MRP II

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Planning for Manufacturing Excellence

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Preface

After attending the International American Production and Inventory Control Conference in 1972, I became part of the "MRP Crusade." For the next 2 years, I directed a program at my company to install material requirements planning, and following that, an additional 2 years was devoted to the implementation of capacity requirements planning. The results, although successful, were not good enough to qualify us as a "Class A" user, nor did our manufacturing performance meet the present-day requirements of a world-class manufacturer.

In the intervening years, our understanding of the role of planning and its relationship to manufacturing execution has expanded and clarified. Competition from abroad as well as domestic competitors has hastened the increased body of knowledge necessary for efficient manufacturing. The relationship of the manufacturing system to the increased emphasis on concepts such as improved customer service, continuous improvement, and employee empowerment must be considered.

This book is an organized collection of material I have used in teaching at community colleges and management seminars. It is an extension of the basic logic of MRP in Joseph Orlicky's *Material Requirements Planning* (1975), coupled with the increased understanding of materials management requirements as well as the availability of more sophisticated software. This book will explain the principles of MRP and how they can be utilized in distribution, job shop, and repetitive and process manufacturing environments.

The object of the book is to meet the training need of MRP courses offered at 4-year colleges, community colleges, and company in-house programs. It is also directed to material and manufacturing practitioners who require in-depth knowledge of MRP or who would use it as a reference book to assist them in APICS certification.

The material is organized to first present the perspective of materials management (Chapters 1 and 2). Defining the product and process is then specified (Chapter 3). The planning functions for demand management, MRP, capacity planning, and distribution planning follow (Chapters 4–8). Executing the plan for job shop, process, and just-in-time operations is then detailed (Chapters 9–11). Finally, system implementation including organization and measurements are discussed (Chapter 12). Simple case studies and solutions are presented in each chapter with the exception of Chapter 1. Each chapter

concludes with a 10-question quiz. The answers to the quizzes can be found in Appendix C.

I have learned from this effort that writing a book is no easy task. Jim Nolan describes the experience as similar to writing a 400-page homework assignment. I would like to acknowledge the assistance and encouragement from Eugene Magad of Harper College as well as the benefits received from manuscript reviews by Jack Gips of Jack Gips Inc., Gary Midkiff of Friedman & Associates, Tom Setlik of Tempel Steel Company, and Larry Sutherland of System Software Associates. It is amazing how critical points can be overlooked or, worse, misstated due to the wrong word in the right place. The above reviewers have been invaluable in their suggestions and corrections.

Finally, I would like to thank the personnel at Letter Perfect Secretarial Service, Inc., who had to put up with my penmanship, and my wife Joan, who had to put up with me.

John W. Toomey

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1
Introduction

In the decade of the nineties, MRP II—Manufacturing Resource Planning has continued to be the predominant system for manufacturing control. It is a key ingredient of world-class manufacturing which calls for

Improved customer service

Elimination of waste

Continuous improvement

IMPROVED CUSTOMER SERVICE

In the past, customer service was measured by such factors as percent shipped on time or average days late on past due orders. The more modern and broader definition of customer service is the ability of the company to meet the total needs of the customer. The goal is continuous customer satisfaction not only with the product but also with the company. This can be accomplished not only by meeting the basic requirements of a product with adequate quality, on-time delivery, and reasonable pricing but also by working with the customer to assist in meeting the marketplace demands of the customer.

Quality is more than a defect-free product that meets specific physical specifications. Quality is also a product designed to give the customer reliable service and fitness for use. The definition can be expanded to include the manner in which the product is packaged and the clarity of included manuals or instructions. Customer communications such as delivery promises, inquiry responses, and invoicing are also quality considerations.

Delivery performance is more than shipping on time. It is understood that the immediate availability of a stocked item (off the shelf) must be met. The delivery of a made-to-order product will best meet the needs of the customer with reduced manufacturing lead time. The shorter the cumulative lead time, the easier the forecasting task for both the customer and the manufacturer.

Flexibility in the manufacturing process will allow quick response when the customer is in need of reduced lead time.

ELIMINATION OF WASTE

Waste is any cost, direct or indirect, that does not add to the value of the product. Traditionally, waste has been considered to be quality losses such as scrap or rework. Often the measurement might show a scrap rate of 4% and a rework cost of 2%. In this circumstance, the quality cost would seem to be 6%. If closer inspection of quality-related costs such as engineering change orders, technical time spent, customer service time, additional freight, and inspection were considered, the initial 6% cost of quality loss might well grow to 20%.

Quality costs are not the only non-value-added costs that are considered waste. Just as inspection adds nothing to the value of the product, material handling and other indirect labor costs are circumspect. Control activities such as transaction reporting are being audited as they, too, add no value to the manufactured product. Employees may be fully occupied, but if their work assignments are not utilizing their abilities, there is a waste of intelligence which perhaps is the most important asset.

Money invested in inventory, although listed on balance sheets as assets, is, in reality, wasted dollars that could be better spent in product or process development. Excessive work-in-process not only adds no value to the product and holds dollars captive, it increases manufacturing lead time and reduces shop-floor flexibility while requiring additional storage space.

CONTINUOUS IMPROVEMENT

Continuous improvement is a strategy that calls for a never-ending quest to eliminate waste. Whereas some projects such as a new system implementation or a capital equipment expansion have a planned completion date, continuous improvement is a lifelong journey. This is because there is no end to improvement.

Improvement goes beyond immediate problem solving. There must be a determination of what will differentiate the company from the competitor. To accomplish this, a management system based on the company as a whole, rather than on a departmental basis, must answer the question, "What is needed and what should be done?" Proper performance measures must be an integral part of the process.

These goals are best achieved with planning systems which allow for optimum manufacturing execution.

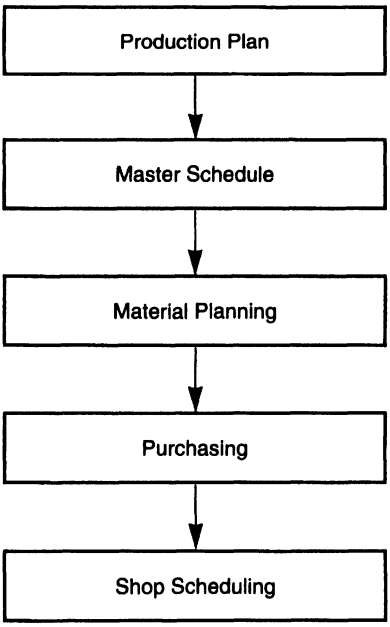

Figure 1-1. Material requirements planning—MRP.

DEFINITIONS

The term "MRP" has three definitions that have evolved since the initial introduction in the 1960s. These definitions as listed in the *APICS Dictionary* are as follows:

Material Requirements Planning (MRP)—A set of techniques as shown in Figure 1-1 that uses bills of material, inventory data, and the master production schedule to calculate requirements for materials. It makes recommendations to release replenishment orders for material. Further, because it is time phased, it makes recommendations to reschedule open orders when due dates and need dates are not in phase. Time-phased MRP begins with the items listed on the Master Production Schedule and determines (1) the quantity of components and materials required to fabricate those items and (2) the date that the components and material are required. Time-phased MRP is accomplished by exploding the bill of materials, adjusting for inventory quantities on hand or on order and offsetting the net requirements by the appropriate lead times.

Closed-Loop MRP—A system built around material requirements planning that includes the additional planning functions of sales and operations (production 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 functions come into play. These include the manufacturing control functions of input–output (capacity) measurement, 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 that not only is each of these elements included in the overall system but also that feedback is provided by the execution functions so that the planning can be kept valid at all times. Closed-loop MRP is illustrated in Figure 1-2.

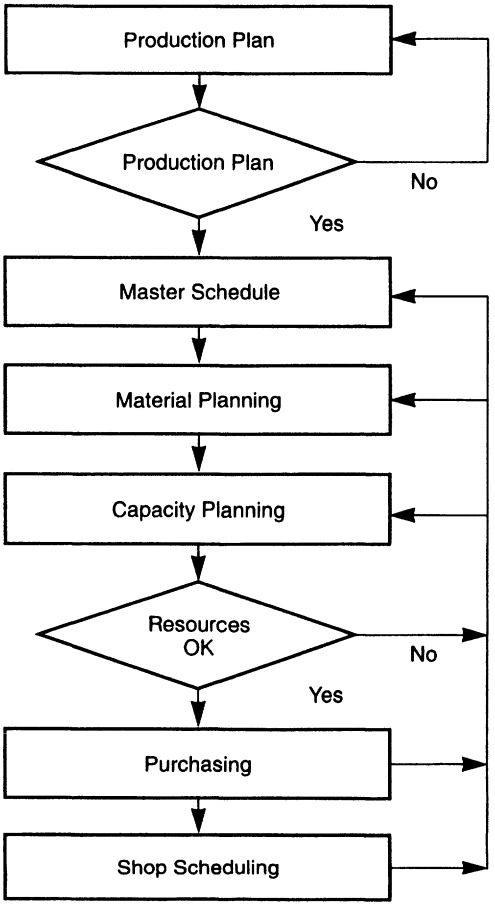

Figure 1-2. Closed-loop MRP.

Manufacturing Resource Planning (MRP II)—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 functions, each linked together: business planning, sales and operations (production 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 business plan, purchase commitment report, shipping budget, inventory projections in dollars, and so on. Manufacturing resource planning is a direct outgrowth and extension of closed-loop MRP as shown in Figure 1-3.

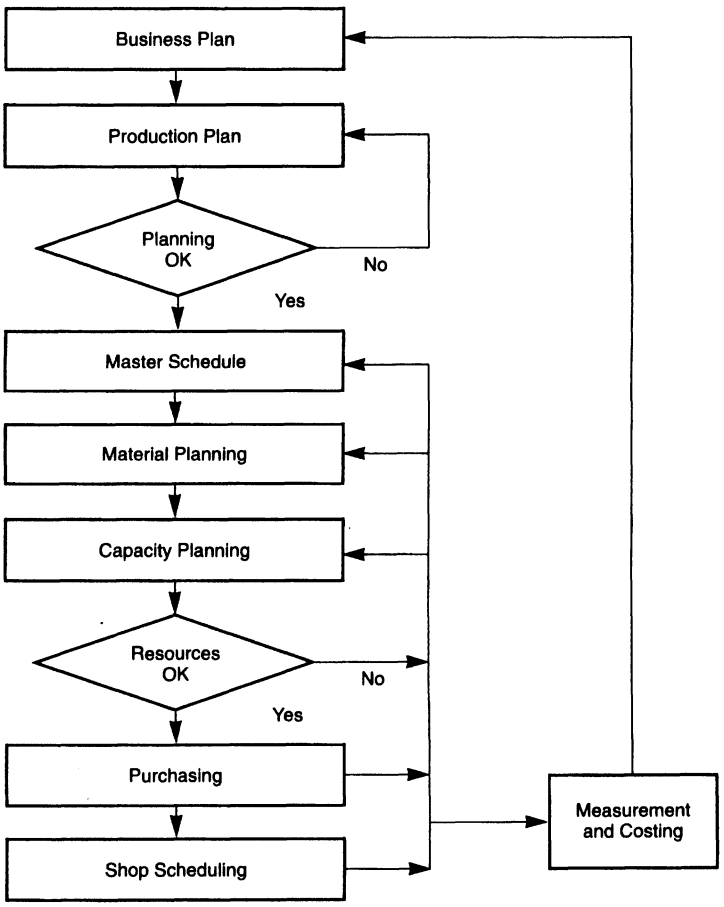

Figure 1-3. Manufacturing resource planning—MRP II.

As the reader progresses through this book, the definitions above will be studied in detail.

WHERE WE HAVE BEEN

To better understand the role MRP plays in industry, we should look back at the course of actions that have evolved in the past in an effort to best manage the manufacturing processes. One of the first scientific techniques put to use was the "Economic Lot Size" formula developed in 1913 and which balances the cost of carrying inventory with the cost of setting up the production run. The EOQ (Economic Order Quantity) is easily calculated based on four variables and has been one of the most used (and abused) techniques ever since.

When to Order

The question of when to order was initially answered through reorder points maintained manually on cards. Reorder points are based on the lead time to manufacture or procure the item and the usage rate of the item during the lead time. When the usage rate forecast is based on past history, the process calls for the calculation of the "statistical order point." The problem of maintaining historical data in precomputer times was simplified with the use of a technique called exponential smoothing. Historical data are used not only in forecasting but also in the calculation of safety stocks. Reorder points, forecasting, lot sizing, and safety stock techniques will be covered later in the book.

Shortcomings in reorder point logic such as not allowing for dependent demand of one item to another or the unrelated lot sizes of the dependent relationships were understood for many years. The logic for calculating the net requirements on one item based on its dependent demand to another item, the time phasing of the item, and projected available inventory were also known for as many years, but until the availability of new computers in the 1960s, the required data processing was unmanageable. With the storage capacities and speed of the third-generation computers as well as a software concept called the Bill of Material processor, calculating the new requirements of all manufactured and purchased items by time period became practical. This set of techniques became known as MRP—Material Requirements Planning.

How to Control

At any point in time, a typical manufacturing facility might be producing 1500 items with 7000 operations still to be scheduled to complete the 1500

items. Using reorder point control, these items would have been released to the shop based on past average usage and expected manufacturing lead time. There would be no understanding of future dependent requirements nor the time phasing of those demands. At the time of order release, the due date may have been based on a 10-week lead time, but during the 10 weeks of run, there would be no knowledge of changes in demand that would call for the item to complete in week 8 rather than week 10. The required expediting would not take place until an actual shortage occurred. On the other hand, there could be demand change that would call for required delivery not in week 10, but week 13. Again, there was no knowledge that the item could be moved back 3 weeks (deexpediting).

With MRP control, the same 1500 items with the same 7000 operations to completion might well remain, as the lot sizes and the lead times have not changed. What would change would be an understanding of each item's planned dependent demand and the time period(s) of the demand. The valid due date of the item demand as well as the scheduled due date at time of order release are known and compared. If the requirement is called for in week 8 compared to the scheduled due date of week 10, expediting (moving up the schedule) is recommended. Again, if the required due date is week 13, compared to a schedule due date of week 10, deexpediting (moving back the schedule) is recommended.

Assuming both accurate inventories and bills of material, an MRP system will give valid due dates of all manufactured and purchased items required for planned end items. What has been overlooked by many practitioners is the difference between a valid due date and a realistic due date. Due to unforeseen usage or scrap, an item originally planned for delivery in 10 weeks may be required in 2 weeks. The week 2 due date is valid, but expected delivery in week 2 may not be at all realistic. An MRP system will supply *valid* due dates, but the operating system can only execute to a *realistic* due date. The distinction between the two has not always been understood.

MRP to Just-In-Time

Led by the "MRP Crusade" of the American Production and Inventory Control Society, the use of MRP increased at an incredible rate in the 1970s. Not only did the scope expand to closed-loop and MRP II, but the available software expanded in numbers and capability. What started with mainframe-based systems moved to mid-size in the 1980s and then to microprocessors. In spite of MRP growth in system sophistication, user knowledge, and successful implementations, manufacturing in the United States in the 1980s was not always competitive on a world-class basis, especially when compared to Japan. To become more competitive, many companies have turned to Just-In-Time (JIT) philosophy of manufacturing.

Some erroneously thought that with Just-In-Time inventory, MRP manufacturing systems would no longer be needed. After over 10 years experience with JIT concepts, it has been found that customers do not always order in continuous steady patterns, that setups and lot sizes cannot be easily reduced as much as desired, that some suppliers cannot or will not deliver based on reasonable flow rates, and that the diverse work force is not easily trained to be multifunctional operators and contributing members of problem-solving work teams. In spite of these problems, we realize that in world competition, there must be continuing efforts to improve our manufacturing operations but not necessarily in the dynamic high-impact improvement projects common in the past but in slow continuous improvement steps as practiced by the Japanese.

WHERE WE MUST GO

The MRP crusade of 20 years ago turned out to be a disappointment to many. Consultants have had clients advise them to use another term rather than MRP when discussing manufacturing planning systems to top management and operating people. The "failure" of MRP was not due to poor software or poor systems implementation, but to the false expectation that MRP could execute the manufacturing plan in an environment of uncontrolled processes. As we take a second look for the "best" planning system, the logic of MRP as stated in Orlicky's *Material Requirements Planning*, in 1975, cannot be challenged. The material requirements of that time, MRP, was an inventory-planning system that listed what parts, both manufacturing and purchased, were required to meet a master plan.

Evolution by Acronym

MRP is driven by the Master Plan or Master Production Schedule (MPS) which represents what the company plans to produce expressed in specific configurations, quantities, and dates. Because MRP assumes infinite capacity, the master plan must be realistic. "Closed-loop MRP" was developed to review capacity in order to allow for adjustments to the master plan to make that plan attainable. Closed-loop MRP uses the logic of MRP as well as detailed routings and capacities found in the manufacturing data base. MRP II (Manufacturing Resource Planning) is an extension of closed-loop MRP and includes financial planning and "simulation" capabilities. Again, the logic of MRP is the base of this system which not only assists in realistic master planning but is an instrument of Business Planning. Whereas MRP, MRP II, and closed-loop MRP are definitive one from the other, actual practice finds the terms used interchangeably.

The logic of MRP has been extended from manufacturing systems to distribution systems. DRP (Distribution Resource Planning) is a tool that plans key resources in distribution and is integrated with the manufacturing plan. Whereas the Master Production Schedule (the parent) drives the MRP, the anticipated needs of the distribution system drive the Master Production Schedule. With DRP, the warehouse is the parent and the Master Production Schedule becomes the component.

To make an MRP system operate effectively, certain disciplines are required, such as inventory record accuracy, data-base integrity, employee understanding, realistic master plans, and so forth. When the system is operating properly, the result will be valid and realistic plans. The plans are worthless if they are not executed as planned. World-class manufacturing cannot be achieved without a first-class plan coupled with world-class execution.

MRP AND MANUFACTURING EXECUTION

MRP was originally designed to control operations in job-shop production environments. Job-shop plants are organized with functional departments such as saw, mill, grinding, and so on. Production lots are routed from department to department and controlled by shop orders (work orders, manufacturing orders, etc.). Job-shop production often results in long lead times, large work-in-process inventories, and lack of responsiveness to requirements. The Just-In-Time philosophy calls for short lead times, reduced work-in-process, and flexibility to demand by producing in a repetitive process environment.

Just-In-Time concepts such as setup reductions and product and process simplification have made great strides in the effort to achieve synchronous product flow but often a specific resource becomes a bottleneck in the process flow. The theory of constraints philosophy accepts the reality of the bottleneck and advocates close management of the bottleneck, which, in turn, will pace the entire system. The process focuses on identifying and exploiting the constraint (bottleneck). Buffer inventory ahead of nonbottleneck operations are planned to allow for temporary bottlenecks due to statistical fluctuations in the process. If the bottleneck is broken, the process of identifying a new constraint is started over.

The reality of both products and process calls for execution concepts ranging from continuous synchronized flow through dedicated equipment to nonsynchronized interrupted flow through functional manufacturing departments. Whatever the execution concepts, the operation must be based on solid plans generated by an MRP plan modified to the needs of the process.

BENEFITS OF MRP II

The benefits of a well-run MRP II program are numerous. Number one is improved customer service which can lead to increased sales or, in increasing competitive situations, the ability to maintain existing sales levels. Improved service can be brought about by faster response to customer needs through reduced lead times. Meeting schedules and, therefore, on-time shipments will allow "promises kept."

Organized plans that are attainable for both in-house manufacturing and purchasing will ultimately increase productivity and therefore reduce costs of both manufactured and purchased items. Reductions in the cost of dollar investment and space will be brought about by lower levels of raw material, in-process, and finished goods inventories.

In the long run, the greatest benefit, not easily measured, will be the benefit of everyone in the operation "singing out of the same hymnal." MRP II starts with a business plan and ultimately will involve every function within the organization. This will result not only in a reduction of waste but also in a reduction in finger pointing.

This book will cover the concepts, requirements, and logic of manufacturing and distribution planning and their place in the continuous manufacturing revolution of the nineties. The goal will be to assist the reader in understanding the basics of planning and planning's relationship to intermittent (job shop), repetitive, and process flow execution. The basics discussed will be the building blocks of knowledge required to properly define a desired planning system. It will not be a book of computer hardware or software but will help the reader to be a better evaluator of a system's computer requirements once the system has been defined.

QUIZ

1. Modern methods of inventory management were made possible with the introduction of
   I. Kardex files
   II. machine tools
   III. computers
   IV. statistics

   a. I
   b. II
   c. III
   d. IV

2. Service level is
   a. part of the bill of material
   b. a measure of delivery performance

c. unique part number
d. a criteria of MRP

3. Customer service is only measured by on-time delivery.
   a. True
   b. False

4. MRP II refers to
   a. material requirements planning
   b. manufacturing resource planning
   c. closed-loop MRP
   d. time-phased order point

5. The economic lot size formula (EOQ) balances the cost of carrying the inventory with
   I. the reorder point
   II. the cost of setting up the run
   III. the selling of the product
   IV. the lead time

   a. I and IV
   b. II
   c. I and III
   d. II and III

6. MRP is designed for dealing with
   I. dependent demand
   II. independent demand
   III. discontinuous service
   IV. Nonuniform demand

   a. I and II
   b. III and IV
   c. I, III, and IV
   d. II, III, and IV

7. Which of the following applications would be best suited to an order point systems?
   a. A product manufactured to customer order
   b. A subassembly that is used in one finished-goods item
   c. Component part inventory having a lumpy demand pattern
   d. A finished-goods item sold off the shelf with level usage

8. MRP is a system for
   I. material requirements
   II. rescheduling recommendations
   III. Execution