Topic 2: Manufacturing Planning and Control

Now we'll move on to look at ways to balance supply against demand. This topic gives an overview of the conventional method of providing this planning and control; the details are explored in the later sections of the course.

Manufacturing planning and control (MPC) is formally defined a little later, but it is basically a method of determining how to prioritize the use of available resources to best satisfy customer demand. These resources include materials and available equipment and worker capacity.

MPC includes priority and capacity planning. Priority relates to demand and is accomplished in production using sales and operations planning, master scheduling, and material requirements planning. Capacity relates to supply and is accomplished using resource planning, rough-cut capacity planning, and capacity requirements planning. Exhibit 1-17 below shows how these systems are arranged to balance each other at successive levels of detail. The overall goal of priority and capacity planning is to balance demand against resources.

Priority refers to what and how much to order or produce and when to order it or produce it, not only to satisfy demand but also to do so in the most efficient manner. It also involves scheduling the purchase and delivery dates of raw materials and components. Capacity refers to considering what it will take to produce the demanded products, factoring in the materials and capacity already on hand versus those that must be acquired.

Manufacturing planning also involves considering how to produce goods and order materials while staying within the guidelines of inventory policies.

Control is used to ensure that the plans are being executed correctly. Control in manufacturing is primarily accomplished by adjusting the timing of orders and the release of input resources. Control includes inventory management to ensure that there is just the right amount of inventory in the right place at the right time.

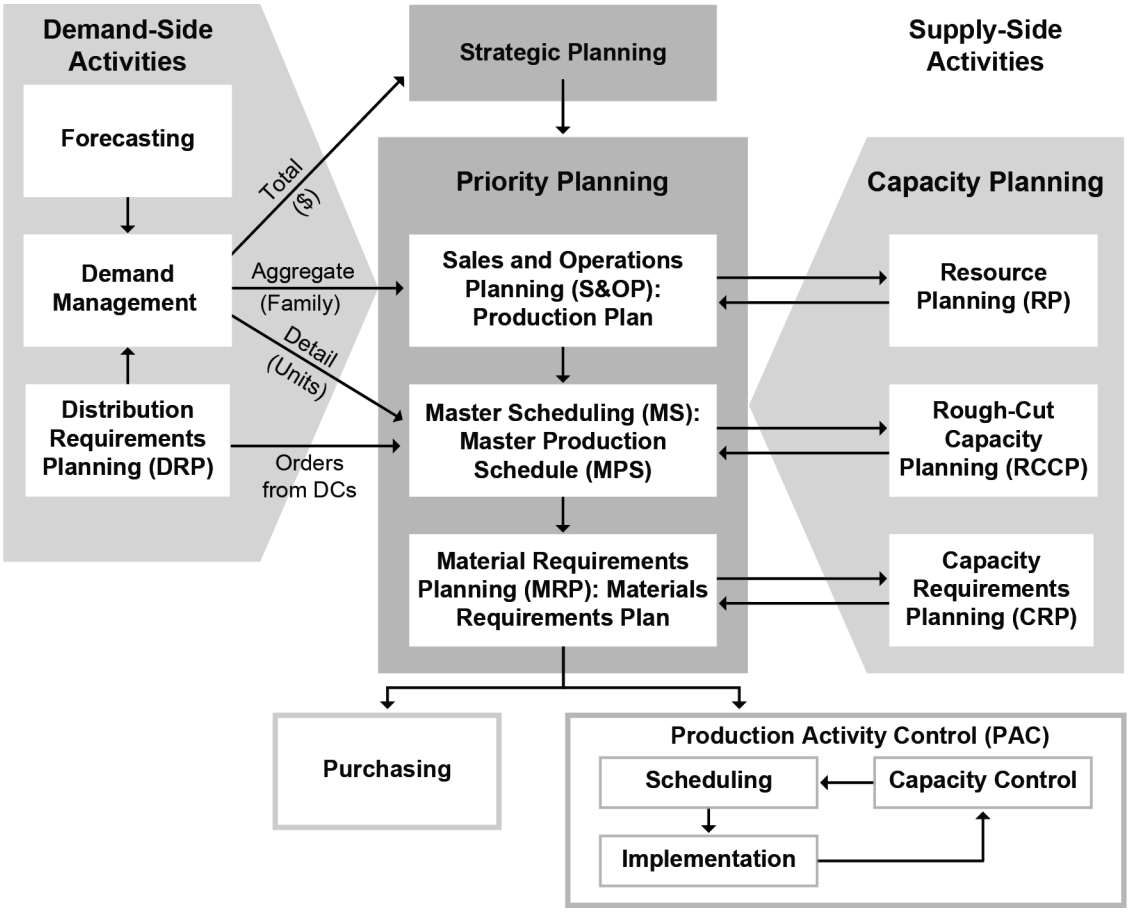
Overview of Components of MPC

The *APICS Dictionary,* 16th edition, defines **manufacturing planning and control system (MPC)** in part as follows:

> A closed-loop information system that includes the planning functions of production planning (sales and operations planning), master production scheduling, material requirements planning, and capacity requirements planning. Once the plan has been accepted as realistic, execution begins. The execution functions include input-output control, detailed scheduling, dispatching, anticipated delay reports (department and supplier), and supplier scheduling.

Closed-loop means that capacity constraints are considered when planning and controlling manufacturing. Closed-loop material requirements planning is defined a little later. Exhibit 1-17 shows how the components of MPC discussed in the definition interrelate.

Exhibit 1-17: Manufacturing Planning and Control



As one moves from the top of the diagram to the bottom, the level of detail increases while the time horizon shrinks.

Let's walk through this diagram and informally define the components. We will save the formal definitions for the sections in which these components are discussed in greater detail. Note that strategic planning is shown at the top. This includes business planning and is usually considered to be an input to manufacturing planning and control rather than a part of it. Strategy and the manufacturing business plan (which is a subset of the strategy) set the direction and goals that manufacturing must meet.

The graphic conveys that the organization's plans face pressure from two directions: the demand side and the supply side. The demand-side pressures are motivated to ensure that all demand is satisfied to maximize revenue; the supply-side pressures are

a push back based on capacity or what is feasible to do given available or planned resources. The center is priority planning, where decisions are made on how to meet demand to the extent possible.

The demand-side activities on the left of the exhibit provide key inputs to manufacturing planning and control in the form of quantities required. These quantities come from forecasting, demand management, and distribution requirements planning (DRP) (addressed in detail in Section M, Topic 2). Forecasts of demand can be made directly, or forecasts or actual orders can be provided from downstream customers, for example, orders from distribution centers (DCs) through DRP. Note that these orders are shown being provided at the master schedule level but any orders already in the system at earlier planning phases will also be accounted for at the higher S&OP or production plan level (the graphic shows this as an arrow up to demand planning and an arrow from there to S&OP). Demand management is used to prioritize this demand when necessary. Demand management also estimates the impact of marketing activities on demand. Consensus opinions of demand from the supply side of the organization are provided to multiple levels of planning. At the strategic planning level, this is in the form of totals such as total projected sales revenues. Using this and other information, the organization sets its strategic sales goals and forms a manufacturing business plan.

At the next level down, manufacturing planning and control meets the supply side of the organization. Demand information in the aggregate (product families or total units) is used to perform master planning. The *APICS Dictionary,* 16th edition, defines **master planning** as

> a group of business processes that includes the following activities: demand management (which includes forecasting and order servicing); production and resource planning; and master scheduling (which includes the master schedule and the rough-cut capacity plan).

Master planning begins with sales and operations planning, which is an executive-level decision-making process where the supply, demand, and financial sides of the organization agree on a consensus plan for satisfying demand in a feasible and profitable manner. The result is a production plan: a consensus set of numbers that the supply side of the organization commits to produce and the demand side (marketing and sales) agrees to set as their sales goals. Resource planning occurs at this point as well, which is the first of several capacity management activities that grow more detailed and shorter in time horizon from this first long-term, big-picture capacity check. At this level, capacity management takes the form of planning for long-term capacity needs such as adding or reducing plants, equipment, and staffing.

The next level of master planning is master scheduling. This is planning over a shorter time horizon, and the demand information provided is now at the detail level for individual units. (These could be raw materials in a make-to-order environment, components in an assemble-to-order environment, or finished goods in a make-to-stock environment.) The second level of capacity planning, rough-cut capacity planning, takes place at this point. This is a check to see if bottleneck work centers and other key resources will have sufficient capacity. Once any adjustments are made, the output of master scheduling is a master production schedule for each product. The schedule indicates what will be made in each time period of the planning horizon.

Continuing down, now we begin the detailed planning and scheduling needed to meet the master production schedule. This involves material requirements planning (MRP), which uses bills of material and other basic inputs (to be discussed later) to calculate all of the raw materials and components that need to be used from inventory or purchased. MRP also calculates when to purchase or release these items so they will arrive on time. This is a highly detailed activity, and the third level of capacity planning, capacity requirements planning, occurs at this point. This capacity check looks at all resource capacities, not just bottlenecks. The result of this process is a finalized material requirements plan.

The bottom level is where planning ends and execution takes over. The material requirements plan results in purchasing wherever resources are not sufficient. Purchasing includes sourcing, ordering, and scheduling deliveries. The parts of the material requirements plan that will be produced in-house become inputs to production activity control (PAC). PAC is used to regulate the flow of work through the production processes, which will involve scheduling. Scheduling can be used to adjust when certain orders are released for production or final assembly. This allows shop floor management to fine-tune production efficiency, accommodate expedited orders, or compensate for delays, material shortages, or quality issues. Capacity control is the fourth level of capacity management and is used here to control work center capacity.

Some key points about this system are as follows:

- Planning occurs from the top down, meaning that every planning and control activity links back to the manufacturing business plan (the exhibit includes this as part of strategy) and ultimately to strategic goals.

- It is a closed-loop system, meaning that it incorporates feedback in the form of reports or action alerts so that plans can be adjusted in the long, medium, and short terms and execution can be adjusted based on events before or during production.

- It is an iterative system, meaning that plans start out in a rough state and are refined by revisiting them multiple times as they become more and more detailed and shorter and shorter in time horizon.

- The system balances tradeoffs to find the optimum result for all stakeholders, including the supply side, the demand side, and finance. This cross-functional collaboration takes place not only during sales and operations planning but also during master scheduling and later during production activity control as priorities can be shifted to account for new information. Advanced planning and scheduling systems can also be used to coordinate the activities of multiple plants or multiple supply chain partners. The *Dictionary* defines **advanced planning and scheduling (APS)** as follows:

  > Techniques that deal with analysis and planning of logistics and manufacturing during short, intermediate, and long-term time periods. APS describes any computer program that uses advanced mathematical algorithms or logic to perform optimization or simulation on finite capacity scheduling, sourcing, capital planning, resource planning, forecasting, demand management, and others.
  >
  > These techniques simultaneously consider a range of constraints and business rules to provide real-time planning and scheduling, decision support, available-to-promise, and capable-to-promise capabilities. APS often generates and evaluates multiple scenarios. Management then selects one scenario to use as the "official plan." The five main components of APS systems are (1) demand planning, (2) production planning, (3) production scheduling, (4) distribution planning, and (5) transportation planning.

- The supply side is concerned with capacity in terms of feasibility and availability, while the demand side is concerned with prioritizing the timing and order of work, especially to satisfy demand from the most important customers or those with the most acute needs.

How MPC Components Fit into the Business Hierarchy

Exhibit 1-18 interrelates the manufacturing planning and control components just introduced to the manufacturing environments and the strategic, tactical, and operational planning elements of the business hierarchy introduced earlier.

Exhibit 1-18: MPC Components and Business Hierarchy

Level	Horizon	Frequency	Detail Level	Process	Validation
Strategic	>2 years	Annually	Summary	Business planning	Financing
Tactical	~18 months	Monthly	Aggregate	S&OP	Resource planning
	~3 months	Weekly	♦ MTS = End item ♦ ATO = Subassembly ♦ MTO = Raw materials	Master scheduling	RCCP
Operational	~10 weeks	Daily	Intense	MRP	CRP
	~6 weeks	Shift	Most intense	♦ Work orders ♦ Purchase orders	Scheduling

This exhibit shows how business planning horizons shrink as planning becomes more detailed and intense. Note that the horizons shown are for illustrative purposes and could differ depending on the industry. Note also how the level of detail at the tactical level will depend on the manufacturing environment. For the "Validation" column, note the addition of financing as a validation step, which would be where the financial merits of the overall strategy are assessed and approved or rejected and how to finance the investment is determined. Note that the lowest operational level encompasses production activity control as well as purchasing.

Evolution to Current Use of Enterprise Resources Planning for MPC

It is important to understand how conventional manufacturing planning and control systems have evolved over the past several decades, because this history provides a great deal of information on the current strengths and weaknesses of these systems. Manufacturing planning and control is extraordinarily complex and involves balancing tradeoffs and constraints in multiple areas, so manufacturers above a certain size generally require computer systems to do these calculations. For most organizations, this means having an enterprise resources planning (ERP) system or an equivalent.

The *APICS Dictionary,* 16th edition, defines **enterprise resources planning (ERP)** as follows:

> Framework for organizing, defining, and standardizing the business processes necessary to effectively plan and control an organization so the organization can use its internal knowledge to seek external advantage. An ERP system provides extensive databanks of information including master file records, repositories of cost and sales, financial detail, analysis of product and customer hierarchies, and historic and current transactional data.

The first part of the definition shows that ERP is not just software but a set of business processes for leveraging internal knowledge. The second part of the definition indicates that the system helps the organization collect all of its data in one place so that it can leverage this information to run every aspect of the business. A centralized storage location is a key part of an ERP system. This single source of data can reflect the impact of transactions from every functional area of the organization in real time and avoids problems like having multiple redundant records that are out of synch. For example, HR might update the shop floor calendar to reflect the next year's holiday schedule, and the calendar would then be used to schedule production.

ERP systems started out decades ago from a manufacturing core. The pressing need was to provide a way to balance supply against demand in the most efficient way—in other words, to provide manufacturing planning and control.

The first iteration of manufacturing planning and control systems involved open-loop MRP controlling the timing and release of materials into a production process. These early systems made a simplifying assumption that there was infinite capacity (thus the open loop). They established a priority plan for when specific quantities of components would be needed so that purchasing and production planning could occur.

The next iteration was to add capacity checks at the master scheduling and MRP stages to ensure feasibility, and this feedback loop defined the major advancement of these systems, called **closed-loop MRP,** which the *Dictionary* defines as follows:

> A system built around material requirements planning that includes the additional planning processes of production planning (sales and operations planning), master production scheduling, and capacity requirements planning. Once this planning phase is complete and the plans have been accepted as realistic and attainable, the execution processes come into play. These processes include the manufacturing control processes of input-output (capacity) measurement and detailed scheduling and dispatching, as well as anticipated delay reports from both the plant and suppliers, supplier scheduling, and so on. The term closed loop implies not only that each of these processes is included in the overall system, but also that feedback is provided by the execution processes so the planning can be kept valid at all times.

Closed-loop MRP linked the production plan to the master production schedule at an earlier stage of the MPC process. The feedback loop provided information to MRP and production activity control so planners and controllers could view and adjust start dates, due dates, and quantities of work orders that were already released. Closed-loop MRP provided data to finance so they could calculate cost data and better perform financial accounting.

Still, these systems were not highly integrated with other functions. The third iteration, manufacturing resource planning (called MRP II to avoid confusion with

material requirements planning), further integrated production, finance, and marketing. The *Dictionary* defines **manufacturing resource planning (MRP II)** as follows:

> A method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units and financial planning in dollars, and has a simulation capability to answer what-if questions. It is made up of a variety of processes, each linked together: business planning, production planning (sales and operations planning), master production scheduling, material requirements planning, capacity requirements planning, and the execution support systems for capacity and material. Output from these systems is integrated with financial reports such as the business plan, purchase commitment report, shipping budget, and inventory projections in dollars. Manufacturing resource planning is a direct outgrowth and extension of closed-loop MRP.

MRP II allowed accurate order promising. Marketing and production were able to collaborate on a weekly or daily basis to adjust due dates or order quantities to better reflect actual demand or adjust the priority plans to reflect capacity shortages first at the master production schedule level and then at the material requirements planning level. Not only did these systems increase the level of operational reporting for better accounting; all transactions conducted by production, marketing, and finance updated the same records and required these functions to work together. For example, MRP II was the first iteration that allowed sales and operations planning to arrive at a consensus supply and demand plan.

Starting in the 1990s and evolving continuously ever since, organizational software systems have come to be called enterprise resources planning systems as they integrate more and more modules for different business functions, including human resources, research and development, logistics (transportation and distribution), and others. The goal is to seamlessly integrate all business functions using a single shared database. From a manufacturing perspective, a key advancement has been the further integration of the requirements and transactions of upstream suppliers and downstream distribution centers and customers using **electronic data interchange (EDI).** The *Dictionary* defines this as

> the paperless (electronic) exchange of trading documents, such as purchase orders, shipment authorizations, advanced shipment notices, and invoices, using standardized document formats.

For example, orders from a distribution center for resupply now go through a distribution requirements planning module, and these orders are automatically included in the plant's gross requirements for master scheduling.

Since ERP has this single source of data, it allows information technology departments to manage the data to ensure accuracy, such as by correcting errors and removing

redundancies. Policies related to data security and so on are called data governance. The *Dictionary* defines **data governance** as follows:

> The overall management of data's accessibility, usability, reliability, and security. Used to ensure data record accuracy.

While all parts of an ERP system need to ensure data record accuracy, from a manufacturing perspective, maintaining the integrity of the data used for manufacturing planning and control is often considered the difference between a successful and a failed ERP implementation. The adage "garbage-in, garbage-out" (GIGO) expresses the fact that a fast system with poor inputs will have nonsensical outputs and just help make erroneous decisions faster.

Data governance also includes securing sensitive data and ensuring that access is restricted to role-appropriate views of the information. (For example, HR can view salaries, but other users cannot.) Securing data while sharing agreed-upon information with outside parties is another advancement of modern ERP systems.

A downside to this highly developed system is that if the organization chooses to reengineer its business processes (e.g., to lean manufacturing), it may be cost-prohibitive to update the transactional ERP system. Updates to new versions of ERP software can be very expensive and time-consuming. Some newer versions of ERP software are hosted online on a cloud as software as a service so that updates can be managed directly by the vendor in exchange for an ongoing lease.