Layout Strategies

9

PowerPoint presentation to accompany
Heizer, Render, Munson
Operations Management, Twelfth Edition, Global Edition
Principles of Operations Management, Tenth Edition, Global Edition

PowerPoint slides by Jeff Heyl

Outline

- **Global Company Profile:** McDonald's
- The Strategic Importance of Layout Decisions
- Types of Layout
- Office Layout
- Retail Layout
- Warehousing and Storage Layouts

Outline - Continued

- Fixed-Position Layout
- Process-Oriented Layout
- Work Cells
- Repetitive and Product-Oriented Layout

Innovations at McDonald's

- Indoor seating (1950s)
- Drive-through window (1970s)
- Adding breakfast to the menu (1980s)
- Adding play areas (late 1980s)
- Redesign of the kitchens (1990s)
- Self-service kiosk (2004)
- Now three separate dining sections

Innovations at McDonald's

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- Drive-through wind
- Adding breakfast t
- Adding play areas
- Redesign of the kit
- Self-service kiosk (2004)
- Now three separate dining sections

Six out of the seven are layout decisions!

McDonald's New Layout

- Seventh major innovation
- Redesigning all 30,000 outlets around the world
- Three separate dining areas
  - Linger zone with comfortable chairs and Wi-Fi connections
  - Grab and go zone with tall counters
  - Flexible zone for kids and families
- Facility layout is a source of competitive advantage

Learning Objectives

When you complete this chapter you should be able to:

9.1 ***Discuss*** important issues in office layout

9.2 ***Define*** the objectives of retail layout

9.3 ***Discuss*** modern warehouse management and terms such as ASRS, cross-docking, and random stocking

9.4 ***Identify*** when fixed-position layouts are appropriate

Learning Objectives

When you complete this chapter you should be able to:

9.5 ***Explain*** how to achieve a good process-oriented facility layout

9.6 ***Define*** work cell and the requirements of a work cell

9.7 ***Define*** product-oriented layout

9.8 ***Explain*** how to balance production flow in a repetitive or product-oriented facility

Strategic Importance of Layout Decisions

The objective of layout strategy is to develop an effective and efficient layout that will meet the firm's competitive requirements

Layout Design Considerations

- 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

Types of Layout

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

Types of Layout

1. *Office layout*: Positions workers, their equipment, and spaces/offices to provide for movement of information
2. *Retail layout*: Allocates display space and responds to customer behavior
3. *Warehouse layout*: Addresses trade-offs between space and material handling

Types of Layout

4. *Fixed-position layout*: Addresses the layout requirements of large, bulky projects such as ships and buildings
5. *Process-oriented layout*: Deals with low-volume, high-variety production (also called job shop or intermittent production)

Types of Layout

6. *Work cell layout*: Arranges machinery and equipment to focus on production of a single product or group of related products
7. *Product-oriented layout*: Seeks the best personnel and machine utilizations in repetitive or continuous production

Layout Strategies

TABLE 9.1	Layout Strategies	
	OBJECTIVES	EXAMPLES
Office	Locate workers requiring frequent contact close to one another	Allstate Insurance Microsoft Corp.
Retail	Expose customer to high-margin items	Kroger's Supermarket Walgreen's Bloomingdale's
Warehouse (storage)	Balance low-cost storage with low-cost material handling	Federal-Mogul's warehouse The Gap's distribution center
Project (fixed position)	Move material to the limited storage areas around the site	Ingall Ship Building Corp. Trump Plaza Pittsburgh Airport

Layout Strategies

TABLE 9.1 Layout Strategies		
	OBJECTIVES	EXAMPLES
Job Shop (process oriented)	Manage varied material flow for each product	Arnold Palmer Hospital Hard Rock Cafe Olive Garden
Work Cell (product families)	Identify a product family, build teams, cross-train team members	Hallmark Cards Wheeled Coach Ambulances
Repetitive/ Continuous (product oriented)	Equalize the task time at each workstation	Sony's TV assembly line Toyota Scion

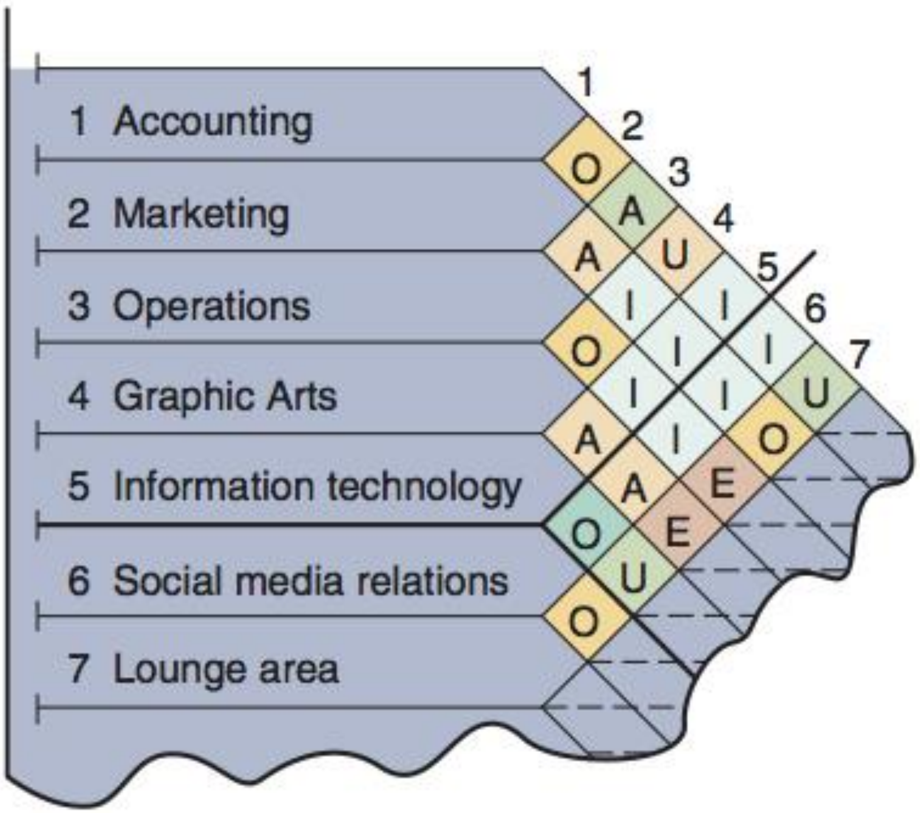
Good Layouts Consider

- Material handling equipment
- Capacity and space requirements
- Environment and aesthetics
- Flows of information
- Cost of moving between various work areas

Office Layout

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

Relationship Chart



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

Figure 9.1

Office Layout

- Three physical and social aspects
  - Proximity
  - Privacy
  - Permission

- Two major trends
  - Information technology
  - Dynamic needs for space and services

Retail Layout

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

Five Helpful Ideas for Supermarket Layout

1. Locate high-draw items around the periphery of the store
2. Use prominent locations for high-impulse and high-margin items
3. Distribute power items to both sides of an aisle and disperse them to increase viewing of other items
4. Use end-aisle locations
5. Convey mission of store through careful positioning of lead-off department

Store Layout

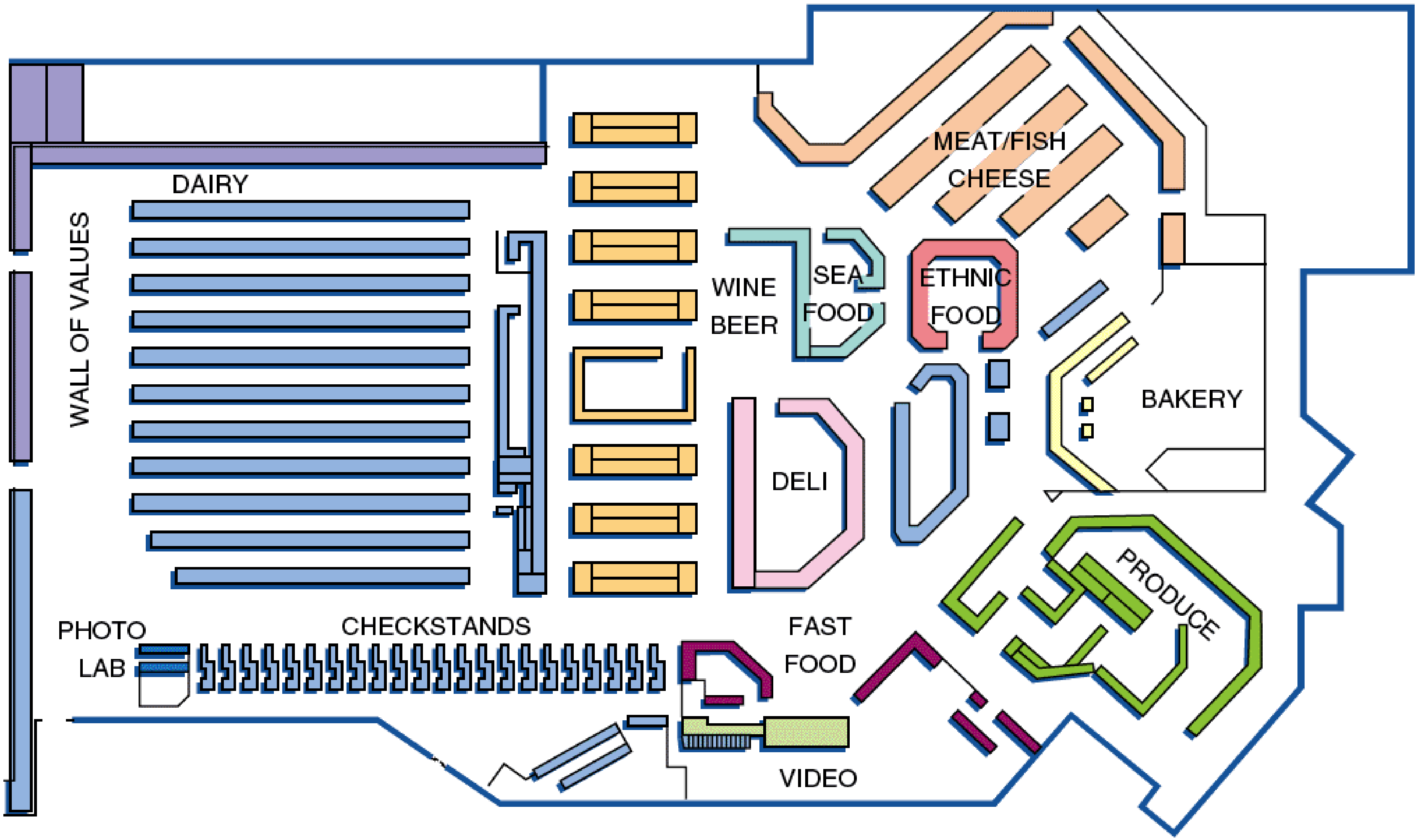


Figure 9.2

Slotting

- Manufacturers pay **slotting fees** to retailers to get the retailers to display (slot) their product
- Contributing factors
  - Limited shelf space
  - An increasing number of new products
  - Better information about sales through POS data collection
  - Closer control of inventory

Servicescapes

1. *Ambient conditions* - background characteristics such as lighting, sound, smell, and temperature
2. *Spatial layout and functionality* - which involve customer circulation path planning, aisle characteristics, and product grouping
3. *Signs, symbols, and artifacts* - characteristics of building design that carry social significance

Warehouse and Storage Layouts

- Objective *is to find the optimum trade-offs between handling costs and costs associated with warehouse space*
- Maximize the total "cube" of the warehouse – utilize its full volume while maintaining low material handling costs

Warehousing and Storage Layouts

Material Handling Costs

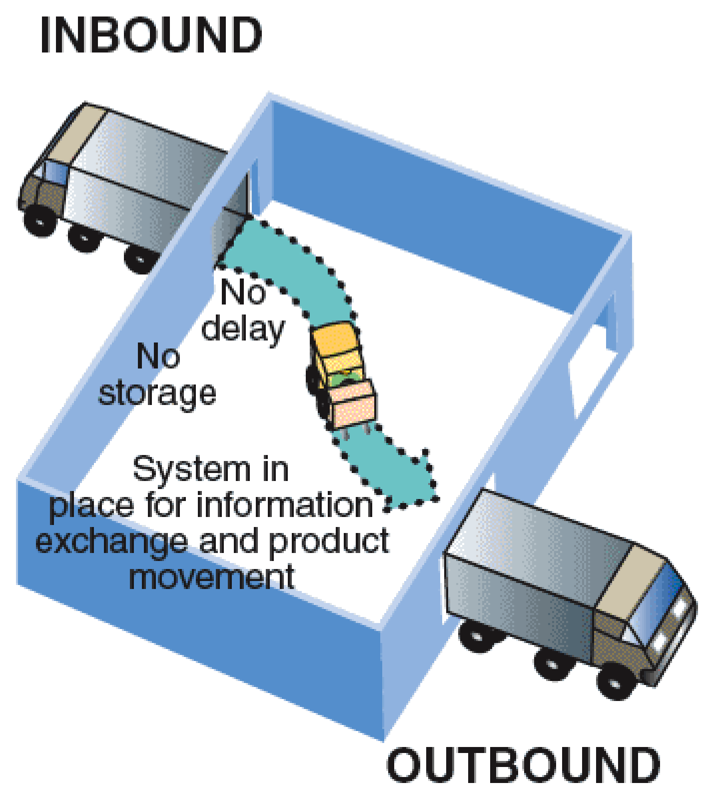
- All costs associated with the transaction
  - Incoming transport
  - Storage
  - Finding and moving material
  - Outgoing transport
  - Equipment, people, material, supervision, insurance, depreciation
- Minimize damage and spoilage

Warehousing and Storage Layouts

- Warehouse density tends to vary inversely with the number of different items stored
- Automated Storage and Retrieval Systems (ASRSs) can significantly improve warehouse productivity
- Dock location is a key design element

Cross-Docking

- Materials are moved directly from receiving to shipping and are not placed in storage in the warehouse
- Requires tight scheduling and accurate shipments, bar code or RFID identification used for advanced shipment notification as materials are unloaded



Random Stocking

- Typically requires automatic identification systems (AISs) and effective information systems
- Allows more efficient use of space
- Key tasks
  1. Maintain list of “open” locations
  2. Maintain accurate records
  3. Sequence items to minimize travel, “pick” time
  4. Combine picking orders
  5. Assign classes of items to particular areas

Customizing

- Value-added activities performed at the warehouse
- Enable low cost and rapid response strategies
  - Assembly of components
  - Loading software
  - Repairs
  - Customized labeling and packaging

Fixed-Position Layout

- Product remains in one place
- Workers and equipment come to site
- Complicating factors
  - Limited space at site
  - Different materials required at different stages of the project
  - Volume of materials needed is dynamic

Alternative Strategy

- As much of the project as possible is completed off-site in a product-oriented facility
- This can significantly improve efficiency but is only possible when multiple similar units need to be created

Process-Oriented Layout

- Like machines and equipment are grouped together
- Flexible and capable of handling a wide variety of products or services
- Scheduling can be difficult and setup, material handling, and labor costs can be high

Process-Oriented Layout

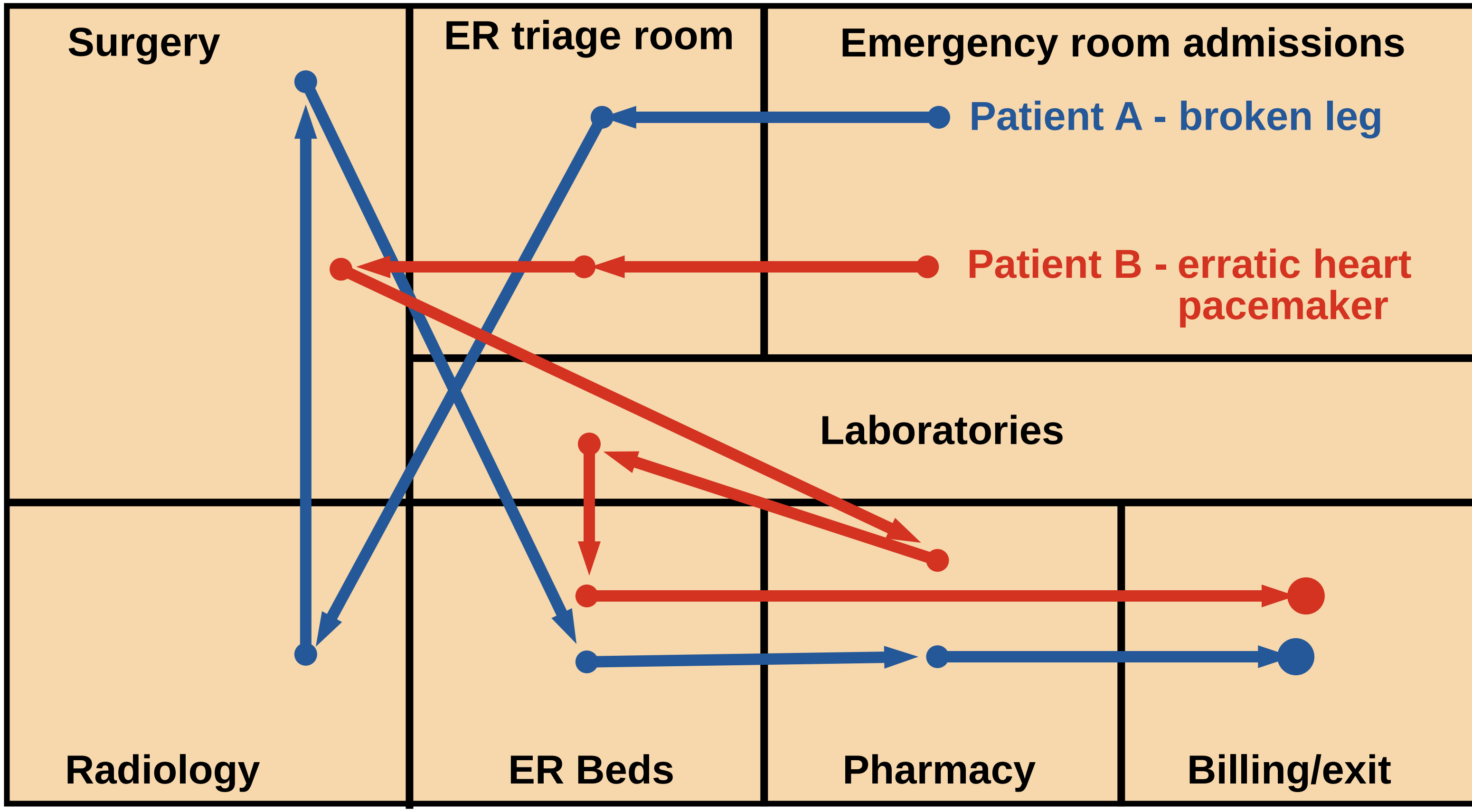


Figure 9.3

Process-Oriented Layout

- Arrange work centers so as to minimize the costs of material handling
- Basic cost elements are
  - Number of loads (or people) moving between centers
  - Distance loads (or people) move between centers

Process-Oriented Layout

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

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

Process Layout Example

Arrange six departments in a factory to minimize the material handling costs. Each department is 20 x 20 feet and the building is 60 feet long and 40 feet wide.

1. Construct a "from-to matrix"
2. Determine the space requirements
3. Develop an initial schematic diagram
4. Determine the cost of this layout
5. Try to improve the layout
6. Prepare a detailed plan

Process Layout Example

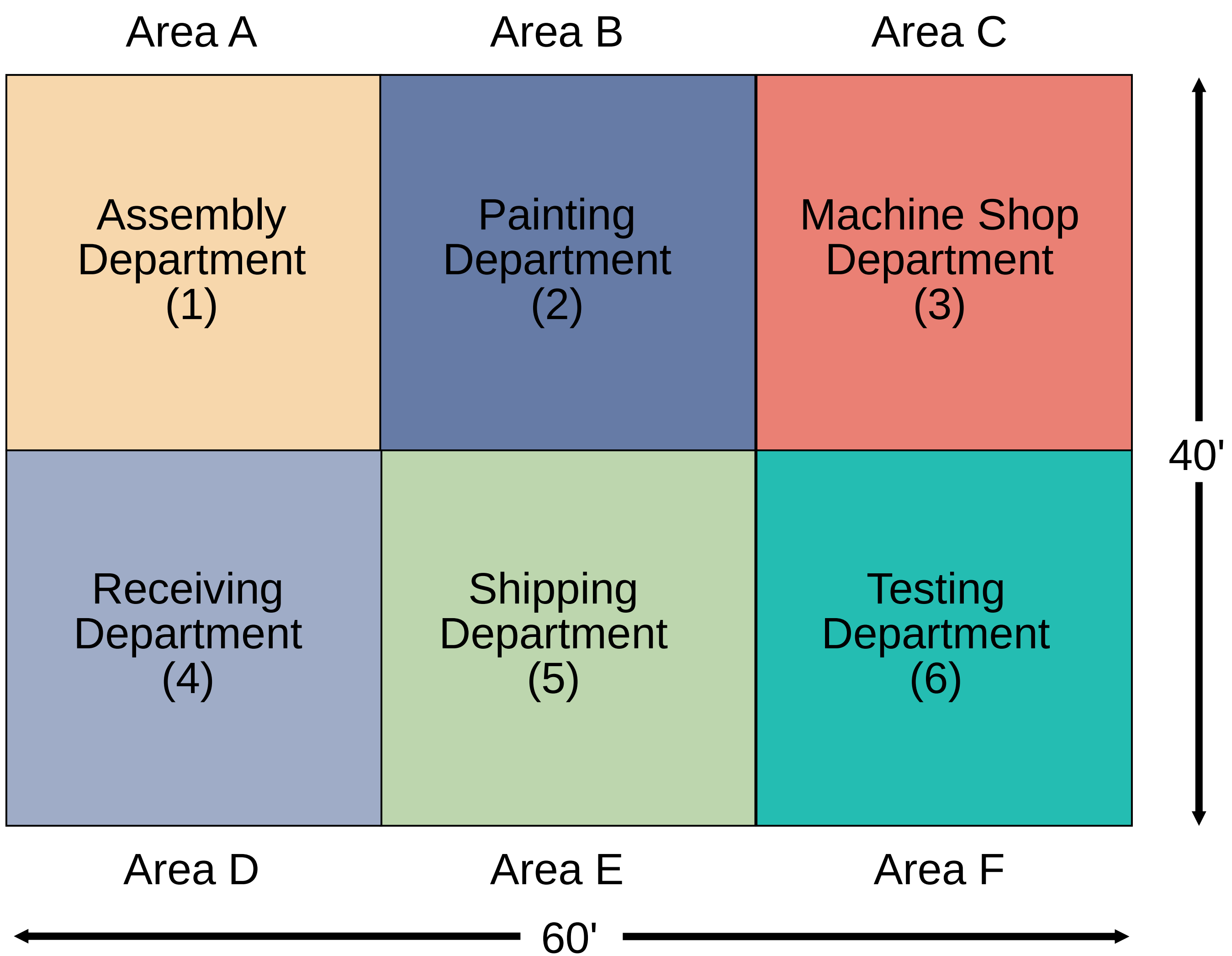
Figure 9.4

Number of loads per week

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

Process Layout Example

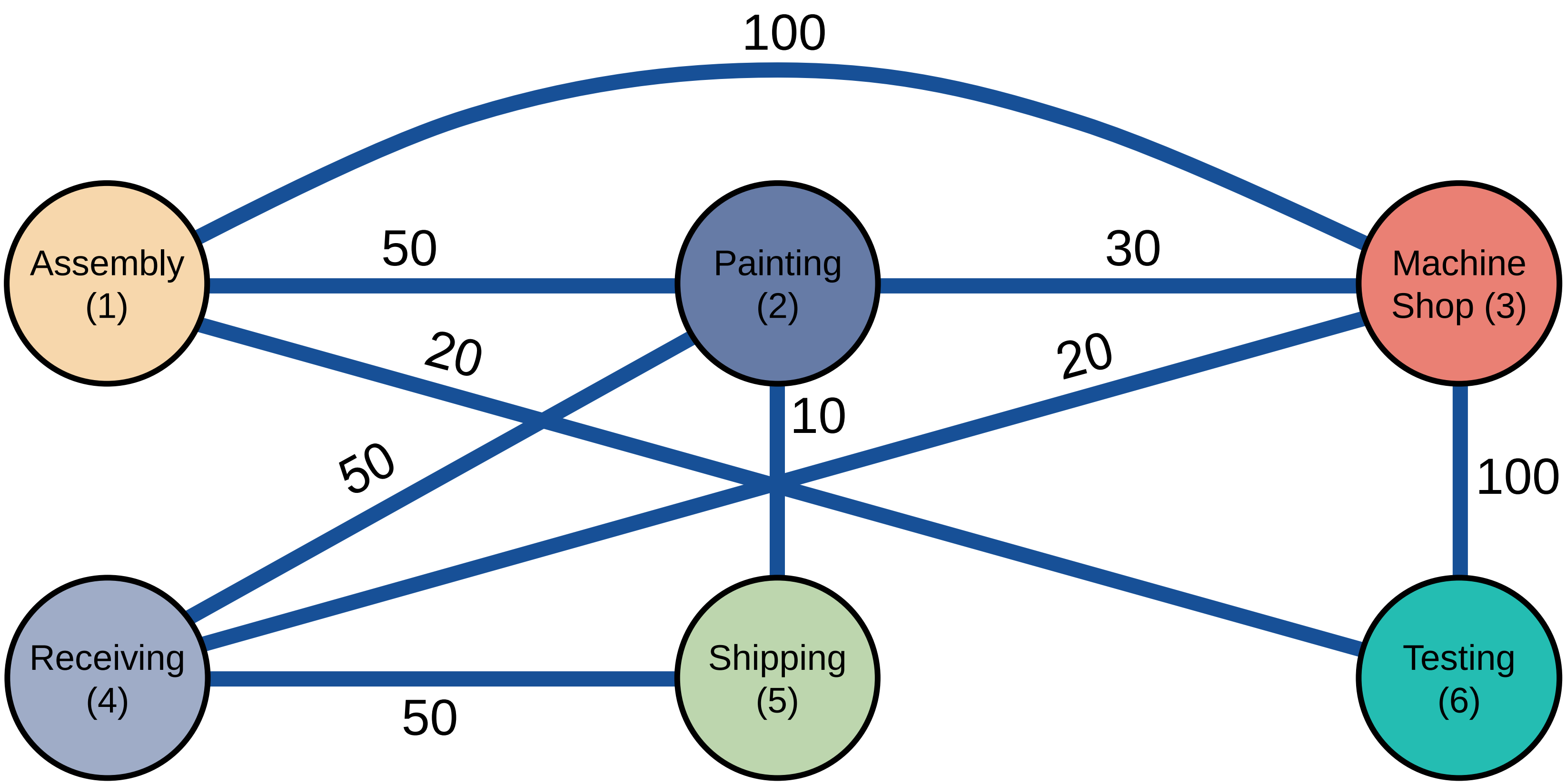
Figure 9.5



Process Layout Example

Interdepartmental Flow Graph

Figure 9.6



Process Layout Example

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

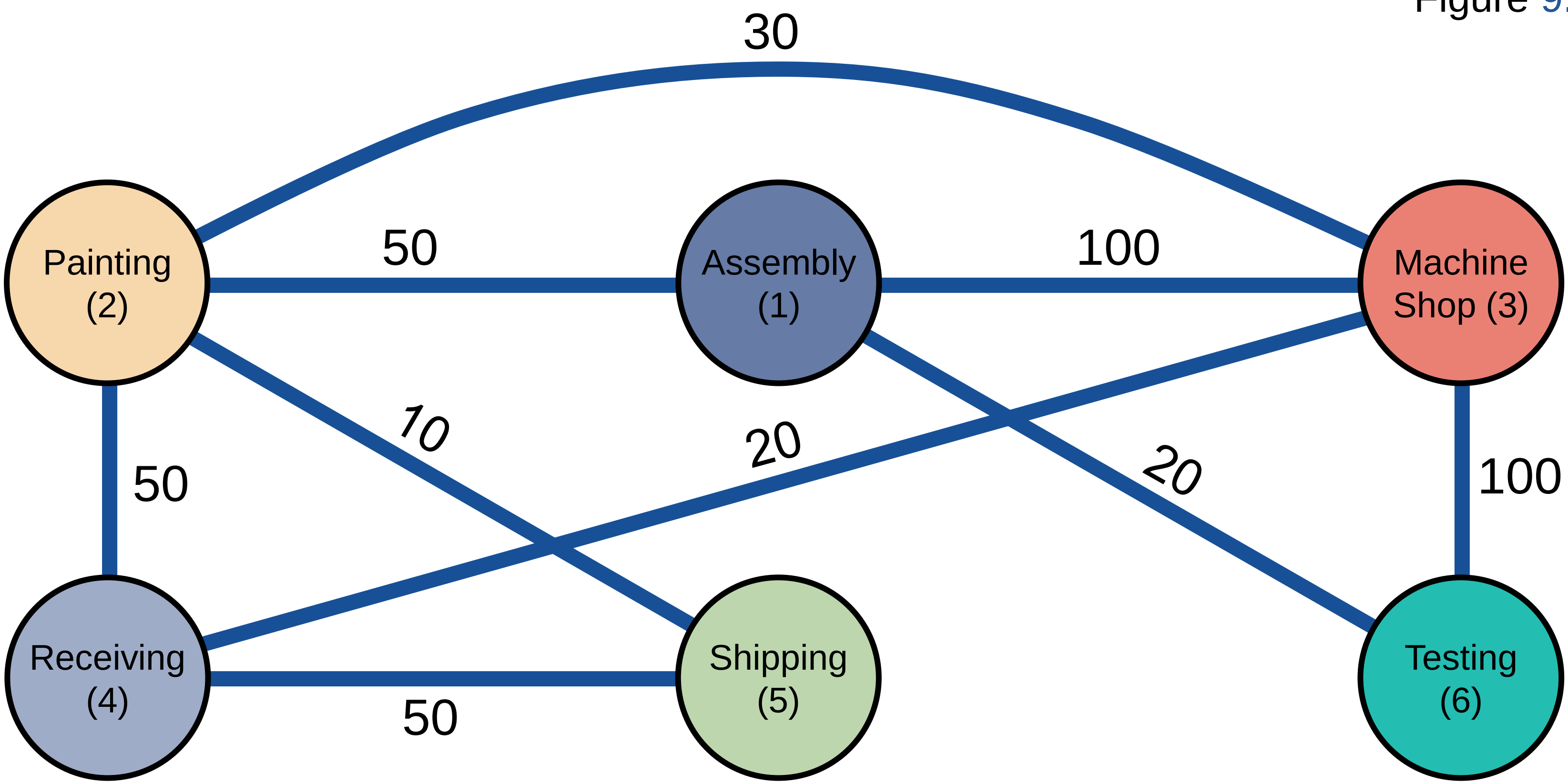
Cost	=	\$50 (1 and 2)	+	\$200 (1 and 3)	+	\$40 (1 and 6)
	+	\$30 (2 and 3)	+	\$50 (2 and 4)	+	\$10 (2 and 5)
	+	\$40 (3 and 4)	+	\$100 (3 and 6)	+	\$50 (4 and 5)

= \$570

Process Layout Example

Revised Interdepartmental Flow Graph

Figure 9.7



Process Layout Example

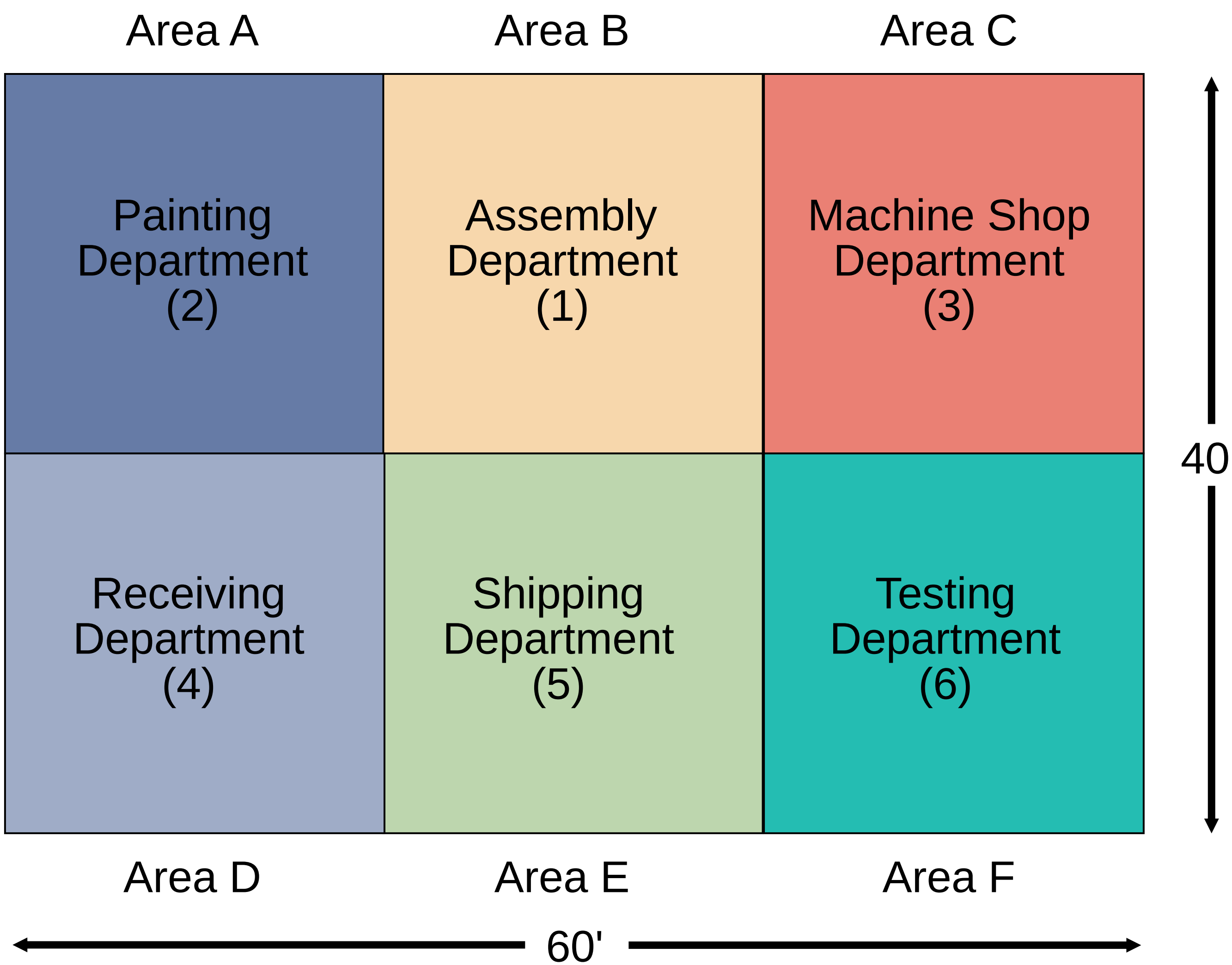
$$\text{Cost} = \sum_{i=1}^{n} \sum_{j=1}^{n} X_{ij} C_{ij}$$

Cost	=	\$50 (1 and 2)	+	\$100 (1 and 3)	+	\$20 (1 and 6)
	+	\$60 (2 and 3)	+	\$50 (2 and 4)	+	\$10 (2 and 5)
	+	\$40 (3 and 4)	+	\$100 (3 and 6)	+	\$50 (4 and 5)

= \$480

Process Layout Example

Figure 9.8



Computer Software

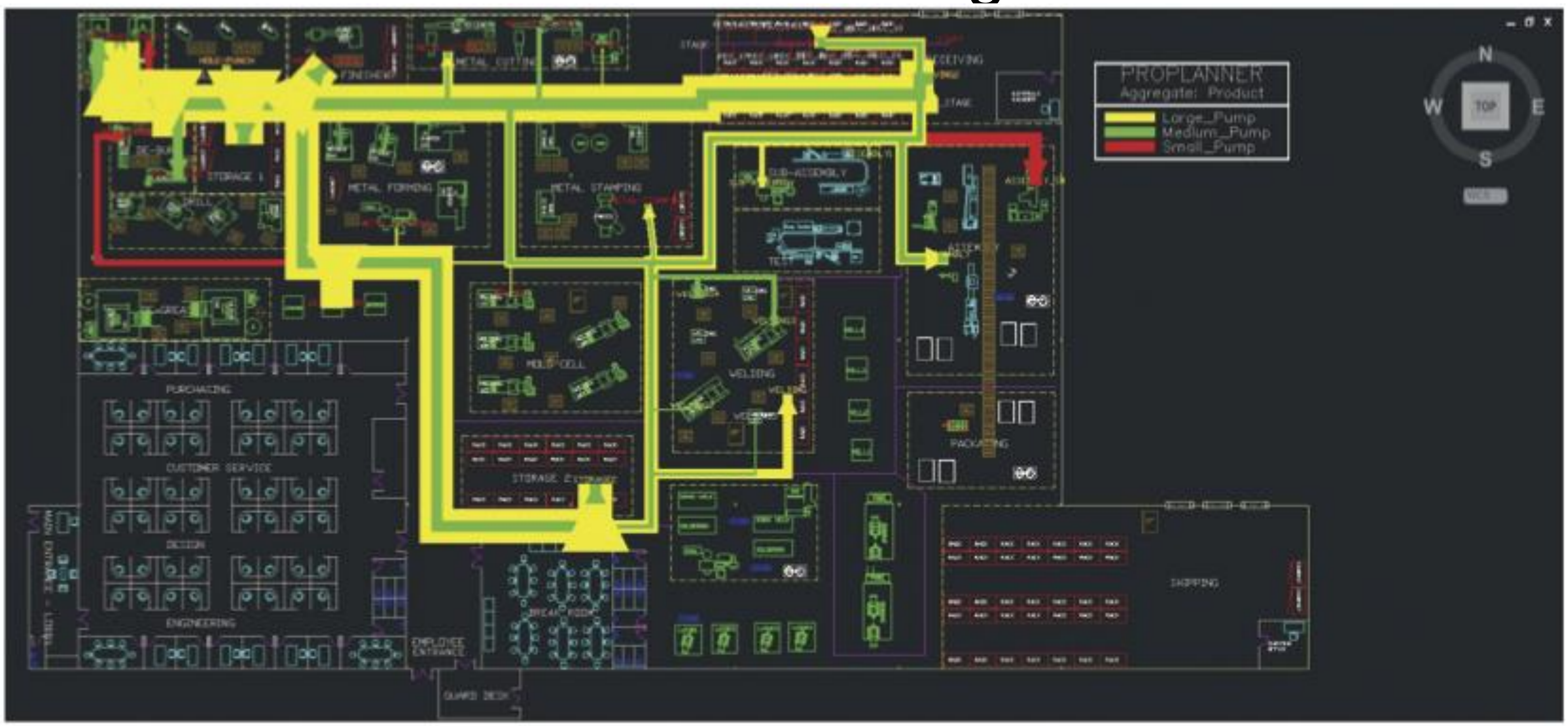
- Graphical approach only works for small problems
- Computer programs are available to solve bigger problems
  - CRAFT
  - ALDEP
  - CORELAP
  - Factory Flow
  - Proplanner

Computer Software

- Proplanner flow path calculator
  - Generate material flow diagrams
  - Calculate material handling distances, times, costs
  - Color-coded flow lines
  - Helps identify excessive material handling

Computer Software

- Proplanner flow path calculator
  - Generate material flow diagrams



Computer Software

- Three dimensional visualization software allows managers to view possible layouts and assess process, material handling, efficiency, and safety issues

Work Cells

- Reorganizes people and machines into groups to focus on single products or product groups
- Group technology identifies products that have similar characteristics for particular cells
- Volume must justify cells
- Cells can be reconfigured as designs or volume changes

Advantages of Work Cells

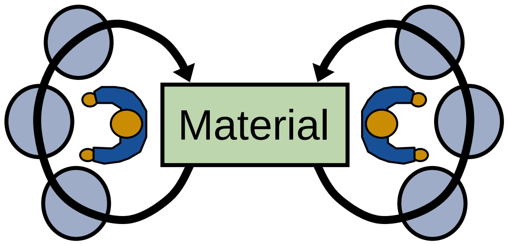
1. *Reduced work-in-process inventory*
2. *Less floor space* required
3. *Reduced raw material and finished goods inventories*
4. *Reduced direct labor cost*
5. *Heightened sense of employee participation*
6. *Increased equipment and machinery utilization*
7. *Reduced investment in machinery and equipment*

Requirements of Work Cells

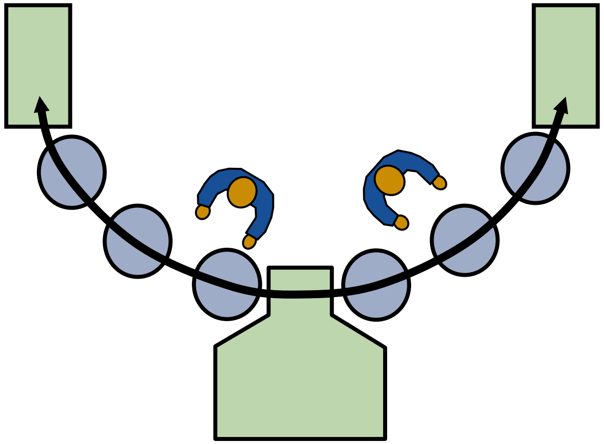
- Identification of families of products
- A high level of training, flexibility and empowerment of employees
- Being self-contained, with its own equipment and resources
- Test (poka-yoke) at each station in the cell

Improving Layouts Using Work Cells

Figure 9.9 (a)



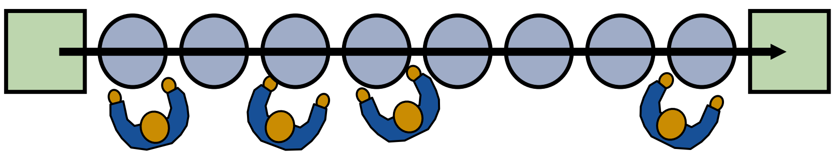
Current layout - workers in small closed areas.



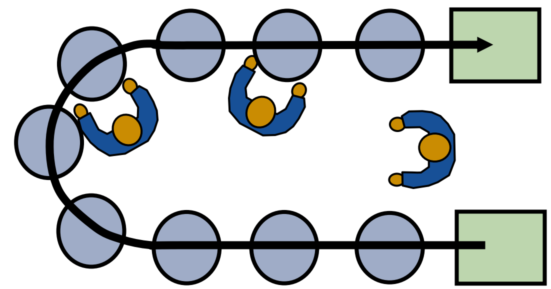
Improved layout - cross-trained workers can assist each other. May be able to add a third worker as additional output is needed.

Improving Layouts Using Work Cells

Figure 9.9 (b)



Current layout - straight lines make it hard to balance tasks because work may not be divided evenly



Improved layout - in U shape, workers have better access. Four cross-trained workers were reduced to three.

U-shaped line may reduce employee movement and space requirements while enhancing communication, reducing the number of workers, and facilitating inspection

Staffing and Balancing Work Cells

Determine the takt time

$$\text{Takt time} = \frac{\text{Total work time available}}{\text{Units required to satisfy customer demand}}$$

Determine the number of operators required

$$\text{Workers required} = \frac{\text{Total operation time required}}{\text{Takt time}}$$

Staffing Work Cells Example

600 mirrors per day required

Mirror production scheduled for 8 hours per day

From a work balance chart total operation time = 140 seconds

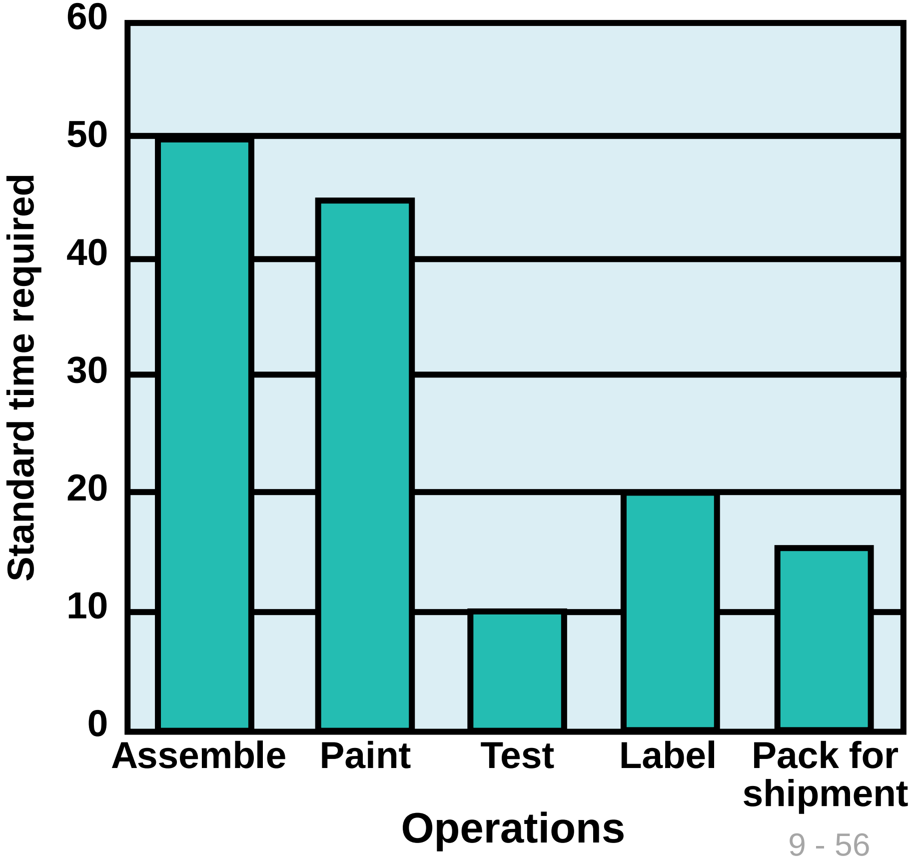


Figure 9.10

Staffing Work Cells Example

600 mirrors per day required
Mirror production scheduled for 8 hours per day
From a work balance chart total operation time = 140 seconds

Takt time = (8 hrs x 60 mins) / 600 units
= .8 min = 48 seconds

$$\text{Workers required} = \frac{\text{Total operation time required}}{\text{Takt time}}$$

= 140 / 48 = 2.92

Work Balance Charts

- Used for evaluating operation times in work cells
- Can help identify bottleneck operations
- Flexible, cross-trained employees can help address labor bottlenecks
- Machine bottlenecks may require other approaches

Focused Work Center and Focused Factory

- Focused Work Center
  - *Identify a large family of similar products that have a large and stable demand*
  - Moves production from a general-purpose, process-oriented facility to a large work cell
- Focused Factory
  - A focused work cell in a separate facility
  - May be focused by product line, layout, quality, new product introduction, flexibility, or other requirements

Repetitive and Product-Oriented Layout

Organized around products or families of similar high-volume, low-variety products

1. Volume is adequate for high equipment utilization
2. Product demand is stable enough to justify high investment in specialized equipment
3. Product is standardized or approaching a phase of life cycle that justifies investment
4. Supplies of raw materials and components are adequate and of uniform quality

Product-Oriented Layouts

- Fabrication line
  - Builds components on a series of machines
  - Machine-paced
  - Require mechanical or engineering changes to balance
- Assembly line
  - Puts fabricated parts together at a series of workstations
  - Paced by work tasks
  - Balanced by moving tasks

Product-Oriented Layouts

- Fabrication line
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- Assembly line
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  - Paced by work tasks
  - Balanced by moving tasks

Both types of lines must be balanced so that the time to perform the work at each station is the same

Product-Oriented Layouts

Advantages

1. Low variable cost per unit
2. Low material handling costs
3. Reduced work-in-process inventories
4. Easier training and supervision
5. Rapid throughput

Disadvantages

1. High volume is required
2. Work stoppage at any point ties up the whole operation
3. Lack of flexibility in product or production rates

McDonald's Assembly Line

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

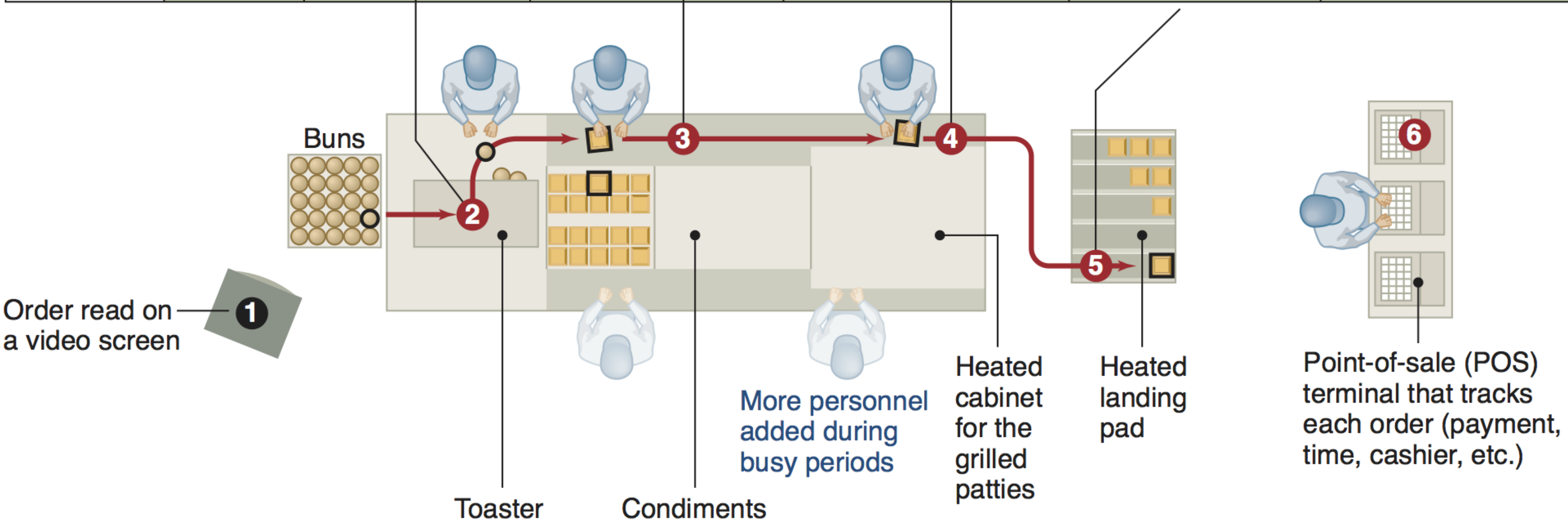


Figure 9.11

Assembly-Line Balancing

- Objective is to minimize the imbalance between machines or personnel while meeting required output
- Starts with the *precedence relationships*
  - Determine cycle time
  - Calculate theoretical minimum number of workstations
  - Balance the line by assigning specific tasks to workstations

Wing Component Example

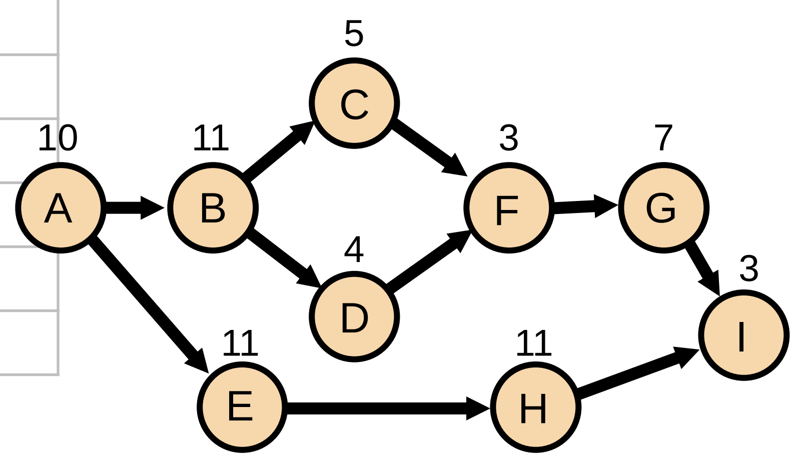
TABLE 9.2	Precedence Data for Wing Component		
TASK	**ASSEMBLY TIME (MINUTES)**	**TASK MUST FOLLOW TASK LISTED BELOW**	
A	10	–	This means that tasks B and E cannot be done until task A has been completed
B	11	A	
C	5	B	
D	4	B	
E	11	A	
F	3	C, D	
G	7	F	
H	11	E	
I	3	G, H	
	Total time 65		

Wing Component Example

TABLE 9.2	Precedence Data for Wing Component	
TASK	**ASSEMBLY TIME (MINUTES)**	**TASK MUST FOLLOW TASK LISTED BELOW**
A	10	–
B	11	A
C	5	B
D	4	B
E	11	A
F	3	C, D
G	7	F
H	11	E
I	3	G, H
Total time	65	

480 available mins per day
40 units required

Figure 9.12



Wing Component Example

TABLE 9.2	Precedence Data for Wing Component	
TASK	**ASSEMBLY TIME (MINUTES)**	**TASK MUST FOLLOW TASK LISTED BELOW**
A	10	
B	11	
C	5	
D	4	
E	11	
F	3	
G	7	
H	11	
I	3	
	Total time 65	

480 available mins per day

40 units required

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

$= 480 / 40$

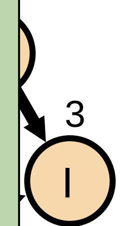
$= 12$ minutes per unit

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

$= 65 / 12$

$= 5.42$, or 6 stations

9.12



Wing Component Example

TABLE 9.3	Layout Heuristics That May Be Used to Assign Tasks to Workstations in Assembly-Line Balancing
1. Longest task time	From the available tasks, choose the task with the largest (longest) task time
2. Most following tasks	From the available tasks, choose the task with the largest number of following tasks
3. Ranked positional weight	From the available tasks, choose the task for which the sum of following task times is the longest
4. Shortest task time	From the available tasks, choose the task with the shortest task time
5. Least number of following tasks	From the available tasks, choose the task with the least number of subsequent tasks

Wing Component Example

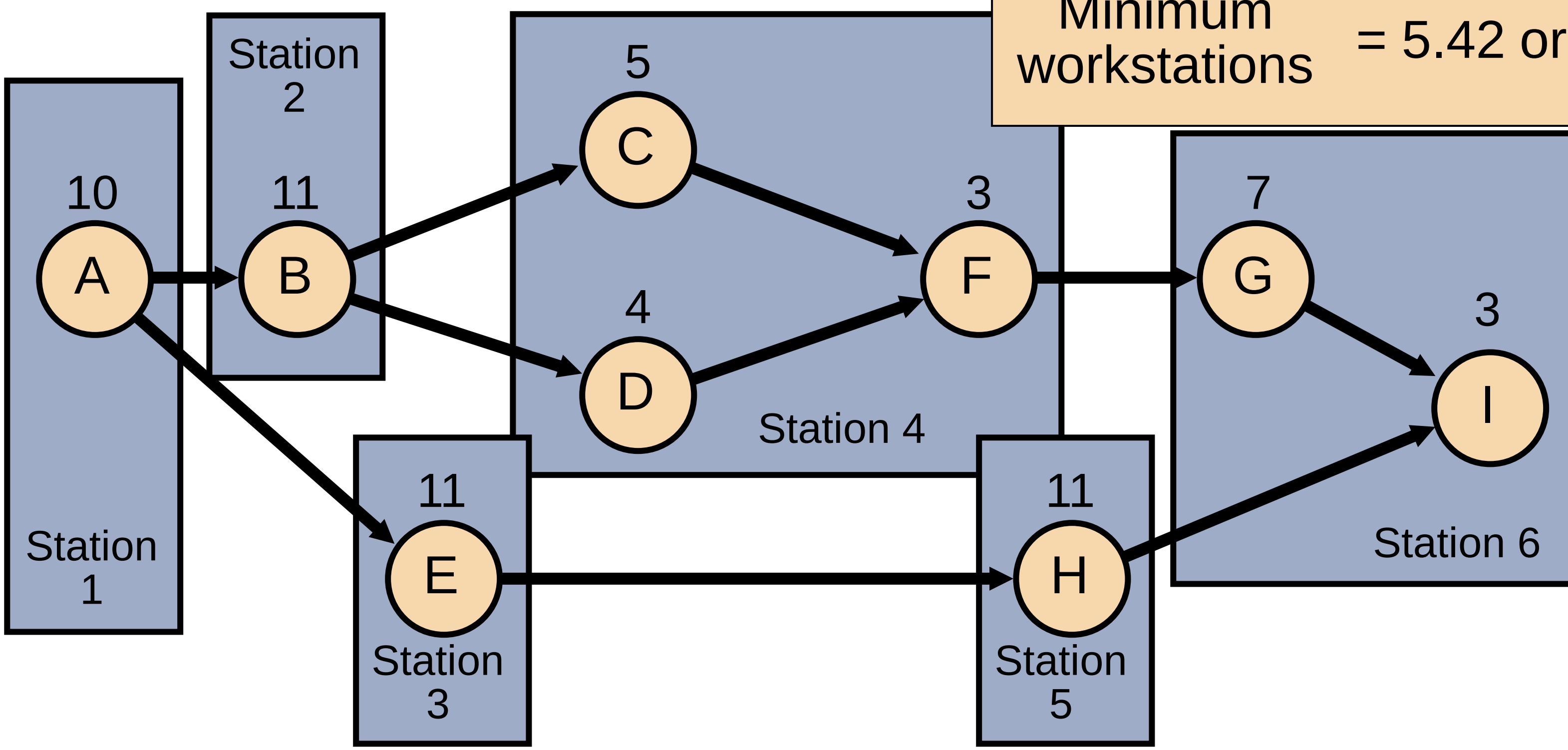
Figure 9.13

480 available mins per day

40 units required

Cycle time = 12 mins

Minimum workstations = 5.42 or 6



Wing Component Example

TABLE 9.2	Precedence Data for Wing Component	
TASK	**ASSEMBLY TIME (MINUTES)**	**TASK MUST FOLLOW TASK LISTED BELOW**
A	10	–
B	11	A
C	5	B
D	4	B

480 available mins per day

40 units required

Cycle time = 12 mins

Minimum workstations = 5.42 or 6

Figure 9.12

$$\text{Efficiency} = \frac{\sum \text{Task times}}{(\textit{Actual} \text{ number of workstations}) \times (\text{Largest cycle time})}$$

= 65 minutes / ((6 stations) x (12 minutes))

= 90.3%

Idle Time = ((6 stations) × (12 minutes)) – 65 minutes = 7 minutes