Aggregate Planning and Master Scheduling

PLANNING AND SCHEDULING STRATEGIES

Production planning is a complex problem! The capacity of most firms is relatively stable, whereas the demand for goods and services is often quite variable. Demand cannot always be met. The objective of aggregate planning is to respond to irregular market demands by utilizing the organization's equipment, personnel, and other resources in the most effective manner possible.

Question: What is aggregate planning?

Aggregate planning is the process of planning the *quantity* and *timing* of output over the intermediate range (often 3 to 18 months) by adjusting the production rate, employment, inventory, and other controllable variables.

Figure 11-1 illustrates how aggregate planning links long-range and short-range planning activities. It is "aggregate" in the sense that the planning activities at this early stage are concerned with homogeneous categories (families) such as gross volumes of products or number of customers served, rather than specific models of individual goods or categories of services.

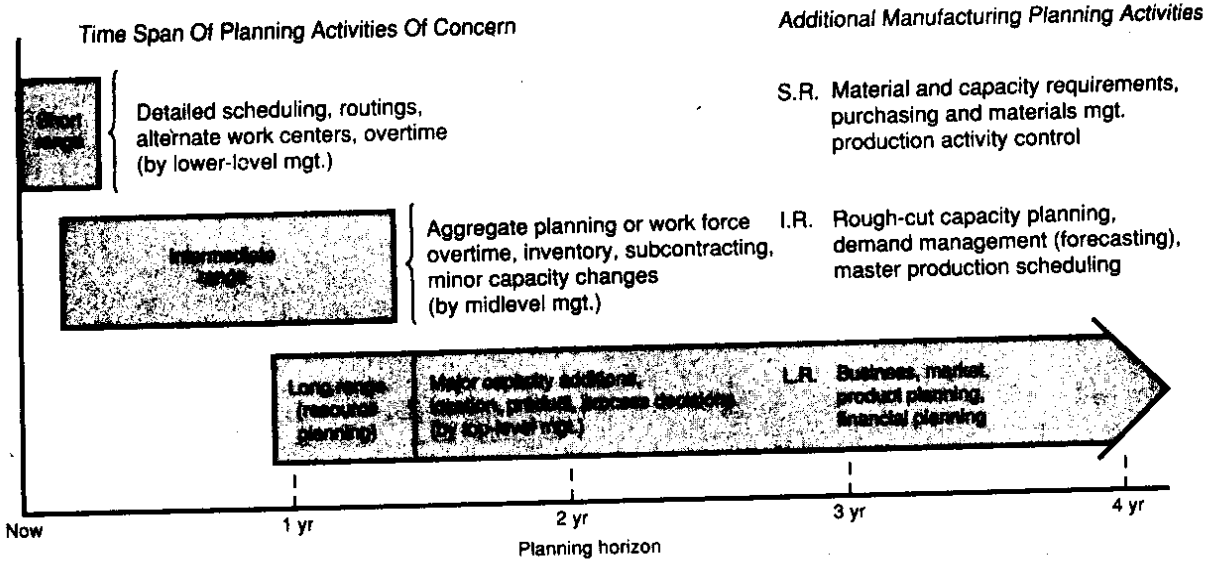

Fig. 11-1 Planning levels and activities

Question: What is master scheduling, and does it differ from aggregate planning?

Master scheduling follows aggregate planning and expresses the overall plan in terms of the amounts of specific end items to produce and dates to produce them. It uses information from both forecasts and orders on hand, and it is the major control (driver) of all production activities. Figure 11-2 illustrates a simplified aggregate plan and master schedule.

Aggregate Plan

Month	J	F	M	A	M	J	J	A	S
Number of motors	40	25	55	30	30	50	30	60	40

Master Schedule

Month	J	F	M	A	M	J	J	A	S
AC motors:									
5 hp	15	—	30	—	—	30	—	—	10
25 hp	20	25	25	15	15	15	20	30	20
DC motors:									
20 hp	—	—	—	—	—	—	10	10	—
WR motors:									
10 hp	5	—	—	15	15	5	—	20	10

Fig. 11-2 Aggregate plan and master schedule for electric motors

ARIABLES USED IN AGGREGATE PLANNING

Aggregate planning is a complex problem largely because of the need to coordinate interacting ariables in order for the firm to respond to the (uncertain) demand in an effective way. Table 11-1 dentifies some of the key variables available to planners and the costs associated with them.

Table 11-1 Some Decision Variables and Costs in Aggregate Planning

Decision Variable	Associated Cost
1. Varying size of work force	1. Hiring, training, and layoff costs
2. Using overtime or accepting idle time	2. Wage premiums and nonproductive time costs
3. Varying inventory levels	3. Carrying and storage costs
4. Accepting back orders	4. Stockout costs of lost orders
5. Subcontracting work to others	5. Higher labor and material costs
6. Changing the use of existing capacity	6. Delayed response and higher fixed costs

To best understand the effect of changes in these variables, it is useful to first focus upon the impact of a change in only one variable at a time, with other variables held constant. The examples that follow show the effect on production costs of (isolated) changes in the decision variables. They are presented in a simplified format in order to best convey the underlying concept; more realistic examples follow in later sections.

Example 11.1 Paris Candy Company has estimated its quarterly demand (cases) as shown in Table 11-2 and Fig. 11-3. It expects the next demand cycle to be similar to this one and wishes to restore ending inventory, employment, etc., to beginning levels accordingly.

Table 11-2 Demand

Quarter	Units
1st	500
2nd	900
3rd	700
4th	300

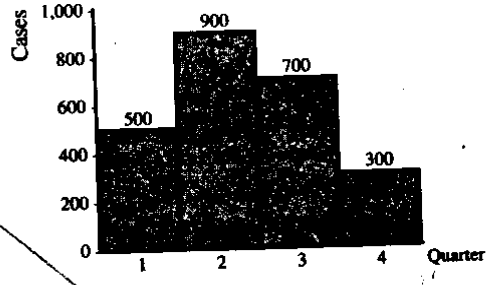

Fig. 11-3 Histogram of demand by quarter

FOCUSED AGGREGATE PLANNING STRATEGIES Basic & Mixed Strategy

Several different strategies have been employed to assist in aggregate planning. Three so-called "pure" strategies are recognized, and a myriad of other "mixed" strategies are possible. The pure strategies stem from early models that depicted production results when only one of the decision variables (see previous examples) was permitted to vary—all others being held constant. The concept of a "pure" strategy has, however, largely shifted to one that has a single focus (focused strategy), such as level employment, but does not necessarily preclude the use of other variables, e.g., overtime. Mixed strategies can incorporate any mix of variables and can be unique to a firm.

Question: What focused strategies are employed by production planners to meet nonuniform demands?

Three focused strategies (apart from numerous mixed strategies) are:

(1) *Vary production to match demand*—by changes in employment. (*Chase demand strategy:* This strategy permits hiring and layoff of workers, use of overtime, and subcontracting as required in each period. However, inventory buildup is not used.)

(2) *Produce at a constant rate*—and use inventories. (*Level production strategy:* This strategy retains a stable work force producing at a constant output rate. Inventory can be accumulated to satisfy peak demands. In addition, subcontracting is allowed and back orders can be accepted. Promotional programs may also be used to shift demand.)

(3) *Produce with stable work force*—but vary the utilization rate. (*Stable work-force strategy:* This strategy retains a stable work force but permits overtime, part-time, and idle time. Some versions of this strategy permit back orders, subcontracting, and use of inventories. Although this strategy uses overtime, it avoids the detrimental effects of layoff.)

We can use the data in Figs. 11-9 and 11-10 to illustrate the three focused strategies describ above. These figures display a histogram and cumulative graph of a 9-month forecast for motors. T total requirement for the 9 months is 360 motors. This works out to an average (mean) of 40 motors p month, which is shown as a dotted line in Fig. 11-9.

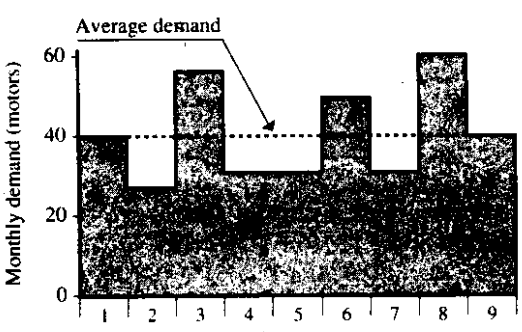

Fig. 11-9 Monthly demand histogram

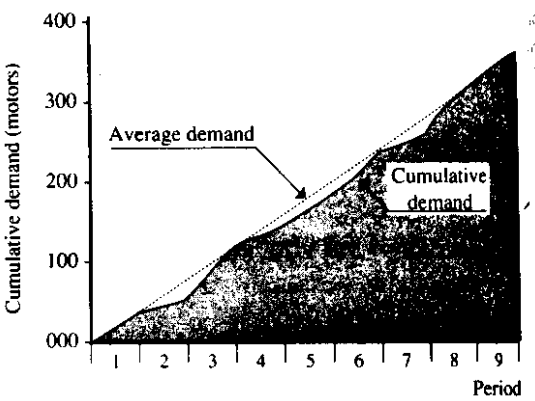

Fig. 11-10 Cumulative demand graph

(#1) Chase Strategy. If the production planner designed a plan to exactly match the forecast of demand shown in Fig. 11-9, by adding or laying off employees to change the level of production, the planner would be using a *chase strategy*. Some overtime or subcontracting might also be used, but no inventories would be accumulated. (*Note:* The resulting aggregate plan would coincide exactly with the one already shown in Fig. 11-2, because the forecast values shown in Fig. 11-9 are the same as the values shown in the aggregate plan of Fig. 11-2.)

(#2) Level Production Strategy. The graph in Fig. 11-9 shows (visually) that the demand exceeds the average requirement in some months and is below average in others. A production plan could be developed to produce at the constant rate of 40 motors per month, accumulating inventory in months 2, 4, 5, and 7, and using that inventory to meet the above average demands in months 3, 6, and 8. Figure 11-10 shows that the cumulative demand (forecast) never exceeds the cumulative averages (production), so no initial inventory is needed to prevent shortages. However, if there were shortages, some back orders could be allowed under a *level production, or inventory, strategy*.

(#3) Stable Work-Force Strategy. Referring to Fig. 11-9, suppose the firm has a stable work force capable of producing 36 motors per month on regular time. Production might go as high as 60 motors per month by using overtime, but if demand falls to less than 36 motors per month, some workers would be idle. Using overtime and idle time to meet demand would be employing a *stable work-force strategy*. As part of this strategy, however, it seems likely that planners would build up some inventory during what might otherwise be idle time periods.

Formats for Presentation and Comparison. Numerous formats have been developed to display the comparative data from an analysis of different plans. Both tabular and graphic presentations are useful; this type of analysis also lends itself to computer modeling and the use of spreadsheets. The solved problems at the end of the chapter illustrate some additional ways of structuring the analysis. Note that when making a comparison among different plans, only the relevant production and cost information (i.e., variables that change from one alternative to another) need be included.

Service activities do not have the inventory strategy available to them, so they tend to rely more upon shifting or managing demand (by fixed schedules, appointments, etc.).

Example 11.6 (*Vary production to match demand*) An aggregate plan is to be developed for the forecast of demand covering nine periods shown in Table 11-4. Other relevant production and cost information is also provided. (Note that since this plan does not allow for any inventory buildup, a decision has been made to carry 10 units of safety stock, but no overtime or subcontract labor is used.) Find the cost associated with an aggregate plan that involves varying the size of the work force in order to have a production rate that matches demand.

MIXED STRATEGIES

The number of mixed strategy alternative production plans is almost limitless. However, the realities of the situation will most likely limit the number of practical solutions. These can be evaluated on a trial-and-error basis to find which plan best satisfies the requirements, taking cost, employment policies, etc., into account.

The optimal solution values can be taken directly from the cells. Thus in period 2, for example, the planners will schedule the full 50 units to be produced on regular time plus 12 units on overtime to be carried forward to period 4. This leaves 3 units of unused overtime capacity and no subcontracting during that period. Because of the similar carrying cost for units produced on regular time or overtime, it does not matter which physical units are carried forward, once overtime production is required. Thus, different optimal solutions (but with identical costs) may be obtained.

MASTER SCHEDULING OBJECTIVES, INPUTS, AND PLANNING HORIZON

The master production schedule (MPS) formalizes the production plan and translates it into specific end-item requirements over a short to intermediate planning horizon. The end items are then exploded into specific material and capacity requirements by the Material Requirements Planning (MRP) and Capacity Requirements Planning (CRP) systems. Thus the MPS essentially drives the entire production and inventory system.

Planners frequently "trial fit" the MPS on the MRP and CRP systems to confirm that a tentative schedule can be met before it is considered firm. A good MPS system should also incorporate feedback from operations to ensure that the order priorities and capacity use data in the system remain valid as the schedule is actually carried out.

Question: What are the major inputs to the master production schedule?

(1) *Forecasts* of demand, e.g., of end items and service parts

(2) *Customer orders*, i.e., including any warehouse and interplant needs

(3) *Inventory* on-hand from the previous period

Forecasts of demand are the major input for make-to-stock items. However, to be competitive, many make-to-order firms must anticipate orders by using forecasts for long lead-time items and by matching the forecasts with customer orders as the orders become available.

Question: What determines the planning horizon length (time span) of a master schedule?

The time horizon depends upon the type of product, volume of production, and component lead times. It can be weeks, months, or some combination, but the schedule must normally extend far enough into the future so that the lead times for all purchased and assembled components are adequately encompassed. Figure 11-13 illustrates a 10-week lead time for an item assembled from three component parts. The master scheduler should allow 10 weeks to produce this item, unless raw materials (or components) are stocked, or unless the machining or assembly times can be shortened (e.g., via use of overtime, subcontracting, etc.).

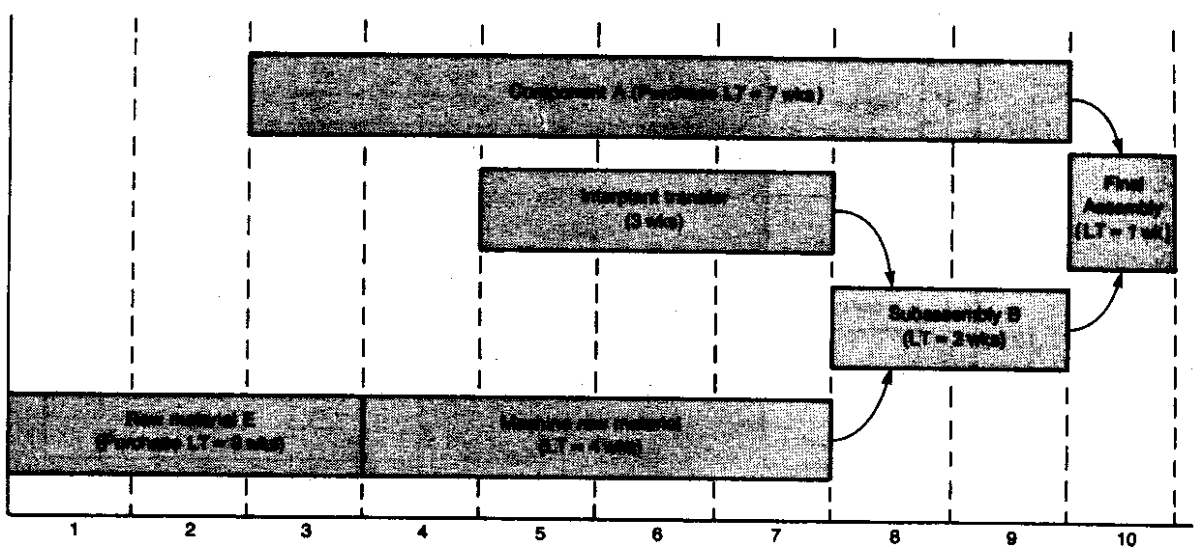

Fig. 11-13 Assembly with 10-week cumulative lead time