CHAPTER 12

MRP and ERP

H.W.: 2, 6, 8, and 17.

Dependent Demand

- Dependent demand
  - Demand for items that are subassemblies or component parts to be used in the production of finished goods.
  - Dependent demand tends to be sporadic or “lumpy”

Independent and Dependent Demand

Independent demand is uncertain. Dependent demand is certain.

Independent & Dependant Demand Pattern

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bicycles

Rims

Rims

Rims

Order 1000 on day 3
Order 1000 on day 8

Reorder point

Discrete

Continuous

Day

Day

12-5

Dependent vs Independent Demand

- Material requirements planning (MRP):
  - A computer-based information system that translates master schedule requirements for end items into time-phased requirements for subassemblies, components, and raw materials.
  - The MRP is designed to answer three questions:
    1. What is needed?
    2. How much is needed?
    3. When is it needed?
What went wrong when EOQ is used to manage a dependent demand item?

- Incorrect assumption of uniform, continuous demand
- Incorrect assumption on item independence
- Lack of Forward visibility

Overview of MRP

• Master Production Schedule (MPS)
• Bill of Materials (BOM)
• Inventory Records

MRP Inputs: Master Schedule

• Master schedule:
  • One of three primary inputs in MRP; states which end items are to be produced, when these are needed, and in what quantities.
  • Managers like to plan far enough into the future so they have reasonable estimates of upcoming demands
  • The master schedule should cover a period that is at least equivalent to the cumulative lead time
  • Cumulative lead time
    • The sum of the lead times that sequential phases of a process require, from ordering of parts or raw materials to completion of final assembly.

MRP Inputs: Bill-of-Materials

• Bill of Materials (BOM)
  • A listing of all of the raw materials, parts, subassemblies, and assemblies needed to produce one unit of a product
  • Product structure tree
    • A visual depiction of the requirements in a bill of materials, where all components are listed by levels
Q. Determine the quantities of B, C, D, E, and F needed to assemble one X.

Low-level coding

- Restructuring the bill of material so that multiple occurrences of a component all coincide with the lowest level at which the component occurs.

Inventory records

- Includes information on the status of each item by time period, called time buckets
  - Information about
  - Gross requirements
  - Scheduled receipts
  - Expected amount on hand
  - Other details for each item such as
    - Supplier
    - Lead time
    - Lot size
    - Changes due to stock receipts and withdrawals
    - Canceled orders and similar events

MRP Inputs: Inventory Records

Assembly Time Chart

- Procurement of raw material D
- Fabrication of part E
- Subassembly A
- Procurement of raw material F
- Procurement of part C
- Subassembly B
- Procurement of part H
- Fabrication of part G
- Final assembly and inspection
### MRP Record

<table>
<thead>
<tr>
<th>Week Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Requirements</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Scheduled Receipts</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Projected on hand</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Net requirements</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Planned-order receipt</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Planned-order release</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

- **Gross requirements**
  - Total expected demand
  - Open orders scheduled to arrive
- **Projected Available**
  - Expected inventory on hand at the beginning of each time period

### MRP: Development

- The MRP is based on the product structure tree diagram
- Requirements are determined level by level, beginning with the end item and working down the tree
  - The timing and quantity of each "parent" becomes the basis for determining the timing and quantity of the children items directly below it.
  - The "children" items then become the "parent" items for the next level, and so on

### MPR Consideration

- **Safety Stock**
  - Theoretically, MRP systems should not require safety stock
  - Variability may necessitate the strategic use of safety stock
  - A bottleneck process or one with varying scrap rates may cause shortages in downstream operations
  - Shortages may occur if orders are late or fabrication or assembly times are longer than expected
  - When lead times are variable, the concept of safety time is often used
    - Safety time
      - Scheduling orders for arrival or completions sufficiently ahead of their need that the probability of shortage is eliminated or significantly reduced

### MPR Lot Sizing Rules

- **Lot-for-Lot (L4L) ordering**
  - The order or run size is set equal to the demand for that period
  - Minimizes investment in inventory
  - It results in variable order quantities
  - A new setup is required for each run

- **Economic Order Quantity (EOQ)**
  - Can lead to minimum costs if usage of item is fairly uniform
    - This may be the case for some lower-level items that are common to different "parents"
    - Less appropriate for "lumpy demand" items because inventory remnants often result
**MPR Lot Sizing Rules**

- **Fixed Period Ordering (POQ)**
  - Provides coverage for some predetermined number of periods

---

**Example MPR**

1. **Shutter**
2. **Frames (2)**
3. **Wood sections (4)**

---

**Example MPR: L-4-L ordering**

---

**Example MRP: EOQ**

---

**MRP Processing Example**

Note: Component D is required by two parents.
Other Considerations

- Safety Stock
- Lot sizing rules
  - Lot-for-lot (L4L) ordering
- Economic (fixed) order quantity
- Fixed-period ordering = periodic ordering = POQ
- Pros and cons of each?

Example: L4L rule with safety stock

<table>
<thead>
<tr>
<th>Item: C</th>
<th>Description: Pedestal assembly</th>
<th>Lot Size: L4L</th>
<th>Lead time: 2 weeks</th>
<th>Safety Stock: 50 units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Gross Requirements</td>
<td>150</td>
<td>120</td>
<td>150</td>
<td>120</td>
</tr>
<tr>
<td>Scheduled Receipts</td>
<td>230</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projected on hand</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned order receipts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned order releases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example: POQ rule with safety stock

<table>
<thead>
<tr>
<th>Item: C</th>
<th>Description: Pedestal assembly</th>
<th>Lot Size: P = 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead time: 2 weeks</td>
<td>Safety Stock: 50 units</td>
<td></td>
</tr>
</tbody>
</table>

| Date    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Gross Requirements | 150 | 120 | 150 | 120 |
| Scheduled Receipts | 230 |
| Projected on hand | 47 |
| Net requirements | |
| Planned order receipts | |
| Planned order releases | |

BOM for End Items A and B

From which item(s) shall we derive the gross requirements of item D?

Deriving G.R. from parent(s)

Updating the System

- An MRP is not a static document
  - As time passes
    - Some orders get completed
    - Other orders are nearing completion
    - New orders will have been entered
    - Existing orders will have been altered
      - Quantity changes
      - Delays
      - Missed deliveries
**MRP Outputs: Primary**

- **Primary Outputs**
  - **Planned orders**
    - A schedule indicating the amount and timing of future orders
  - **Order releases**
    - Authorizing the execution of planned orders
  - **Changes**
    - Revisions of the dates or quantities, or the cancellation of orders

**MRP Outputs: Secondary**

- **Secondary Outputs**
  - **Performance-control reports**
    - Evaluation of system operation, including deviations from plans and cost information
    - e.g., missed deliveries and stockouts
  - **Planning reports**
    - Data useful for assessing future material requirements
    - e.g., purchase commitments
  - **Exception reports**
    - Data on any major discrepancies encountered
      - E.g., late and overdue orders, excessive scrap rates, requirements for nonexistent parts

**MRP in Services**

- **Food catering service**
  - End item => catered food
  - Dependent demand => ingredients for each recipe, i.e. bill of materials
  - Hotel renovation
  - Activities and materials “exploded” into component parts for cost estimation and scheduling

**Benefits of MRP**

- Enables managers to easily
  - Determine the quantities of each component for a given order size
  - To know when to release orders for each component
  - To be alerted when items need attention
- Additional benefits
  - Low levels of in-process inventories
  - The ability to track material requirements
  - The ability to evaluate capacity requirements
  - A means of allocating production time
  - The ability to easily determine inventory usage via backflushing

**MRP Requirements**

- To implement an effective MRP system requires:
  - A computer and the necessary software to handle computations and maintain records
  - Accurate and up-to-date
  - Master schedules
  - Bills of materials
  - Inventory records
  - Integrity of data files

**MRP II**

- Manufacturing resources planning (MRP II)
  - Expanded approach to production resource planning, involving other areas of the firm in the planning process and enabling capacity requirements planning
  - Most MRP II systems have the capability of performing simulation to answer a variety of "what if" questions so they can gain a better appreciation of available options and their consequences
When MRP II systems began to include feedback loops, they were referred to as **closed loop MRP**.

**Closed Loop MRP**
- Systems evaluate a proposed material plan relative to available capacity.
- If a proposed plan is not feasible, it must be revised.
- This evaluation is referred to as capacity requirements planning.

**Capacity Planning**
- Capacity requirements planning (CRP)
  - The process of determining short-range capacity requirements.
  - Inputs to capacity requirement planning:
    - Planned-order releases for the MPR
    - Current shop loading
    - Routing information
    - Job time
  - Key outputs:
    - Load reports for each work center

**Using MRP to Assist in CRP**

**ERP**
- Enterprise resource planning (ERP)
  - ERP was the next step in an evolution that began with MRP and evolved into MRPII.
  - ERP, like MRP II, typically has an MRP core.
  - Represents an expanded effort to integration financial, manufacturing, and human resources on a single computer system.
  - ERP systems are composed of a collection of integrated modules.

**Requirements Planning—the evolution**
- MRP: generates schedules that meet the materials needs identified in the MPS.
- MRP II: ties basic MRP to the company’s financial system; allows for “what if” analysis (MPS, cash flow, etc.).
- ERP: enables firms to deal directly with suppliers to assess their resources availability (also includes quality, field services, distribution, marketing, accounting, etc.).
ERP Systems

- ERP represents a comprehensive information technology approach that brings all of an organization’s information, including all data related to sales and order management, manufacturing operations, financial systems, human resources, and marketing and distributions into a central repository.

- When implemented successfully, an ERP can link all areas of an enterprise with external suppliers, alliances, and customers into a tightly integrated system with shared data and visibility.

A Typical ERP System

ERP Potential Benefits:

- Drastic decline in inventory ($146 billion/year).
- Breakthrough reduction in working capital.
- Abundant information about customer wants and needs.
- Ability to view and manage extended enterprise.
- Reduced capacity-related costs ($240 billion/year).

ERP Implementation Success/Failure

- ERP success/failure:
  - 40% achieved partial implementation
  - 66-90% do not achieve return on investment
  - 20% total failure/abandoned
  - 50+% failure rate
  - 90% late or over-budget

ERP Strategy Considerations

- High initial cost
- High cost to maintain
- Future upgrades
- Training

Additional Company Experience with ERP

Muscatello, J., Small, M., and Chen, I.J.