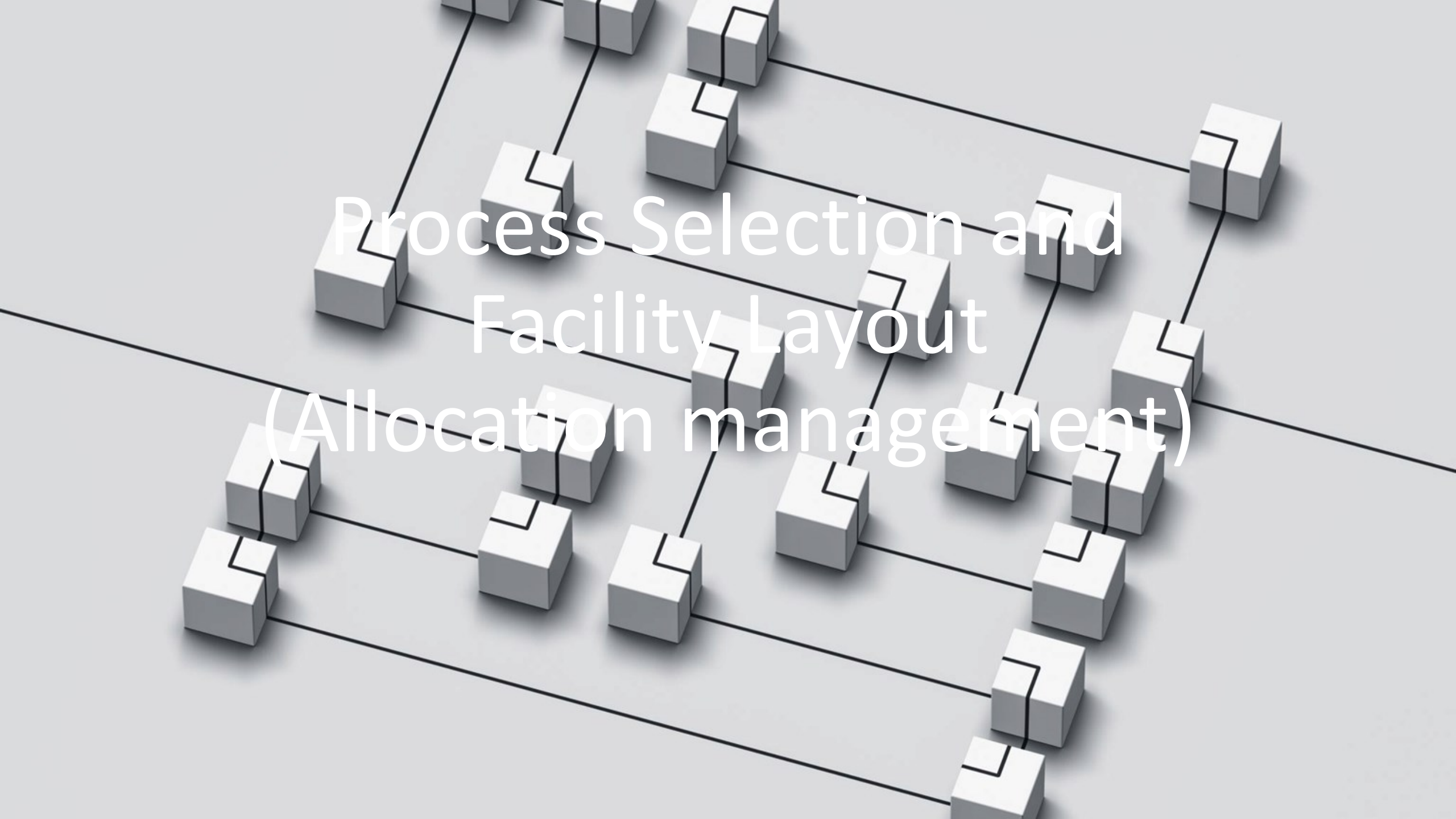


Process Selection and Facility Layout (Allocation management)

FACILITY LAYOUT

Strategic Issues of facility design

Need for facility layout arises when an organization:

1. move to a different location
2. or the present facility is no more effective

} ***where*** *to locate the different economic activity centers?*

Objective: arrange the activity centers **such that there are smooth workflow** or a particular traffic pattern that would result in efficient and effective operations.

Strategic Issues of facility design

Some of the **most common causes** for redesigning an existing facility layout arise out of the following:

- Sudden rise in operating cost with marked fall in output
- Increase of accidents in the work centers
- Introduction of new production technology
- Changes in product design or services or changes in the product mix or services
- Increase in worker turnover, absenteeism, anxiety or strain
- Skilled workers doing unskilled works, etc.

This shows that layout has **many strategic implications** for the organization. Altering an existing layout or selecting a new layout can affect an organization's ability **to meet competition in the market**.

Objective of a good layout

- **to design facility so that operations can be carried out as cost-effectively as possible**.
- Several **factors contribute** to operations costs:
  - some direct (material movement, space utilization) and
  - some indirect (worker's safety, moral, etc.).

Considering the above, some of the following objectives are attempted through facility layout:

- ❑ Facilitate flow or movement of materials and information
- ❑ Identify and reduce bottlenecks
- ❑ Reduce machine interference
- ❑ Improve working conditions and employee satisfaction
- ❑ Increase efficient utilization of equipment and labor

- ❑ Utilize available space effectively and efficiently
- ❑ Provide ease of supervision and control
- ❑ Ease of future expansion or contraction
- ❑ Compatibility with long-range plans
- ❑ Reduce the level of capital investment, etc.

Facility layout plan

The Facility Layout plan institutionalizes the fundamental organizational structure.
Every layout has four fundamental elements:

- 1. Space Planning Units (SPUs)
- 2. Affinities
- 3. Space
- 4. Constraints

The basic principles to consider for the layouts

1. The emphasis should be on **gross material flow**, personal space and communication.

2. Socio-technical considerations should be key in determining the layout.

3. It should facilitate arrangement of physical facilities, which allows most efficient use of men, machines and materials needed for operations to meet the requirements of capacity and quality.

4. It should be based on the premise that a properly designed facility is a crucial source of competitive advantage.

SUMMARY

Layouts should try to have as many as the following characteristics to have the most efficient use of men, machines and materials:

1. Operate at low cost
2. Effectively use space
3. Provide for easy supervision
4. Provide fast delivery
5. Minimum cost of material handling
6. Accommodate frequent new products
7. Produce many varied products
8. Produce high or low volume products
9. Produce at the highest quality level
10. Worker's convenience and safety
11. Provide unique services or features

Four basic types of layouts:

- 1. Process layout
- 2. Product layout
- 3. Fixed layout
- 4. Group layout

1. Process/Functional layout (non-repetitive)

Similar machines or operations located in one place as per the function.

F.e.: all milling operations are carried out at one place while all lathes are kept at a separate location.

Examples of **usage**:

- This layout is useful for **job production** and **non-repetitive** manufacturing environment.
- Required when **demand** for a particular product/service is **uncertain** or when an organization is expected to provide **different types of similar products**.
- Common also in office and non-manufacturing organizations. Most offices are arranged according to the function of the tasks carried out by the employees: such as Accounts Dept, Marketing Dept, Purchase Dept.
    - This type of arrangements are also noted in hospitals, library, banks, universities, and restaurants.
    - In **hospital** the facilities are arranged according to the type of treatment provided, like units that handle maternity, surgery, pediatrics, and emergency.
    - In **universities**: Business Schools, Medicine Schools, Science Schools, etc., each providing specialized teaching.

Pros of Process layout

1. ***Flexibility in use of equipment/employees and in pace of operations***: the system is less vulnerable to changes in the market demand, product mix or internal change in marketing strategy and can have higher quality and production.
2. ***Lower Investment***: the layout avoids duplication of equipment; the resources are relatively general purpose, often less costly and easier to maintain. Similarity of machine reduces the need to invest in different types of spare parts.
3. ***Less vulnerable to equipment failure or absenteeism***: as idle equipment are usually available to replace machines temporarily out-of-order.
4. ***High utilization of resources***: The design of the facility allows pooling of resources. When the demand for a particular product is low, the same set of equipment can be used to service different types of product ensuring that the resource does not sit idle.
5. ***Less interdependence of successive operations***: because the products are processed in lots.
6. ***Specialized supervision***: Supervisors, in general, are responsible for a single specialized area, which allows them to become highly knowledgeable about the function under their direction (specialize).
7. ***High workers' morale*** given by diversity of tasks.
8. ***Easier to implement individual Incentive plan***: the final product can be easily attributed to a specific employee.

Cons of Process layout

1. ***Inefficient Material handling***: resulting from backtracking and long movement. Automated and efficient handling equipment are not suited for this type of layouts, (they need variable path devices as wheelbarrows).
2. ***Routing and scheduling complexity***: because the same set of machines are used to process different types of product. The time lag between order receipt and delivery tends to be long.
3. ***Lower productivity***: The processing rate tends to be slow. Since each job is different, it requires different setups, and thus production time is lost in changing from one product to another. At times, workers must wait long period between tasks.
4. ***Space and inventory***: Because of jumbled and variable flows, more space and capitals are tied up in inventory. Valuable inventory tends to build up around each job, requiring expensive storage space and results in delay in delivery.
5. ***Span of supervision***: Job complexities often reduces the span of supervision requiring more supervisors to give attention to fewer workers resulting in higher supervisory cost.
6. ***Wages***: due to job complexity workers need to have extensive training and broader skills pushing wages higher.
7. ***Other management functional area***: like accounting, inventory control, production control, are much more involved than in any other type of layout.

2. Product/Line Layout (Repetitive)

- **The various facilities**, such as machine, equipment, work force, etc., **are located based on the sequence of operation on parts.**
- Where the facility is needed again after few other operations, **the facility is duplicated as required by the sequence of operations**.
- Product layout **is used for continuous operations**, where the part variety is less, production volume is high and part demand is relatively stable.

Usage of Product / Line Layout

- resources and activities **are arranged according to the processing needs of a single product**, rather than shared among different types of product.
- the **products move in a zig-zag manner from center to center.**
- It is often called **an assembly line, production line, or flow-line layout**.
- **Possible only if the design of the product is highly standardized**, there is a high demand for the product and the product processing operations is standardized and repetitive.
- Jobs are **divided into a series of standard tasks, permitting specialization of labor and equipment.**
- Straight line arrangement of resource centers permits use of automatic conveyor belts to handle materials.

Product / Line Layout usage

- These layouts often rely heavily on **specialized, capital-intensive resources**. But the additional cost of these specialized equipment are offset by **large production volume** that this type of system generally handles.
- It is very easy to decide where to locate different resource centers because operations must occur in a predetermined order.

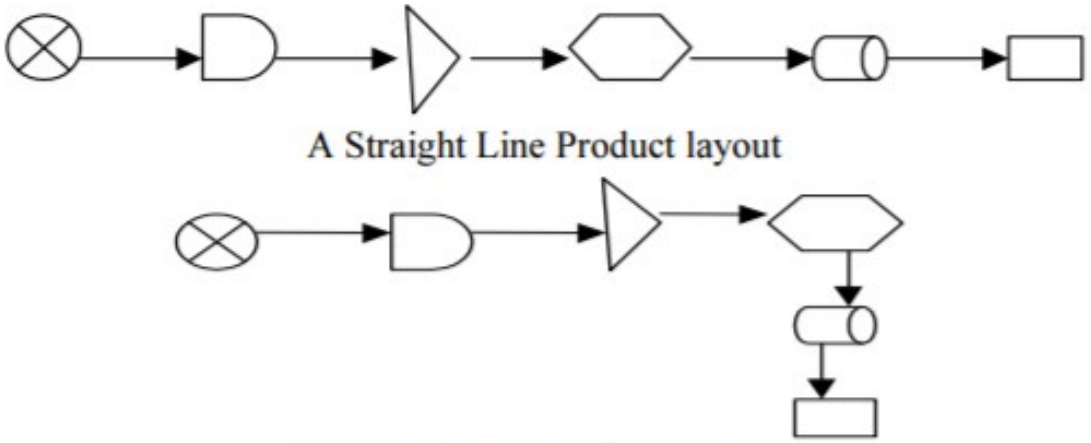
For example, in a cafeteria students must first pick up a tray, then go for a plate of rice, next a bowl of meat/fish then a bowl of dal and a glass of water. Finally, he has to pass by the cashier to pay for what he wants to eat.

Food arranged in this sequence would ensure **easy flow** of students through the system.

The challenge is to **group together activities into workstations** that reduces the need for the lowest level of resources.

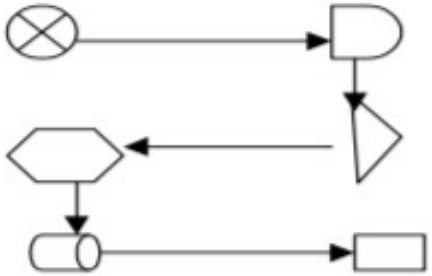
(Repetitive) Product or Line Layout – product flow

In a product layout the flow of the product is always in a straight line or L, S or U line shaped (see figure) and the product never backtrack towards the beginning of the line:

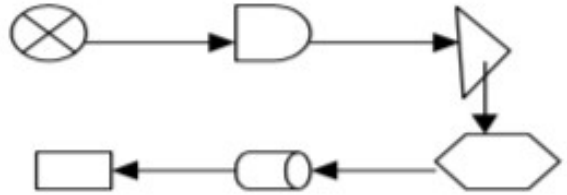


A Straight Line Product layout

An 'L' Shaped Product Layout



An 'S' Shaped Product Layout

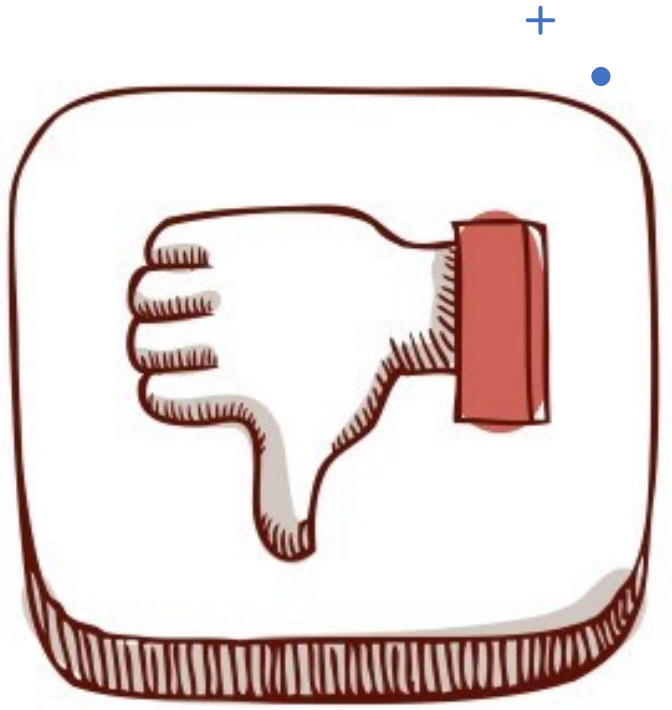


Pros of Product or Line Layout

1. ***High rate of output***: because the resources are dedicated to only a specific product, workers do repetitive work and the flow of product can be regulated.
2. ***Lower inventories***: less need to decouple one operation from the next, and items move directly from one operation to the next without interruption (i.e. lower investments in it).
3. ***High degree of utilization of both labor and machineries*** thanks to simplified workflow; less time is lost in unproductive activities (e.g. change-overs, retuning of machineries, wait for materials, etc). This in turn reduces per unit cost of production.
4. ***Division of labor***: series of standard tasks, that unskilled laborers can carried out. Their train is quick. As such, extensive training need is reduced, resulting in low costs for training. It also results in high span of supervision.
5. ***Reduced per unit material handling costs***: thanks to mechanical material able to handle equipment like conveyor belts. Flow of work is in a straight line which is suitable for use of conveyor belts or other automatic mechanical handlers.
6. ***Simplified production planning and control***: At the design stage production planning and control are built into the system. Once the system is fine-tuned it does not require monitoring. For regular day-to-day works, predetermined plans and controls can be used again and again.
7. ***Simplified flow of product through the system***: The machinery are arranged such that the product does not have to backtrack through the system.

Cons of Product or Line Layout

1. ***Lack of flexibility***: The system is not at all flexible. Change in product design or volume may require extensive and expensive changes in the system.
2. ***Large investment***: Duplication of equipment is in no way uncommon in product layout. Multiple of the same type of equipment may be required by the system to ensure no backtracking of the flow of the product through the system. In addition, this type of layout require special purpose automated equipment. All these result in high investment in equipment.
3. ***Division of labor***: Intensive division of labor results in workers becoming bored by the endless repetition of dull and simple tasks. Scope for advancements are few that leads to moral problem. Incentive plans are impractical: the rate of output per worker is dependent on the speed of the workers preceding him.
4. ***Dependence of the whole on each part***: The system is highly susceptible to breakdowns or absence of workers. Each machine and labor in the system is dependent on others in the system.
   If one machine breakdown or if one worker remains absent the whole system collapses. So, preventive maintenance is required on a regular basis to avoid unnecessary shutdowns.
   However, no amount of preventive measures can completely eliminate failure of machinery. The procedure of preventive maintenance can become very expensive because of the need to inventory large quantity of spares for the specialized equipment.



3. Cellular or Group Layout

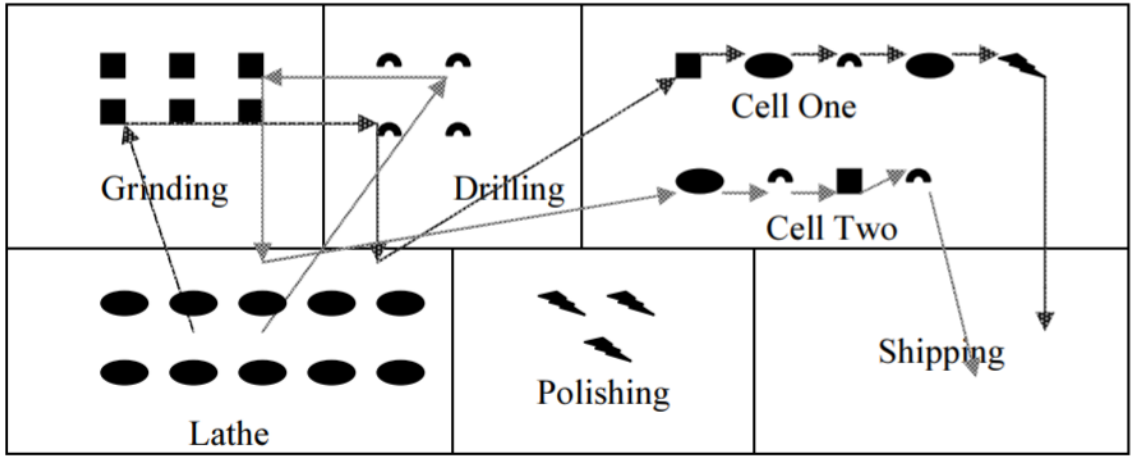
- Combination of process and product types of layout is known as hybrid layout
- It is also commonly called combination layout, mixed layout, grouped technology, or flexible layout.
- A layout based on **group technology** principles used to **improve the efficiency of production**.
- Conventional layouts, product and process layouts are **two extremes** of the spectrum.
- A combination of both **process** and **product layout** and incorporates the strong points of both.
- This layout is suitable when a large variety of products are needed in small volumes (or batches).
- The group technology principle suggests that **parts which are similar in design or manufacturing operations are grouped into one family**, called a part-family.

Cellular or Group Layout

- For each part-family, a **dedicated cluster of machines** (“machine cells”) are identified.
- Generally, all the processing requirements of a particular part-family are completed in its corresponding machine cell, eliminating inter-cell transfers of the part.
- Group technology and cellular layouts **can be combined** and used to produce families of parts more economically than can traditional process or product layouts.
- Data is gathered to identify parts with similar characteristics, which are also manufactured similarly.
- Groups of items can be formed either according to:
  - similarities in their design (external features such as size, shape, use, etc.)
  - or according to similarities in their manufacturing process.

Usage of cellular layouts

- The major emphasis of a hybrid layout is to take advantages of the **good features of process and product layout**, and at the same time avoid their shortcomings.
- Hybrid layout, where **part of the operations** are based on process layout and part on product layout, represent efforts to move toward this direction.
- *Many of the manufacturing organizations are moving **away from pure process** layout in their effort to take **advantage of low per unit** production cost that can be derived from product layout.....But low volume of demand does not permit them to invest heavily on specialized equipment.*



Pros of Hybrid layout

1. **Facility utilization**: facility utilization is generally high contributing to low per unit production cost.

   Grouping activities into cells reduces the number of time a machine has to be tooled or re-tooled.
   Inventory build-up is low in front of workstations and the need to wait for processing is reduced.

1. **High Worker morale**: Repetitive and simple tasks are combined with skilled activities giving the workers a sense of accomplishment.
   In many hybrid arrangements teamwork is essential.

2. **Low Material handling cost and in-process inventory**: Hybrid layout groups act together reducing the total number of workstations and the need to move products from workstation to workstation.

Cons of Hybrid layout

Planning and grouping products into common cells:

- It is **difficult to identify products** that require the same sequence of processing activities.
- At least at different stages of the production process some of the product may have a set of activities with similar or near similar sequences.
- It is not only **difficult to identify the products but also their sequences**, but it is also difficult to plan for those products and schedule their activities.

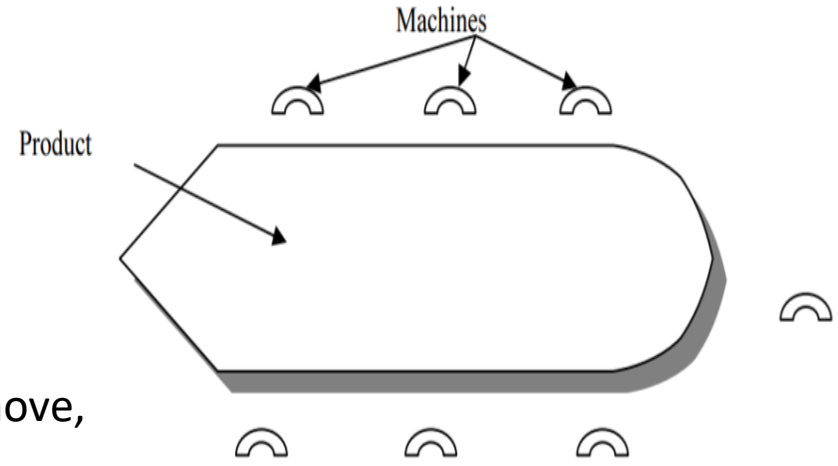
Expensive Equipment:

- Hybrid layout **requires automatic processing** equipment.
- In most cases the **worker is only responsible for loading and unloading** the product and when required tooling and re-tooling the machine.
- These type of **machine are expensive** to buy and costly to maintain.

4.Fixed Position Layout

The material remains at a fixed position and tools, machinery and workers are brought to the location of the material.

- Is **essential** when the products are difficult to move.
- Need for it arises **in case of extremely large and heavy products**.
- **Examples**: production of aircraft, ships, dams, bridges, and housing industry.



The product stays stationary and the machines move around the product

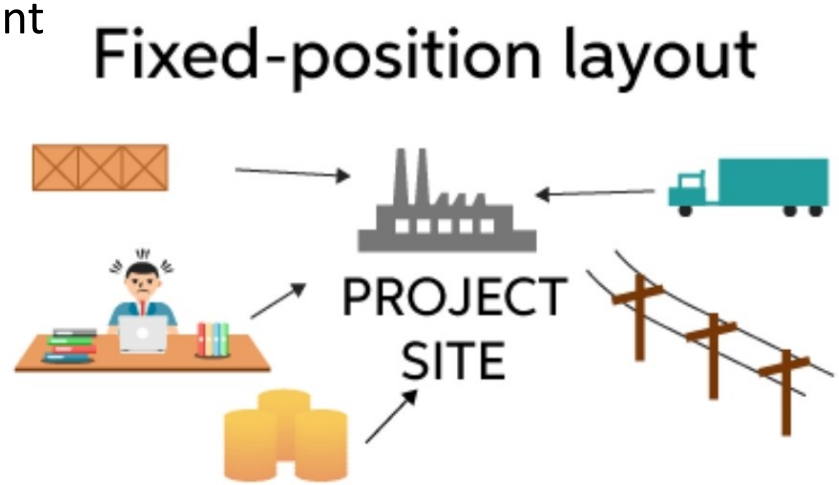
Usage of fixed position layout

- The product stays stationary and, as required, machines, workers and materials move around the product.
- There are many products that are very heavy or large and as such is difficult to move, or can be moved at a high cost, such as aircrafts, ships, locomotives or tanks.
- On the other hand, other products, fragile and susceptible to breakage if moved frequently, like man-made earth satellite.
- There are also products to be produced in the site they will be used and anchored to the earth, like bridges, dams, and buildings.
  For all these type of products fixed position layout is most appropriate.

Specifications of fixed – position layout

- The **demand** for the product is **relatively low,**
- **Emphasis is always on the sequence of activities, schedule of the activities, and availability of space.**
- Tasks are arranged according to their **process sequence** requirement and material.
- Machines are arranged and scheduled according to their **technological priority**.
- If the scheduling of activities is not done carefully machine and material along with labor would arrive ahead of their requirement and occupy the available space.
- Lack of space can be a big problem for the planners. Diverse and specialized workers are generally required, resulting in narrow span of supervision, but the equipment used are of general purpose in nature.

- **It minimizes the number of time that a product has to be moved**. The size and weight of the product necessitate this type of layout.



The limitations of fixed position layout

1. Capital investment may be for a one-off product, which can make it expensive.
2. Due to long duration to complete a product, average utilization of capital equipment is limited.
3. Space requirements for storage of material and equipment are generally large.

Pros of Fixed Position Layout

1. It **is flexible** with regard to change in design, operation sequence, labor availability, etc.
2. It is **essential** in large project jobs, such as construction and shipbuilding etc., where large capacity mobile equipment is required.
3. **Very cost effective** when similar type of products are being processed, each at a different
4. **Minimized cost and** low chance of **damage**: During the production stage the product is rarely moved. However, the cost of moving machinery and labor increases.
5. **Continuity of work**: Since the product stays stationary and does not have to be moved from one production center to another, there is continuity of the assigned tasks.

- *In process type of layout, delays occur because of built up of work-in-process inventories at different departments or workstations.*
  But in fixed position layout this type of delay are avoided since there are no separate workstations.

Cons of Fixed Position Layout

1. **Worker skill**: Same set of workers is expected to carry out different types of tasks. Recruitment of skilled general-purpose workers is essential. The necessary combination of such skill can be obtained only at a high cost from the market or the in-house workers have to be given extensive training to develop the desired skills.
2. **Supervision**: Span of supervision is narrow. Same set of workers have to be employed at different stages of production requiring close supervision and attention.
3. **Movement of machinery, material and workforce**: be moved frequently to and from the work area. This increases the total cost of production.
4. **Utilization**: utilization of production resources are low. Many of the resources are transported to site and after a sequence of use have to be kept on site, because they would be required at a later stage, instead of moving to another production site to make use of it during the idle period in the present site.
5. **Administration**: Planning of the production, scheduling of tasks and control of activities are very important. All tasks are dependent on their preceding activities and space is generally in short supply, as such strict monitoring is essential to avoid clogging of space. Frequent rescheduling is the norm.

Scheduling of operations

Scheduling: definition

- **Scheduling can be defined as:**
  - "*Establishing the timing for performing a task*" and observing that, in manufacturing firms, **there are multiple types of scheduling**, including the detailed scheduling of a shop order that shows when each operation must start and be completed.
  - *"A plan that usually tells us when things are supposed to happen"*
  - *"The actual assignment of starting and/or completion dates to operations or groups of operations to show when these must be done if the manufacturing order is to be completed on time"*
  - *"Scheduling is the allocation of shared resources over time to competing activities"*

Scheduling: definition

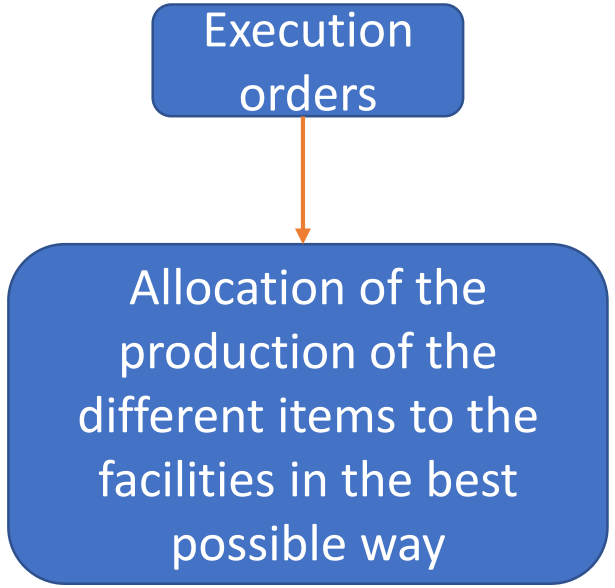
- Production scheduling problems based on 3 attributes:
  - the presence of setups,
  - the presence of due dates,
  - the type of products.

- It describes in detail **the activities to be performed and how the factory's resources will be utilized** to succeed in the plan.
- The **problem is to allocate** machines to competing jobs over time, subject to the constraints.

Short –term production planning model STPPM

- **Aim**: to perform the tasks in order to comply with priority rules and to respond to strategy.
- An optimal STPPM aims at gaining time and saving opportunities.
- Scheduling **presumes** the existence of approaches for **optimization**.
- Plan **consists of activities performed in a manufacturing company** to manage and control the execution of a production process.
- Scheduling **changes can be projected over time** enabling the identification & analysis of starting and completion times, idle time of resources, lateness, etc.
- A **well-done scheduling** plan can lead to better forecasts about completion date for each released part and provide data for deciding the next tasks to do.

Optimal short-term production planning model



Characteristics of a Good Schedule

- It starts from **planning** and springs from respecting resource conflicts, **managing** the **release of jobs** to a shop and **optimizing completion time** of all jobs. It defines the starting time of each task and determines whatever and how delivery promises can be met.
- The **minimization** of one or more objectives has to be accomplished (e.g., n° of jobs that are shipped late, set up costs minimization, the maximum completion time of jobs and maximization of throughput, etc.).
- **Criteria** can be: applying simple rules to determine which job has to be processed next at which work-centre (i.e., dispatching) or to the use of advanced optimizing methods attempting at max the performance of the given environment. Fortunately, many of these objectives are mutually supportive (e.g., reducing manufacturing lead time reduces work in process and increases probability to meeting due dates).
- In order to **identify** the exact sequence among a plethora of possible combinations, the final schedule needs to apply rules in order to quantify urgency of each order (e.g., assigned order's due date - defined as global exploited strategy; amount of processing that each order requires - generally the basis of a local visibility strategy).
- It's up to operations management to **optimize** the **use** of **limited resources**.

Effective scheduling

Establishing the timing of the use of equipment, facilities and human activities in an organization.

Effective scheduling can:

- Yield Scheduling
- Cost savings
- Increases in productivity

High-Volume Success Factors

- Process and product design
- Preventive maintenance
- Rapid repair when breakdown occurs
- Optimal product mixes
- Minimization of quality problems
- Reliability and timing of supplies

Priority rules

Simple heuristics used to select the order in which jobs will be processed. Everything is #1 Priority

Different priority rules are :

- FCFS - first come, first served
- SPT - shortest processing time
- EDD - earliest due date
- CR - critical ratio
- S/O - slack per operation
- Rush – emergency

Rule	Average Flow Time (days)	Average Tardiness (days)	Average Number of Jobs at the Work Center
FCFS	20.00	9.00	2.93
SPT	18.00	6.67	2.63
EDD	18.33	6.33	2.68
CR	22.17	9.67	3.24

Scheduling difficulties

Difficulties because of variability in:

- ☐ Setup times
- ☐ Processing times
- ☐ Interruptions
- ☐ Changes in the set of jobs
- ☐ No method for identifying optimal schedule
- ☐ Scheduling is not an exact science
- ☐ Ongoing task for a manager

Minimizing Scheduling Difficulties

Set realistic due dates

Focus on bottleneck operations

Consider lot splitting of large jobs

- To control the timing of all operations, managers set up schedules:
  - they select jobs to be performed during the production process,
  - assign tasks to work groups,
  - set timetables for the completion of tasks,
  - and make sure that resources will be available when and where they're needed.
- There are a number of scheduling techniques. Two of the most common are **Gantt** and **PERT charts**.

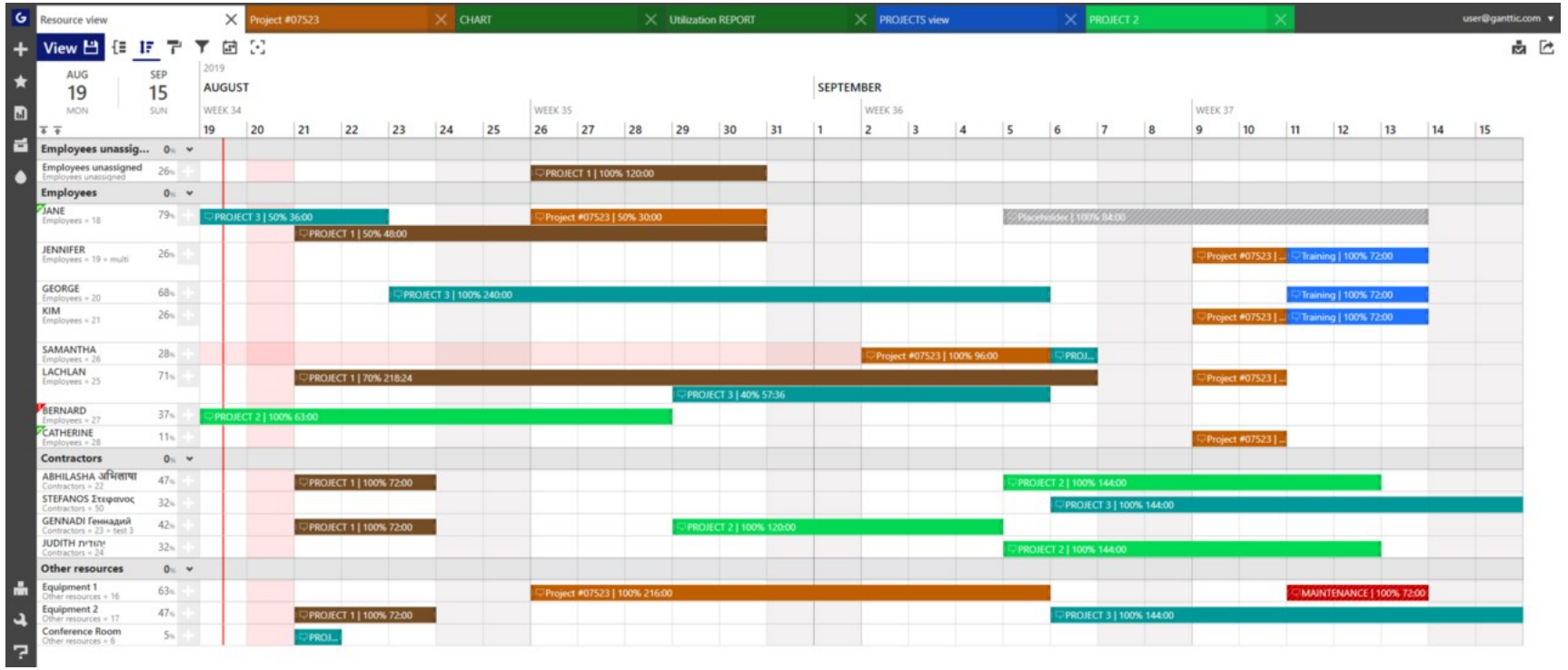
Graphic tools

A Gantt chart:

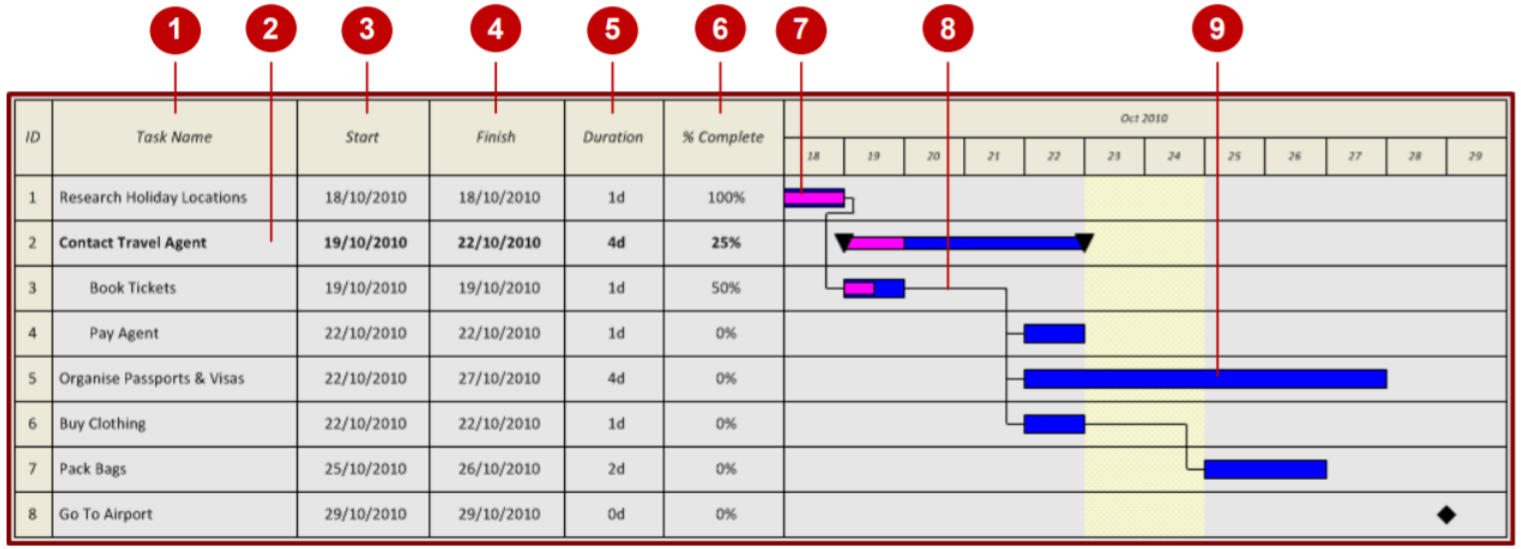
- named after the designer, Henry Gantt,
- is an easy-to-use graphical tool that helps operations managers **determine the status of projects**.
- Gantt charts are graphical representations of task-based projects.
- The tasks in a Gantt chart are both listed in a tabular format and displayed graphically as task bars, reflecting their duration.

Usage of Gantt chart:

- Projects usually comprise multiple tasks. When you manage a project, it can be difficult to track the tasks, their relationships, duration and status.
- A change in one task can affect the progression of a project and it is therefore important to have an overview of that project.
- Gantt charts are **bar charts that depict activities in a project, their duration and their interrelationships**



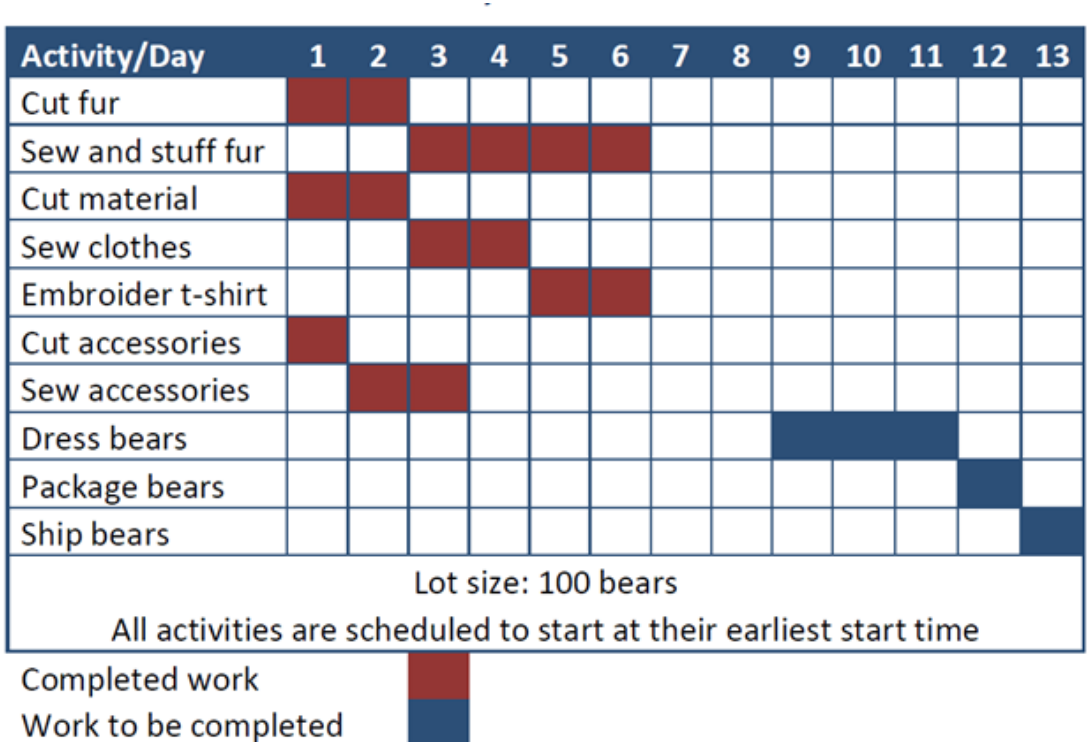
Construction of Gantt Chart



- The **individual tasks** are listed in the Task Name column.
- A task is automatically formatted as **bold** when a task below it is indented. The bolding indicates that the task is a summary task and the indented tasks below it are subtasks of the summary task.
- The **Start date** determines the start position of the task bar.
- The **Finish date** determines the end position of the task bar.
- The **Duration** of a task determines the length of the task bar.
- The **% complete** is reflected in the task bar by a proportion of the task bar appearing in a different colour.
- The percentage complete is reflected in the task bar by a proportion of the task bar appearing in a different colour.
- **Task bar** represent graphically each tasks. This makes it much easier to gauge the progress of a project.
- Linked tasks are connected by **connector lines**.

Example of Gantt chart

- Let's say that you're in charge of making the **"hiking bear" offered by the Vermont Teddy Bear Company.**
- A Gantt chart to produce one hundred of these bears.
- Several activities must be completed before the bears are dressed: the fur has to be cut, stuffed, and sewn; and the clothes and accessories must be made.
- Our Gantt chart tells us that by day six, all accessories and clothing have been made.
- The sewing and stuffing, however, which must be finished before the bears are dressed, isn't scheduled for completion until the end of day eight.
- As operations manager, you'll have to pay close attention to the progress of the sewing and stuffing operations to ensure that finished products are ready for shipment by their scheduled date.



PERT and Gantt chart: differences

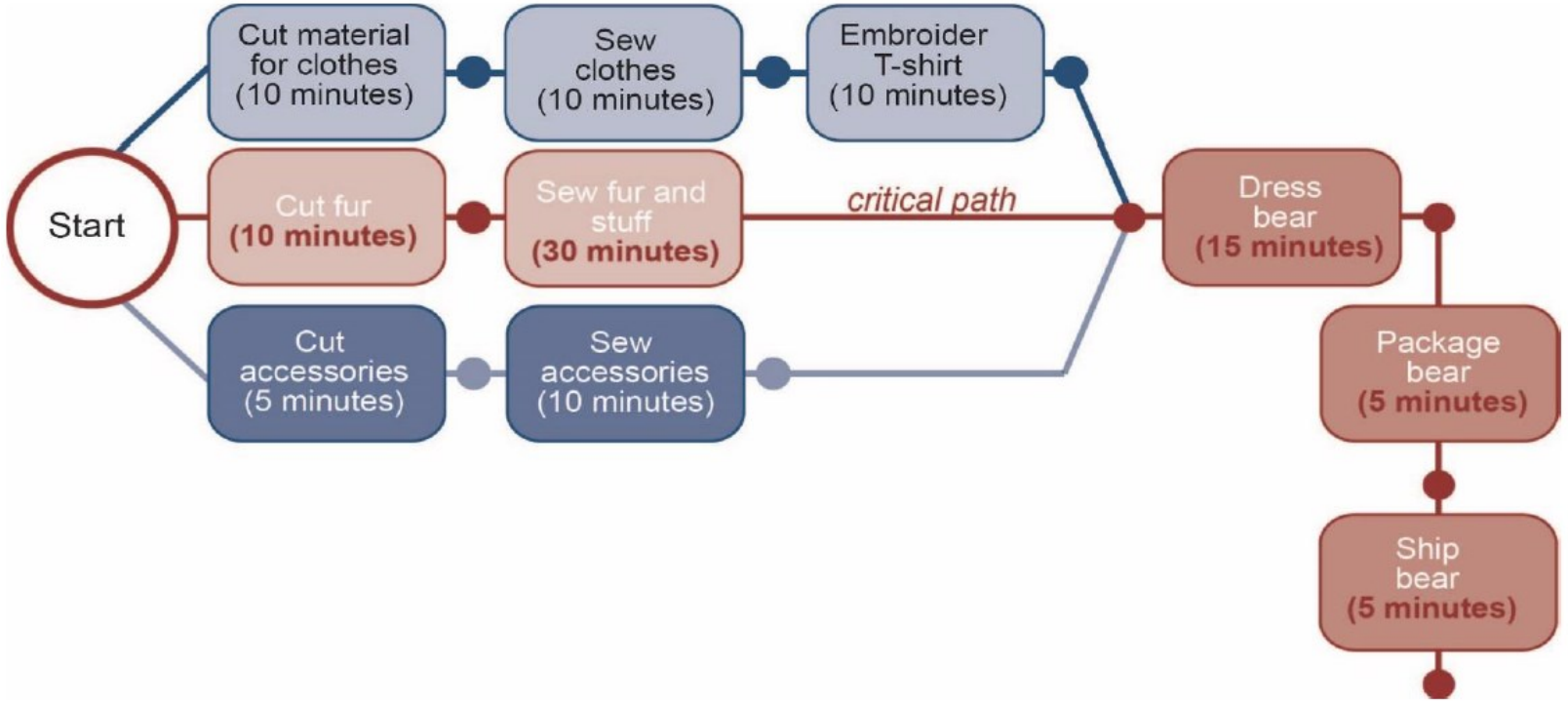
Gantt and PERT chart difference

- **Gantt** charts are useful when the production **process** is **fairly simple** and the activities aren't interrelated.
- For more complex schedules, operations managers may use PERT charts.
- **PERT** (Program Evaluation and Review Technique): designed to diagram the activities required to produce a good, specify the time required to perform each activity in the process, and organize activities in the most efficient sequence.
- It also identifies a critical path: the sequence of activities that will entail the greatest amount of time.

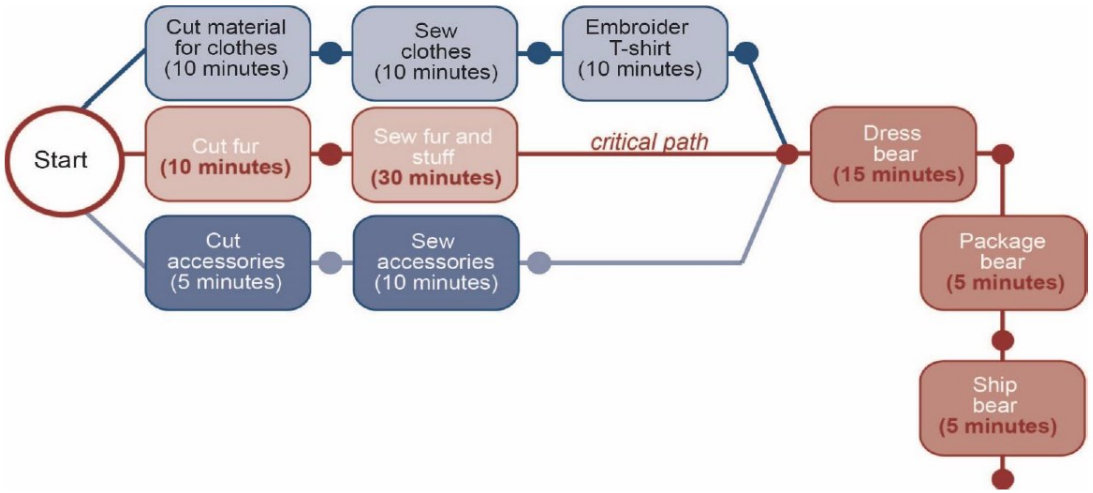
chart: Example

Teddy bear example: PERT diagram showing the process for producing one “hiker” bear
The Chart shows **how the activities involved** in making a single bear are **related**.

- It indicates that the production process begins at the cutting station.
- Next, the fur that’s been cut for this particular bear moves first to the sewing and stuffing stations and then to the dressing station.
- While its fur is moving through this sequence of steps, the bear’s clothes are being cut and sewn and its T-shirt is being embroidered.
- Its backpack and tent accessories are also being made at the same time.
- Note that fur, clothes, and accessories all **meet at the dressing station**, where the bear is dressed and outfitted with its backpack.
- Finally, the finished bear is packaged and shipped to the customer’s house.



What was the critical path in this process?



- **The path that took the longest amount of time** was the sequence that included cutting, stuffing, dressing, packaging, and shipping—a sequence of steps taking sixty-five minutes.
- If you wanted to produce a bear more quickly, you'd have to **save time on this path**.
- Even if you saved the time on any of the other paths, you still wouldn't finish the entire job any sooner: the finished clothes would just have to wait for the fur to be sewn and stuffed and moved to the dressing station.
- We can gain efficiency only **by improving our performance on one or more of the activities along the critical path**.

Scheduling of workers

- In manufacturing, managers focus on scheduling the activities needed to transform raw materials into finished goods.
- In service organizations, they focus on **scheduling** workers so that they're available to handle fluctuating customer demand.

- Examples:
  - Each week every BK store manager schedules employees to cover both the peak periods of breakfast, lunch, and dinner and slower periods in between.
  - If he or she staffs too many people, **labor cost** per sales dollar will be **too high**. If there aren't enough employees, **customers** have to **wait in lines**. Some get discouraged, and even leave, and many may never come back.
  - Scheduling is made easier by information provided by a point-of-sale device built into every BK cash register. The register sends data on every sandwich, beverage, and side order sold by the hour, every hour of the day, every day of the week to a computer system that helps managers set schedules.
  - To determine how many people will be needed for next Thursday's lunch hour, the manager reviews last Thursday's data, using sales revenue and a specific BK formula to determine the appropriate staffing level.
  - Each manager can adjust this forecast to account for other factors, such as current marketing promotions or a local sporting event that will increase customer traffic.

Thank you for your attention!

Questions?