Chapter 15: Learning Outcomes

When you complete this chapter you should be able to:
1. Develop a product structure
2. Build a gross requirements plan
3. Build a net requirements plan
4. Determine lot sizes for lot-for-lot, Economic Order Quantity (EOQ), and Part-period balancing (PPB)
5. Describe MRP II (next chapter)
6. Describe closed-loop MRP (next chapter)
7. Describe Enterprise resource planning (ERP)
Contributors to MRP and theme of MRP

- Joseph Orlicky
- George Plossl
- Oliver Wight
- American Production and Inventory Control Society

The theme of MRP is "Getting the right amount of the right materials to the right place at the right time"

What is MRP?

- Computerized Inventory Control system
- Production Planning System
- Management Information System
- Manufacturing Control System
When to use MRP

- Job Shop Production (Other name is what?)
- Complex Products
- Assemble-to-Order Environments
- Discrete and Dependent Demand Items

What can MRP do?

- Reduce Inventory Levels
- Reduce Component Shortages
- Improve Shipping Performance
- Improve Customer Service
- Improve Productivity
- Simplified and Accurate Scheduling
- Reduce Purchasing Cost
- Improve Production Schedules
- Reduce Manufacturing Cost
- Reduce Lead Times
- Less Scrap and Rework
- Higher Production Quality
What can MRP do? (cont.)

- Improve Communication
- Improve Plant Efficiency
- Reduce Freight (cargo) Cost
- Reduction in Excess (extra) Inventory
- Reduce Overtime
- Improve Supply Schedules
- Improve Calculation of Material Requirements
- Improve Competitive Position

Three Basic Steps of MRP

- Identifying Requirements
- Running MRP – Creating the Suggestions
- Firming the Suggestions
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Step 1: Identifying the Requirements

- Quantity on Hand
- Quantity on Open Purchase Order
- Quantity in/or Planned for Manufacturing
- Quantity Committed to Existing Orders
- Quantity Forecasted

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Step 1: Important Information

MRP is.....
- Company Sensitive
- Location Sensitive
- Date Sensitive
Step 2: Running MRP – Creating the Suggestions

- Critical Items
- Expedite Items (make the delivery of an items faster)
- Delay Items

Step 3: Firming the Suggestions

- Manufacturing Orders
- Purchasing Orders
- Various Reports
Overview of the MRP System

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MRP Inputs

- Product Structure File
- Master Production Schedule
- Inventory Master File
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Product Structure File

- Bill of Materials (This is the sequence of everything that goes into the final product).
- Other names are: Product structure tree, a schematic, a flow diagram

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Master Production Schedule

- Schedule of Finished Products
- Represents Production, not Demand
- Combination of Customer Orders and Demand Forecasts
- What Needs to be Produced
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Inventory Master File

- On-Hand Quantities
- On-Order Quantities
- Lot Sizes
- Safety Stock
- Lead Time
- Past-Usage Figures

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MRP Process

- Schedules the Production of all items using an MRP Matrix

<table>
<thead>
<tr>
<th>Item:</th>
<th>Low-Level Code:</th>
<th>Lot Size:</th>
<th>Lead Time:</th>
<th>PD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</tbody>
</table>
Terms Defined

- Item – name or number for the item being scheduled
- Low-Level Code – the lowest level of the item on the product structure file
- Lot Size – order multiples of quantity
- Lead Time – the time from when an order is placed to when it is received
- PD – Past Due Time Bucket, orders behind schedule

Terms Defined

- Gross Requirements – demand for an item by time period
- Scheduled Receipts – material already ordered
- Projected on Hand – expected ending inventory
- Net Requirements – number of items to be provided
- Planned Order Receipts – net requirements adjusted for lot size
- Planned Order Releases – planned order receipts offset for lead times
Materials Requirements Planning (MRP)

- Materials Requirements Planning (MRP) is a forward-looking, demand-based approach for planning the production of manufactured goods and ordering materials and components to minimize unnecessary inventories and reduce costs.

- The output of an MRP system is a schedule for obtaining raw materials and purchased parts, a detailed schedule for manufacturing and controlling inventories, and financial information that drives cash flow, budget, and financial needs.

Disaggregation in Manufacturing

1. Dependent demand is demand that is directly related to the demand of other Stock Keeping Units (SKUs) and can be calculated without needing to be forecasted. Demand for materials needed to produce finished goods is dependent on the number of finished goods planned.

2. Time phasing: all dependent demand requirements do not need to be ordered at the same time, but rather are time-phased as necessary.

3. Lot sizing is the process of determining the appropriate amount and timing of ordering to reduce costs.
MRP explosion

**MRP explosion** is the process of using the logic of dependent demand to calculate the quantity and timing of orders for all subassemblies and components that go into and support the production of finished goods.

Lot sizing is the process of determining the appropriate amount and timing of ordering to reduce costs.

- There are three common lot sizing methods for MRP:
  1. Lot-for-lot (LFL)
  2. Fixed order quantity (FOQ)
  3. Periodic order quantity (POQ)
  4. Economic Order Quantity (EOQ)

  Each of these is illustrated in the following examples.

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**MRP System—Other Issues**

- Safety stock?
- Lot size?
  - Lot-for-lot (L4L or LFL): lot size matches net requirements.
  - Economic order quantity (EOQ): Minimizes the total costs of Carrying and Ordering
  - Least total cost (LTC): calculates a lot size that equalizes holding and ordering costs.
  - Least unit cost (LUC): averages the LTC across the lot size.
### Safety stock

**Need for safety stocks:**
- Variations in demand due to end-item forecast errors and inventory errors
- Variations in supply – both lead-times and quantities

**Since demand is not random, traditional statistical techniques do not apply.**

**Options to provide safety factors:**
- Fixed quantity buffer stocks
- Safety lead-time
- Increase gross requirements

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### Safety stock - Palestine

**Fixed quantity buffer stocks**
- Good rule of thumb: Set buffer = max. demand likely in a single period
- *Never* generate order solely to replenish buffer stocks

**Safety time method**
- Simply order early
- Distorts LTs and priorities
- Better than buffer stocks for items with infrequent demand
- Also better for purchases outside company

**Increase in gross requirements**
- Should be done at end item level only so that
  - Components available in matched sets
  - Safety stocks are not duplicated at different levels
Lot for Lot (L4L)

- Order exactly what is needed
- Changes as requirements change
- Requires time-phased information
  - MRP or Master Schedule
- No unused inventory
- Most often used with ‘A’ items

Fixed Order Quantity

- Order the same amount each time
- Easy to understand
- Does not minimize costs
- Min-max system
  - Order when you go below the minimum
  - Order up to the max
Economic Order Quantity

- Minimizes the total costs of Carrying and Ordering
- Assumptions
  1. Demand is relatively constant and known
  2. The item is purchased in lots or batches
  3. Preparation costs and ordering costs are constant and known
  4. Replacement occurs all at once

When not to use EOQ

- Make-to-order when customer sets the quantity needed
- Shelf life is short
- There are other limitations
  - Tool life is limited
  - Raw material batch size has limitations
Period Order Quantity (POQ)

- EOQ assumes demand is uniform
  - this is usually not true
- EOQ orders a quantity that attempts to balance the cost of ordering with the cost of carrying
- POQ sets a time interval that orders the same number of times per year as the EOQ
- POQ can reduce carrying costs especially with non-uniform demand

Independent and Dependent Demand

Independent demand is uncertain: Demand for final products

Dependent demand: Dependent demand is certain, demand for items that are subassemblies or component parts to be used in production of finished goods.

Independent Demand

Dependent Demand

Independent demand is uncertain (Demand for final products)
Product Structure Tree

Level 0

Chair

Level 1

Leg Assembly

Seat

Back Assembly

Level 2

Legs (4) Cross Bar (2)

Side Rails (2) Cross Back Supports (3)

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Explosion Example

- How many leg assemblies are needed for 1 chair?
- How many Cross bars are needed for 5 chairs?

Computing how many parts are required per a final product is called BOM explosion.

MRP answers these questions by taking production lead times into account: Not only it tells how many, but also when.
Bill of Materials – Example 1

How many more of each component is needed to make 15 $\text{X}$s if there are 5 of each already in stock?

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>$10$</td>
</tr>
<tr>
<td>B</td>
<td>$15$</td>
</tr>
<tr>
<td>C</td>
<td>$5$</td>
</tr>
<tr>
<td>D</td>
<td>$40$</td>
</tr>
<tr>
<td>E</td>
<td>$180$</td>
</tr>
<tr>
<td>F</td>
<td>$5$</td>
</tr>
</tbody>
</table>

$\text{X:10, B:15, C:5, D:40, E: 180, F:5}$

Bill of Materials – Example 2

How many more of each component is needed to make 15 $\text{X}$s if there are 8 of each already in stock?

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>X</td>
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<tr>
<td>B</td>
<td>$6$</td>
</tr>
<tr>
<td>C</td>
<td>$0$</td>
</tr>
<tr>
<td>D</td>
<td>$10$</td>
</tr>
<tr>
<td>E</td>
<td>$38$</td>
</tr>
<tr>
<td>F</td>
<td>$0$</td>
</tr>
</tbody>
</table>

$\text{X:7, B:6, C:0, D:10, E: 38, F:0}$
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Lead Times

Assembly Time Chart (time phased)

1 2 3 4 5 6 7 8 9 10

1 2 3 4 5 6 7 8 9 10 11

Days
Assume that we’ve scheduled 500 chairs to be ready five weeks from now.

... Now what?

Material Needed for a Chair:
- Side rails (2)
- Front legs (2)
- Cross bars (2)
- Back supports (3)
- Seat
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Chair Structure Tree (aka “Bill of Materials”)

Chair

<table>
<thead>
<tr>
<th>Leg Assembly</th>
<th>Seat</th>
<th>Back Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legs (2)</td>
<td>Side rails (2)</td>
<td>Back Supports (3)</td>
</tr>
<tr>
<td>Cross bar</td>
<td>Cross bar</td>
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</tbody>
</table>

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Example of MRP Logic and Product Structure Tree

Given the product structure tree for “A” and the lead time and demand information below, provide a materials requirements plan that defines the number of units of each component and when they will be needed.

Product Structure Tree for Assembly A

A

<table>
<thead>
<tr>
<th>B(4)</th>
<th>C(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(2)</td>
<td>E(1)</td>
</tr>
</tbody>
</table>

Lead Times

- A: 1 day
- B: 2 days
- C: 1 day
- D: 3 days
- E: 4 days
- F: 1 day

Demand

- Day 10: 50 A
- Day 8: 20 B (Spares)
- Day 6: 15 D (Spares)
First, the number of units of “A” are scheduled backwards to allow for their lead time. So, in the materials requirement plan below, we have to place an order for 50 units of “A” in the 9th week to receive them in the 10th week.

<table>
<thead>
<tr>
<th>Day</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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</tbody>
</table>

Next, we need to start scheduling the components that make up “A”. In the case of component “B” we need 4 B’s for each A. Since we need 50 A’s, that means 200 B’s. And again, we back the schedule up for the necessary 2 days of lead time.

<table>
<thead>
<tr>
<th>Day</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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Example of MRP Logic and Product Structure Tree (cont.)
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Example of MRP Logic and Product Structure Tree (cont.)

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<tr>
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Example of the MRP Process

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<th>PD</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
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</tbody>
</table>

Gross Requirements

Scheduled Receipts

Projected on Hand

Net Requirements

Planned Order Receipts

Planned Order Releases

Part D: Day 6

40 + 15 spares
Example of the MRP Process

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<th>Item: A</th>
<th>Lot Size: 25 min</th>
<th>Lead Time: 1</th>
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<tr>
<td>Item: A</td>
<td>Lot Size: 25 min</td>
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<th>PD</th>
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</thead>
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</table>

MRP Outputs

- Manufacturing Orders
- Purchasing Orders
- Various Reports
Summary of MRP

MRP is a.....
• Computerized Inventory Control
• Production Planning System
  that.....
• Schedules Component Items as Needed
  which will.....
• Track Inventory and.....
• Help you in many other aspects of business