Richard Ivey School of Business
The University of Western Ontario

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NOTE ON MATERIAL REQUIREMENTS PLANNING

Material Requirements Planning (**MRP**) is arguably one of the most important, and potentially most useful computer developments in materials management. It has been credited by the late Oliver Wight for reducing inventories by an average of 33 per cent, increasing worker productivity 10 per cent, while reducing overtime by 50 per cent, and reducing purchasing costs an average of five per cent.

MRP is a mature planning tool. It is now almost 30 years since Joseph Orlicky installed the first system in 1961 at the J.I. Case Company tractor plant in Racine, Wisconsin. Since that time, thousands of manufacturing companies all over the world have implemented one version or another of MRP, and many of them have reported similar benefits.

Nevertheless, MRP systems are anything but a sure thing. History is repeated over and over again, as plants of large multinational firms "pull the plug" on their million-dollar MRP systems, after investing months of work and thousands of man-hours. Moreover, the number of MRP installations reported to have reached their potential is only 10 per cent of the number installed, a fraction that has not changed for at least 10 years. MRP implementation is most effectively completed in an 18-month period, yet many materials management professionals report being in year three or later of their MRP implementation process with no early end in sight.

This note will explain how MRP works, indicate some of the essential ingredients for success, and suggest some of the implications.

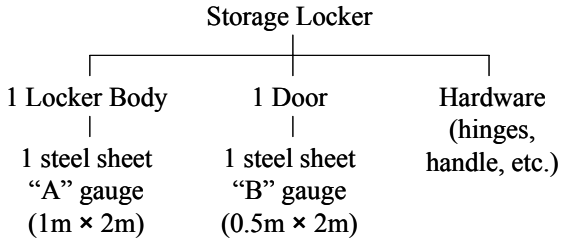
What is MRP?

Like many great inventions, MRP is based upon a simple idea. Whenever a product or service is composed of several inputs, the demand for these inputs is **dependent** upon the amount of product to be produced. Thus, if we know how much of our product we wish to make, we can **calculate** what our material requirements will be.

For purposes of illustration, let's assume that we manufacture steel storage lockers. Figure 1, below, shows the simple bill of materials used in fabricating and assembling the product.

Figure 1

BILL OF MATERIAL



In our discussion to follow, we will call the item located immediately above a given component as the parent of that component. Thus, for example, we will refer to the locker as the parent of the door, and the door as the parent of the sheet of "B" gauge steel.

The first step in material requirements planning is to establish a Master Production Schedule (or **MPS**). An example of an MPS for our lockers is shown in Figure 2. The MPS illustrates an important point about effective MRP implementations. Note that the planned order releases are not necessarily equal to the sales forecasts. In our storage locker example, we produce every second week, and store the resulting finished goods inventory in the intervening week. If demand was seasonal, our planned order releases might also include some production aimed at satisfying peak requirements in the future.

Figure 2

MASTER PRODUCTION SCHEDULE

Week	0	1	2	3	.	52
Sales forecast		8	12	10	.	
Expected receipt		16	0	20	.	
Projected on hand	4	12	0	10	.	
Planned order release		16	0	20	.	

Consider the input requirements (for the door, say), of our planned orders for lockers. The **quantity** that we will require can be calculated by multiplying the inputs required by each unit of the parent (as listed on the bill of material), by the number of units of the parent that we wish to produce. Since we use one sheet of "B" gauge steel in each door, we will need 16 sheets in week one and 20 sheets in week three to support our planned order releases for lockers. These amounts are usually referred to as the gross requirements. Since we already have 19 doors available, however, we should subtract the quantity on hand plus on order from the gross requirements, to obtain a net requirement of 17 doors to be ordered.

Furthermore, if we know how long it will take to obtain the doors, the **timing** of the order can be calculated by subtracting the lead time from the date at which the doors are to be used. The quantity to be ordered at this date is called the planned order release. If this happens to be the present date, the purchase or shop order can be released, with its expected receipt to be the date that the doors are needed.

Figure 3 illustrates the MRP entries for the doors, given a one-week lead time for fabricating the doors.

Figure 3

MATERIAL REQUIREMENTS PLAN, DOORS

Week	0	1	2	3	.	52
Gross requirements		16	0	20	.	
Expected receipt		0	0	17	.	
Projected on hand	19	3	3	0	.	
Planned order release		0	17	0	.	

Figure 4 shows the material plan for the "B" gauge steel sheets, which also have a one-week lead time.

Figure 4

MATERIAL REQUIREMENTS PLAN, "B" STEEL

Week	0	1	2	3	.	52
Gross requirements		0	17	0	.	
Expected receipt		0	9	0	.	
Projected on hand	8	8	0	0	.	
Planned order release		9	0	0	.	

When this logic is repeated for each item on the MPS, and then repeated at successively lower levels of the bill of materials, a time-phased requirements plan will be obtained that encompasses all of the items manufactured and purchased by the firm. This plan will show the time and quantity of the planned order releases that are necessary to support the MPS.

That is about all there is to it. If we have only a few products with few components, and if their lead times are relatively short, MRP is very easy. So easy, in fact, that we can probably do it in our heads or on the back of an envelope, so we may not even need a formal MRP system. When our products become more numerous, or more complex, or our component lead times take weeks instead of hours, a computer-based MRP system becomes essential.

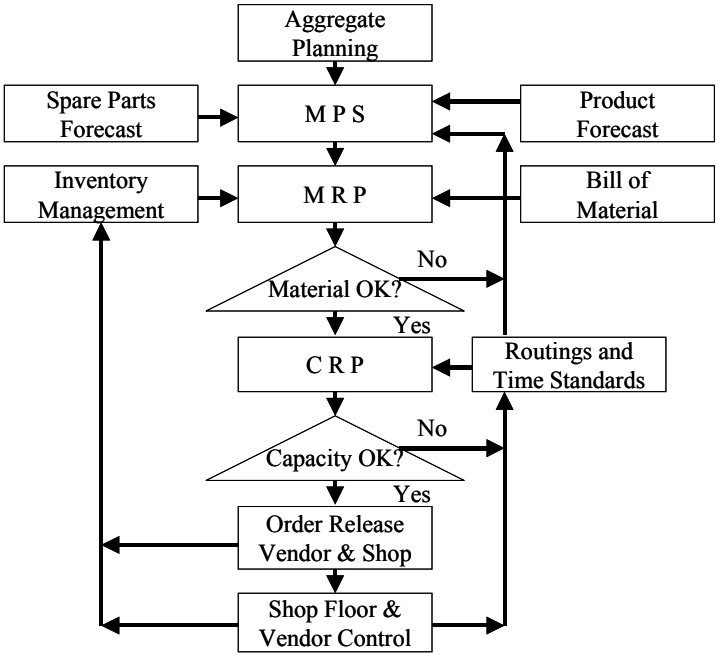
Note that MRP itself is a "dumb" planning tool, in the sense that it has no ability to respond to current or projected material shortages. If the current MPS cannot be followed, it is up to the human planners either to revise the MPS, or to resolve the shortages. Effective management of these adjustments is crucial to the success of any MRP system.

MRP System Building Blocks

A full-fledged MRP system is shown in Figure 5. The elements that have not already been discussed will now be introduced.

Figure 5

CLOSED LOOP MATERIAL REQUIREMENTS PLANNING



Aggregate Planning

Aggregate planning establishes overall production rates, and manpower policies which the MPS must maintain. Management may choose, for example, to build inventory during slow periods to stabilize production.

Forecasting

Besides product forecasts, forecasts of maintenance spare parts requirements must be added where applicable, since MRP computes dependent demand only. Note, however, that the requirements generated by scheduled maintenance are actually good candidates for MRP, and need not be forecast as spare parts. The overhaul schedule, and its predictable assortment of long lead time replacement parts, could be treated as parts of the MPS and bill of materials, respectively. Yet many maintenance organizations seem surprised by their usage levels, even when the jobs generating the requirements were scheduled many weeks in advance.

Capacity Requirements Planning

Capacity Requirements Planning (**CRP**) is a vital component of any complete MRP system. CRP does the same thing for capacity requirements that MRP does for material requirements.

Returning to our locker example, let us assume that we wish to obtain the load on our paint shop. If we know how long it should take to paint each item of the time-phased requirements plan, then the workload implicit in each planned order can be calculated by multiplying the quantity required times the unit paint time, and then adding any required setup time. Shop load in each period is simply the sum of the times for all of the individual orders. Shop capacity, on the other hand, depends on the number of resource units available, and the hours of operation that are scheduled. For our paint shop example, let’s assume that there are two paint booths, and that each is scheduled to operate 38 hours a week. Therefore, 76 hours a week are available.

If our calculation of shop load results in a figure of 85 hours for week one, our shop load would be about 112 per cent, or slightly in excess of available capacity. This would call for a slight rebalancing of the schedule, or the use of nine hours of overtime. Expressing shop loads in percentage terms is common since it allows a planner to see underloaded or overloaded work centres at a glance.

Figure 6 illustrates the type of information provided by CRP.

Figure 6

CAPACITY REQUIREMENTS PLAN, PAINT SHOP

Week	0	1	2	3	.	52
Planned load hours		85	60	70	.	
Available hours		76	76	76	.	
Surplus (shortage)		(9)	16	6	.	
Per cent load		112	79	92	.	

CRP as described above should be viewed as a capacity load projector, not a capacity balancer. If a given MPS results in an even capacity load, CRP will tell us so. It will not tell us, however, what to do if the load is not balanced. This task is left to the planner in just the same way as an MRP material shortage.

Finally, a comment is warranted on Figure 5's title, closed loop MRP. Many MRP systems in use today fail to achieve their full potential because they are used only to launch orders, not to control them. A closed loop system monitors transactions such as receipts and issues, and verifies that they are consistent with the plan. If, for example, a purchase order was issued for 100 chrome-plated handles to be used in our deluxe locker, and only 90 are received, a closed loop system would initiate a request for replanning, since the MPS may no longer be valid.

MRP Extensions: DRP and MRP II

MRP has evolved in several directions beyond the bounds shown in Figure 5. One of these is Distribution Requirements Planning (**DRP**).

Distribution Requirements Planning

DRP derives the forecast requirements of the MPS from inventory status information obtained from the distribution system. In many cases, companies ship their output into a distribution channel, and not to the final customer. In these cases, the demand at the factory is **dependent** upon the inventory replenishment policies of the channel members. DRP can be thought of as a simulation of the ordering behaviour of the distribution centres, which place orders directly on the factory, and whose demand frequently occurs in large chunks due to lot-sizing.

Manufacturing Resource Planning

Another extension is Manufacturing Resource Planning (**MRP II**). MRP II encompasses MRP as one of its modules, and applies the MRP and CRP results to financial planning. Once a valid MPS has been established, the net cash flows from sales, purchased materials and labour are projected from the MPS, MRP and

CRP, respectively. In this way, MRP II supports far greater precision in business planning than was previously possible. Nonetheless, MRP II has the same limitations as MRP and CRP. It projects the implications of plans; it does not create or revise them. MRP II will tell us what our financial position will be, but not what to do about it!

MRP Problems that Management Must Avoid

Given the elegant simplicity of MRP, it is perhaps surprising that so many firms find it troublesome to implement. Why do they find it so difficult to meet the minimal requirements of MRP, namely, a feasible MPS, and accurate information on inventory status, bills of material, and lead time requirements?

Production-Marketing Interface Problems

Part of the answer lies in the past. In traditional manufacturing environments, inventory control and purchasing used historical component usages to guess what would be needed to support unspecified future manufacturing needs. Meanwhile, marketing predicted whatever was necessary to meet its sales targets. Manufacturing, of course, made only the products for which it happened to have enough material in stock to make efficiently. Expeditors were used to reconcile informally the many conflicting requirements that emerged.

This traditional way of doing things sometimes leads management to argue that it is impossible to schedule production, since what will have to be produced will depend on what orders are received. Forecasting will be held to be so unreliable as not to be worth doing. If these managers had their wish, they would keep enough material on hand to be able to make any quantity of any product. Rarely is it financially feasible, however, to follow such a strategy.

MRP offers a way out of the problems, but only if management is prepared to alter existing practice. Perhaps the most difficult problem is the conflicting needs of marketing and operations. Marketing will wish to keep the MPS as loose as possible, since the more detail that is provided, the more likely it is to be in error. Operations will want to define the MPS tightly, and to accommodate as little change as possible, so that previously scheduled capacities and materials are used as planned. The key to satisfactory negotiations in this area is an understanding by all parties of the costs and benefits of the various policy alternatives. MRP can provide the information (such as stock positions and work centre capacity loadings) that is needed to support these negotiations.

The crucial MRP requirement is a valid MPS. That is, if MRP is to work, the MPS used to drive it must:

- work with the material available; and
- work with the capacity available.

Once material and capacity have been allocated to a particular plan, it must be recognized that further changes to the MPS are unlikely to be cost-free. Thus, successful implementers of MRP have adopted formal procedures which:

- require marketing and manufacturing to negotiate regularly and sign off on a jointly-agreed MPS; and
- govern how the parties may change the MPS after it has been adopted.

Inadequate Capacity Planning

For a variety of reasons (some budgetary and some related to system complexity), CRP implementation occurs much later than the other system modules. This practice may account for a large fraction of the firms who have had trouble implementing MRP. If the capacity loads implicit in the MPS have not been evaluated, it is unlikely that the MPS can be followed in practice, whether marketing signs off or not. In the unlikely event that the MPS is followed, it is often because department foremen are allowed to retain large work-in-process (WIP) inventories that allow them the leeway to arrange feasible capacity loads within their work centers. The problems of MPS non-compliance and excessive WIP that are caused by CRP's absence can have the unhappy effect of delaying or even cancelling the later stages of MRP's implementation plan. These are the stages which almost always include CRP!

Lack of Data Integrity

MPS problems can be compounded by a lack of data integrity of inventory records, bills of material, or lead times. More subtle, but equally serious, complications can occur if design changes or material substitutions are allowed after orders have been released. Housekeeping concerns such as these should be attended to prior to MRP implementation, and their rectification should be made a high priority.

What are the Consequences?

What are the consequences for firms that are unable to address these problems? The most frequent symptoms are sustained quantities of past due items, on the one hand, and underloaded work centres, on the other. The problems perpetuate themselves. Each week, work in overloaded work centres is rescheduled into the following week, while unneeded inventory is built up in underloaded work centres to avoid low productivity or layoffs. The result can be discrepancies between the production quantities that MRP recommends, and what actually occurs.

Although lack of MPS validity and data integrity may have been the real cause, an undertrained management may see MRP as the problem source, and not its solution. Since few of the benefits of MRP accrue under these conditions, the real costs of MRP will lead to reduced support for MRP, or even to its termination.