MATERIAL REQUIREMENTS PLANNING (MRP)

- A basic tool for performing the detailed material planning function in the manufacture of component parts and their assembly into finished items.
- MRP’s managerial objective is to provide ‘the right part at the right time’ to meet the schedules for completed products.
- MRP is central to developing detailed plans for part needs of companies assembling end items from components produced in batch manufacturing process.
- Material requirement planning is characterised by the use of time-phased (period-by-period) requirement records.
- As MRP requires time-phased records, master production schedule also should be represented in time-phased manner.
- Two other inputs for the MRP are Bill of material (BOM) and Inventory status.
- A BOM shows, for each part number, what other part numbers are as direct components.
- The MRP output (time-phased requirement for a part number) can also be used as input to the detailed capacity planning.
- Developing material and capacity plans is an iterative process where the planning is carried out level by level.

THE BASIC MRP RECORD

- At the heart of the MANUFACTURING PLANNING AND CONTROL system is a universal representation of the status and plans for any part number, which is the MRP time-phased record.

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>Gross requirements</td>
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<tr>
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<tr>
<td>Projected available balance</td>
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<tr>
<td>Planned order release</td>
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</tbody>
</table>

*Fig. 1 – A basic MRP record*

Managing All the Single Part Records

- A single record provides the correct information on each part in the system.
• All the single records associated with the parts needed for a complex product is linked together for proper managing

• Key elements for linking the records are the bill of material, the explosion process and lead time offsetting

Bill of Material (BOM)
• BOM shows exactly what goes into what instead of being just a part list
• Two ways the bill of material is represented
  ➢ Product structure diagram
  ➢ Indented bill of material

Fig. 2 - Snow shovel shown with component carts and assemblies
Fig. 3 - Product structure diagram for shovel

1605 End product – Shovel
13122 Top Handle Assembly (1 required)
   457 Top handle (1 required)
   082 Nail (2 required)
11495 Bracket Assembly (1 required)
   129 Top Handle Bracket (1 required)
   1118 Top Handle Coupling (1 required)
048 Scoop-shaft Connector (1 required)
118 Shaft (1 required)
062 Nail (4 required)
314 Scoop Assembly (1 required)
   2142 Scoop (1 required)
   019 Blade (1 required)
   14127 Rivet (4 required)

Fig. 4 – Intended Bill of Material

082 Nail (2 required)
457 Top handle (2 required)
11495 Bracket assembly
2142 Scoop
019 Blade
14127 Rivet (6 required)
Explosion Process

- Explosion is the process of translating product requirements into component part requirements, taking existing inventories and scheduled receipts into account until every part number (purchased parts, raw material, manufactured components, subassembly and assembly) requirements are exactly calculated.
- As explosion take place, only the component part requirement net of any inventory or scheduled receipts are considered.
- In this way, only the necessary requirements are linked through the system.
- Gross to net explosion not only provides the basis for calculating the appropriate quantities but also serves as the communication link between part numbers.
- This is the basis for dependent demand estimation and it remove uncertainty from the requirement calculation.
- The independent demand items, such as the end item, are subjected to demand from outside the firm.
- The need for end items will have to be forecasted.
- The concept of dependent demand is often called the fundamental principle of MRP.

Lead Time Offseting

- Lead time offsetting is related with when each component and subassembly is needed.
  - The BOM contains precedent relationships. They indicate the order in which things must be done.
  - When to schedule each component part depends on how long to produce the part (i.e., lead-time). Usually this information is also incorporated in the BOM.

Forward Schedule

- Processing of all parts starts as soon as possible.
- Lead to unnecessary work-in-process inventories.
- Lead-time differences are ignored.

Backward Schedule

- Processing of all parts starts as late as possible.
- Work-in-process is less and it considers lead-time difference.
- In these schedules critical path operations does not have any change in schedule. The planning horizon should be greater than the sum of duration of all critical path operations.
- MRP achieves the benefits of the back schedule approach and performs the gross to net explosion.

Linking the MRP Records

- The Gross requirements for end items or options come from MPS.
- Gross requirement of a part shows the quantity and timing - when it is required for the parent to make.
- Planned order release of the parent becomes the gross requirements for the components.
Planned order release quantity is the net of gross requirement, scheduled receipt and projected available balance.

As MRP record of a part is available, the planned order release of the part is passed down as gross requirement to its components, following the BOM on a level-by-level basis.

When a part receives its requirement from more than one source, the gross requirement will reflect needs from more than one planned order release source.

MRP records take account of gross to netting, back scheduling, allows for explicit timings, desired lot sizing procedure, safety stocks and part commonality.

With the MRP approach, the person planning a part need not explicitly coordinate his planning with planning of component parts. The MRP system accomplishes the coordination.

**Example on Linking MRP Records**

The master production schedule of *snow shovel* shows the requirements as follows:

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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</thead>
<tbody>
<tr>
<td>MPS</td>
<td></td>
<td>20</td>
<td></td>
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<td>20</td>
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<td>5</td>
<td>35</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

- The lead time to make this item is 2 week when the level 1 component parts are available.
- The lot sizing procedure for *snow shovel* is lot-for-lot.
- One of the component part required to make *snow shovel* is *top handle assembly*.
- The above requirements of *snow shovel* create a ‘gross requirement’ for *top handle assembly* as shown in the MRP record of this item in figure 5.
- This record shows that there is no order which is outstanding. So there is no ‘scheduled receipt’.
- There are 25 units available on hand. This is the ‘projected available balance’ which is available as beginning inventory for period 1.
- The ‘planned order release’ is calculated as follows: First the net requirement is determined.
- Net requirement of current period = Gross requirement of current period – Scheduled receipt in the current period – Project available balance of previous period
- If this net requirement is a negative quantity, an order has to be planned.
- The order quantity is adjusted according into the lot sizing method. If the lot sizing method is lot-for-lot, the order quantity is the net requirement.
- For other method of lot sizing: if the lot-size quantity is greater than the net requirement, the order quantity is the lot size quantity. If the net requirement is greater than the lot size quantity, order the net requirement.
- Now, the order quantity shows the quantity required in the period of ‘gross requirement’ for which an order has to be placed.
- The quantity corresponds to the ‘planned order release’ is the order quantity but, the period in which the order release will occur depends on the lead time of the item.
• The period of ‘planned order release’ is obtained when the gross requirement period is advanced by lead time.

• For instance, there is a net requirement of 5 units in period 4 for this item and the lead time is 2 weeks. The ‘planned order release’ will be in the period 2 as you have to advance by 2 periods from the gross requirement period.

• *Top handle, nail and bracket assembly* are required to make the *top handle assembly*.

• When ‘planned order release’ is executed, it is assumed that these items are available. Hence, similar to the planning of the *top handle assembly*, a planning has to be carried out for these items also.

• That is, ‘planned order release’ of *top handle assembly* creates ‘gross requirement’ for these items.

• For example, the ‘planned order release’ of *top handle assembly* for 5 units in period two generates a ‘gross requirement’ in period two for *top handle*.

• Similarly, for other items – *nail* and *bracket assembly* the gross requirement can be identified.

• If current inventory status of the items - *top handle, nail* and *bracket assembly* are available, the MRP record of these items can be prepared and these records are available in figure 5.

• Like this the MRP record of children of bracket assembly can be prepared.

<table>
<thead>
<tr>
<th>13122 Top handle assembly</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3  4  5  6  7  8  9  10  11  12</td>
</tr>
<tr>
<td>Gross requirements</td>
<td>20 10 20 5 35 10</td>
</tr>
<tr>
<td>Scheduled receipts</td>
<td></td>
</tr>
<tr>
<td>Projected available balance</td>
<td>25 5 5 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Planned order release</td>
<td>25 5 5 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Lead time = 2 periods</td>
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</tr>
<tr>
<td>Lot size: Lot-for-lot</td>
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</table>

<table>
<thead>
<tr>
<th>457 Top handle</th>
<th>Period</th>
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<tbody>
<tr>
<td></td>
<td>1  2  3  4  5  6  7  8  9  10  11  12</td>
</tr>
<tr>
<td>Gross requirements</td>
<td>5 20 5 35 10</td>
</tr>
<tr>
<td>Scheduled receipts</td>
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</tr>
<tr>
<td>Projected available balance</td>
<td>22 17 42 22 17 17 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Planned order release</td>
<td>18 10</td>
</tr>
<tr>
<td>Lead time = 2 periods</td>
<td></td>
</tr>
<tr>
<td>Lot size: Lot-for-lot</td>
<td></td>
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</tbody>
</table>
### Technical Issues

**Processing Frequency**

- **Static Vs dynamic construction of records**
- The discussion till now was static construction of the MRP records and how they are linked together
- As the condition changes and new information is received, the MRP records must be brought up to date so plans can be adjusted

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**Fig. 5 – MRP records for the shovel top handle assembly**
This is possible by processing the MRP records anew, incorporating current information.

Two issues associated with this are:
- How frequently the records should be processed and
- Whether all the records should be processed at the same time

Processing all the records in one computer run is called **regeneration**.

All part number records are completely reconstructed each time the records are processed.

An alternative is **net change** processing, in which only those records affected by the new or changed information are reconstructed.

The processing frequency depends on the firm, its products, and its operations.

Most common practice is weekly processing using regeneration.

**Bucketless System**
- A Bucketless MRP system specifies the exact release and due dates for each requirement, scheduled receipt, and planned order.

**Lot Sizing**
- Time-phased record permits us to develop discrete lot sizes that will exactly satisfy the net requirement for one or more periods.
- Several formal procedures are available for lot sizing time-phased requirements.
- The basic trade-off usually involves elimination of one or more set-ups at the expense of carrying inventory longer.
- A simple procedure of lot sizing is lot-for-lot sizing which consider the exact requirement in a period is the order quantity.
- Batching planned orders at one level will increase gross requirements at the next level in the product structure.
- So larger lot sizing near the end item level of the bill of materials cascades down through all levels.
- Thus it turn out that lot-for-lot is better than we might expect in actual practice.
- Many firms employ lot sizing primarily at the end item and basic component levels, while intermediate subassemblies are planned on a lot-for-lot basis.

**Safety Stock and Safety Lead Time**
- **Safety stock** is a buffer of stock above and beyond that needed to satisfy the gross requirements.
- **Safety lead-time** is a procedure whereby shop orders or purchase orders are released and scheduled to arrive one or more periods before necessary to satisfy the gross requirements.
- When safety stock is used the projected available balance does not fall below the safety stock level instead of reaching zero.
- To incorporate safety lead-time, orders are issued (planned) earlier and are scheduled (planned) to be received into inventory before the time that the MRP logic would indicate as necessary.
• Safety lead-time is not just inflated lead-time
• Safety stock tends to be used in MRP system where uncertainty about quantities is the problem (eg:- Where some small amount of scrap, spare part demand, or other unplanned usage is a frequent occurrence)
• Safety lead time is used when the major uncertainty is in the timing (eg:- Supplier often misses delivery dates)

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>Lead time = 1 period, Lot size = 50 units</td>
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</table>

Fig. 6 – An MRP record without safety stock or safety lead-time

<table>
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<th>3</th>
<th>4</th>
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<tr>
<td>Planned order release</td>
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<tr>
<td>Lead time = 1 period, Lot size = 50 units, Safety Stock = 10</td>
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</tbody>
</table>

Fig. 7 – The above record in figure 6 with safety stock

<table>
<thead>
<tr>
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<th>5</th>
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<tr>
<td>Lead time = 1 period, Lot size = 50 units, Safety Lead-time = 2 period</td>
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</tbody>
</table>

Fig. 8 – The above record in figure 6 with safety lead-time

**Low-Level Coding**
• It is particularly suitable when common parts exists at different levels
• Low-level coding helps to accumulate all its gross requirements and after that to start the record processing
• If an item is used in multiple levels, the low-level code of the item is the lowest level number
• The low-level code assigned to any part number is based on the part’s usage in all products

• Once low-level codes are established, MRP record processing proceeds from one level code to the next, starting at level 0

• Within a level, the MRP record processing is typically done in part number sequence

**Pegging**

• It relates all the gross requirements for a part to all the planned order releases or other sources of demand that created the requirements

• Pegging records contain the specific part number or numbers of the sources of all gross requirements

  ➢ 0 level – specific customer orders, and for lower-level items – higher level items and some times service parts

• It is the reverse of the explosion process as it is possible to go through the MRP records from raw material gross requirements to some future customer order

• Pegging is a selective where-used file

• Where-used data indicate for each part number, the part number of all items on which the part is used

• Pegging information can trace the impact of a material problem all the way up to the order it would affect

**Firm Planned Orders**

• Planned order releases from one record processing cycle to the next will be different, if changes have taken place

• The effect cascade throughout the product structure

• Firm planned orders (FPO) prevent the cascading down through the product structure

• It is a planned order that the MRP system does not automatically change when condition change

• To change either the quantity or timing of a firm planned order, managerial action is required

**Service Parts**

• Service part demand must be included in the MRP record if the material requirements are not to be understated

• Service part demand is forecasted and is added directly into the gross requirements for the part

• The low-level code for a part used exclusively for service would be zero

**Planning Horizon**

• Number of periods for which planning is carried out is called planning horizon

• It should be greater than the cumulative lead-time

• A rolling horizon is usually used
Rolling through time requires updating the records to reflect the actual conditions.

<table>
<thead>
<tr>
<th>Period</th>
<th>Jan. 1st week</th>
<th>Jan. 2nd week</th>
<th>Jan. 3rd week</th>
<th>Jan. 4th week</th>
<th>Jan. 5th week</th>
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<td>Planned order release</td>
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</tbody>
</table>

Lead time = 1 period, Lot size = 50 units

Fig. 9 – An MRP record with 5 weeks as planning horizon

The current period for the above record is January first week. When the first week is over, the record will look like the one given below.

<table>
<thead>
<tr>
<th>Period</th>
<th>Jan. 2nd week</th>
<th>Jan. 3rd week</th>
<th>Jan. 4th week</th>
<th>Feb. 5th week</th>
<th>Feb. 6th week</th>
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</table>

Lead time = 1 period, Lot size = 50 units

Fig. 10 – The MRP record after rolling through time

Scheduled Receipts Versus Planned Order Releases

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
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</table>

Lead time = 1 period, Lot size = 50 units

Fig. 11 – An MRP record

A planned order release is in an action bucket of the above record. After, this period and next record processing, the record is like the one shown below.
### Gross requirements

<table>
<thead>
<tr>
<th>Period</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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</tbody>
</table>

### Scheduled receipts

- 50

### Projected available balance

<table>
<thead>
<tr>
<th>Period</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>27</td>
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</tr>
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</table>

### Planned order release

- 50

Fig. 12 – Previous MRP record after a processing cycle

- A scheduled receipt represents a commitment, whereas the planned order is only a plan

### USING THE MRP SYSTEM

#### The MRP Planner

- The Primary actions taken by an MRP planner are:
  1. Release orders
  2. Reschedule due dates of existing open orders when desirable
  3. Analyse and updates system planning factors such as changing lot sizes, lead times, scrap allowances or safety stocks
  4. Reconcile errors or inconsistencies and try to eliminate root causes of these errors
  5. Find the key problem area requiring action now to prevent future crises
  6. Use the system to solve critical material shortage problems so action can be captured in the records for the next processing

#### Order Launching

- It is the process of releasing orders to the shop or to vendors (purchase orders) – planned order release is in the action bucket
- When an order is launched, it is sometimes necessary to include a shrinkage allowance for scrap and other process yield situations (this increases shop order quantity)

#### Allocation and Availability Checking

- Allocation is a process a step prior to order launching that involves an availability check for the necessary components
- If sufficient quantities of each component are available, the shop order can be created
- If the order is created, then the system allocates the necessary quantities to the particular shop order
- After availability checking and allocation, picking tickets are typically created and sent to the stockroom

#### Exception Codes

- Exemption codes are used “to separate the vital few from the trivial many”
- Two categories
Checking the input data accuracy
Activity directly supports the MRP planning

**Bottom-UP Replanning**

- Using pegging data to solve material shortage problems
- Compromising lead times throughout the product structure using the system and bottom-up replanning, might leads to solutions for the material shortage problem

**SYSTEM DYNAMICS**

- To cope with changes, accurate transaction processing and replanning activities are necessary

**Transaction During a Period**

- An MRP record produced over the weekend preceding week 1 is given below

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross requirements</td>
<td>30</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>Scheduled receipts</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projected available balance</td>
<td>10</td>
<td>30</td>
<td>10</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Planned order release</td>
<td>50</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Fig. 13 – An MRP Record*

- Planner’s first action would be to try to launch the planned order for 50 units in period 1
  - Check availability of the raw material for this part
  - Allocate the necessary raw material
  - Issue an order to the shop to make 50
  - Remove the 50 from the planned order release
  - Create a scheduled receipt for 50 in week 3
  - Send a pick ticket to the raw material area

- Assume that the following changes occurred during week 1, and the transactions were processed:
  - Actual disbursements from stock for the item during week 1 were only 20 instead of the planned 30
  - The scheduled receipt for 50 due in week 1 was received on Tuesday, but 10 units were rejected; so only 40 were actually received into inventory
  - The inventory was counted on Thursday and 20 additional pieces were found
  - The requirement data for the 45 pieces in week 5 was changed to week 4
  - Marketing requested an additional five pieces for samples in week 2
  - The requirement for week 6 has been set at 25

- The resultant MRP record produced over the weekend preceding week 2 is presented below
### Rescheduling

- The MRP record shown above suggests two important activities for MRP planners:
  - Indicating the sources of problems that will occur as a result of data base changes
  - Suggesting actions to ensure the system is telling the truth
- Exception message in the above record may be ‘reschedule the receipt currently due in week 3 to week 4’

### Complex Transaction Processing

- An action required on the part of an MRP planner may have been caused by a very complex set of data base transactions involving several levels in the bill of material

### Example

- Consider a product which include three levels in the product structure with the following parts A, B, C, X and Y. Part C is used as a component in both part A and B as well as being sold as a service part. Part C, in turn, made from part X and Y.
- The part C MRP record is correctly stated at the beginning of the week 1 in the figure 15 shown below.
- While the two scheduled receipts for part C are currently scheduled correctly, transactions involving part A and B can have an impact on the proper due dates for these open orders.
- Consider the following transactions involving changes:
  - An inventory count adjustment in the first period for part A make the POR in the first week change to 3\textsuperscript{rd} week
  - In this case 95 units of part C would not be needed until week 3.
  - Any change in timing for the planned order release of 25 units of part A in week 4
  - Results in reschedule of the due date for 91 units of part C
  - Suppose a transaction involving 75 additional units of part B in week 5 is processed
  - Immediate release of 100 units of part C
Procedural Inadequacies

- MRP replanning and transaction processing activities are two essential aspects of ensuring the MPC system database remains accurate.

- Inaccuracy may arise due to inadequate procedures to process transactions.

Illustration:

- Consider the above example where 4 or more pieces scrapped on the shop order for 95.

- This necessitating rescheduling of the order for 91 one week earlier.

- If the scrap transaction were not reported the MRP record would appear as shown in the above figure 15, indicating that no need of rescheduling.

- If the person in charge of the stockroom discovers the shortages, when he put away the order, then only one week would be lost before the next MRP report shows the problem.

- If, however, the stockroom person does not count, or if the person who made the scrap puts the defective parts at the bottom of the box where they go undetected by quality control, then the problem will only be discovered when the assembly lines are trying to build As and Bs in week 3.

- Such a discovery comes under the category of unpleasant surprises.

- Now rush down to the shop to get 1 piece from the batch of 91.

- The very person who failed to report the earlier scrap may well now be screaming, ‘Why don’t those idiots know what they need’.