INVENTORY CONTROL

Johan Oscar Ong, ST, MT
I.1 DEFINITION

- **Inventory** are material held in an idle or incomplete state awaiting future sale, use, or transformation. (*Tersine*)

- **Inventory** are a stock of goods. More generally, inventory can be regarded as an idle resources that has economic value. An inventory is made up of one or more items where each item is a unique supply item, raw material, purchased or manufactured part, assembly, or final product. (*Smith*)
I.2 TYPES OF INVENTORY (1/2)

- Inventory may consist of supplies, raw material, in-process goods, and finished goods.

**FIGURE 1-1  Inventory**

Material held in an idle or incomplete state awaiting future sale, use, or transformation.
I.2 TYPES OF INVENTORY (2/2)

- **Supplies** are inventory items consumed in the normal functioning of an organization that are not a part of the final product. Typical supplies are pencils, paper, light bulbs, disks, drill bits, cutting tools, and facility maintenance items. (Factory supplies are called MRO, for maintenance, repair, and operating supplies)

- **Raw materials** are items purchased from suppliers to be used as inputs into the production process. Typical raw materials for a furniture manufacturer are lumber, stain, glue, screws, varnish, nails, paint, and so forth.

- **In-process goods** are partially completed final products that are still in the production process.

- **Finished goods** are the final product, available for sale, distribution, or storage
1. Lot-size inventories (cycle inventories or working stock) is inventory acquired and held in advance of requirements so that ordering can be done on a lot size rather than on an as needed basis.

- These inventories exist because there is some economy of scale in replenishment.
- It is economical to replenish in large lots or at least at a rate faster than demand.
- The sources of these economies of scale are setup costs, costs of preparing production or purchase orders, transportation price breaks, and vendor quantity discounts.
2. **Safety stocks (fluctuation stock)** is inventory held in reserve to protect against the uncertainties of supply and demand.

- **Lead times** may be longer than expected.
- The quantity rejected at **inspection** can only be estimates in advance.
- Safety stock protect against failure to satisfy the needs of manufacturing or fill customer orders on time due to these uncertainties.
3. Anticipation stock (seasonal stock or stabilization stock or leveling inventory) is inventory built up to cope with peak seasonal demand, erratic requirements (promotional programs, strikes, or vacation shutdowns), or deficiencies in production capacity.
4. **Pipeline stock (transit stock or work-in-process or transportation inventories)** is inventory put in transit to allow for the time it takes to receive material at the input end, send material through the production process, and deliver goods at the output end.

- **Externally**, pipeline stock is inventory on trucks, ships, and railcars or in a literal pipeline.
- **Internally**, it is being processed, waiting to be processed, or being moved.
5. **Decoupling stock** is inventory accumulated between dependent activities or stage to reduce the requirement for completely synchronized operations. It isolates one part of the system from the next to allow each to operate more independently.
6. **Psychic stock** is retail display inventory carried to stimulate demand and act as a silent salesperson. It increases the chance an item is seen and considered for purchased.
The objective of inventory management is to have the appropriate amounts of materials in the right place, at the right time, and at low cost.

1. Purchased cost,
2. Order/setup cost,
3. Holding cost,
4. Stockout cost.
1. Purchased cost \((P)\) of an item is the unit purchased price if it is obtained from the external sources, or the unit production cost if it is produced internally.

- For purchased items, it is the purchased price plus any freight cost.
- For manufactured items, the unit cost includes direct labor, direct material, and factory overhead.
2. Order/setup cost (C) originates from the expense of issuing a purchased order to an outside supplier or from internal production setup costs.

- The **order cost** includes such items as making requisitions, analyzing vendors, writing purchased orders, receiving materials, inspecting materials, following up orders, and doing the processing necessary to complete the transaction.

- The **setup cost** comprises the costs of changing over the production process to produce the ordered item. It usually includes preparing the shop order, scheduling the work, preproduction setup, expediting, and quality acceptance.
3. **Holding cost** (H), synonymous with carrying cost, subsumes the costs associated with investing in inventory and maintaining the physical investment in storage. It incorporates such items as **capital costs**, **taxes**, **insurance**, **handling**, **storage**, **shrinkage**, **obsolescence**, and **deterioration**.
I.5 INVENTORY COSTS (5/5)

4. **Stockout cost (depletion cost=π)** is the economic consequence of an external or an internal shortage. An external shortage occurs when a customer’s order is not filled; an internal shortage occurs when an order of a group or department within the organization is not filled.

- A customer order for a make-to-stock item that is not in stock result either lost sale or back order. If it is a **lost sale**, then the direct profit is lost. If the order is **back-ordered**, the cost includes any expediting that may be required, such as extra setup costs incurred when a shop order is split. Or it might involve paying to air express the item from a distant regional warehouse.
- Whether the shortage results in a lost sale or a back order, there is a potential loss of goodwill.
- If the item is used internally, the cost of a shortage may consist of expediting costs plus the cost of an idle machine or assembly line waiting for the part.
I.6 INVENTORY FLOW CYCLE

**Figure 1-4** Manufacturing inventory flow cycle

- **SUPPLY**
  - (Purchasing)
  - Raw materials & supplies
  - (Production control)
  - In-process goods
  - (Production control)
  - Finished goods
  - (Marketing)

- **DEMAND**
The two fundamental questions posed to any inventory system are *how many* and *when to order*.

The same number of units (how many) always is ordered, and the time between order (when) is not expected to vary. The stock level is reviewed with each transaction, and whenever the inventory position reaches a predetermined point (reorder point), an order for a fixed number of units is placed.

Thus, the two defining parameters of the system are the **reorder point (B)** and **the size of the order (Q)**.

The fixed order size system also is termed a **Q-system**, since the size of the order (Q) is fixed for each replenishment. A typical example is depicted in figure 3-1.
I.7.1 FIXED ORDER SIZE SYSTEMS (2/2)

![Flowchart diagram]

**Stock available**

Demand occurs (units withdrawn)

Determine stock position (on hand + on order - backorders)

Is stock position ≤ Reorder point?

Yes

Issue replenishment order

(stock receipt)

**Figure 3-1** Fixed order size system
I.7.1.1 ECONOMIC ORDER QUANTITY (EOQ) - Single Items (1/7)

- The order size that minimizes the total inventory cost is known as the economic order quantity (EOQ).
- The classical inventory model assumes the idealized situation shown in figure 3-2, where $Q$ is the order size. Units are withdrawn from inventory at a constant demand rate, which is represented by the negative sloping lines. **When the inventory reaches the reorder point $B$, a new order is placed for $Q$ units.**
- The new lot is received just as the inventory level reaches zero, so the **average inventory** is $(Q+0)/2$, or $Q/2$.

---

**Figure 3-2** Classical inventory model

- $Q = \text{lot size}$; $Q/2 = \text{average inventory}$; $B = \text{reorder point}$; $ac = ce = \text{interval between orders}$; $ab = cd = ef = \text{lead time}$. 
If stockouts are not permitted, the total inventory cost per year is graphically depicted by figure 3-3 and by the following formula:

$$\text{TC} = PR + \frac{CR}{Q} + \frac{HQ}{2}$$

Where:
- $R =$ annual demand in units,
- $P =$ purchase cost of an item,
- $C =$ ordering cost per order,
- $H =$ holding cost per unit per year,
- $Q =$ lot size or order quantity in units,
- $F =$ annual holding cost as a fraction of unit cost.
I.7.1.1 ECONOMIC ORDER QUANTITY (3/7)

FIGURE 3-3  Annual inventory costs
To obtain the minimum cost lost size (EOQ), take the first derivative of total annual cost with respect to the lot size \((Q)\) and set it equal to zero:

\[
\frac{dTC}{dQ} (Q) = \frac{H}{2} - \frac{CR}{Q^2} = 0
\]

Solving the equation for \(Q\), we get the Economic Order Quantity (EOQ):

\[
Q^* = \sqrt{\frac{2CR}{H}} = \sqrt{\frac{2CR}{PF}}
\]

Once the economic order quantity is known, the number of orders placed during the year, \(m\), and the time between order, \(T\), can be determined:

- Number of orders during year = \(m = \frac{R}{Q^*} = \frac{\sqrt{HR}}{2C}\)
- Order interval = \(T = \frac{1}{m} = \frac{Q^*}{R} = \sqrt{\frac{2C}{HR}}\)
• The reorder point is obtained by determining the demand that will occur during the lead time period. When the stock position (on hand + on order - backorders) reaches the reorder point, an order will be placed for $Q^*$ units, the economic order quantity. The following formula gives the reorder point when the lead time $L$ expressed in months:

$$B = \frac{RL}{12}$$

= reorder point in units.

• If the lead time $L$ expressed in weeks, the reorder point is expressed as:

$$B = \frac{RL}{52}$$

= reorder point in units.

• The minimum total cost per year is obtained by substituting $Q^*$ for $Q$ in total annual cost equation. A simplified formula for the minimum total cost per year results:

$$TC(Q^*) = PR + HQ^*$$
The classical EOQ model is based on the following assumptions:

1. The demand rate is known, constant, and continuous.
2. The lead time is known and constant.
3. The entire lot size is added to inventory at the same time.
4. No stockouts are permitted; since demand and lead time are known, stockouts can be avoided.
5. The cost structure is fixed; order/setup costs are the same regardless of lot size, holding cost is a linear function based on average inventory, and unit purchase cost is constant (no quantity discount)
6. There is sufficient space, capacity, and capital to procure the desired quantity.
7. The item is a single product; it does not interact with any other inventory items (there are no joint orders).
**Example:**
The Siapa Manufacturing Company purchases 8000 units of a product each year at a unit cost of $10.00. The order cost is $30.00 per order, and the holding cost per unit per year is $3.00. What are the economic order quantity, the total annual cost, the number of orders to place in one year, and the reorder point when lead time is two weeks?

- \( Q^* = \sqrt{\frac{2CR}{H}} = \sqrt{\frac{2(30)8000}{3}} = 400 \) units,
- \( TC(Q^*) = PR + HQ^* = 10(8000) + 3(400) = $81,200, \)
- \( m = \frac{R}{Q^*} = \frac{8000}{400} = 20 \) orders/year,
- \( B = \frac{RL}{52} = \frac{8000(2)}{52} = 307.7 \) units.