Ch 25 Production Planning and Control

Sections:

1. Aggregate Production Planning and the Master Production Schedule
2. Material Requirements Planning
3. Capacity Planning
4. Shop Floor Control
5. Inventory Control
6. Extensions of MRP

Production Planning and Control

- Concerned with the logistics problems in manufacturing:
  - Managing the details of what, when, and how many products to produce
  - And obtaining the raw materials, parts, and resources to produce them
- PPC solves these logistics problems by managing information
- PPC is the integrator in computer integrated manufacturing

Production Planning

- Concerned with:

  1. Deciding which products to make, how many of each, and when they should be completed

  2. Scheduling the delivery and/or production of the parts and products

  3. Planning the manpower and equipment resources needed to accomplish the production plan
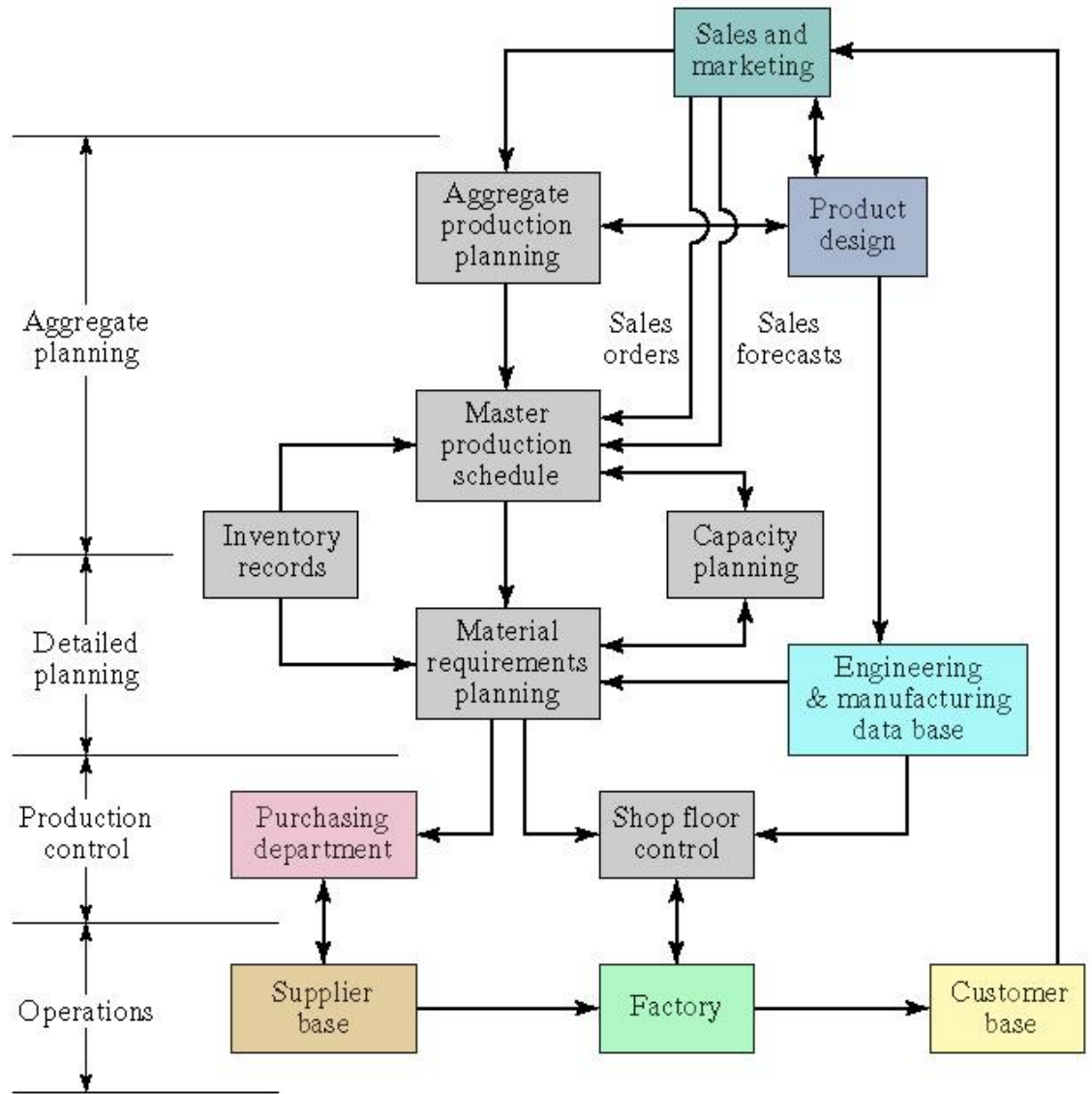
Activities in Production Planning

- Aggregate production planning – planning the production output levels for major product lines
  - Must be coordinated with product design, production, marketing, and sales
- Master production planning – specific schedule (master production schedule) of the quantities of individual models in each major product line
- Material requirements planning (MRP) – detailed schedule of raw materials and parts production for models in master schedule
- Capacity planning – planning labor and equipment resources to achieve the master schedule

Production Control

- Concerned with determining whether the necessary resources to implement the production plan have been provided
  - If not, it attempts to take corrective action to address the deficiencies
- Major topics in production control:
  - Shop floor control
  - Manufacturing execution systems
  - Inventory control
  - Manufacturing resource planning
  - Enterprise resource planning

Activities in a Production Planning and Control System

Aggregate Production Planning

Planning the production output levels for major product lines

- High-level corporate planning activity
- Must be coordinated with the plans of the sales and marketing departments
  - Includes products that are currently in production
    - Must consider current and future inventory levels of those products
  - Also includes new products currently being developed
- Marketing plans for current and new products must be reconciled against total capacity resources of the company

Aggregate Production Plan

Product line	Week									
	1	2	3	4	5	6	7	8	9	10
M model line	200	200	200	150	150	120	120	100	100	100
N model line	80	60	50	40	30	20	10			
P model line							70	130	25	100

- Indicates production output levels for the major product lines of the company

Master Production Schedule

The specific schedule of individual products and models that is derived from the aggregate production plan

- It is a list of the products to be manufactured, when they should be completed and delivered, and in what quantities

- Master production schedule includes three categories of items:
    1. Firm customer orders
    2. Forecasted demand
    3. Spare parts

Master Production Schedule

	Week									
Product line	1	2	3	4	5	6	7	8	9	10
M model line	200	200	200	150	150	120	120	100	100	100
N model line	80	60	50	40	30	20	10			
P model line							70	130	25	100

|	Week									
Product line models	1	2	3	4	5	6	7	8	9	10
Model M3	120	120	120	100	100	80	80	70	70	70
Model M4	80	80	80	50	50	40	40	30	30	30
Model N8	80	60	50	40	30	20	10			
Model P1								50		100
Model P2							70	80	25	

Specific schedule of individual products, quantities and times

Material Requirements Planning (MRP)

Computational technique that converts the master production schedule for end products into a detailed schedule for the raw materials and components used in the end products

- Useful for dependent demand items, not independent demand items
  - Independent demand items
    - Final products and spare parts
  - Dependent demand items
   - Component parts used in final products

Structure of an MRP System
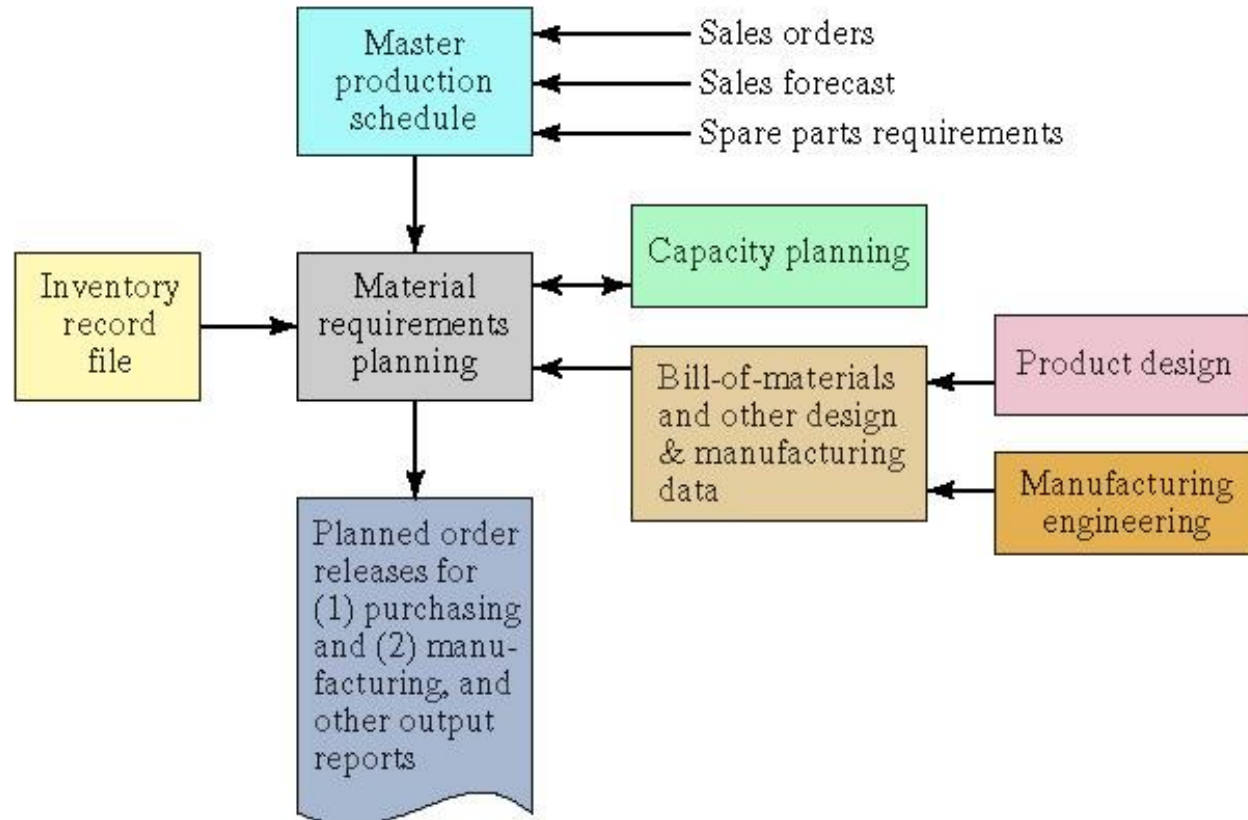
Inputs to the MRP System

1. Master production schedule
    - Expressed in terms of time buckets
2. Bill of materials file – product structure and list of component parts in each product
3. Inventory record file (item master file) – includes:
    - Item master data – part number, order quantities, lead times
    - Inventory status – time-phased record of inventory status
    - Subsidiary data – purchase orders, engineering changes

Typical Product Structure
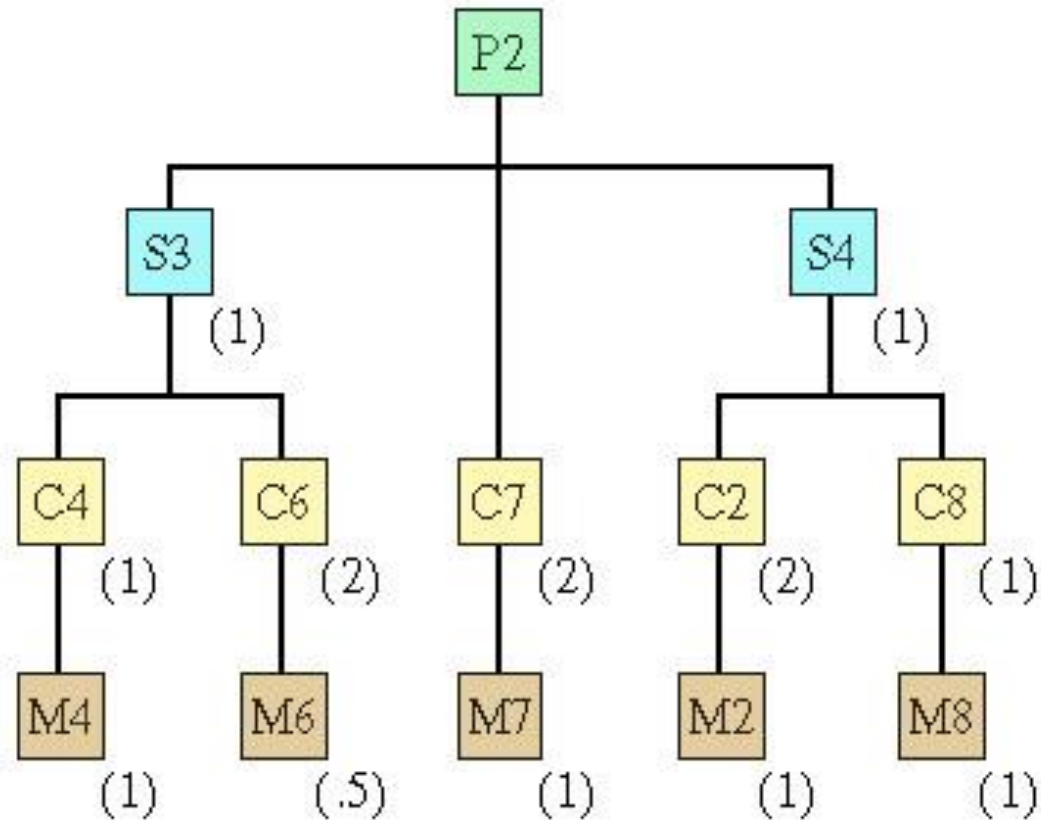
Inventory Record File

Period		1	2	3	4	5	6	7
Item: **Raw material M4**								
Gross requirements								
Scheduled receipts				40				
On hand	50	50	50	90				
Net requirements								
Planned order releases								

Complicating Factors in MRP

- Net requirements = gross requirements less on-hand inventories and less quantities on order

- Common use items – raw materials and components used on more than one product

- Lead times – scheduled delivery of end products must be translated into time-phased requirements of components and materials by factoring in lead times

  - Ordering lead times – time between purchase requisition and receipt from vendor

  - Manufacturing lead times – time between order release and completion

MRP Outputs

1. Planned order releases
   - Purchase orders – to buy raw materials and parts
   - Work orders – to make parts and products
2. Report of planned order releases in future periods
3. Rescheduling notices
4. Cancellation notices
5. Inventory status reports
6. Performance reports
7. Exception reports
8. Inventory forecasts

MRP Benefits Reported by Users

1. Reduction in inventory
2. Quicker response to changes in demand
3. Reduced setup and changeover costs
4. Better machine utilization
5. Improved capacity to respond to changes in master production schedule
6. Aid in developing the master schedule

# Why Some MRP Systems Do Not Succeed

1. Application was not appropriate
   - Usually because product structure did not fit data requirements of MRP
2. MRP computations based on inaccurate data
3. Master production schedule was not coupled with capacity planning
   - MRP generated an unrealistic schedule of work orders that overloaded the factory

Capacity Planning

Concerned with determining labor and equipment resources required to meet the current master schedule as well as long-term future production needs of the firm

- Also serves to identify the limitations of the available production resources so that an unrealistic master schedule is not planned

- Accomplished in two stages:

  1. Rough-cut capacity planning – to assess feasibility of master production schedule

  2. Capacity requirements planning – detailed capacity calculation for individual departments and work cells

Two Stages of Capacity Planning
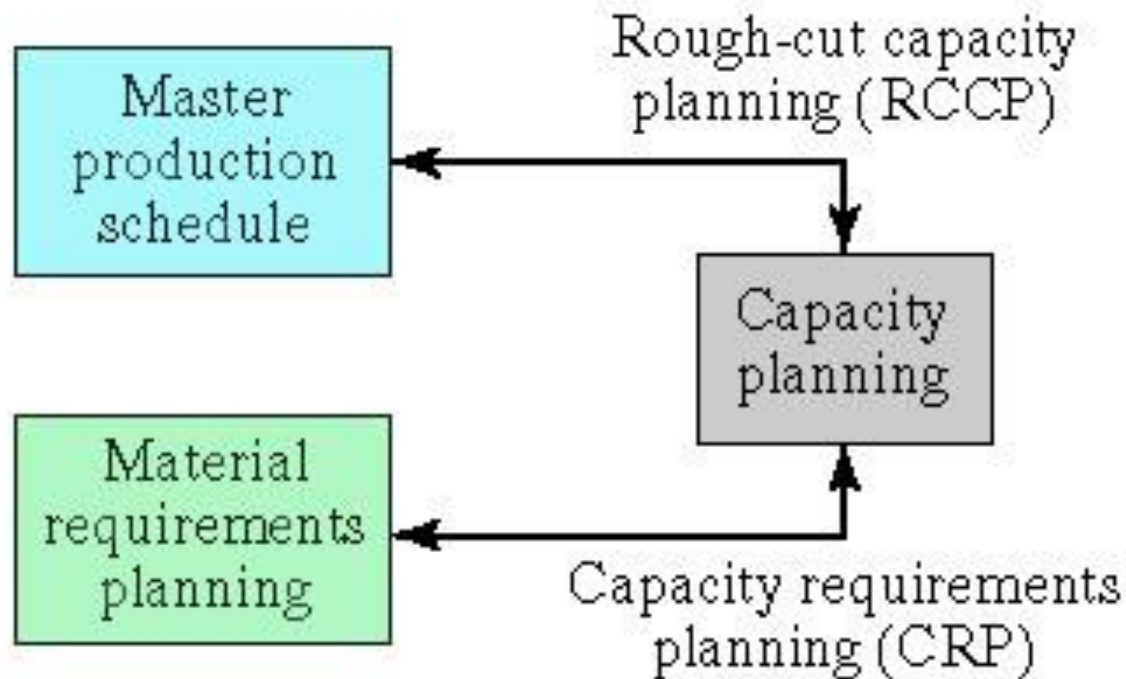
Short Term Capacity Adjustments

- Employment levels – hiring vs. layoffs
- Temporary workers
- Number of work shifts per period
- Labor hours per shift – overtime or reduced hours
- Inventory stockpiling – to smooth production and maintain steady employment
- Order backlogs
- Subcontracting – letting jobs during busy periods, taking in work during slack periods

Long Term Capacity Adjustments

- New equipment investments
- New plant construction
- Purchase of existing plants from other companies
- Acquisition of existing companies
- Plant closings

Shop Floor Control

Concerned with releasing production orders to the factory, monitoring and controlling the progress of the orders through the plant, and acquiring current information on the status of the orders

- Manufacturing execution system (MES) - the computer software that supports shop floor control
  - Typically includes capability to respond to on-line inquiries about the status of orders in the shop
  - Other MES functions may include generation of process instructions, real-time inventory control, and labor tracking

Three Phases in Shop Floor Control
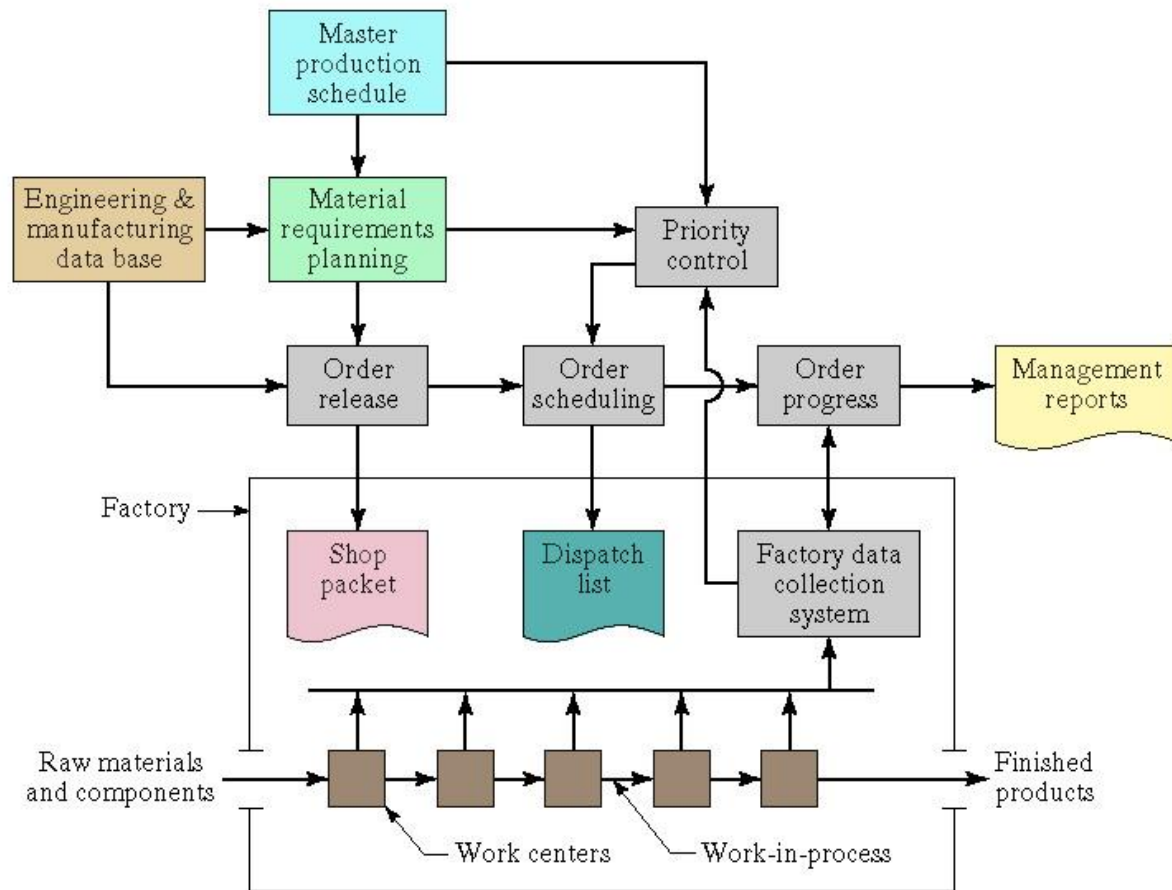
Three Phases of Shop Floor Control

1. Order release
2. Order scheduling
3. Order progress

Order Release

Provides documentation to process a production order through the factory

- Documentation (shop packet):
    - Route sheet – process plan
    - Material requisitions – to draw raw materials from inventory
    - Job cards - to report direct labor hours expended on order and track progress of order
    - Move tickets - to authorize transport of parts between work centers
    - Parts list (if assembly)

Order Scheduling

Assigns production orders to work centers in the plant

- Executes the dispatching function in production planning and control
- Solves two problems in production control:
  1. Machine loading – allocating orders to work centers
     - Shop loading – loading all machines in the plant
  2. Job sequencing – determining the sequence in which orders will be processed through each work center

Priority Control

Sets appropriate priority levels for production orders
- Possible dispatching rules in priority control:
  - First-come-first-serve
  - Earliest due date
  - Shortest processing time
  - Least slack time
    - Slack time = time remaining until due date minus processing time remaining
  - Critical ratio
    - Ratio of time remaining until due date divided by processing time remaining

Order Progress

Monitors the status of the orders in the plant, WIP, and other parameters that indicate production progress and performance

- Purpose is to provide information useful to manage the factory based on data collected from the factory
- Reports generated by order progress module:
    - Work order status reports – whether orders are on schedule or behind
    - Progress reports – number of orders completed vs. number that should have been completed
    - Exception reports – overdue jobs, other exceptions

Factory Data Collection System

Consists of the various paper documents, terminals, and automated devices throughout plant for collecting data on shop floor operations

- Includes methods to compile and process the data
- Functions of factory data collection system:
  1. To supply status and performance data to the shop floor control system
  2. To provide current information to production foremen, plant management, and production control personnel

Types of Data Collected

- Direct labor time on each order
- Parts scrapped or needing rework
- Piece counts completed at each work center
- Equipment utilization and downtime
- Time clocks for employees

Manual (Clerical) Data Input Techniques

Production workers read and fill out paper forms indicating order progress data - examples:

- Job traveler – workers must record their time spent, piece counts, rejects, etc., onto log sheet that travels with shop packet

- Employee time sheets – workers fill out daily time sheet indicating orders worked on, pieces completed

- Operation tear strips – preprinted sheets that can be separated from shop packet, filled out, and turned in

- Prepunched cards – similar to tear strips

Automated and Semi-Automated Data Collection Systems

- Hardware and technology includes:
  - Specialized keypads or conventional keyboards
  - Optical bar code readers
  - Other AIDC systems
- Configurations:
  - One centralized terminal
  - Satellite terminals
  - Workstation terminals

Inventory Control

- Concerned with achieving an appropriate compromise between two opposing objectives:

  1. Minimizing the cost of holding inventory

     - Implies keeping inventory to a minimum

  2. Maximizing customer service

     - Implies keeping large stocks on hand so the customer can immediately take possession

Costs of Holding Inventory

1. Investment costs
   - Cost of money tied up in inventory until the customer pays for the finished product
2. Storage costs
   - Cost of space to store the inventory
3. Cost of possible obsolescence or spoilage
   - Reduction in value of inventory when it cannot be used
- Collectively, these costs are referred to as carrying costs or holding costs

Order Point Inventory Systems

- Concerned with two related problems that must be solved when managing inventories of independent demand items:

  1. How many units should be ordered?

     - Often solved by using economic order quantity formulas

  2. When should the order be placed?

     - Can be solved using reorder point methods

Inventory Model in Make-To-Stock
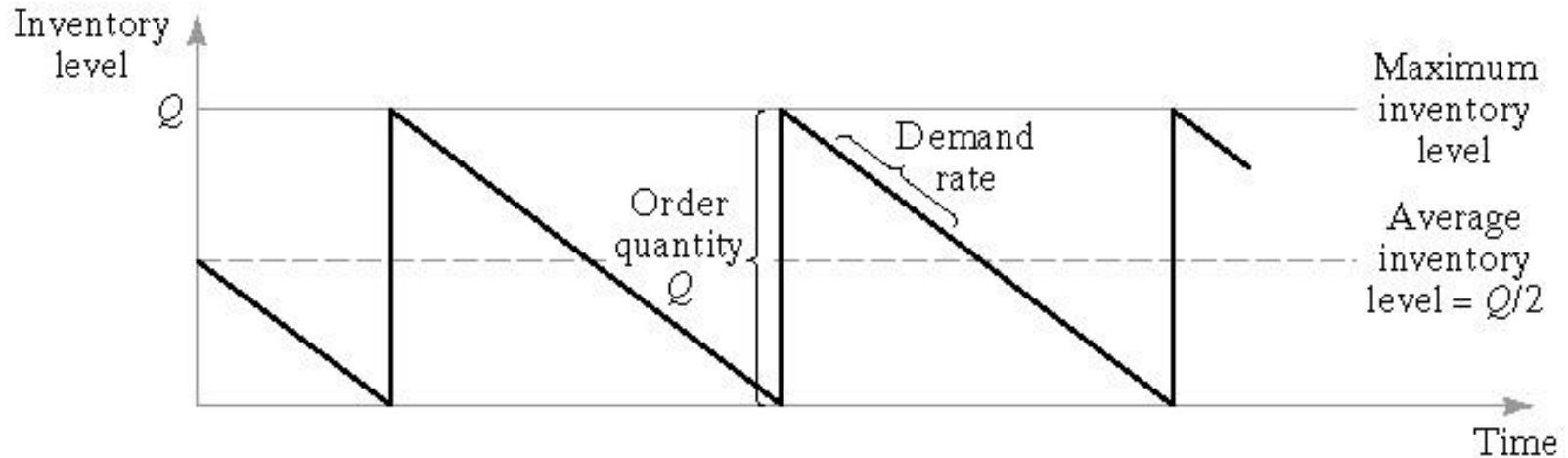
Inventory level over time in a typical make-to-stock situation

Economic Order Quantity Formula

- Situations when EOQ formula is appropriate:
  1. Demand rate for the item is fairly constant
  2. Rate of production is significantly greater than the demand rate

Total Inventory Cost Equation

- Total annual cost of inventory includes two terms
  1. Cost of holding inventory
  2. Cost of reordering or setup
- Equation for total inventory cost *TIC*

$$TIC = \frac{C_h Q}{2} + \frac{C_{su} D_a}{Q}$$

where C_h = holding cost, Q = order quantity, C_{su} = setup cost, and D_a = annual demand for the item

EOQ Formula

- By taking the derivative of *TIC* with respect to *Q* and setting the derivative equal to zero, the minimum cost order quantity can be determined

$$Q = EOQ = \sqrt{\frac{2D_a C_{su}}{C_h}}$$

Reorder Point Systems

- The actual demand rate for the item is not constant throughout the order cycle
- The time to reorder occurs when the actual inventory level falls below a point known as the reorder point

Operation of Reorder Point System
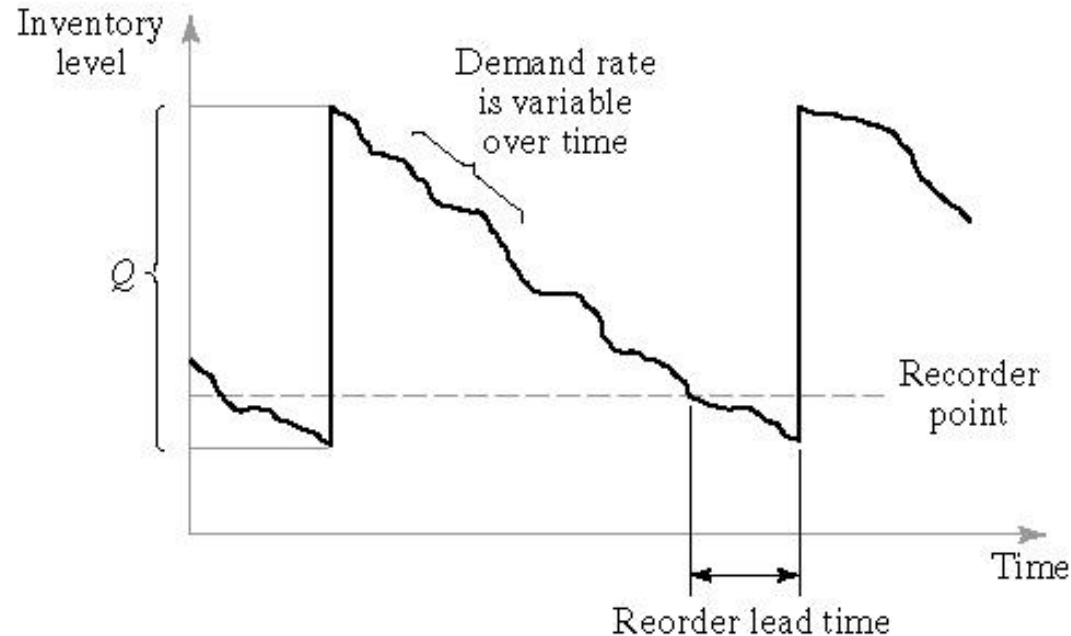
When inventory level reaches the reorder point, the next order for quantity *Q* is placed

Extensions of MRP

- Manufacturing resource planning (MRP II)
- Enterprise resource planning (ERP)

Manufacturing Resource Planning (MRP II)

Computer-based system for planning, scheduling, and controlling the materials, resources, and supporting activities needed to meet the master production schedule

- Typical modules in MRP II:
  - Management planning – aggregate production planning, master production scheduling
  - Customer service – sales forecasting, order entry, finished goods inventory
  - Operations planning – MRP enhanced with capacity requirements planning
  - Operations execution – purchasing, production scheduling and control, shop floor control

Enterprise Resource Planning (ERP)

Defined as a computer software system that organizes and integrates all of the data and business functions of an organization through a single, central database

- The functions include:

Sales	Marketing	Purchasing
Operations	Logistics	Distribution
Inventory control	Accounting	Finance
Human resources		

- ERP runs as a client-server system - users access the system through their PCs
- ERP operates company-wide, not just plant-based

ERP Uses a Single Database

- Avoids problems such as
  - Data redundancy or conflicting data in different databases
  - Time delays in entering the data
  - Communication issues between different databases
- Everyone in the organization has access to the same sets of data according to their individual job responsibilities
  - Not all of the data can be accessed by all employees

ERP Systems Include Multiple Software Modules

- Each module is focused on a different business function or group of functions
- Modules are integrated through the ERP framework
- Modules can be classified into four main groups
  1. Production and materials management - MRP II, master production scheduling, process planning
  2. Sales and marketing - order input, customer service, delivery, invoicing, product returns
  3. Finance and accounting - budgeting, cost control, asset management, accounts payable
  4. Human resources - payroll, benefits, training, job descriptions, employee personal data