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Operations Management

Layout Strategy

Chapter 9
Outline

- GLOBAL COMPANY PROFILE: MCDONALD’S
- THE STRATEGIC IMPORTANCE OF LAYOUT DECISIONS
- TYPES OF LAYOUT
- FIXED-POSITION LAYOUT
- PROCESS-ORIENTED LAYOUT
  - Computer Software for Process-Oriented Layouts
  - Work Cells
  - The Focused Work Center and the Focused Factory
Outline - Continued

- OFFICE LAYOUT
- RETAIL LAYOUT
  - Servicescapes
- WAREHOUSING AND STORAGE LAYOUTS
  - Cross-Docking
  - Random Stocking
  - Customizing
- REPETITIVE AND PRODUCT-ORIENTED LAYOUT
  - Assembly-Line Balancing
Learning Objectives

When you complete this chapter, you should be able to:

*Identify or Define:*

- Fixed-position layout
- Process-oriented layout
- Work cells
- Focused work center
- Office layout
- Retail layout
- Warehouse layout
- Product-oriented layout
- Assembly-line factory
Learning Objectives

When you complete this chapter, you should be able to:

Describe or explain:

- How to achieve a good layout for the process facility
- How to balance production flow in a repetitive or product-oriented facility
McDonald’s - New Kitchen Layout

♦ Fifth major innovation - kitchen design
  ♦ No food prepared ahead except patty
  ♦ Elimination of some steps, shortening of others
  ♦ New bun toasting machine (11 seconds vs 30 seconds)
  ♦ Repositioning condiment containers (one motion, not two)
  ♦ Sandwiches assembled in order
  ♦ Production levels controlled by computer
  ♦ Discard only meat when sandwiches do not sell fast enough
  ♦ Savings of $100,000,000 per year in food costs
McDonald’s - New Kitchen Layout

- No food prepared ahead except patty
- Elimination of some steps, shortening of others
- New bun toasting machine (11 seconds vs 30 seconds)
- Repositioning condiment containers (one motion, not two)
Innovation at McDonald’s

- Indoor seating (1950’s)
- Drive-through window (1970s)
- Adding breakfast to the menu (1980s)
- Adding play areas (1990s)

(three out of the four are layout decisions)
Objectives of the Layout Strategy

- Develop an economical layout which will meet the requirements of:
  - product design and volume (product strategy)
  - process equipment and capacity (process strategy)
  - quality of work life (human resource strategy)
  - building and site constraints (location strategy)
Types of Layouts

- Fixed-position layout
- Process-oriented layout
- Office layout
- Retail layout
- Warehouse layout
- Product-oriented layout
What is Facility Layout

- Location or arrangement of everything within & around buildings
- Objectives are to maximize
  - Customer satisfaction
  - Utilization of space, equipment, & people
  - Efficient flow of information, material, & people
  - Employee morale & safety
Strategic Importance of Layout

Proper layout enables:

- Higher utilization of space, equipment, and people
- Improved flow of information, materials, or people
- Improved employee morale and safer working conditions
- Improved customer/client interaction
- Flexibility
Six Layout Strategies

- **Fixed-position layout**
  - large bulky projects such as ships and buildings

- **Process-oriented layout**
  - deals with low-volume, high-variety production (“job shop”, intermittent production)

- **Office layout**
  - positions workers, their equipment, and spaces/offices to provide for movement of information
Six Layout Strategies - continued

- Retail/service layout
  - allocates shelf space and responds to customer behavior

- Warehouse layout
  - addresses trade-offs between space and material handling

- Product-oriented layout
  - seeks the best personnel and machine use in repetitive or continuous production
### Layout Strategies

<table>
<thead>
<tr>
<th>Project (fixed-position)</th>
<th>Job Shop (Process-oriented)</th>
<th>Office</th>
<th>Retail</th>
<th>Warehouse (storage)</th>
<th>Repetitive /Continuous (product-oriented)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingal Ship Building Corp.</td>
<td>Shouldice Hospital</td>
<td>Allstate Insurance</td>
<td>Kroger’s Supermarket</td>
<td>Federal-Mogul’s Warehouse</td>
<td>Sony’s TV Assembly Line</td>
</tr>
<tr>
<td>Trump Plaza</td>
<td>Olive Garden</td>
<td>Microsoft</td>
<td>Walgreens</td>
<td>The Gap’s distribution center</td>
<td>Dodge Caravans Minivans</td>
</tr>
<tr>
<td>Pittsburgh Airport</td>
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</tr>
</tbody>
</table>

### Examples

- Pittsburgh Airport
- Shouldice Hospital
- Allstate Insurance
- Kroger’s Supermarket
- Federal-Mogul’s Warehouse
- Sony’s TV Assembly Line
- Olive Garden
- Microsoft
- Walgreens
- The Gap’s distribution center
- Dodge Caravans Minivans

### Problem

- Move material to the limited storage areas around the site
- Manage varied material flow for each product
- Locate workers requiring frequent contact close to each other
- Expose customer to high-margin items
- Balance low-cost storage with low-cost material handling
- Equalize the task time at each workstation
Layout Example - Office
Requirements of a Good Layout

- an understanding of capacity and space requirements
- selection of appropriate material handling equipment
- decisions regarding environment and aesthetics
- identification and understanding of the requirements for information flow
- identification of the cost of moving between the various work areas
Constraints on Layout Objectives

- Product design & volume
- Process equipment & capacity
- Quality of work life
- Building and site
Layout Strategies, Examples, and Criteria

<table>
<thead>
<tr>
<th>Layout strategy</th>
<th>Example</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service/retail</td>
<td>Drug store/Grocery store/Department store</td>
<td>Expose customer to high margin items</td>
</tr>
<tr>
<td>Storage</td>
<td>Distributor/Warehouse</td>
<td>Minimize storage and handling costs</td>
</tr>
<tr>
<td>Product oriented</td>
<td>TV assembly line</td>
<td>Minimize line imbalance, delay, and idle time</td>
</tr>
</tbody>
</table>
Areas of Concern in Layout Strategy

- Communication
- Service Areas
- Material Attributes
- Work Cell
- Material Flow
- Warehousing
- Safety
Fixed-Position Layout

- Design is for stationary project
- Workers and equipment come to site
- Complicating factors
  - Limited space at site
  - Changing material needs
Factors Complicating a Fixed Position Layout

- There is limited space at virtually all sites
- At different stages in the construction process, different materials are needed – therefore, different items become critical as the project develops
- The volume of materials needed is dynamic
Process-Oriented Layout

- Design places departments with large flows of material or people together
- Department areas having similar processes located in close proximity
  - e.g., All x-ray machines in same area
- Used with process-focused processes
Emergency Room Layout

- E.R. Triage room
- E.R. Admissions
- Pharmacy
- Billing/exit
- Surgery
- Radiology

Patient A - broken leg
Patient B - erratic pacemaker

E.R. beds
Hallway
Steps in Developing a Process-Oriented Layout

1. Construct a “from-to matrix”
2. Determine space requirements for each department
3. Develop an initial schematic diagram
4. Determine the cost of this layout
5. By trial-and-error (or more sophisticated means), try to improve the initial layout
6. Prepare a detailed plan that evaluates factors in addition to transportation cost
Cost of Process-Oriented Layout

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

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 \( j \)
## Interdepartmental Flow of Parts

<table>
<thead>
<tr>
<th></th>
<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
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</tbody>
</table>

This table represents the flow of parts between different departments, with values indicating the number of parts transferred. The diagonal represents zero transfer within the same department.
Interdepartmental Flow Graph Showing Number of Weekly Loads

1  →  2: 50
2  →  3: 30
2  →  1: 100
2  →  4: 50
3  →  6: 100
4  →  5: 50
4  →  2: 50
5  →  4: 50
5  →  6: 100
5  →  2: 20
6  →  2: 20

Possible Layout 1

Room 1

Assembly Department (1)

Room 2

Printing Department (2)

Room 2

Machine Shop Department (3)

Room 4

Receiving Department (4)

Room 5

Shipping Department (5)

Room 6

Testing Department (6)

60’

40’
Interdepartmental Flow Graph
Showing Number of Weekly Loads

1  ➔  2: 30
1  ➔  3: 50
1  ➔  4: 100
2  ➔  1: 50
2  ➔  2: 100
2  ➔  3: 20
2  ➔  4: 20
3  ➔  1: 100
3  ➔  2: 100
4  ➔  1: 50
4  ➔  2: 50
5  ➔  4: 50
5  ➔  5: 50
6  ➔  3: 100
6  ➔  4: 100
6  ➔  5: 20
Possible Layout 3

Room 1
Painting Department (2)

Room 2
Assembly Department (1)

Room 2
Machine Shop Department (3)

Room 4
Receiving Department (4)

Room 5
Shipping Department (5)

Room 6
Testing Department (6)

40'
60'
Computer Programs to Assist in Layout

- CRAFT
- SPACECRAFT
- CRAFT 3-D
- MULTIPLE
- CORELAP
- ALDEP
- COFAD
- FADES - expert system
Out-Patient Hospital Example

CRAFT

<table>
<thead>
<tr>
<th></th>
<th>1</th>
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<th>4</th>
<th>5</th>
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<tbody>
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<td>E</td>
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<td>E</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

Legend:

A = xray/MRI rooms
B = laboratories
C = admissions
D = exam rooms
E = operating rooms
F = recovery rooms

Total cost: 20,100
Est. Cost Reduction: 0.00
Iteration: 0

Total cost: 14,390
Est. Cost Reduction: 70.00
Iteration: 3

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Cellular Layout - Work Cells

- Special case of product-oriented layout - in what is ordinarily a process-oriented facility
- Consists of *different* machines brought together to make a product
- Temporary arrangement only
- Example: Assembly line set up to produce 3000 identical parts in a job shop
Improving Layouts by Moving to the Work Cell Concept

Note in both (a) and (b) that U-shaped work cells can reduce material and employee movement. The U shape may also reduce space requirements, enhance communication, cut the number of workers, and make inspection easier.

(a)

Current layout—workers in small closed areas. Cannot increase output without a third worker.

(b)

Current layout—straight lines make it hard to balance tasks because workers may not be able to divide tasks evenly.

Improved layout—workers can assist each other. May be able to add a third worker.

Improved layout—in U shape, workers have better access. Four workers were reduced to three.
Work Cells - Some Advantages

- Reduced work-in-process inventory
- Less floor space required
- Reduced raw material and finished goods inventories required
- Reduced direct labor costs
- Heightened sense of employee participation
- Increased utilization of equipment machinery
- Reduced investment in machinery and equipment
Work Cell Advantages

- Inventory
- Floor space
- Direct labor costs

- Equipment utilization
- Employee participation
- Quality
Requirements for Cellular Production

- Identification of families of products - group technology codes
- High level of training and flexibility on the part of the employees
- Either staff support or flexible, imaginative employees to establish the work cells initially
- Test (poka-yoke) at each station in the cell
## Work Cells, Focused Work Centers and the Focused Factory

<table>
<thead>
<tr>
<th><strong>Work Cell</strong></th>
<th>A temporary assembly-line-oriented arrangement of machines and personnel in what is ordinarily a process-oriented facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>job shop with rearranged machinery and personnel to produce 30 unique control panels</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Focused Work Center</strong></th>
<th>A permanent assembly-line-oriented arrangement of machines and personnel in what is ordinarily a process-oriented facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>manufacturing of pipe brackets at a shipyard</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Focused Factory</strong></th>
<th>A permanent facility to produce a product or component in a product-oriented facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>a plant to produce window mechanisms for automobiles</td>
</tr>
</tbody>
</table>
Number of Product Lines and Operating Performance

- More focused plants
  - J(1)
  - G(1)
  - H(2)
  - I(2)
- Less focused plants
  - E(4)
  - C(5)
  - B(5)
  - F(6)
  - A(6)

Sales ($M)
Office Layout

- Design positions people, equipment, & offices for maximum information flow
- Arranged by process or product
  - Example: Payroll dept. is by process
- Relationship chart used
- Examples
  - Insurance company
  - Software company
Relationship Chart

1 President

2 Costing

3 Engineering

4 President’s Secretary

I = Important

U = Unimportant

Ordinary closeness: President (1) & Costing (2)

Absolutely necessary: President (1) & Secretary (4)
Office Relationship Chart

1. President
2. Chief Technology Officer
3. Engineer’s Area
4. Secretary
5. Office entrance
6. Equipment cabinet
7. Photocopy equipment
8. Storage room
9. Storage room

Val. | Closeness
--- | ---
A | Absolutely necessary
E | Especially important
I | Important
O | Ordinary OK
U | Unimportant
X | Not desirable
Retail/Service Layout

- Design maximizes product exposure to customers
- Decision variables
  - Store flow pattern
  - Allocation of (shelf) space to products
- Types
  - Grid design
  - Free-flow design
Retail Layouts -
Some Rules of Thumb

- Locate high-draw items around the periphery of the store.
- Use prominent locations such as the first or last aisle for high-impulse and high margin items.
- Remove crossover aisles that allow customers the opportunity to move between aisles.
- Distribute what are known in the trade as “power items” (items that may dominate a shopping trip) to both sides of an aisle, and disperse them to increase the viewing of other items.
- Use end aisle locations because they have a very high exposure rate.
Retail /Service Layout - Grid Design

Grocery Store

- Bread
- Meat
- Milk
- Produce
- Frozen Foods
- Office
- Carts
- Check-out
Store Layout - with Dairy, Bread, High Drawer Items in Corners
Retail/Service Layout - Free-Flow Design

Apparel Store

Feature

Trans. Counter

Display Table

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Retail Store Shelf Space Planogram

- Computerized tool for shelf-space management
- Generated from store’s scanner data on sales
- Often supplied by manufacturer
  - Example: P&G

2 ft.

5 facings

Retail Store Shelf Space Planogram

- Computerized tool for shelf-space management
- Generated from store’s scanner data on sales
- Often supplied by manufacturer
  - Example: P&G

2 ft.

5 facings
A Good Service Layout
(Servicescape) Considers

- **Ambient conditions** - background characteristics such as lighting, sound, smell, and temperature.

- **Spatial layout and functionality** - which involve customer circulation path planning

- **Signs, Symbols, and Artifacts** - characteristics of building design that carry social significance
Warehouse Layout

- Design balances space (cube) utilization & handling cost
- Similar to process layout
  - Items moved between dock & various storage areas
- Optimum layout depends on
  - Variety of items stored
  - Number of items picked
Warehouse Layout Floor Plan

- **Truck**
- **Conveyor**
- **Zones**
- **Order Picker**
Cross Docking

- Transferring goods
  - from *incoming* trucks at receiving docks
  - to *outgoing* trucks at shipping docks

- Avoids placing goods into storage

- Requires suppliers provide effective addressing (bar codes) and packaging that provides for rapid transshipment
Random Stocking Systems Often:

- Maintain a list of “open” locations
- Maintain accurate records of existing inventory and its locations
- Sequence items on orders to minimize travel time required to pick orders
- Combine orders to reduce picking time
- Assign certain items or classes of items, such as high usage items, to particular warehouse areas so that distance traveled is minimized
Product-Oriented Layout

- Facility organized around product
- Design minimizes line imbalance
  - Delay between work stations
- Types: Fabrication line; assembly line
Product-Oriented Requirements

- Standardized product
- High production volume
- Stable production quantities
- Uniform quality of raw materials & components
Product-Oriented Layout - Assumptions

- Volume is adequate for high equipment utilization
- Product demand is stable enough to justify high investment in specialized equipment
- Product is standardized or approaching a phase of its life cycle that justifies investment in specialized equipment
- Supplies of raw materials and components are adequate and of uniform quality to ensure they will work with specialized equipment
Product-Oriented Layout Types

Fabrication Line

- Builds components
- Uses series of machines
- Repetitive process
- Machine paced
- Balanced by physical redesign

Assembly Line

- Assembles fabricated parts
- Uses workstation
- Repetitive process
- Paced by tasks
- Balanced by moving tasks
Product-Oriented Layout Advantages

- Lower variable cost per unit
- Lower material handling costs
- Lower work-in-process inventories
- Easier training & supervision
- Rapid throughput
Product-Oriented Layout
Disadvantages

- Higher capital investment
  - Special equipment
- Any work stoppage stops whole process
- Lack of flexibility
  - Volume
  - Product
An Assembly Line Layout
Repetitive Layout

Note: 5 tasks or operations; 3 work stations
Assembly Line Balancing

- Analysis of production lines
- Nearly equally divides work between workstations while meeting required output

Objectives
- Maximize efficiency
- Minimize number of work stations
Assembly Line Balancing
The General Procedure

- Determine cycle time by taking the demand (or production rate) per day and dividing it into the productive time available per day
- Calculate the theoretical minimum number of work stations by dividing total task time by cycle time
- Perform the line balance and assign specific assembly tasks to each work station
Assembly Line Balancing Steps

1. Determine tasks (operations)
2. Determine sequence
3. Draw precedence diagram
4. Estimate task times
5. Calculate cycle time
6. Calculate number of work stations
7. Assign tasks
8. Calculate efficiency
Precedence Diagram Example

A → B: 10 Min.
B → C: 11
C → D: 5
D → E: 4
D → F: 3
E → F: 12
F → G: 3
G → I: 7
F → H: 11
H → I: 3
Assembly Line Balancing Equations

Cycle time = \frac{\text{Production time available}}{\text{Demand per day}}

Minimum number of work stations = \frac{\sum \text{Task times}}{\text{Cycle time}}

Efficiency = \frac{\sum \text{Task times}}{(\text{Actual number of work stations}) \times (\text{Cycle time})}
Six Station Solution
Layout Heuristics for Assigning Tasks in Assembly Line Balancing

- **Longest task time** - choose task with longest operation time
- **Most following tasks** - choose task with largest number of following tasks
- **Ranked positional weight** - choose task where the sum of the times for each following task is longest
- **Shortest task time** - choose task with shortest operation time
- **Least number of following tasks** - choose task with fewest subsequent tasks