among those available in the general locale.
OBJECTIVE

Maximize the benefit of location to the firm
Location factors

1. Nearness to Market
2. Nearness to raw or/and unworked materials
3. Transportation
4. Availability of power
5. Climate and Fuel
6. Labor and Wages
7. Laws and Taxation
8. Community Services and Attitude
9. Availability of water
Industrial Location Decisions

**Cost focus**
- Revenue varies a little between locations
- Location is a major cost factor
  - Affects shipping & production costs (e.g., labor)
  - Costs vary greatly between locations
Service Location Decisions

Revenue focus
- Costs vary a little between the market areas

Location is a major revenue factor
- Affects amount of customer contact
- Affects volume of business
Location Decision Sequence

Country

Region/Community

Site

Maryland

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LOCATION EVALUATION METHODS
Usually, the criterion or objective is to minimize some cost function. Often, the distance traveled is chosen as the cost function. Thus, the objective becomes one of minimizing total distance traveled.
Sometimes the objective, or least a consideration, may be to minimize the maximum distance traveled

(as, for example, in locating fire stations or hospitals where the maximum or worst response distance is important)
Location Decision-Making Techniques

Location Factor Rating
Factor Rating System

1. Identify the specific criteria or factors to be considered.
2. Assign a weight to each factor.
3. Select a common scale for rating each factor.
4. Rate each potential location on each of the factors.
5. Multiply each factor’s score by its weight.
6. Sum the weighted scores and select the location with the highest score.
Factor-Rating System Example

The Low-Credit Card Interest Bank

<table>
<thead>
<tr>
<th>Factor</th>
<th>Weight</th>
<th>Rating Site A</th>
<th>Rating Site B</th>
<th>Score Site A</th>
<th>Score Site B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size and education of workforce within 15 miles</td>
<td>20</td>
<td>60</td>
<td>75</td>
<td>1,200</td>
<td>1,500</td>
</tr>
<tr>
<td>Availability of part-time workers (students)</td>
<td>10</td>
<td>45</td>
<td>20</td>
<td>450</td>
<td>200</td>
</tr>
<tr>
<td>Distance to telecommunication infrastructure</td>
<td>25</td>
<td>80</td>
<td>90</td>
<td>2,000</td>
<td>2,250</td>
</tr>
<tr>
<td>Distance to higher education facilities</td>
<td>5</td>
<td>50</td>
<td>35</td>
<td>250</td>
<td>175</td>
</tr>
<tr>
<td>Cost of living index</td>
<td>15</td>
<td>85</td>
<td>80</td>
<td>1,275</td>
<td>1,200</td>
</tr>
<tr>
<td>Cultural amenities</td>
<td>10</td>
<td>65</td>
<td>40</td>
<td>650</td>
<td>400</td>
</tr>
<tr>
<td>Crime statistics</td>
<td>15</td>
<td>95</td>
<td>90</td>
<td>1,425</td>
<td>1,350</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>100</strong></td>
<td></td>
<td></td>
<td><strong>7,250</strong></td>
<td><strong>7,075</strong></td>
</tr>
</tbody>
</table>
Location Decision-Making Techniques

Center-of-Gravity Method
Location Decision-Making Techniques – Center-of-Gravity Method

- Finds the “most central location” by calculating the X and Y coordinates that minimize transportation costs.

\[
C_x = \frac{\sum d_{ix} V_i}{\sum V_i}
\]

\[
C_y = \frac{\sum d_{iy} V_i}{\sum V_i}
\]

where

- \(C_x\) = X coordinate of the center of gravity
- \(C_y\) = Y coordinate of the center of gravity
- \(d_{ix}\) = X coordinate of the \(i\)th location
- \(d_{iy}\) = Y coordinate of the \(i\)th location
- \(V_i\) = Volume of goods moved to or from the \(i\)th location
Example

- Regional bottler finding good location for a new facility
- Uses data on the locations of its four suppliers and the number of truckloads shipped from each
Center-of-Gravity Example

For the cardboard and paper supplier, 
\( d_{ix} = 60 \), \( d_{iy} = 290 \), and \( V_i = 13 \)

\[
C_x = \frac{\sum d_{ix} V_i}{\sum V_i} \quad C_y = \frac{\sum d_{iy} V_i}{\sum V_i}
\]

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Truckloads per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard and paper goods</td>
<td>13</td>
</tr>
<tr>
<td>Aluminum cans</td>
<td>15</td>
</tr>
<tr>
<td>Plastic bottles and tops</td>
<td>19</td>
</tr>
<tr>
<td>Syrup concentrate</td>
<td>60</td>
</tr>
</tbody>
</table>
Location Decision-Making Techniques – Center-of-Gravity Example

\[ C_x = \frac{(60 \times 13) + (340 \times 15) + (120 \times 19) + (440 \times 60)}{13 + 15 + 19 + 60} \]

\[ = 322.99 \]

\[ C_y = \frac{(290 \times 13) + (280 \times 15) + (200 \times 19) + (110 \times 60)}{13 + 15 + 19 + 60} \]

\[ = 171.68 \]
Example

- The coordinates for the center-of-gravity location are approximately (323, 172)
The objective is to minimize material handling cost by placing interacting departments as close together as possible.
Product layout is useful in a mass-production situation. Machines are organized so that each operation is performed at work stations arranged in a fixed sequence.

Example: mass production systems where workers are stationary and a belt moves work to them.
Process layout is necessary in the other extreme—job lot production. Self contained work stations not organized in a fixed sequence.

Provides flexibility in making a wide variety of products tailored to customers.
Process Layout

Lathe Department

Milling Department

Drilling Department

Grinding Department

Receiving and Shipping

Painting Department

Assembly

Lathe Department

Milling Department

Drilling Department

Grinding Department

Receiving and Shipping

Painting Department

Assembly
All incoming jobs and materials

Product Layout

Finished product

Process Layout

Incoming job 1

Finished product 1

Incoming job 2

Finished product 2

Workstation  Product
Fixed-position layout is useful when the product is so extremely large that it is easier to bring the workstation to the product rather than the product to the workstation.

Examples of fixed-position layout include larger shipbuilding and airplane manufacturing.
Layout types

![Diagram showing the relationship between Quantity, Variety/Size, Product Layout, Process Layout, and Fixed Layout.]
Operations Process Chart

- An operations process chart depicts the flow of the material through the various processes.
- It shows only operations and inspections; it does not show transportations, storages, or delays.

- Operation

- Inspection
The following questions should be asked about each activity:

1. Is this activity necessary, or can it be eliminated?
2. Can this activity be combined with another or others?
3. Is this the proper sequence of activities, or should the sequence be changed?
4. Can this activity be improved?
5. Is this the proper person to be doing this activity?
• In the operations process chart, a complete unit is shown on a page (whenever possible).
• The chief component starts at the top and subsidiary components are added as the flow progress to the right and down.
Cold milk

whip

Jello

beat

eggs

sugar

thaw and drain

blend

boil

mix

place in refrigerator
to cool

mix

pour into shells

place in refrigerator
to cool

serve
2. Flow Process Charts

- A flow process chart is a chart of all activities involved in a process.
- It is similar to an operations process chart, except that more detail is shown by including transportations and delays as well as operations, inspections, and storages.
- As in operations process charts, the objective is to list every detail and to examine each detail closely.
When producing a product, manufacturers must consider the time and cost to make what it is they wish to sell (for a profit) to their customers.
Cost accumulate...

1. When holding an incomplete product in inventory
2. When performing manufacturing operations
3. When performing inspections
4. When moving the product about
5. And even when the product just sits idly on the production floor.
• Many of these “cost adding” steps do not change the functionality or shape of the raw material as it is being readied for the delivery to the customer.

• Any step we observe that increases customer usefulness is a VALUE ADDING step.

• Conversely, any unnecessary step, or just an idle time delay, is considered a Non-value adding step or more appropriately a COST ADDING step… and one that should be minimized or eliminated.
Symbol 1: OPERATION

- An operation is identified by this symbol:

  ![Symbol](image)

  The product being studied is materially changed by an operation.

Is an OPERATION a value ADDING process?

By changing a product with an OPERATION, its functionality is increased -- and Value is added!
Symbol 2: TRANSPORTATION

- Transportation steps are essential to material handling MOVEMENTs that bring materials into position to ADD VALUE.
- However, to maximize profitability, transportation distances (and thus time and cost) must be minimized.
- Transportation uses the ARROW symbol.
Symbol 3: INSPECTION

- An inspection is designed by a square

- Is an inspection a value adding step?

- The correct answer is NO!
- While inspections are often necessary, the product is not materially changed -- thus its value is not improved.
- (A company must strive to eliminate inspection to increase profitability)
Symbol 4: DELAY

- It is a totally unplanned (an undesired) processing step. This leads to idle time within the product flow path and increased cost of product. When charting a delay, the material handling specialist or IE must estimate the likely delay time so that it can be studied and eliminated.
Symbol 5: STORAGE

- Storage is a step where parts are held and protected against unauthorized removal. Storage is indicated by a triangle.
- Storage differs from a delay in that it is planned and can even be a VALUE_ADDing step.
OPERATIONS PROCESS CHART

Operations
Inspections

FLOW PROCESS CHART

Operations
Inspections
Transportations
Delays
Storages
The following questions should be asked about each activity:

1. Is this activity necessary, or can it be eliminated?
2. Can this activity be combined with another or others?
3. Is this the proper sequence of activities, or should the sequence be changed?
4. Can this activity be improved?
5. Is this the proper person to be doing this activity?
The activity relationship diagram shows the desired closeness of departments and areas within the plant.
<table>
<thead>
<tr>
<th>Letter</th>
<th>Closeness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Absolutely necessary</td>
</tr>
<tr>
<td>E</td>
<td>Especially Important</td>
</tr>
<tr>
<td>I</td>
<td>Important</td>
</tr>
<tr>
<td>O</td>
<td>Ordinary Closeness</td>
</tr>
<tr>
<td>U</td>
<td>Unimportant</td>
</tr>
<tr>
<td>X</td>
<td>Not Desirable</td>
</tr>
</tbody>
</table>

**Diagram:**

```
+----------------+----------------+----------------+----------------+----------------+
|                 |                |                |                |                |
| Paper Storage   | Design         | Binding and    | Handwork       | Printing       |
|                 |                |                |                |                |
|                 | U              | I              | E              | O              |
|                 |                |                |                |                |
|                 |                | O              | O              | E              |
|                 |                |                |                |                |
|                 |                |                | O              | O              |
|                 |                |                |                | O              |
|                 |                |                |                |                |
|                 |                |                |                | I              |
|                 |                |                |                |                |
|                 |                |                | E              | U              |
|                 |                |                |                |                |
|                 |                |                | U              | A              |
|                 |                |                |                |                |
|                 |                |                | U              | A              |
|                 |                |                |                |                |
|                 |                |                | U              |                |
|                 | U              |                |                |                |
```
A from-to chart shows the number of trips from one area to another area and is based on historical data or proposed production (Matrix 1)

<table>
<thead>
<tr>
<th></th>
<th>Paper Storage</th>
<th>Design</th>
<th>Binding and Handwork</th>
<th>Printing</th>
<th>Customer Service</th>
<th>Packaging and Shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Storage</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>260</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>Design</td>
<td>0</td>
<td>12</td>
<td>10</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Binding and Handwork</td>
<td>0</td>
<td>310</td>
<td>8</td>
<td>440</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Printing</td>
<td>0</td>
<td>6</td>
<td>560</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer Service</td>
<td>0</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging and Shipping</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Distances between the areas of the building (**Matrix 2**)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>30</td>
<td>60</td>
<td>15</td>
<td>40</td>
<td>70</td>
</tr>
<tr>
<td>B</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>40</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>C</td>
<td>60</td>
<td>30</td>
<td>0</td>
<td>70</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>40</td>
<td>70</td>
<td>0</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>E</td>
<td>40</td>
<td>15</td>
<td>40</td>
<td>30</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>F</td>
<td>70</td>
<td>40</td>
<td>15</td>
<td>60</td>
<td>30</td>
<td>0</td>
</tr>
</tbody>
</table>
Total distance obtained by multiplying values in Matrix 1 and Matrix 2

Exhibit 15.15 Distance Matrix for Proposed Layout

<table>
<thead>
<tr>
<th></th>
<th>Paper Storage</th>
<th>Design</th>
<th>Binding and Handwork</th>
<th>Printing</th>
<th>Customer Service</th>
<th>Packaging and Shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Storage</td>
<td>0</td>
<td>0</td>
<td>3,600</td>
<td>3,900</td>
<td>800</td>
<td>3,500</td>
</tr>
<tr>
<td>Design</td>
<td>0</td>
<td>360</td>
<td>400</td>
<td>225</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>Binding and Handwork</td>
<td>0</td>
<td></td>
<td>21,700</td>
<td>320</td>
<td>6,600</td>
<td>0</td>
</tr>
<tr>
<td>Printing</td>
<td>0</td>
<td></td>
<td>0</td>
<td>180</td>
<td>33,600</td>
<td>0</td>
</tr>
<tr>
<td>Customer Service</td>
<td>0</td>
<td></td>
<td>0</td>
<td>0</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Packaging and Shipping</td>
<td>0</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Total distance = 75,735

Minimize total distance