Facility and Layout Design

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Facility Layout Design

Facility Layout Design : *Arrangement of machines, storage areas, and/or work areas usually within the confines of a physical structure, such as a retail store, an office, a warehouse, or a manufacturing facility.*

- Factors that influence layout
  - Volume, weight of items to be produced.
  - Nature of the service to be provided.
  - Cost of the building to house the operation.
  - The product mix that must have a facility.
  - The fragility of the product or component.

History of Facilities Design

1900
Industrial Revolution

1910 Factory Organization & Administration Book by Hugo Diemer

1914 Moving automotive assembly line by Henry Ford

1954 Quadratic assignment problem for macro & micro level by Kopmans & Beckman

1955-1995 Optimal & Heuristic Algorithm

1959 Systematic Layout Planning by Muther

1963 CRAFT by Armour & Buffa

1980 Flexible manufacturing system

Late 1980s Automation

1985 Modern software application

1990-2000 Dynamic & robust layout

Typical Design and Planning Problems

- Facility Location
- Type, Volume of Products to be Manufactured or Service to be Provided
- Manufacturing (Service) Processes Required
- Design of Components (Service)
- Type, Number of Equipment Required
- Layout of Equipment within Each Cell
- Layout of Machine (Service) Cells
- Determination of Machine (Service) Cells
- Tooling, Fixture Determination
- Process Planning
- Determining Material Handling Methods
- Type, Number of Material Handling Devices
- Determining Flow of Products (People)
- Scheduling and Planning of Jobs (Services Steps)
- Overall System Design
- Quality Control and Customer Service
- Distribution of Goods
- Inventory Control

Why is Facilities Layout Important?

- 20 - 75% of product cost attributed to materials handling (Sule, 1991 and Tompkins et al. 2003)
- Layout of facilities affects materials handling costs
  - *Facilities* includes machines, departments, workstations, locker rooms, service areas, etc.
- Determine level of decision
  - Strategic design or Long-term design ?
  - Planning or Intermediate design ?
  - Operational or short-term design ?

- Good layout increases productivity efficiency
- Reducing congestion permits smooth flow of people and material
- Space utilization is effective and efficient
- Facilitates communication and supervision
- Safe and pleasant working environment

A Good Layout ...

- Reduces bottlenecks in moving people or material.
- Minimizes materials-handling costs.
- Reduces hazards to personnel.
- Utilizes labor efficiently.
- Increases morale.
- Utilizes available space effectively and efficiently.
- Provides flexibility.
- Provides ease of supervision.
- Facilitates coordination and face-to-face communication where appropriate.

Constraints in Developing Facilities Layout

Some pairs of departments must be adjacent

Some pairs of departments must not be adjacent

Some departments only in specific locations

Existing building constraints

OSHA regulations, fire codes, etcc

Types of Layout Problems (some examples)

- ✓ Just in Time (JIT) manufacturer
- ✓ Re-layout of an existing facility
- ✓ Re-layout due to increased traffic (resulting from a merger)
- ✓ Consolidation of manufacturing operations from two or more sites to one
- ✓ Leasing of office space in a multi-story building
- ✓ Find a better layout in existing space
- ✓ Introduction of new product lines

Types of Projects

- New Facility
- General Re-layout (retrofit)
  - Expansion due to new product(s)
  - Expansion due to sales growth in existing products
  - Re-organization of work areas (evolutionary design)
  - Outsourcing of logistics capability
  - Addition of automation technology
  - Problem elimination
  - Cost reduction
  - Product discontinuation

Operations Review for Office Layouts

(Suskind, 1989)

- Is the company outgrowing its space?
- Is available space too expensive?
- Is building in the proper location?
- How will a new layout affect the organization and service?
- Are office operations too centralized or decentralized?
- Does the office structure support the strategic plan?
- Is the new layout in tune with the company's image
- Does customer physically participate in service delivery?

Applications of Facilities Layout

Manufacturing

Healthcare

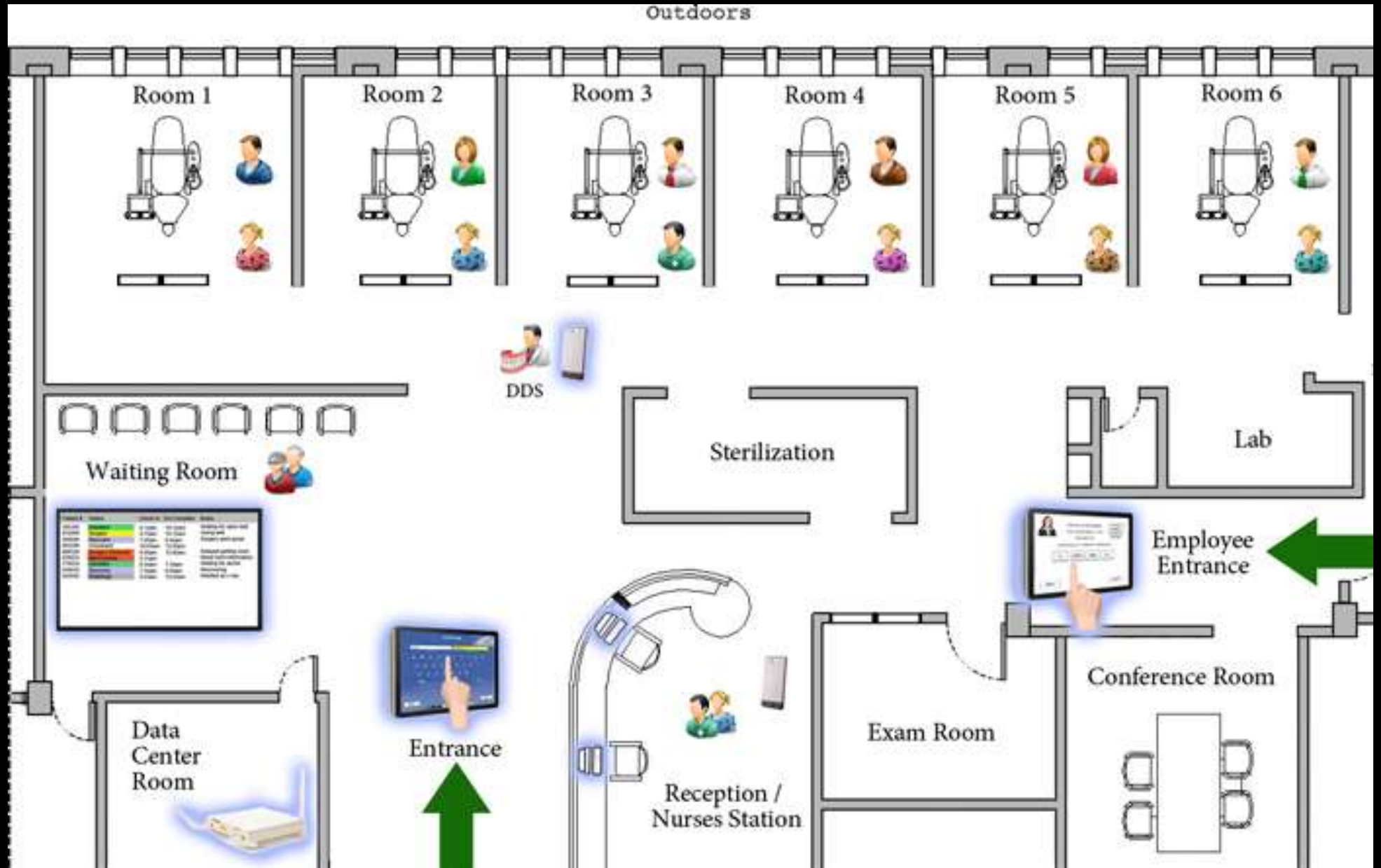
College

Airport

Logistics (Warehouse)

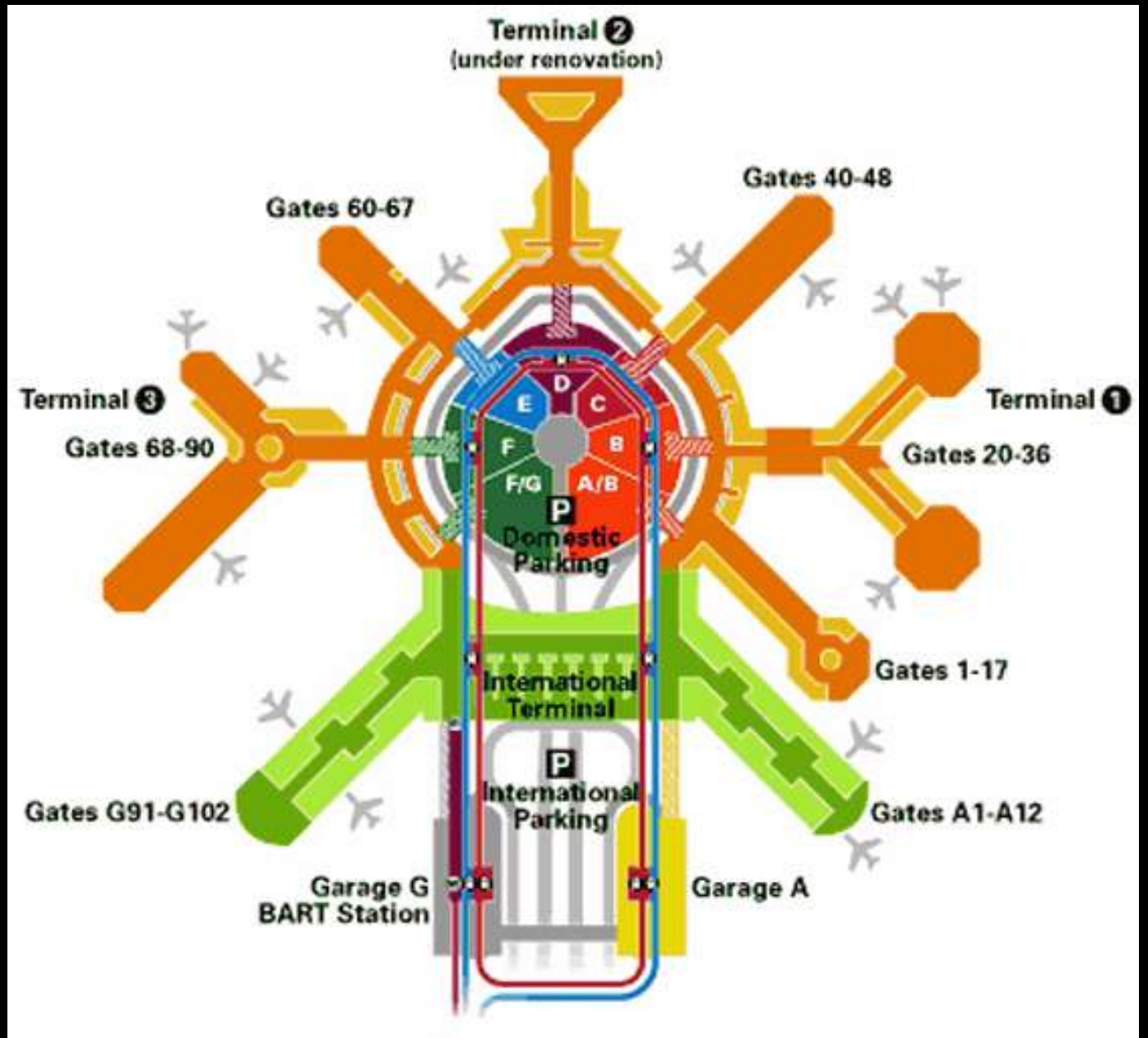
Ports/ Terminals

Service Layout – Dental Office (example)



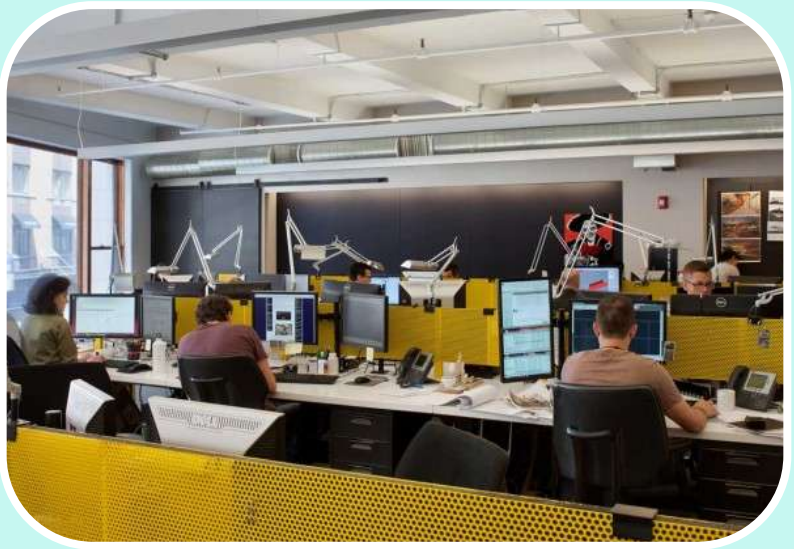
Service Layout – Grocery Store (example)

Service Layout – Airport (example)



Office Space Structures

Closed structure



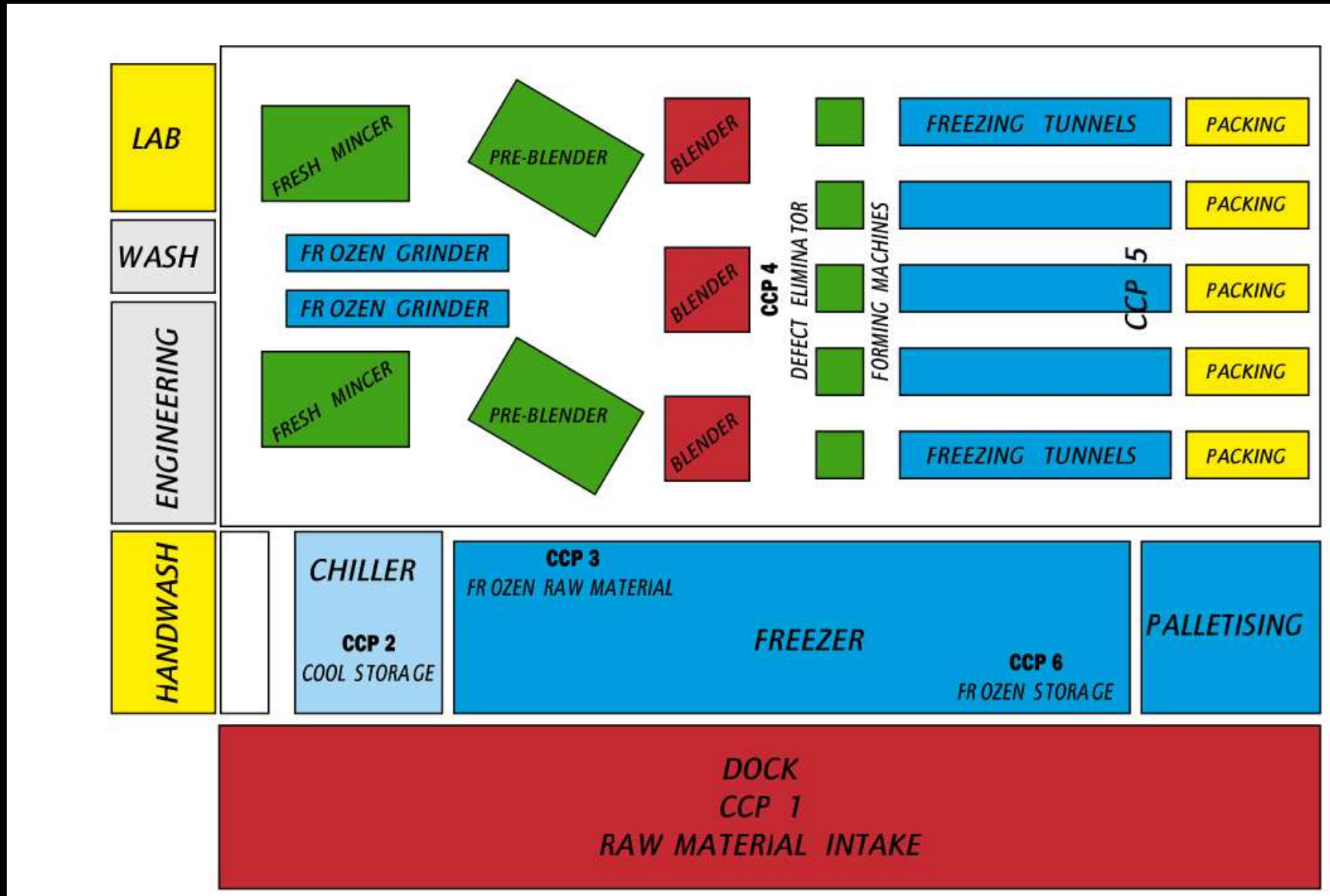
Open structure

Semi structure

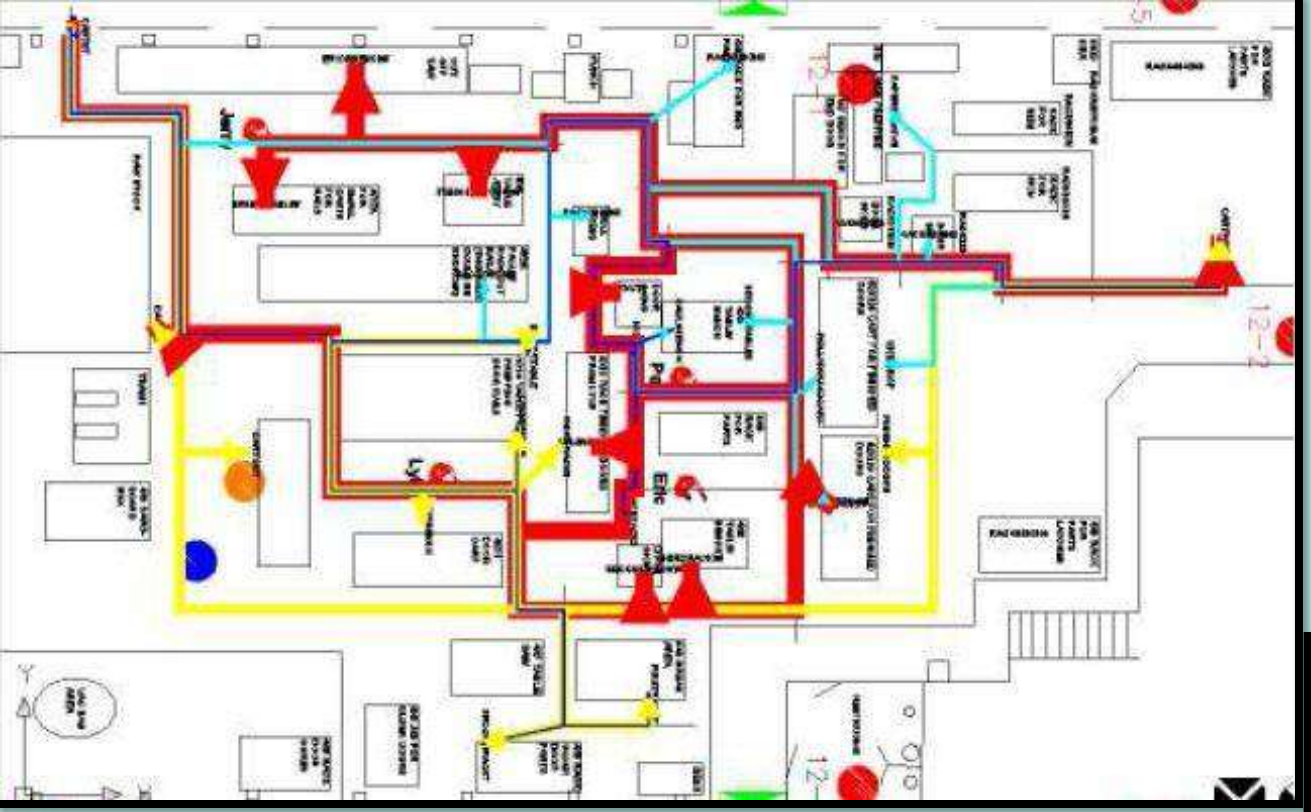
Manufacturing Layout

- Minimize transportation cost of raw materials, sub-assemblies, work-in-process inventory, tools, parts, finished products, etc.
- Facilitate traffic flow
- Improve employee morale
- Minimize or eliminate risk of injury and property damage
- Ease of supervision and face-to-face communication

Manufacturing Layout – Food Factory (example)

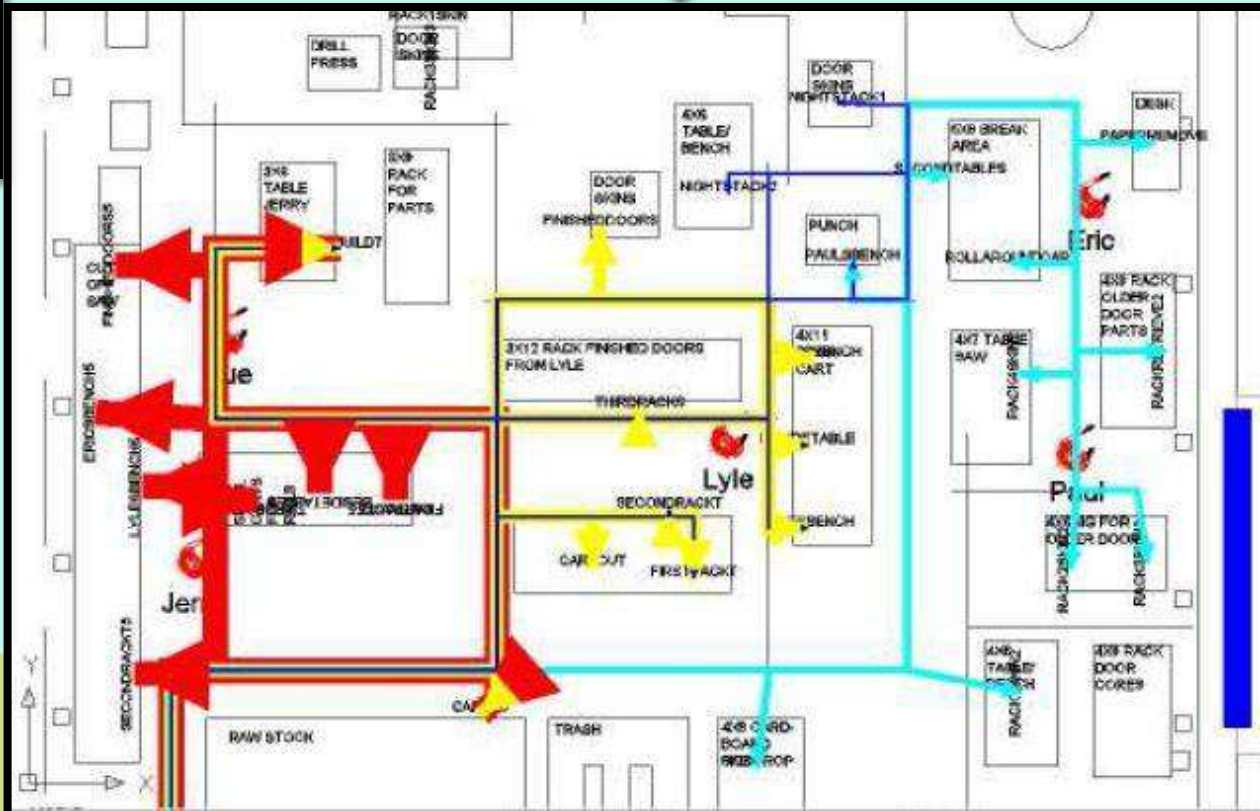


Assembly Dept. Layout (example)

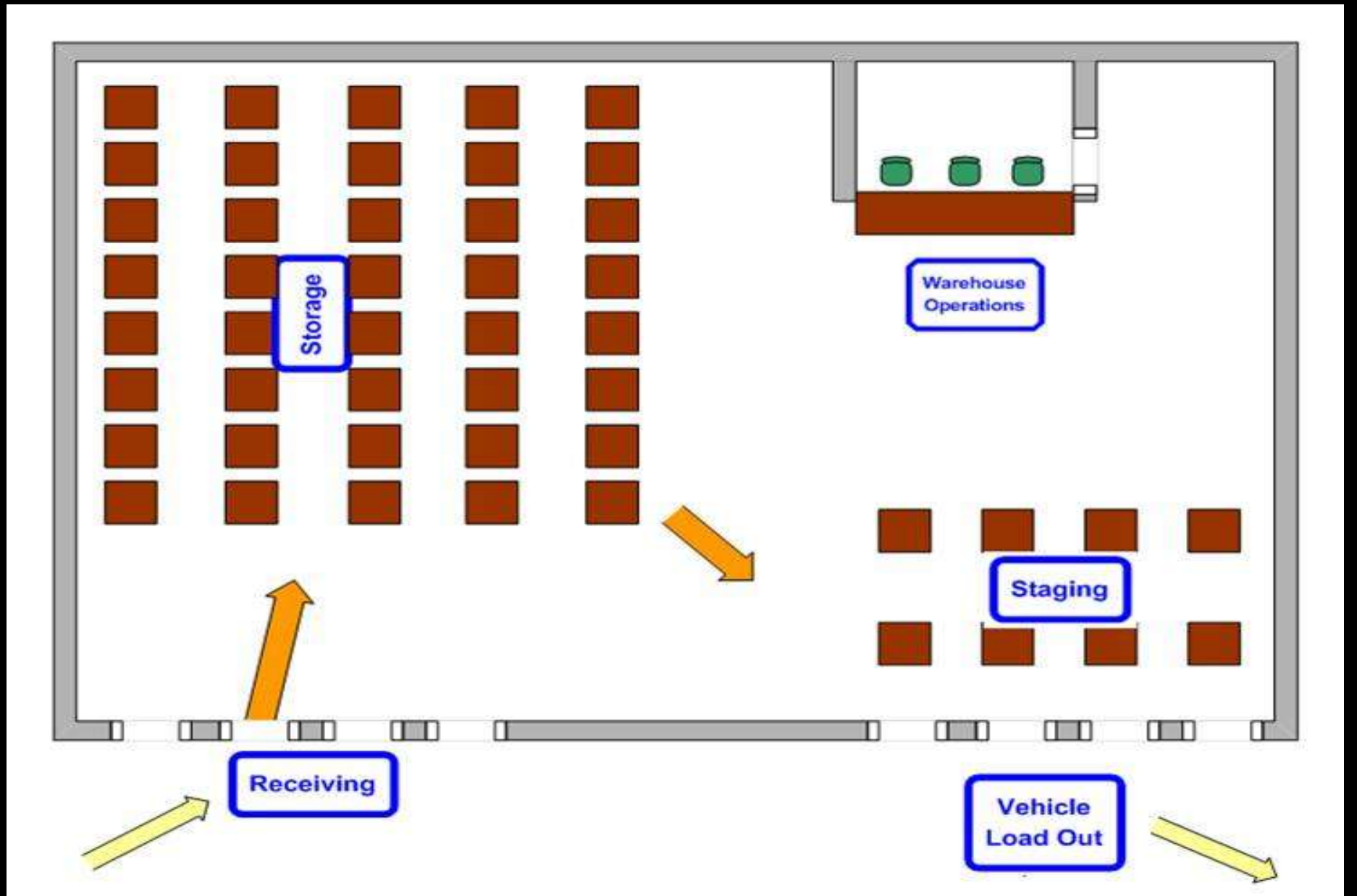


Existing Layout

Future Layout



Warehouse Layout (example)



Type of Layout

1. Flow Line Layout
2. Process Layout
3. Fixed Position Layout

1. Flow-Line/Product Layout

Applicable to both manufacturing and non manufacturing operations.

Arrange machines and/or workers in accordance with the sequence of operations for a given product or service.

- **Advantages :**
  - Reduces materials handling.
  - Accommodates small amounts of work in process.
  - Reduces transit times.
  - Simplifies production planning and control systems.
  - Simplifies tasks, enabling unskilled workers to learn task quickly.

- **Disadvantages :**
  - Lack of process flexibility.
  - Lack of flexibility in timing: the product can not flow through the line faster than the slowest task can be accomplished unless that task is performed at several stations.
  - Large investments: special-purpose equipment and duplication is required to offset lack of flexibility in timing.
  - Dependence of the whole on each part: a breakdown of one machine or absence of enough operators to staff all work stations may stop the entire line.
  - Worker fatigue: workers may become bored by the endless repetition of simple tasks.

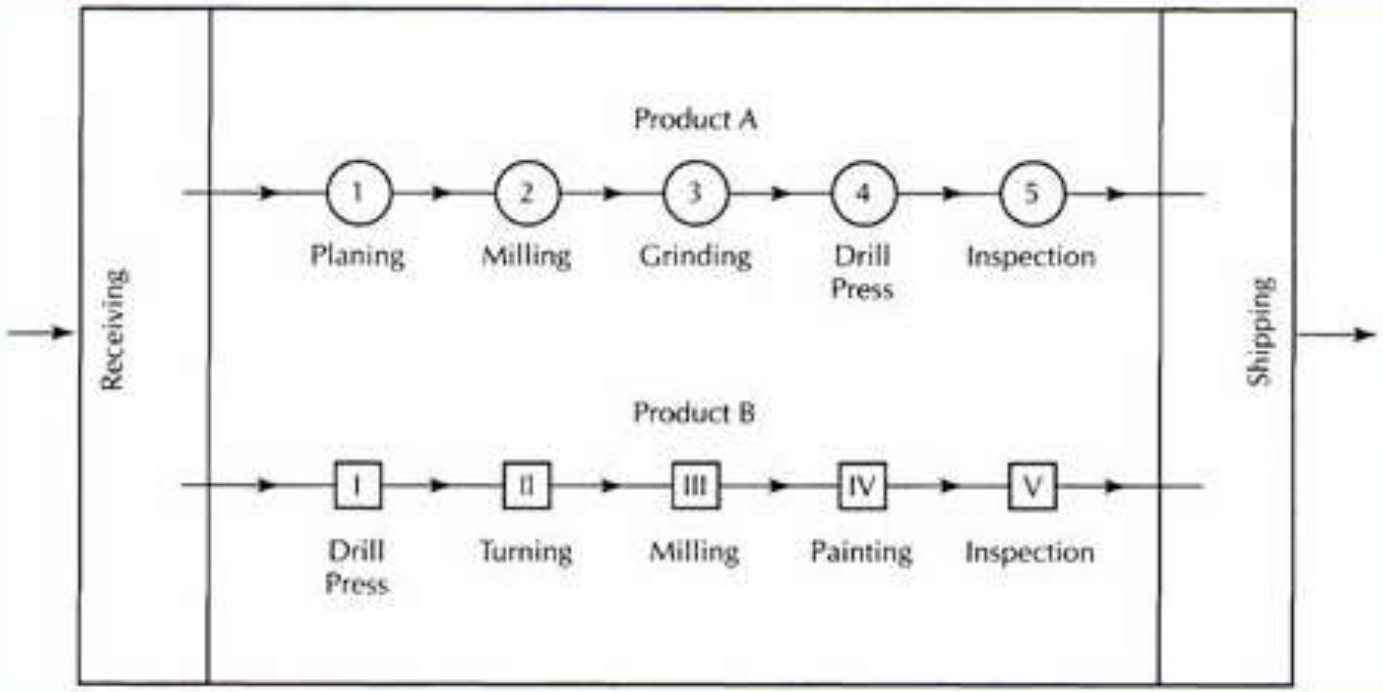
2. Process Layout

Applicable to both manufacturing and non manufacturing operations.

Grouping together of machines and/or workers doing similar tasks.

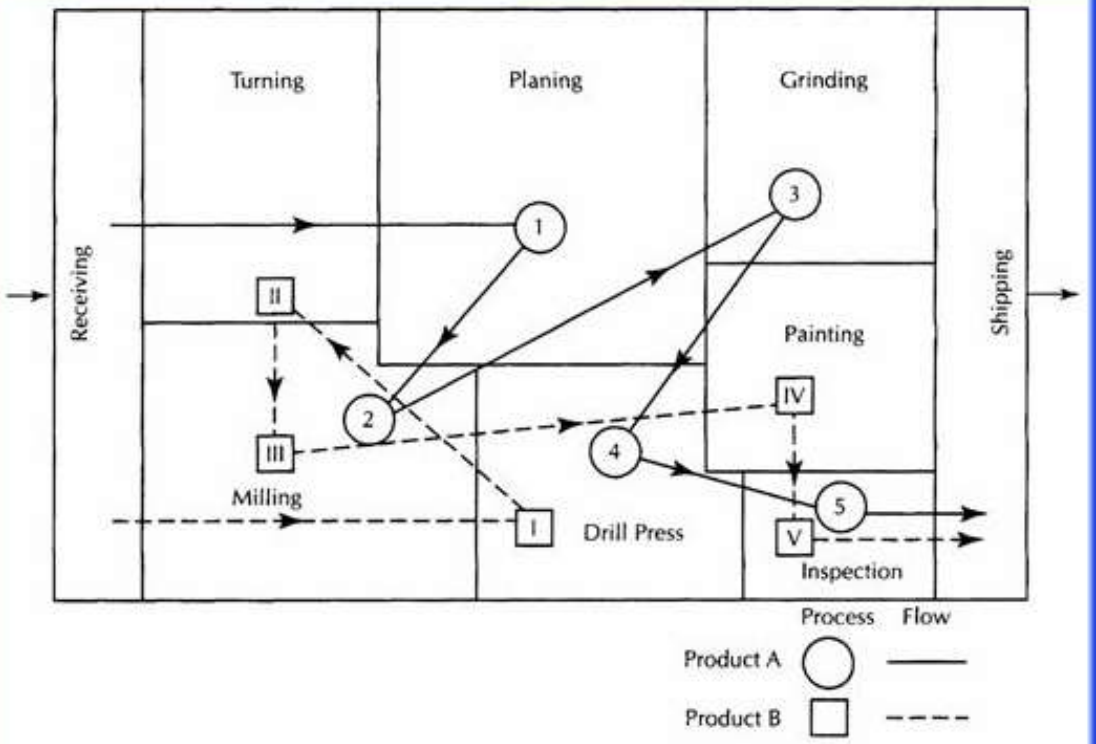
- **Advantages**
  - Flexibility: equipment and personnel can be used where they are needed.
  - Smaller investment in equipment: duplication is not necessary unless volume is large.
  - Expertise: supervisors for each department become highly. knowledgeable about their functions
  - Diversity of tasks: changing work assignments make work more satisfying for people who prefer variety.

- **Disadvantages :**
  - Lack of process efficiency: backtracking and long movements may occur in the handling of materials.
  - Lack of efficiency in timing: workers must wait between tasks.
  - Complication of production planning and control.
  - Cost: workers must have broad skills and must be paid higher wages than assembly line workers.
  - Lowered productivity: because each job is different it requires different setups and operator training.



Product Layout

Process Layout



3. Fixed Position Layout

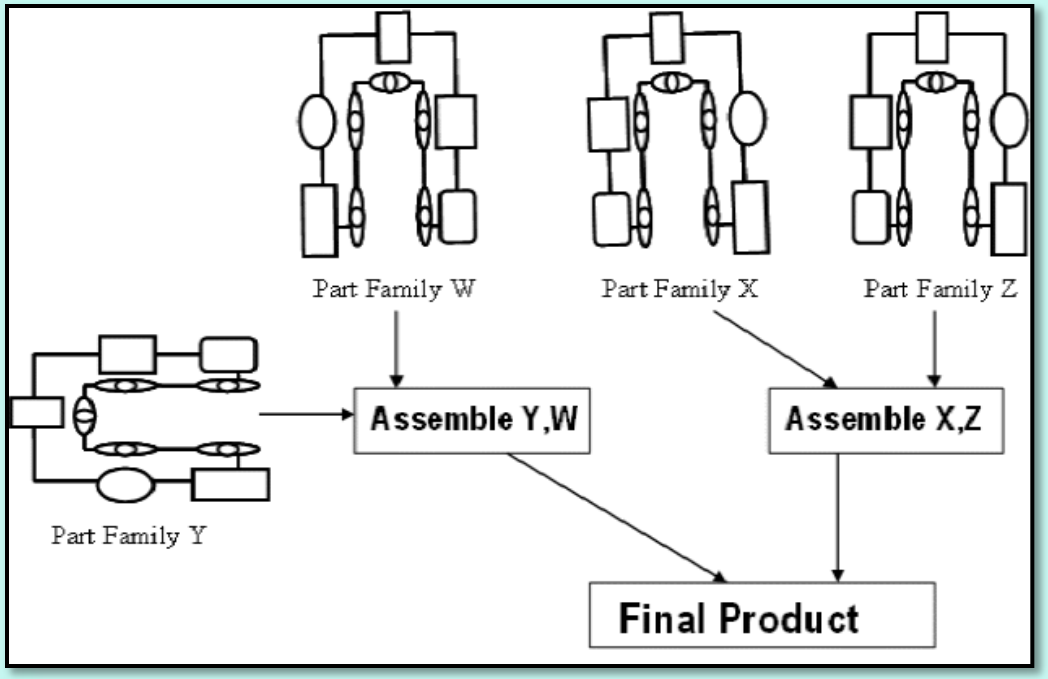
Manufacturing and non-manufacturing operations of bulky or fragile products, e.g., ships and planes

Move machines and/or workers to the site; products normally remains in one location for its entire manufacturing period.

- **Advantages**
  - Reduces movement of work items; minimizes damage or cost of moving.
  - More continuity of the assigned work force (since the item does not go from one department to another). This reduces the problems of re-planning and instructing people each time a new type of activity is to begin.

- **Disadvantages :**
  - Since the same workers are involved in more operations, skilled and versatile workers are required. The necessary combination of skills may be difficult to find and high pay levels may be necessary.
  - Movement of people and equipment to and from the work site may be expensive.
  - Equipment utilization may be low because the equipment may be left at a location where it will be needed again in a few days rather than moved to another location where it would be productive.

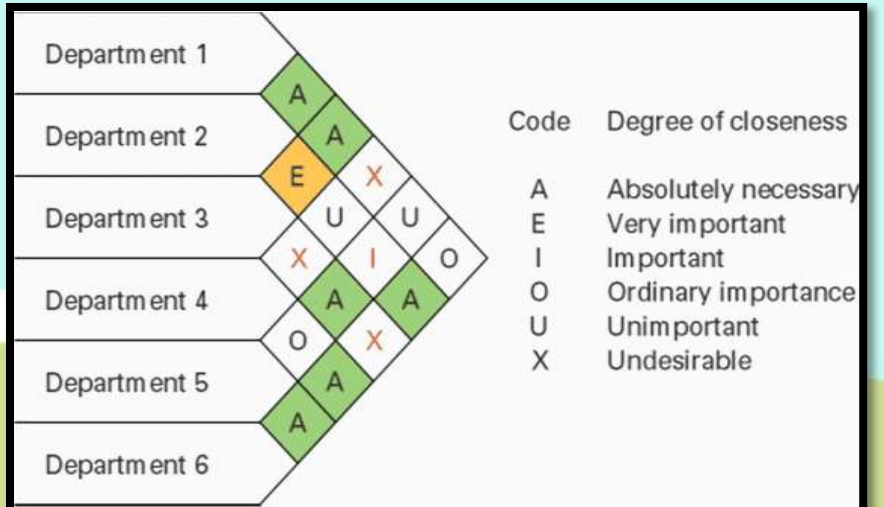
Group Technology Layout



- Group technology *is the technique of identifying and bringing together related or similar parts in a production process in order to utilize the inherent economy of flow production methods*. (V. B. Solaja)
- Group Technology layout is also called **manufacturing cell layout.**
- Example : A plant producing 10,000 part numbers may be able to group the parts into 50 or 60 families. Each family would possess similar design and manufacturing characteristics.
- Hence, the processing of each member of a given family would be similar, and this results in manufacturing efficiencies in the form of:
  - Reduced set-up,
  - Lower in-process inventories,
  - Better scheduling,
  - Improved tool control,
  - Standard process plan.

Analysis of Layout By Process

- Steps involved:
  1. Determine the size of each department.
  2. Determine the arrangement of the department with respect to one another.
  3. Determine the arrangement of the equipment and people within each department.
- ***Richard Muther's Systematic Layout Planning***
  - Utilizes a grid matrix to display the ratings of the relative importance of the distance between department
  - Closeness ratings:



Distance Measurements

- Typically measured from department center to department center.
  - **Euclidean** distances are appropriate when the layout space is very open and movement within it can follow a direct path.
  - **Rectilinear** (sometimes called rectangular) distance is more appropriate for layouts aisles or hallways where one generally reaches a destination after making one or more right turns.

Computer Packages for Layout Problem

- **Heuristic,** improvement algorithms.
- **CRAFT (Computerized Relative Allocation of Facilities Techniques)** is the best known of the heuristics approaches; attempts to minimize materials-handling cost by calculating cost, pair-wise interchanging departments, calculating more costs until a good solution is obtained.
- **ALDEP (Automated Layout Design Program)** and **CORELAP (Computerized Relationship Layout Planning)** attempt to maximize a nearness rating within the facility dimension constraints.
- **PREP (Plant Re-layout and Evaluation Package)** analyzes multilevel structures and is based on actual footage traveled by materials-handling equipment.

Let’s Try!

Load Distance Analysis

- Each department is 10 feet by 10 feet, distances are rectilinear, which of the following two layouts is better?

Layout A		*Layout B*	
3	8	4	7
7	4	10	1
1	10	2	9
9	2	5	6
6	5	8	3

Product	*Department Processing Sequence*	*Quantity Processed Per Month*
A	1→ 5→ 4→10	1,000 units
B	2→ 6→ 3→ 9	2,000
C	2→10→ 1→ 9	3,000
D	1→ 7→ 8→10	1,000
E	2→ 5→ 6→ 9	2,000
F	1→ 7→ 4→10	4,000

Solution (1/2)

- Compute the total travel for each product through each layout alternative.

Product	*Department Processing Sequence*	*Distance per Product (feet) Layout A*	*Distance per Product (feet) Layout B (feet)*
A	1→ 5→ 4→10	30+30+10= 70	30+30+10= 70
B	2→ 6→ 3→ 9	20+40+30= 90	20+10+10= 50
C	2→10→ 1→ 9	10+10+10= 30	10+10+10= 30
D	1→ 7→ 8→10	10+20+20= 50	10+50+30= 90
E	2→ 5→ 6→ 9	10+10+10= 30	10+10+10= 30
F	1→ 7→ 4→10	10+10+10= 30	10+10+10= 30

Solution (2/2)

- Compute total distance traveled per month by each product through each layout alternative.

	Units per	*Distance per Product*		*Distance per Month*	
Product	*Month*	*Layout A*	*Layout B*	*Layout A*	*Layout B*
A	1000	70	70	70,000	70,000
B	2000	90	50	180,000	100,000
C	3000	30	30	90,000	90,000
D	1000	50	90	50,000	90,000
E	2000	30	30	60,000	60,000
F	4000	30	30	120,000	120,000
			Totals	570,000	530,000*


systems
Industrial
Engineers
Engineering
Business
processes
operations
design
control
planning
knowledge
engineering
production
manufacturing
analyze
program
scheduling
system
large
college
skills
complex
individual
allows
quality
Offered
pursue
flexibility
disciplines
inventory
particular
equipment
mathematics
management
facilities
Entrepreneuership
interpersonal
communication
simulation
problem
methods
degrees
allocation
customize
information
perspective
number
ability
broad
tailor
choose
resource
group
interest
goals
manage
systematic
rooms
assurance
option
credits
variety
people
workplaces
integrators
Minor
wide
buildings
assignment


KEEP
CALM
YOU'RE AN
INDUSTRIAL
ENGINEER