**UNITIV PRODUCTION SCHEDULING** 9

Production Control Systems-Loading and scheduling-Master Scheduling-Scheduling rules-Gantt charts-Perpetual loading-Basic scheduling problems - Line of balance – Flow production scheduling Batch production scheduling.

**TYPES OF PLANNING LEVELS**

1. Short – range plans
2. Intermediate – range plans
3. Long – range plans

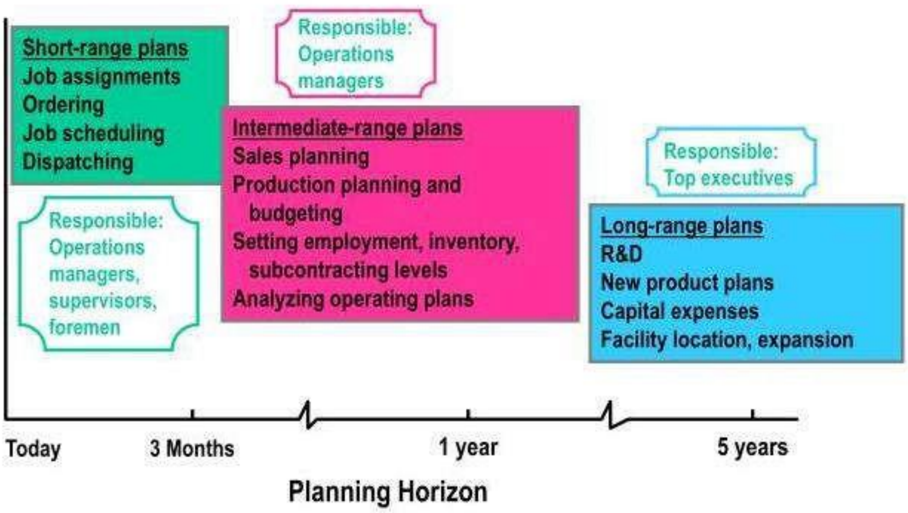


Fig – Planning Horizons

## Overview of Planning Levels

- **Short-range plans (Detailed plans)**
  - Machine loading
  - Job assignments
  - Job sequencing
  - Order quantities
  - Work Schedule
- **Intermediate plans (General levels)**

  General levels of:
  - Employment
  - Output
  - Finished-goods inventories
  - Subcontracting
  - Backorders
- **Long-range plans**
  - Long term capacity
  - Location / layout
  - Product Design

Fig 2.2 – Overview of Planning Levels

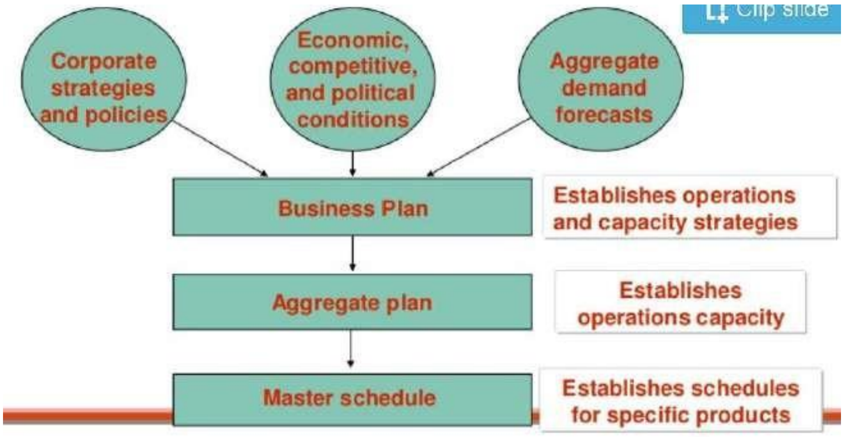


Fig – Planning Sequence

**AGGREGATE PLANNING**

- Aggregate production planning is concerned with the determination of production, inventory, and work force levels to meet fluctuating demand requirements over a planning horizon that ranges from six months to one year
- Aggregate planning is a planning method in the production process which is also considered a marketing activity used to determine the required resource capacity to meet expected demand.
- The aggregate planning is done in advance of 6 – 18 months and includes a combination of sub-contracting, sourcing, outsourcing, employment, labor overtime, amount of inventory and planned output to match demand and supply cost-effectively.
- Aggregate planning is critical to an organization which wants to optimize its operational activity because it helps in balancing short term production plans and long term strategic plans.

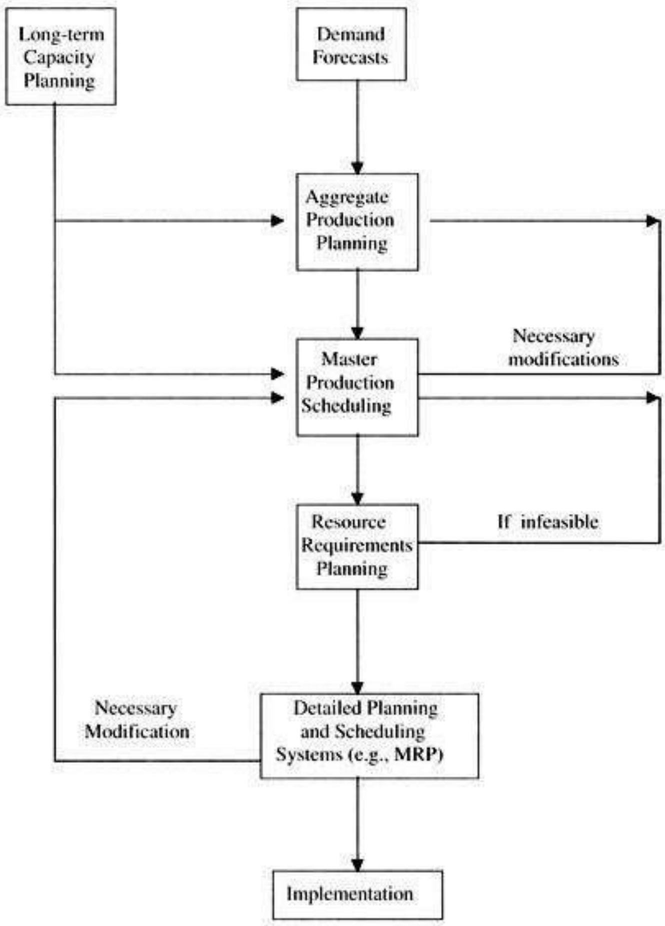


Fig –Sequence for Aggregate Planning

## Aggregate Planning Inputs and Outputs

| Input | Output |
|---|---|
| Resources<br>-Workforce/production rates<br>-Facilities and equipment | Total cost of plan |
| Cost<br>-Inventory carrying cost<br>-Backorders<br>-Hiring/firing<br>-Overtime<br>-Inventory changes<br>-Subcontracting | Projected levels of:<br>Inventory<br>Output<br>Employment<br>Subcontracting<br>Backordering |
| Demand forecast | |
| Policies on workforce changes | |
| Subcontracting | |
| Overtime | |
| Inventory levels/changes | |
| Backorders | |

Fig – Aggregate Planning Inputs and Outputs

**Importance of aggregate planning**

Aggregate planning is a proven technique that brings an element of foresight and stability into manufacturing. It helps the management to achieve the long-term objectives of a company. The importance of aggregate planning include-

- Creates a satisfied and happy workforce
- Reduce changes in the levels of the workforce
- Helps to determine resources for the short-term
- Helps in maximum utilization of space
- Meets the overall goals and objectives of a company
- Helps to adjust capacity to meet demand
- Minimizes costs associated with inventory stocking
- Reduce investments related to various inventories
- Matching demand with supply and minimizing the waiting time for the customers to maximize customer service
- Offers better customer value
- Proper utilization of production facilities
- Maximum usage of various types of equipment
- Reducing the changes in production rates
- Removes variable cost and improves the bottom line of the financial statement for achieving the business goals of an organization

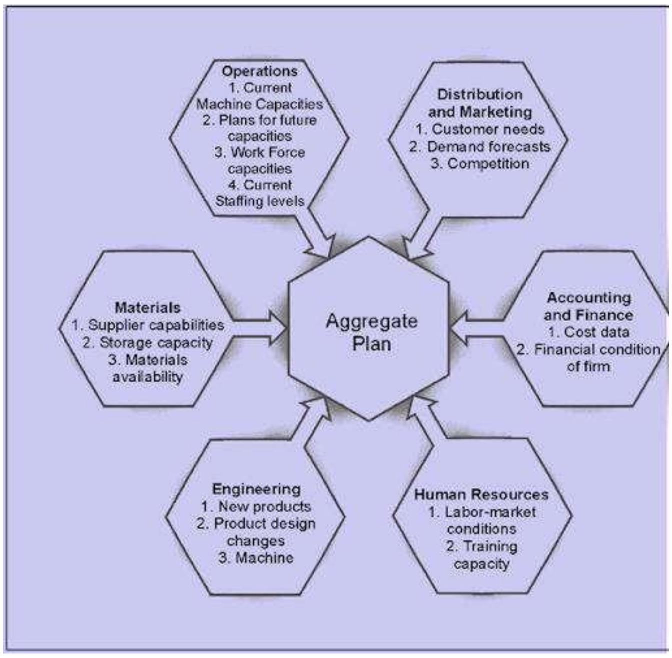


Fig – Various Elements of Aggregate Planning

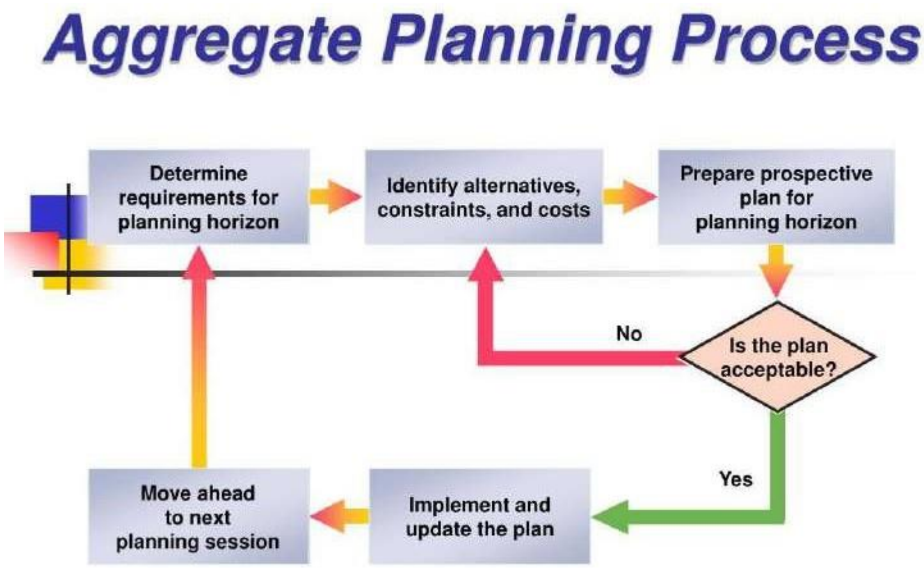


Fig 2.7 – Aggregate Planning Process

**Aggregate Planning Strategies**

There are two pure planning strategies available to the aggregate planner: a level strategy and a chase strategy. Firms may choose to utilize one of the pure strategies in isolation, or they may opt for a strategy that combines the two.

**Level strategy**.

- A level strategy seeks to produce an aggregate plan that maintains a steady production rate and/or a steady employment level.
- In order to satisfy changes in customer demand, the firm must raise or lower inventory levels in anticipation of increased or decreased levels of forecast demand.
- The firm maintains a level workforce and a steady rate of output when demand is somewhat low.
- This allows the firm to establish higher inventory levels than are currently needed.
- As demand increases, the firm is able to continue a steady production rate/steady employment level, while allowing the inventory surplus to absorb the increased demand.
- A second alternative would be to use a backlog or backorder.
- A backorder is simply a promise to deliver the product at a later date when it is more readily available, usually when capacity begins to catch up with diminishing demand.
- In essence, the backorder is a device for moving demand from one period to another, preferably one in which demand is lower, thereby smoothing demand requirements over time.

- A level strategy allows a firm to maintain a constant level of output and still meet demand.
- This is desirable from an employee relations standpoint.
- Negative results of the level strategy would include the cost of excess inventory, subcontracting or overtime costs, and backorder costs, which typically are the cost of expediting orders and the loss of customer goodwill.

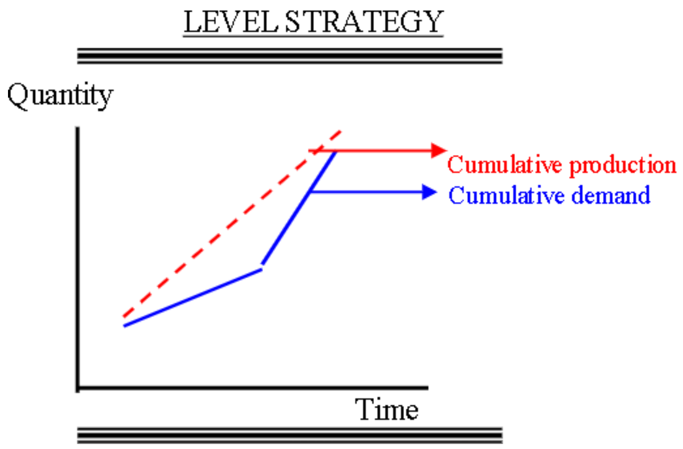


Fig – Level Strategy

**Chase strategy**

- A chase strategy implies matching demand and capacity period by period.
- This could result in a considerable amount of hiring, firing or laying off of employees; insecure and unhappy employees; increased inventory carrying costs; problems with labor unions; and erratic utilization of plant and equipment.
- It also implies a great deal of flexibility on the firm's part.
- The major advantage of a chase strategy is that it allows inventory to be held to the lowest level possible, and for some firms this is a considerable savings.
- Most firms embracing the just-in-time production concept utilize a chase strategy approach to aggregate planning.
- Most firms find it advantageous to utilize a combination of the level and chase strategy.
- A combination strategy (sometimes called a hybrid or mixed strategy) can be found to better meet organizational goals and policies and achieve lower costs than either of the pure strategies used independently.

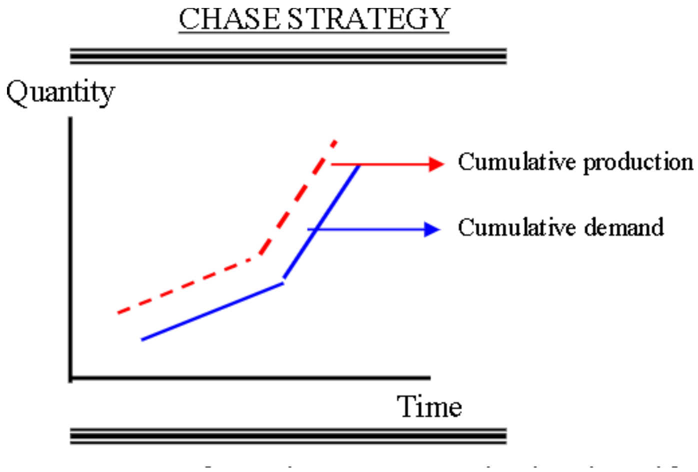


Fig – Chase Strategy

**Hybrid strategy**

As the name indicates, the Hybrid strategy is an integration of both level and chase strategies to get a better result.

- It maintains a sufficient balance between stock level, recruiting, termination and production rate.
- In the hybrid strategy of aggregate planning, the organizations build up inventory before rising demands. It uses backorders to level with high peak periods.
- It can easily cover short-term peaks by hiring workers temporarily or by subcontracting production.
- Hiring, lay-off and reassigning workers is a normal part of the hybrid strategy.


Fig – Level vs Chase Strategy

**Techniques For Aggregate Planning**

Techniques for aggregate planning range from informal trial-and-error approaches, which usually utilize simple tables or graphs, to more formalized and advanced mathematical techniques. William Stevenson's textbook Production/Operations Management contains an informal but useful trial-and-error process for aggregate planning presented in outline form. This general procedure consists of the following steps:

- **Determine demand for each period.**

  Determine capacity for each period. This capacity should match demand, which means it may require the inclusion of overtime or subcontracting.

  Identify company, departmental, or union policies that are pertinent. For example, maintaining a certain safety stock level, maintaining a reasonably stable workforce, backorder policies, overtime policies, inventory level policies, and other less explicit rules such as the nature of employment with the individual industry, the possibility of a bad image, and the loss of goodwill.

- **Determine unit costs for units produced.**
  These costs typically include the basic production costs (fixed and variable costs as well as direct and indirect labor costs). Also included are the costs associated with making changes in capacity. Inventory holding costs must also be considered, as should storage, insurance, taxes, spoilage, and obsolescence costs. Finally, backorder costs must be computed. While difficult to measure, this generally includes expediting costs, loss of customer goodwill, and revenue loss from cancelled orders.
- **Develop alternative plans and compute the cost for each.**

  If satisfactory plans emerge, select the one that best satisfies objectives. Frequently, this is the plan with the least cost. Otherwise, return to step 5.

**Advantages**

Advantages for Management and Users

The advantages associated with aggregate planning include-

1. It helps the organization in dealing with production facilities in a lean manner. If a manufacturing facility has an excess of finished products, then it is not suitable for it. The chance of product damage before reaching the end target is higher and this means loss. Moreover, excess inventory costs mean additional expense for the company. The only way to minimize these costs is by implementing a proper aggregate planning process.
2. The process helps to develop effective strategic plans as well as relationships with distributors and suppliers. It also assists in making developing accurate market research

3. The planning helps in the optimization of inventory. Carrying excessive inventory will mean additional expenses for a manufacturing company. It also results in more storage space to keep it properly because the chances of damage increase if the storage space is not proper. The organization will also have to invest in more resources, labor and equipment to manage the inventory and for its movement. The process makes an adequate estimation for the anticipated inventory that will be sufficiently able to meet projected demands.
4. An essential advantage is that it serves as a useful tool for making viable forecasts about product demand. A business entity is now able to make predictions about staff requirements, for instance, the number of additional workers it will need temporarily or the number of employees it will need to lay-off. Proper forecasting helps the company to fill the positions with temporary staff from agencies. The need for additional hires is easily met without other expenses that are part of the full-time workforce. The aggregate planning method helps the organization to make considerable savings in terms of both money and time that would have to be spent on the hiring and training process.
5. It helps to adjust capacity so that it can meet demands
6. The aggregate planning process helps to calculate capacity, for instance, how many units can be produced daily or in a week or a month.
7. Production orders cannot be constant throughout the year. It will vary and this makes it difficult for the business entities to keep up with a similar production plan for all times. The aggregate planning process takes this thought into consideration and allows for contingency measures. These are put in place so that the manufacturing facilities can accommodate the changes that occur in production as well as orders from the customers. The organization keeps shifting between the level strategy, chase strategy and hybrid strategy to keep up with the changes.
8. It helps the organization to identify the best options so that it can meet the demands easily.
9. It assists in knowing about the inefficiencies that exist within the organization
10. It helps to determine resources for instance amount of raw materials on hand, availability of total machine hours and the total number of workers along with products in progress, packaging materials, and tools required for manufacturing finished goods
11. An advantage of the planning process is that it helps to project demand and figure out the units in need for the short-term by factoring in advertising campaigns, special pricing, and promotions.
12. It encourages the optimized utilization of space. The facilities that are used by organizations for manufacturing purposes are too costly and it is not feasible to own or rent it at all times. Besides paying for space, an organization also has to pay for maintenance and utilities. The aggregate planning helps the company to avoid any

scenario where the space is unused for an extended period and it has to bear unnecessary expenses

13. It helps to offer optimized value to both the direct buyers from which it is getting raw materials etc. and end customers to which it will sell the products. The process reduces the production costs and this helps them to pass on savings. Ultimately the end consumer gets the best quality products at the minimum price levels

**Disadvantages of Aggregate Planning**

Data and Bias

Like with all plans, they are only as good as the people who make them. Planners often have biases, prejudices and habituation that derive from their experience and education. These, if unchecked, can lead to a plan that misreads economic indicators or relies on faulty data like economic forecasting models. A production plan cannot take shocks into consideration, such as a spike in oil prices, Federal Reserve policies, interest rate hikes or changes in consumer confidence. As the name suggests, these plans can only deal with "aggregates" or averages that are only a partially successful tool to predict fluctuations in demand.

Labor and Uncertainty

Labor remains one of the most serious problems of aggregate production planning. For example, a company plans to increase overtime hours and hire part-time workers for peak demand seasons. It will then cut hours and give unpaid furloughs during poor demand seasons. This implies that workers, especially long-term ones, will become increasingly dissatisfied and cynical about company policy and will not work up to capacity. Even more, well-qualified workers will choose other companies because of the constant insecurity of such a production policy. As most aggregate models forecast alternations in labor conditions, this can cause problems among full-time workers. It introduces insecurities and uncertainty into the workplace.

**MASTER PRODUCTION SCHEDULE**

- Master Production Scheduling is the process that helps manufacturers plan which products and related quantities to produce during certain periods.
- MPS is proactive in that it drives the production process in terms of what is manufactured and what materials are procured.

**Master Production Schedule**

- As the name implies, the MPS decides what products are manufactured and when.
- The required raw materials are then identified by the finished goods BOM, the data from which is then integrated with current inventory data to create the MRP for raw materials procurement.

- The Master Production Schedule forms the basis of communication between sales and manufacturing.
- Using the MPS as a contract between sales and production means that sales can make valid order promises. The MPS is not a rigid plan. MPS is a dynamic plan and can be changed when there are changes in demand or capacity.

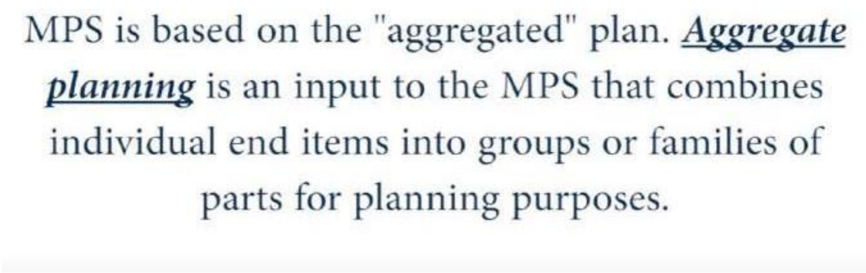


Fig 2.11 – Input to MPS


Fig 2.12 – MPS Inputs


Fig 2.13 – MPS Outputs

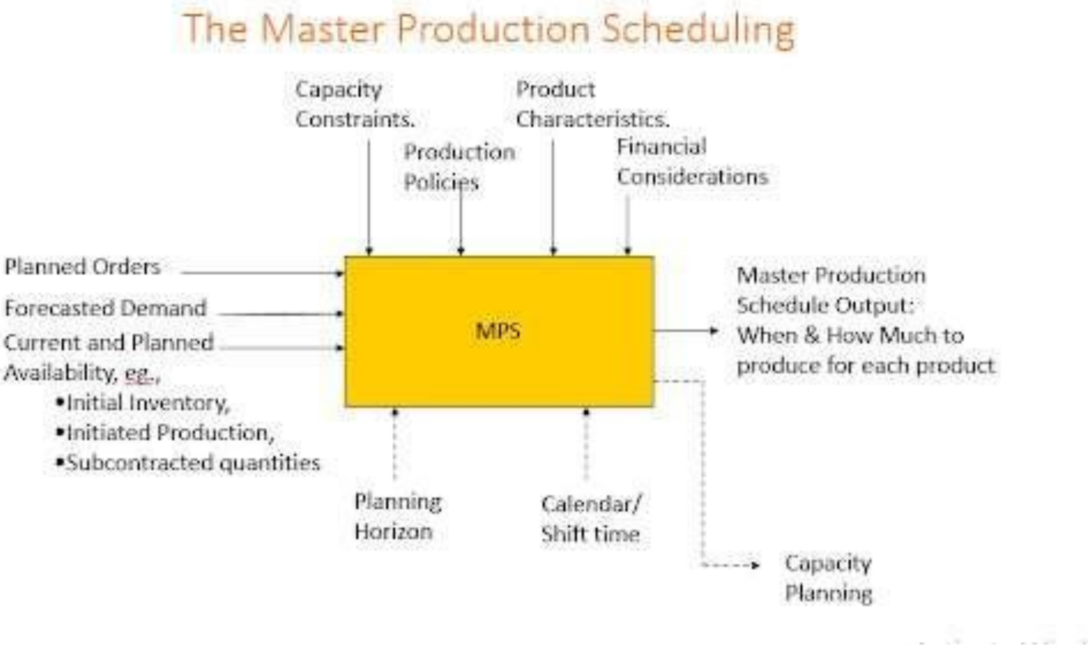


Fig – Master Production Scheduling

**Apple**

| A | B | C | D | E |
|---|---|---|---|---|
| | IPad Aggregate Plan | Jan | Feb | Mar |
| Product | Ipad Family | 1000 | 1000 | 1000 |
| | TOTALS | 1000 | 1000 | 1000 |

| A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MPS | | Jan | | | | Feb | | | | Mar | | | |
| Week | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Product | Ipad | 100 | | 150 | 100 | 100 | | 150 | 100 | 100 | | 150 | 100 |
| | Ipad Mini | 150 | 100 | 100 | | 150 | 100 | 100 | | 150 | 100 | 100 | |
| | Ipad Pro | | 150 | | 150 | | 150 | | 150 | | 150 | | 150 |
| | TOTALS | 1000 | | | | 1000 | | | | 1000 | | | |

Fig – Example of MPS from Aggregate Plan

### Main Functions of Master Production Scheduling

The MPS strives to form a detailed plan that fulfils the following objectives:

- Achieve desired customer service levels
- Make the most efficient use of resources
- Maintain a desirable level of inventory

### Objectives of Master Production Scheduling (MPS)

The main objectives of Master Production Scheduling (MPS) include the following:

- Inventory Control - MPS oversees inventory and attempts to keep a desired level of inventory available within the company. This is completed through making perfect use of the resources available and minimizing overall cost and waste within the operation. Inventory control is one of the main objectives of MPS and can benefit the manufacturing operation immensely.
- Setting Up Due Dates - This objective pertains to setting up the due dates for availability of end items and also providing information pertaining to resources and materials. This objective acts as the foundation of aggregate planning within the production facility.
- Customer Service - Delivery time is extremely important in ensuring for customer service satisfaction - which MPS can help with. Master production scheduling helps keep customer delivery promises through delivering in a timely and cost-effective manner.
- Scheduling - MPS sets up particular schedules for production of parts and components that are utilized as inputs to materials requirements planning. This ensures for an optimized and efficient production schedule that will ensure for on-time delivery and for the product to be completed in the time that it is given with the available resources.

### Parts of a Master Production Schedule

The correct procedure for developing a master production schedule is to include the following elements:

— Product List — All product models you produce. After you have completed your ABC analysis, you can order them by popularity, so the items you produce the most are at the top of the list;

— Variation Sub-Lists for Each Product — Have a field for each product variation. One for each SKU (Stock keeping unit). For example, you can split backpacks into S, M, and L for size. You can further split these into other variations like color;

— Year, month, and week — This is useful for planning and keeping records, which is necessary for accurate demand forecasting. Split up your schedule into months and weeks. The aim is to have a solid plan of what you will produce for the next few months.You can reassess your projected demand every few months. Don't be afraid to make adjustments sooner if the demand calls for it; and

— Production quantities — This is the number of units you decide to manufacture each week. Say, after analyzing your demand plan, you decide to manufacture 200 units of product in a week. You then add the number 200 to the bottom of each weekly column.But don't stop there, as you now need to allocate how many of each product variation will make up the 200 total. This depends on what you already have in stock, and what the projected demand is. For example, one week all 200 units could be of on e SKU, whereas the next week the production could be more evenly distributed across product models.

**Different Master Production Scheduling techniques**

The MPS needs to plan for what will be manufactured at the most efficient level. If the MPScovers too many items, it will be difficult to put the plan into action, effectively. Whereas, ifthe plan is not detailed enough, the production will suffer. As a general rule, master scheduling should happen where the smallest number of product alternatives exists.

- In **make-to-stock** environments, a limited number of items are assembled from a larger number of components, for example, video recorders or computers. The MPS should in this case be a schedule of finished goods items.
- In a **make-to-order** environment, many different finished goods can be produced from a relatively small number of raw materials. A great example of this process would be how cars are manufactured. The subassemblies for many cars will be the same but the different models of cars manufactured differ in specific options such as color, stereo, sunroof, and electric windows. The MPS in a make-to-order environment is a schedule of the actual customer orders.
- **Assemble to order** environments make use of raw materials to form basic components and complete subassemblies. These components and subassemblies make up a variety of finished products. The Master Production Schedule should therefore take place at the subassembly level.

**LINE BALANCING**

- **A production line is said to be in balance when every worker's task takes the same amount of time.**
- **Line balancing is a manufacturing-engineering function in which whole collection of production-line tasks are divided into equal portions. Well-balanced lines avoid labour idealness and improve productivity.**

Production Line Balancing

Line-balancing strategy is to make production lines flexible enough to absorb external and internal irregularities. There are two types of line balancing, which we have explained as –

- Static Balance – Refers to long-term differences in capacity over a period of several hours or longer. Static imbalance results in underutilization of workstations, machines and people.

- Dynamic Balance – Refers to short-term differences in capacity, like, over a period of minutes, hours at most. Dynamic imbalance arises from product mix changes and variations in work time unrelated to product mix.

**Example of line balancing:**

- Everyone is doing the same amount of work
- Doing the same amount of work to customer requirement
- Variation is ‘smoothed’
- No one overburdened
- No one waiting
- Everyone working together in a **BALANCED** fashion

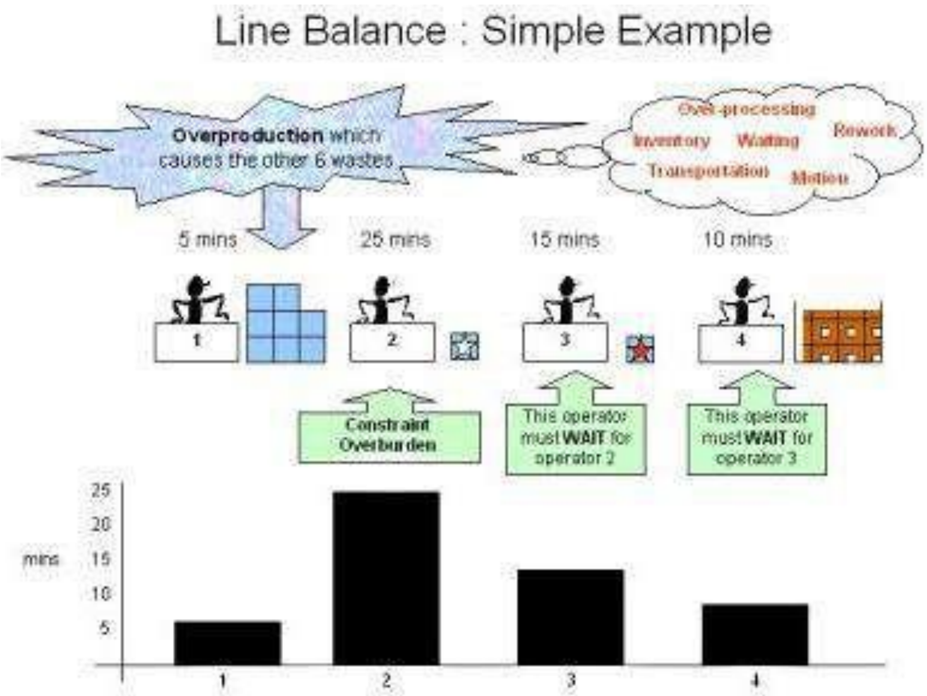


Fig 2.25 – Line Balance: Simple Example

- Here we see operator number 1 over-producing, thus creating the other 6 wastes.
- Re-balance the work content (Re distribute some of the work), using a Yamazumi board as it is often known

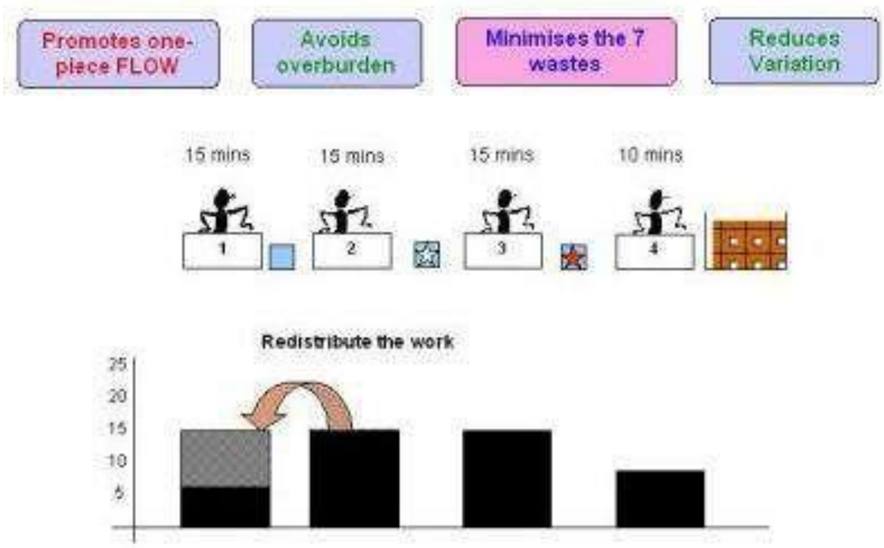


Fig 2.26 – Line Balance: Simple Example

**Main Objectives:**

- ✓to equalize the work load among the operators
- ✓to identify the bottleneck operation
- ✓to establish the speed of the production line
- ✓to determine the number of workstations
- ✓to determine the labor cost of production and pack out
- ✓to establish the percentage workload of each operator
- ✓to assist in plant layout
- ✓to reduce production cost

- Line balancing technique was used normally in assembly line of the automotive industry which is called ALB.
- Most of the Small and Medium Industries do not use line balancing method in the production line.

Line balancing operates under two circumstances:

1. **Precedence Constraint:** Products cannot progress to other station if it doesn't complete necessary task at that station. It should not across other station because certain part needs to be performed before other activities.
2. **Cycle time Restriction:** Cycle time is maximum time for products spend in every workstation. Different workstation has different cycle time.

## LINE BALANCING PROCEDURE

1. Determination of tasks that must be performed to complete one unit of a product.
2. Determining the order or sequence of performing the whole set of tasks.
3. Drawing precedence diagram. In this flowchart circles represents task and joining arrows represents precedence.
4. Estimation of task time.
5. Calculation of cycle time.
6. Determination of minimum number of workstation required.
7. Using one of the heuristics to assign tasks to workstations for balancing production line.

**Terms in Line Balancing Technique**

There is range of terms used in assembly line balancing system. Each of them has their meaning and purposes.

I. **Cycle Time:** Maximum amount of time allowed at each station. This can be found by dividing required units to production time available per day. This is the time expressed in minutes between two simultaneous products coming of the end of production line.
II. **Lead Time:** Summation of production times along the assembly line.
III. **Bottleneck:** Delay in transmission that slow down the production rate. This can be overcome by balancing the line.
IV. **Task Precedence:** It is the sequence by which tasks are carried out. It can be represented by nodes or graph. In assembly line the products have to obey this rule. The product cannot be moved to the next station if it doesn't complete at the previous station.
V. **Idle time:** A period when system is not in used but is available.
VI. **Productivity:** Defined as ratio of output over input. Productivity depends on several factors such as workers skills, jobs method and machine used.
VII. **Takt times:** The time needed by competent worker or unattended machine to perform a task. This is usually expressed in minutes. Takt time is pre-requisite procedure in doing line balancing task. Takt time is the swiftness of production that aligns production with client demand. It shows how fast the need to manufacture product in order to fill the customer orders. Producing faster than takt time results in overproduction which is a type of waste whereas producing slower than takt time results in bottlenecks where the customer orders may not be fulfilled in time. There are numerous benefits of using takt time. These include,
   i. Achieve a steady and continuous flow of production.
   ii. Eliminate the waste of overproduction by producing actual customer demand.
   iii. Improves accuracy of planning.
   iv. Encourage the development of standardize work instructions, promoting quality and efficiency.
   v. Set real time targets for production that shows operators exactly where their work output should be at any given point of time.
   vi. Establish what-if scenario for customer demand based on flexible manning.

**The TAKT Time Formula = (Net Time Available for Production)/(Customer's Daily Demand)**.

VIII. **Work station:** A physical area where a worker with tools / one or more machines or unattended machines such as robot perform specific task in a production line.
IX. **Downtime:** Downtime explained as the time that is non value added. It is often associated with the seven wastes as under:
   a. Defects: Defect is direct costs of a company.
   b. Overproduction: One of the severe wastes discourages a smooth flow of goods and services, which may lead to unnecessary lead and storage time. It will lead to the defects

which cannot be detected earlier and then the products may deteriorate. It will also leadto excess work-in-progress stocks.

c. Waiting: It occur when the goods are not moving or being worked on. It affects both goods and workforce where the waiting time should be used for some value added activities such as training and maintenance.
d. Transportation: Any movement in factory can be considered as waste. Double handlingand excessive movements are likely to cause damage and deterioration with the distance of communication between processes proportional to time taken. It takes to feedback reports of poor quality and needs corrective action.
e. Unnecessary inventory: There is a problem with extra inventory. Inventory will increasethe lead time, preventing quick identification of problems and increasing space. Significant storage costs are wasted which absolutely lower the competitiveness of the organization of value stream.
f. Unnecessary motion: Involve the ergonomics of production where operation might haveto stretch, bend and pick up when these actions actually could be avoided. It not only tires the workers but also leads to poor productivity.
g. Inappropriate processing: Over-complexity of a process discourages ownership and encourages the employees to over produce to recover the large investment in the complex machines. It encourages poor quality and takes corrective action.