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INTRODUCTION

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What is Enterprise Resource Planning?

According to the definition given in the APICS Dictionary (American Production and Inventory Control Society, 1995), an enterprise resource planning (ERP) system differs from the typical manufacturing resources planning (MRP II) system in its use of technical innovations such as graphical user interfaces, relational databases, fourth generation languages, open system platforms, and client/server architectures. Although these technical tools are the most obvious differences between the two, there should be deeper insights into ERP. Why has “manufacturing” changed to “enterprise”? Is an ERP system applied to a whole enterprise rather than a single manufacturing site? Can ERP systems be applied to non-manufacturing businesses? In chapter two, we will use an example to demonstrate how traditional manufacturing resources planning systems and material requirement planning logic can also be applied to service businesses. In this book, we focus the discussion of ERP mainly on its application to allocating manufacturing resources.

History of ERP

- *Pre-history*

As early as 1744, an advertisement for the Franklin Stove described the use of its components in the production of the end product. This is believed to have been the first bill of material in the world. (Plossl, 1980). Production control techniques emerged in the beginning of the 19th century. The first complete production control system was used in a plant at Watertown Arsenal in 1880 (Scheel *et al*, 1960). Research into matching manufacturing methods with order quantity, however, did not start until the beginning of the 20th century. Harris invented the economic order quantity (EOQ) technique in 1915 (Harris, 1915). In 1934, in ground-breaking work, Wilson developed a re-order point

(ROP) system and combined it with EOQ to develop an inventory planning technique which became industry doctrine for more than two decades. Wilson stated that his ROP/EOQ technique reduced inventories by 15%, and stock out rate by 20% (Wilson, 1934). By 1942, many production planning and control techniques such as master production schedules, bills of material, shop floor production schedules, shop orders, picking orders, purchase orders, etc., had been developed. However, since all documents were manually prepared and the requirements were manually calculated, the schedules were not stable and a position called “expeditor” was employed to expedite the materials.

- *MRP and MRP II Era*

The first commercial computer was created in 1954 and it was not long before planners recognized its potential usefulness to the field. An explosion in bills of material was immediately computerized. By the end of 1950s, the techniques, approaches, tools, documents, and rules were all ready. It was time to introduce the use of computers more completely into production planning and control. American Bosch developed a primitive regeneration MRP system in 1959. J. I. Case developed the first net change MRP system in 1962. Milestone developments in the field soon followed. In a seminal event in 1965, Dr. Orlicky proposed the concept of dependent and independent demands, which stated that the reorder point system could only be applied to independent demands while MRP should be applied to dependent demands (Orlicky, 1974). Equally significant, Starr introduced the concept of modular production (Starr, 1965). This concept enables people to master schedule the modules or main components of a manufacturing process and enormously reduce the complexity of MRP calculations.

MRP boomed in the 1970’s. APICS facilitated long term planning for MRP in efforts that became known as the “MRP Crusades”. Manufacturing resources planning (MRP II) emerged in the 1980’s. MRP II includes all manufacturing resources: material, human resource, equipment, and finance.

- *ERP Era*

Advances in computing and networking have been rapidly changing the way business is done around the world in the 1990’s. Competitive strategy has changed from a focus on low price, high quality, and high variety to high speed. Old competitive factors are no less important today, but they are now only prerequisites for remaining competitive. Speed is

the key to competitive strategy in the ERP era. Traditional MRP II systems can be upgraded to ERP systems with implementation of open systems, client/server or three-tier computing architecture, local area networks, wide area networks, relational databases, and user-friendly graphical interfaced application systems written in fourth generation languages.

The differences between ERP and MRP II systems go beyond technological tools. ERP systems connect all the plants and offices of a business group across the world. An ERP system enables a company to design products with input from engineers around the world, set up factories in various areas to produce parts and components for each other, purchase materials from many different countries, and share information among all related parties. Traditional MRP II systems are meant only to plan the allocation of resources for a plant or a company. ERP systems plan the resources for all the entities of an enterprise. ERP systems can even be applied to a service business.

Manufacturing Resources

Traditional resources in a manufacturing enterprise include 4 M's, i.e., Material, Machine, Manpower, and Money. In the past decade, computerized information systems have commonly been applied to planning and control within enterprises, resulting in drastic changes in management practices. These systems are now perceived as strategic weapons for competition, and information viewed as an important resource for enterprises. Enterprises' information includes the master files for the other four resources, planning files, and transaction files.

- *Master files*

The master files include item master, bill of material, routing, accounting, personnel, inventory, etc. Master files maintain the attributes and states of the resources. The attributes of resources are called the fundamental data files, and the states of resources are called the status data files. Item master, bill of material, and routing are fundamental data files; inventory, account balance, etc. are status data files.

- *Planning files*

The planning files include production plan, demand requirement plan, master production schedule, material requirement plan, rough-cut capacity plan, capacity requirement plan, etc.

- *Transaction files*

The transaction files include all the information relevant to operations such as customer orders, purchase orders, subcontract orders, work orders, picking lists, store-in, store-out, shipping, etc.

In an enterprise, the fifth resource, information, is as important as the other four resources. An ERP (enterprise resource planning) system manages information and uses this information to manage all the other resources.

Problems in Manufacturing

- *Difficult, if not impossible, to forecast.*
Forecasts are usually wrong. Forecasts are more accurate for families or groups of products than for individual items. However, only individual items are manufactured and sold. An often cited forecasting rule is “Sherman’s Law of Forecasting Accuracy,” which states that “Forecast accuracy improves in direct correlation to its distance from usefulness.”
- *Short lead-time and urgent delivery.*
Because of shorter product life cycles and fluctuations in customer demand, the necessary lead times of customer orders have become shorter and shorter. When the market is booming, the manufacturers’ capacities are fully occupied. Order deliveries are always urgent. When demand is soft, customers place their orders as late as possible. Though capacities are sometimes idle, the order deliveries are still urgent.
- *Difficult to control engineering change.*
If design or quality problems occur, engineering change procedures are required. As customer preference changes, engineering change tends to increase.
Engineering change involves many functional areas such as marketing, R&D, engineering, production, purchasing, warehousing, accounting, and after-service. It is difficult to control engineering change procedures.
- *Difficult to coordinate related activities.*
In manufacturing, there are many activities that must be properly coordinated to ensure that production is efficient. Engineering change is just an example. Effective new product design requires coordination among R&D, engineering, purchasing, cost accounting, marketing, etc. A master scheduler coordinates the sales and

manufacturing departments with ATP (available to promise). There are many other examples of complex coordination of related activities in a manufacturing company.

- *Frequently changing production schedule.*

It is difficult to make a production schedule stable because there is always so much change occurring. The only constant in production is change itself. Customers change their order due dates, suppliers change their delivery dates, employees are unexpectedly absent, machines go down, defects occur, etc. Manufacturing firms face these sort of changes everyday. The challenge is not how to eliminate change but rather how to cope with it.

- *Poor response to schedule change.*

Properly implementing MRP or ERP systems may prevent undesired fluctuations from occurring. Unavoidable changes can be dealt with only through good daily practices. It is not easy to respond rapidly to schedule changes, even in a highly computerized manufacturing company.

- *Progress on shop floor is not clear.*

If the workers on a shop floor do not provide accurate and timely feedback, the people who need this information will not be able to incorporate it into their activities. The computer system does not know what is happening and may generate results based on incorrect data that may lead to wrong decisions. Except in the use of automatic machines, it is difficult to collect data on the shop floor.

- *Difficult to measure shop floor performance.*

As long as humans are involved in shop floor manufacturing, it is difficult to measure performance. Traditional work measurement methods may not be applicable in many industries. There are two ways to measure performance on the shop floor. One is to employ fully automatic production machines whose performance can be accurately measured. The other way is to create a culture and a group incentive system to eliminate the need to measure shop floor performance.

- *Manufacturing cost is not correct.*

As products are changing, records of costs of parts and components may not be maintained well. Some basic data such as bills of material, routing, and item masters may not be correct. Unpredictable interrupts on shop floors or quality problems also

cause costing difficulties.

- *Short of information for management decision.*

Even for companies that have used MRP or ERP for many years, systems are used mainly to support operational activities. Information systems are rarely used to determine firm-wide strategy and management decisions.

- *Difficult to control the suppliers' delivery dates.*

Many suppliers are small businesses that may not have the concepts or skills to meet due dates. Some suppliers do not even care whether you place orders with them or not. In newly industrialized countries (NIC) such as Taiwan, most of the companies are small businesses. Both suppliers and buyers are typically small businesses. There are few suppliers dependent on a single, large buyer. Therefore, it is difficult for a buyer to dictate the delivery dates of a supplier.

- *Suppliers' quality is not stable.*

The quality from the suppliers may not be stable. An end-product manufacturer's quality cannot be stable without better quality management in the entire industry, particularly among the suppliers. In the 1990's, when many Taiwanese manufacturers moved their operations to China to reduce costs, they encouraged their suppliers to follow because qualified local suppliers were not available in China.

Problems in Systems

- *Invalid data.*

If the discipline of data collection is not performed well, the outputs of the system will not be correct, and the system will inevitably lose credibility among users. Because of data errors, MRP has sometimes become known as "More Ridiculous Planning"

- *Lack of integration.*

Data flowing from product engineering, process engineering, order entry, purchasing, shop floor, and many other activities into planning and control can be delayed, disrupted in timing, or inaccurate.

- *Overselling and over-sophistication.*

MRP or ERP systems provide infrastructure for better management, but they do not

guarantee better management. MRP or ERP providers tend to oversell their packages. Practices in manufacturing are complicated, but most of them should cover human activities instead of computerized systems. Many MRP/ERP systems try to model the sophistication of the real world, rather than a common framework. In doing so, they sometimes lose simplicity and integrity and become hard to implement.

What Is Manufacturing?

Manufacturing is not just buying and selling. It also involves the conversion of low-value materials to high-value products. The essence of manufacturing is twofold: the flow of materials from suppliers, through plants to customers, and the flow of information to all parties about what was planned, what has happened, and what should happen next. Time is the most precious resource employed in the manufacturing process. All benefits are directly proportional to the speed of the flow of materials and information. Quick response and agility are essential for successful manufacturing.

Manufacturing can be described with three main categories: processing characteristics, lot size, and production environment. Processing characteristics can be divided into discrete manufacturing and process manufacturing. Lot size can be classified into continuous production, intermittent production, and project-based production. Production environment can be categorized as made-to-stock and made-to-order. The latter is further divided into assembled-to-order and engineered-to-order.

- *Discrete manufacturing*
Discrete manufacturing is a way of producing a product by assembling distinct items. Examples include automobiles, appliances, and computers.

- *Process manufacturing*
Process manufacturing is the production that adds value by mixing, separating, forming, and/or performing chemical reactions. Examples include wafer fabrication, oil refinement, and investment casting.

- *Continuous production*
A production system in which the productive equipment is organized sequentially according to the steps involved in producing the product. The routing of the jobs is fixed and setups are seldom changed.

- *Intermittent production*
A production system in which jobs pass through the functional departments in lots. Each lot may have different routing.
- *Project-based production*
A production system in which the product is fixed at a location, and jobs are performed around it. The production quantity in a project-based line is typically very small, the physical volume of the product is very large, and the value is normally huge. Examples include buildings, airplanes, and ships.
- *Make-to-stock*
A production environment where products can be and usually are finished before receipt of a customer order. Customer orders are typically filled from existing stocks, and production orders are used to replenish those stocks.
- *Assemble-to-order*
An environment where a product can be assembled after receipt of a customer order. The key components used in the assembly or finishing process are planned and possibly stocked in anticipation of a customer order. The receipt of a customer order initiates the assembly of the customized product.
- *Engineer-to-order*
An environment where the customer specification of a product requires unique engineering design or significant customization. Each customer order results in a unique set of part numbers, bills of material, and routings.

Principle to Manufacturing Planning and Control

- *There is one system framework common to all types of manufacturing.*
The common system framework consists of a planning horizon, customer requirements, priority planning, capacity planning, priority control, and capacity control. This planning is not only for manufacturing. It is also applicable to service sections such as hotel management or airport services. In fact, most of the planning and control procedures described in this book can be used in the production of services as well as products. This is why manufacturing planning and control is sometimes

referred to as production planning and control, or operations planning and control. This principle can be restated as “There is one system framework common to all types of operations.”

- *There is no single best way to control a manufacturing business.*

Companies manufacturing the same products may require different ways of planning and control even though their system frameworks are identical. Corporate cultures, top management philosophies, strategies, scales, etc may affect the way a company is managed. The best way to managing a particular company can only be derived from the unique characteristics of that company itself. There is no single best way to control a manufacturing company.

- *Do not commit any flexible resource to a specific use until the latest possible moment.*

Try not to commit a resource too soon since a committed resource loses its flexibility and cannot be used for other purposes. For instance, a schedule should be fixed as late as possible. Customer requirements often fluctuate. A flexible schedule can cope with these requirement changes. To fix a schedule means to commit related resources. But manufacturing a product requires lead times to procure materials, fabricate components, and assemble them. Lead times are the most important factors to maintaining the flexibility of resources. Short purchasing and manufacturing lead times allow schedules to be made as late as possible, and ensure the flexibility of resources.

- *Priority information and material schedules cannot be valid if resources are or will be inadequate; such plans are impossible to execute.*

A production schedule is not a wish list. It must be realistic. The priority plan for activities such as purchasing or manufacturing must be consistent with available capacity. A master production schedule (MPS) is the key to making other detailed schedules realistic. For discrete manufacturing, material replenishments are the most complicated. A realistic MPS leads to realistic purchase plans and build plans. Rough-cut capacity planning (RCCP) is used to validate the MPS. For process manufacturing, materials are not the problem. Shop floor control is the key factor to success. The production rate in the MPS should not exceed the available production rate. The actual production rate should be compared to the planned production rate.

Manufacturing Planning and Control System

Planning in an enterprise proceeds in this order: long-term business planning first, middle term production planning next, and then short term MPS and MRP. Currently popularly used MRP or ERP systems cover production planning, MPS and MRP, and corresponding RCCP and capacity requirement planning. Priority and capacity controls are performed in the execution stage. Traditional approaches compare actual inputs and outputs to planned inputs and outputs. The JIT (Just-In-Time) approach controls the material flows by monitoring the actual consumption, subject to the constraints of the priority plans. We will introduce traditional and current approaches to production control in this book but emphasize the JIT approach.

Figure 1 shows the relationship of these priority/capacity planning and priority/capacity control functions for both traditional and JIT environments. Material and information flows are shown in figure 2.

Why do we need to know the theory of MRP/ERP systems? Why not just install and use it? Human nature! People would rather live with a problem they cannot solve than solve it with an approach they do not understand. Education and training are very important to successfully implement MRP/ERP systems.

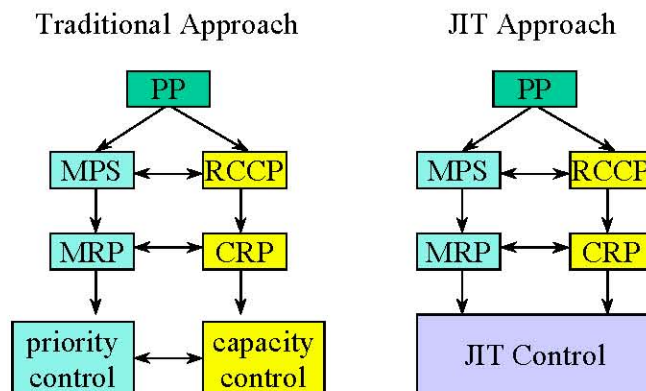


Figure 1: Manufacturing Planning and Control Framework

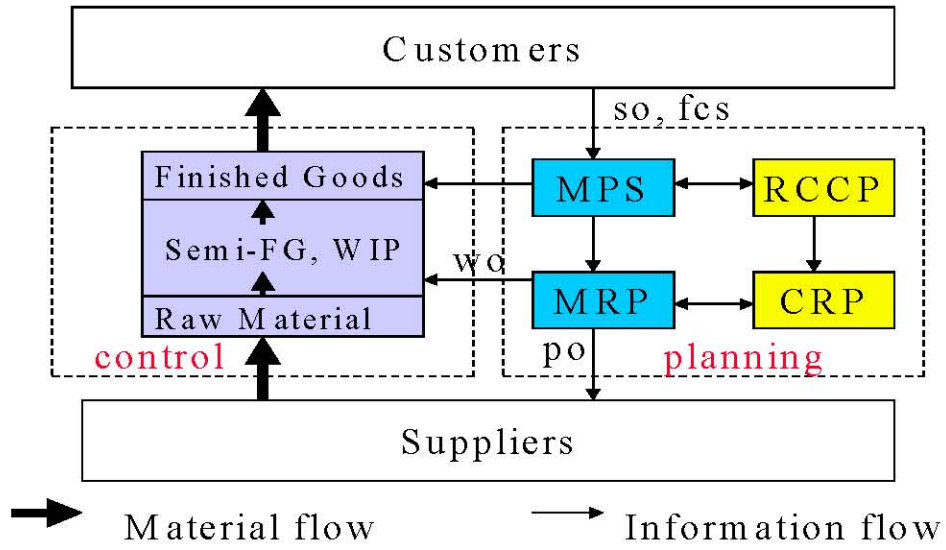


Figure 2: Material and Information Flow in MPC