

## Chapter 16

### Inventory Management

Empty Shelves (as shown in Figure 16.1)– are they empty because of poor inventory management or poor forecasting? A good case could be made for either. Obviously with the panic buying of 2020, no one could have forecasted the rush to hoard products or stock enough products in a store to accommodate the rapid demand for inventory. However, contingency planning for inventory could have partially alleviated some of the stockouts.



**Figure 16.1: Empty Shelves in Florida in 2020**

Proper and accurate inventory management is critical to the overall success of the supply chain and the operations management chain. This is one of the strongest links between operations management and accounting. Inventory management is an accounting activity. Some of the banks in Brazil are starting to see the link between finance and inventory management. These banks are starting to view ATMs as retail outlets, the banks as mini-distribution centers,

the central bank as the long term storage warehouse, and the inventory is the cash in the ATM. They have to determine the inventory levels for the retail outlets (ATMs) and the reorder points to keep these retail facilities stocked.

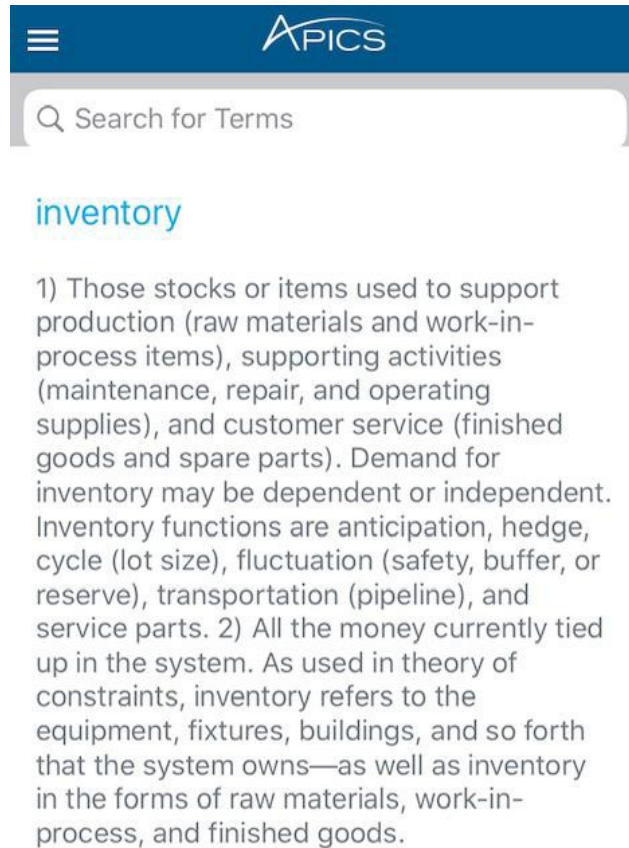
The inventory manager must answer four basic questions and work closely with the forecasting to ensure that the right amount of inventory is available. Most texts only list the first three questions, however, in 21<sup>st</sup> Century Supply Chains, the fourth question is just as important. The four questions that must be answered by the inventory manager are:

1. What should be ordered?
2. When should it be ordered?
3. How much should be ordered?
4. Where should it be stocked?

The goal of this chapter is to help the operations manager and the inventory manager answer the first three of these questions. Question number 4 is linked to location analysis and an understanding of the customer base and customer clusters. Answering these questions creates a balancing act for the inventory manager. How much is enough and how much is too much?

### **What Is Inventory?**

Inventory is an insurance policy against stocking out and against not having what the customer wants at the time that the customer wants it. The APICS/ASCM Dictionary defines inventory as:



**Figure 16.2: Screenshot of APICS Dictionary App definition for Inventory<sup>89</sup>**

Unlike automobile insurance or homeowner’s insurance, for this form of insurance you want just the right amount and you want to use your insurance. Most people that pay for insurance buy the insurance with the hope that it will never be used. The insurance known as inventory is one type of insurance that you want to use every day in meeting the customers’ needs because the reason for the insurance level is based on your desired customer service levels. You want your insurance to be there to prevent the customer from going to the competition. This is where the balancing act comes in. You want enough inventory to meet the needs of the

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<sup>89</sup> The APICS Dictionary app is available for free from the Apple Store and provides a readily available resource for supply chain and operations management terms.

customer without having so much inventory that it goes bad, becomes obsolete, or costs the company large amounts of money to store the product while waiting for the customer to want the product. Inventory that does not sell is a liability to the company and consumes resources that could be used for other activities or for more of the right inventory.

There is another balancing act in inventory management. This balancing act is between the financial managers, the inventory managers, and the procurement/acquisition managers. Financial managers see inventory as a liability because the only good inventory to the finance managers is cash. Therefore, finance managers want lower inventory levels and higher levels of cash. Inventory managers want high stockpiles of the right raw materials. Marketing managers want the proper levels of finished goods to meet customer needs. The procurement/acquisition managers have to purchase the right amounts of inventories to meet the production requirements and finished goods requirements while trying to keep the financial managers happy at the same time. This is one reason why procurement folks usually do not smile much.

Inventory is simply the stocks maintained by a company to meet normal demand patterns. Safety stock is maintained to cover the variability in demand. The decisions made concerning inventory levels and the types of inventories maintained have impacts other areas of operations management and may impact positively or negatively the profitability of the company.

### **Types of Inventory**

There are many different types of inventory that a company may have to meet the customers' needs. This list is not an exhaustive list, but it does show the primary forms of inventory.

- ❖ **Raw materials:** In any manufacturing operation, somewhere in the manufacturing chain raw materials are needed to produce products. The operations manager has to manage the inventory levels of raw materials, especially if there is a shelf life for the raw material. In other words, will the materials spoil/rot/deteriorate over time if more than the required amount is stocked or if the amount stocked exceeds the needs of the company?
- ❖ **Purchased parts:** If the company does not make the product from raw materials then it will most likely stock the assemblies that will be used to assemble the product. Raw materials and purchased parts are not an either/or stockage. A company may use some raw materials for certain parts of the product and assemblies for the rest of the product.
- ❖ **Labor:** Most textbooks will tell you that this is a form of inventory. It is included in this list to show that in the real world this should never be considered a form of inventory. The reason for this is that with the exception of professional sports, labor is not bought and sold or stored waiting for consumption like inventory. During the eighteenth and nineteenth centuries, in the United States (and continuing into this century in some countries)<sup>90</sup>, the use of people as a commodity that was bought, sold, and traded was practiced. This practice almost destroyed the United States and is still impacting the country over 150 years after the practice was abolished. The picture in Figure 16.3 is the Old Slave Mart in Charleston, South Carolina. This Mart was the largest in the United

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<sup>90</sup> One of the biggest concerns and areas of interests in 21<sup>st</sup> Century Supply Chain is who is making the product and is the worker being forced to work in the factory or serving some form of indentured servitude or slavery while working on the products. Concerns center around knowing what is going on in a supply chain and what suppliers are doing to produce the goods at the low prices.

States and continued to operate long after the sale of slaves was outlawed in the country.

**The key with people is: you manage things and you lead people! In other words you manage inventory and since you do not manage people, they should not be considered a category of inventory. Companies do not own their employees and although employees are the greatest asset of a company, they are led not managed.**



**Figure 16.3: The Slave Mart in Charleston, South Carolina**

If you are ever in Charleston, SC, I highly recommend that you visit this museum to remind you of what this type of activity can do to a person and a country. The effects of this activity linger today and can be seen from a historical perspective in Kansas City, MO, at the Negro Leagues Baseball Museum. <sup>91</sup>

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<sup>91</sup> The Negro Leagues Baseball Museum ([www.nlbm.com](http://www.nlbm.com)) was established to memorialize the time period when baseball was segregated and people of color were not allowed to play in the Major Leagues of Baseball. Like the Old Slave Mart Museum in Charleston, SC, this museum is a great place to get an historical perspective of what life used to be like in the USA.

- ❖ **Work-in-Process (WIP):** Work-In-Process inventory is simply items that are somewhere between raw materials and finished goods. WIP is partially completed products and is the only form of inventory that everyone in the company agrees is a liability. WIP has no value to anyone. It cannot be sold as a finished product and cannot be put back on the shelf for later use. Figure 16.4 shows work-in-process at Krispy Kreme Doughnuts. The process for producing a doughnut involves a “rising” process for the formed doughnuts and then the raw doughnut is placed in the hot oil to cook the doughnut. The doughnut is then flipped so that both sides of the doughnut get evenly cooked. Even a lover of hot Krispy Kreme doughnuts would not want a half-cooked doughnut. Sometimes the doughnut does not flip. In this case the WIP doughnut is thrown away before the product reaches the frosting waterfall.



**Figure 16.4: Doughnuts as Work-In-Process at Krispy Kreme**

In a manufacturing environment WIP builds up behind unbalanced workstations (refer back to the discussion on process design) and may show an inventory manager where the constraints are in the process. Like the half-cooked Krispy Kreme doughnuts, the WIP in the manufacturing environment is of no value to the company or the customer.

Work in Process inventory is considered a liability by everyone in the supply chain, efforts to reduce WIP will help contribute to adding value to the operation.

- ❖ **Component parts:** This inventory category includes the nuts, bolts, screws, washers, and fasteners used to assemble a product. This type of inventory is not usually the high dollar inventory items but is just as critical to the success of the manufacturing operations and should not be neglected. A \$2 dollar component may be just as important to the assembly of a product as the \$2000 component.
  
- ❖ **Maintenance, Repair, and Operations (MRO):** This is an aspect of inventory that is often overlooked by most academic textbooks. According to the *APICS Operations Management Body of Knowledge*, MRO inventory is defined as: “items used to support general operations and maintenance, such as spare parts, and consumables used in the manufacturing process and supporting operations.”<sup>92</sup> Although these parts are critical to the successful operations of a facility or manufacturing process and not the glamorous inventory items like raw materials and finished goods inventory, MRO inventory should be managed as carefully as other forms of inventory. A spare part for any of the machines or material handling equipment will bring an operation to as quick a stop as the shortage of the component parts. While managing MRO inventory it is important to remember that a \$6.00 fan belt can cripple a machine as quickly as a \$3000 engine. This makes it critical to understand each item that is or may be stocked in MRO inventories.

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<sup>92</sup> MRO, *APICS Operations Management Body of Knowledge*, 2nd edition, APICS, Chicago, IL, 2010, p.



MRO inventory is not limited to manufacturing operations. In an office setting MRO inventory is found in the supply room as office supplies. Work in an office can come to a halt without the necessary office supplies. Can you put together a professional presentation without printer cartridges or printer paper? Of course, you cannot.

MRO supplies are also necessary in an academic environment. Imagine trying to take an exam in a large classroom without the printed exams or the scantron sheets or the “blue” essay books, or pencils?

- ❖ **Working capital:** This is the finance manager’s favorite form of inventory. This form of inventory is necessary for the success of the any operation. A lack of cash flow or available cash will cripple any operation regardless of the size of the company.
- ❖ **Tools, machinery, and equipment:** In a manufacturing environment or in a distribution operation, the tools, machines, and equipment used to make the products or move the products are part of the inventory. If the proper levels of this category of inventory are not maintained, the capacity and production capabilities of the company could be significantly reduced.

In the distribution center a shortage of pallet jacks, pallet racks, or forklifts can impact the ability to provide rapid response to the customers. In the classroom the shortage of desks or chairs impacts the capacity of the school to provide quality education if it means students are sitting in folding chairs or on the floor.

- ❖ **Safety stock:** Safety stock is an insurance policy on the insurance policy of inventory or maybe an insurance rider. Safety stock is stockage above normal stock levels to help prevent a stockout due to increased demands for the product, longer than normal lead times for replenishment, or variability in the levels of the demand for the product.

The US Army’s manual for warehousing operations refers to safety stock as a safety level and describes the safety stock as the “quantity of stock on hand to sustain operations in the event the demand rate changes unusually or the replenishment time becomes longer than expected. It is a safety factor intended to be used while replenishment requisitions are still due in.”<sup>93</sup>

Safety stock does not need to be carried for every item. A company may decide to take acceptable risk with certain high dollar items in order to have safety stock for more less expensive items. After all, a smaller, less expensive repair part such as a fan belt can cripple a car just as quickly as a blown engine and probably a fan belt needs to be replaced more often than a complete engine. Therefore, a repair parts company will more likely have safety stock for fan belts and windshield wipers than automobile engines.

Nor does the safety stock need to be kept at each location. It may be more economical for the company to maintain safety stock at a central location rather than at every distribution center or at every store. A centrally located safety stock for a retail operation with 100 stores would mean one set of safety stock rather than 100 sets of safety stock. This concept only works if the centrally located safety stock can be delivered to the needed location quickly. This may be the justification for a safety stock distribution center located near the FedEx or UPS major sorting facilities. Otherwise, the savings from the centralized stock may be negated by premium shipping charges or lost sales due to stockouts.

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<sup>93</sup> Department of the Army Pamphlet 710-2-2, Supply Support Activity Supply System: Manual Procedures, Headquarters, Department of the Army, Washington, DC, 1998, p. 19.

- ❖ **Just-in-case:** Just-in-case inventory is the opposite of just-in-time inventory. Just-in-case stocks are kept in the inventory just in case a customer may want it. Just-in-case inventory is not supported by any calculation or inventory model. This form of inventory may or may not be demand supported or even productive inventory. In many cases, the just-in-case inventory may be reducing the inventory turns calculations because the inventory is not moving as it is there just in case someone orders it or asks for it.

Sometimes just-in-case inventory is a good thing. Some items in inventory need just-in-case stocks to prevent stocking out of the items. Toilet paper is a good example of stocks that should be kept as just-in-case, because stocking out of toilet paper is not a good thing. Beer at a party is another example of the need for just-in-case stocks. Why? Because if you run out in the middle of the party there is a chance that the person going to get more beer will not come back to the party (especially when a flawed decision process allows a driver who has already had too much beer to pick up the beer ).

However, in the real world just-in-case stocks manifest themselves as stock on the shelves of the stores just in case a customer may need that product again in the future. The key here is to determine that point in the life cycle of a product that the repair part should no longer be stocked or how long a product should be kept on the shelf before it is removed from the inventory.

- ❖ **Vendor Managed Inventory (VMI):** This concept was discussed in the supply chain chapter but needs to be discussed here to complete the discussion of inventory. VMI is inventory on the shelf but does not count against the inventory value of the facility. The inventory on the shelf belongs to the vendor until it is sold by the store. An example of this is the tool department at The Home Depot. The tools belong to the vendors until the

product is sold. The bottom line of the VMI program is that the onus is on the vendor to keep the products stocked on the shelf.

Wal-Mart and Proctor and Gamble have perfected the partnership on VMI. The benefit to Proctor and Gamble is information on what is being sold in order to better schedule deliveries and production. The benefit to Wal-Mart is a savings of eight-man years per store per year by not having to count the products on the shelves, place orders for the items, receive the items, and place the items on the shelves. With “8,613 retail units under 55 different banners in 15 countries”<sup>94</sup> this amounts to approximately 69,000-man years for Wal-Mart. At an average wage of \$12 an hour, this means that the VMI partnership with Proctor and Gamble saves Walmart approximately \$1.7 billion annually.

- ❖ **Finished goods:** Upon completion of the manufacturing process, inventory may take the form of finished products awaiting shipment or waiting for customer orders in the case of make-to-stock items. If the forecasts are relatively accurate for the make-to-stock items, the amount of finished product held for sale will not become obsolete inventory. These finished goods may be in warehouses/distribution centers or may be in-transit inventory.
- ❖ **In-transit inventory:** This form of inventory is finished goods that have departed the manufacturing facility enroute to a distribution center or from a distribution center to a customer or retailer. The problem with in-transit inventory is that this inventory, if not enroute to a customer, is not available to for sale to a customer or available for use in a manufacturing facility. The goal of all companies is to minimize in-transit inventory. In

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<sup>94</sup><http://walmartstores.com/AboutUs/>, accessed September 27, 2010.

2009, Maersk Lines announced that they would save over \$1 billion (USD) by reducing shipping speeds by half. For Maersk Lines this move produced savings from reduced fuel costs. For customers of Maersk Lines this move doubled the in-transit times for product in-transit—more dollars tied up in inventory that is not available for sale to customers.

**Addiction to Inventory.** Unfortunately, the bottom line is that sometimes inventory is held in all of the above forms as an addiction. Some managers become addicted to inventory – the more one has, the more value that they perceive they are to the company (akin to the idea of he who dies with the most toys...). Inventory is used to cure ills and inefficiencies in a company’s processes or supply chains. When I was at the US Army’s National Training Center the first time, I had over 120 days of inventory on hand. The average lead time/replenishment cycle was over 58 days if I did not have it on the shelf.

My customer base changed every 28–35 days. Simple math shows that any item ordered by a customer that was not on my shelves probably would not during their training cycle of 28-35 days. But because I had so much inventory on the shelves, I was not worried about any shortfalls or possible inefficiency or inefficiencies in the supply chain. All of my supply chain ills were cured by the huge pile of inventory on my shelves. This pile of inventory is sometimes referred to as mountains of inventory.

No good discussion of inventory management is complete without some form of a “water” diagram. In Figure 16.5, the water level represents inventory levels and the boulders under the water represent the problems or ills cured by the inventory. As long as the water level remains high the inefficiencies or boulders are not a problem.

Here is where this text and other texts disagree. Most texts recommend lowering the inventory levels to reveal the inefficiencies—or in line with the water analogy, lower the water level to reveal the boulders. The problem with this is if the water is lowered, the boat will hit the rocks, or the waterway will be impassable. This technique also assumes that all inventory is productive inventory. Reducing nonproductive inventory has no impact on the operations and will not produce savings or reduce inefficiencies.

The best way to improve inventory efficiencies while reducing the inventory levels is to start by walking the process and identifying the inefficiencies protected by the excess inventory levels. Then and only then should the inventory levels be reduced.

The solution to the high levels of inventory at the National Training Center was to walk the process and identify the inefficiencies that drove the high levels of inventory. While walking the process it was discovered that the shipping time from the supporting wholesale distribution center was taking ten days on average. However, the driving time from the distribution center was eight hours in a small Ford Escort.

When asking questions as to why it was taking so long for the delivery, it was discovered that the company point of view was: “We’ve been delivering here for almost twenty years. The first time we delivered there we had a mechanical problem and it took ten days. No one complained, so we assumed ten days was the standard.”

Further questioning produced a new solution. The transportation manager said, “We can close the door on the truck at 8:00 p.m. tonight and deliver to your door by 8:00 a.m. tomorrow morning.” By walking the process almost ten days was removed from the in-transit time. This improvement allowed us to reduce the inventory levels accordingly.

Each subsequent process walk revealed more inefficiency in the system. Each time any inefficiency was identified and fixed the inventory levels were further reduced again.

Walking the process, identifying inefficiencies and fixing them enabled us to reduce the inventory level from approximately \$200 million (USD) to approximately \$20 million while reducing the replenishment times from 58 days to 4.6 days over a couple of years.



**Figure 16.5: Water levels and Inventory Management**

### **Why Have Inventory?**

Now that we have discussed the types of inventory, it is important to discuss why companies have inventory. As we saw in the previous section, companies may have inventory to cover up the inefficiencies in their supply chains—even if they do not realize that this is the reason for their high levels of inventory. Other reasons for maintaining inventory on hand include:

- ❖ The primary reason to have inventory in the supply chain is to ensure that the company covers any variations in the demand of the customers. As mentioned earlier, this form of inventory is an insurance policy against a stockout. When the company maintains inventory for this purpose, the goal is to have what the customer wants in the quantities the customer wants to improve customer service.
- ❖ Inventory may serve as a buffer to prevent stockouts in the manufacturing chain. If all of the facility is not balanced or if the demand for the products being produced varies, insurance can provide a buffer to keep the operation flowing.
- ❖ Inventory may serve as an insurance policy against price increases or to take advantage of price breaks for purchasing large quantities. There is a downside to this type of inventory management practice. A company has to conduct a good analysis of the carrying costs of having the inventory on the shelf. A price break for a large quantity of inventory that is excess to the needs of the company is not a savings. A purchase that provides the company a hedge against inflation or against a price increase that results in so much inventory that the inventory becomes obsolete is not deal for the company; or if the cost to keep the inventory on the shelf exceeds the “savings” from the price break or anticipated price increase, there is no benefit to the company.
- ❖ Inventory may provide a buffer for contingencies such as hurricanes, fires, or any bad weather. Rapid response supply chains should maintain certain levels of stocks to support operations during such occasions. For example, an agency or company may stockpile generators, bottled water, and staple food items to posture the supply chain to support any disaster relief operations—manmade or natural. Contingency stocks may very well



include a backup stock of wine and other important items to carry one through an emergency.

### **Reasons against Having Inventory**

Just as there are valid reasons to have inventory in the supply chain, there are also reasons against having inventory. Keeping in mind the need for customer service to remain a viable entity, these reasons may not be as valid from a holistic supply chain perspective.

The first reason against having inventory has been touched on already—using the inventory to mask inefficiencies in the supply chain. As long as large piles of inventory (sometimes called mountains of inventory) exist companies may not become concerned with non-value-added processes and non-value-added inventory. So, the argument becomes get rid of the inventory and improve the system. As we discussed earlier, this may not fix the problems.

One company that I worked with reduced inventory by 20% across the board based on this philosophy of getting rid of inventory to improve operations. Costs did not decrease as rapidly, but the customer service levels did decrease as a result of the decreased inventory levels. Why? These reductions also included reducing the authorized levels of the nonproductive inventory. As the nonproductive inventory items were not selling, the value of those Stock Keeping Units (SKUs) did not decrease and the impact on inventory turns remained the same. An item that is not selling will not turn over and will lower the inventory turns for the facility or the company. In addition, the 20% reduction to the fast-moving items resulted in sales that exceeded the ability to replenish, thus producing stockouts, also known as zero balance lines.

Other reasons for not maintaining include not tying up precious financial resources with inventory—especially if the inventory is not moving. Large levels of inventory

(especially non-selling inventory) divert management attention from other strategic issues. More companies are discovering the value of strategic and aggregate inventory management as a cost savings and to improve efficiency and customer service.

### **Aggregate Inventory Management**

*“Every management mistake ends up in inventory.”*

*—Michael C. Bergerac, Former CEO, Revlon, Inc.*

Aggregate inventory management seeks to answer the questions of inventory management by answering the following questions:

1. How much do we have now? What is our on-hand inventory? Knowing how much we have on hand is important before any inventory decisions are made. If a company does not have a good idea of how much inventory is on the shelf, they may order more or find themselves unable to fill customer orders. Not knowing the amount of an item on the shelf is an indicator of poor inventory management and poor warehouse/distribution center management.
2. How much do we want? The answer to this question is based on the forecast of what the company needs to make or needs to ship to customers. In order to know how much inventory a company wants depends on knowing the answer to the first question.
3. What will be the output? How much product does the company need to make? This is based on the manufacturing forecast or hopefully from the Master Production Schedule. How many products the company is going to make from the items in the inventory drives the previous questions. How many end items the company will make drives the total number of the component items the company must have in the inventory at the start of production.

4. What input must we get? In order to know how many items the company needs to order, the company needs to know how many end items need to be produced less the on-hand balance. This produces the amount of each component or raw material that needs to be ordered to meet the production numbers.
5. When do we need to order the items? This is the final aggregate inventory question necessary to be successful in operations management. The answer to this question may be more important than knowing how much to order. Why? Because if a company knows how much to order but does not know when the item should be ordered, the product may not arrive in time to meet the production requirements. However, if the company knows when the product should be ordered but does not have an exact number that needs to be ordered because of other warehouse problems, at least some of the finished product can be made to meet part of the customer orders.

Good aggregate inventory management leads to customer satisfaction and meeting the needs of the customers. Poor inventory management decisions can be identified by looking for the following symptoms:

- ❖ A large number of backorders. This is a good indicator of not having the right items on the shelves at the retail facility or distribution center to fill the orders of the customers. A similar symptom may be filling the customer orders from another distribution center in the supply chain. Backorders or passing of orders to another distribution center is a red flag that should indicate to management that the inventory on the shelves is either too little or consists of wrong items.

- ❖ The first symptom may lead to another symptom. This symptom is customer turnover or customer churn. The inventory management problem in the previous symptom leads to this problem. If an activity does not have what the customer wants and passes the action or backorders the action, customers will leave and “shop” elsewhere. This may be evident by the number of orders that are cancelled by the customers as a result of the backorders. Customers usually only order something when they need it and they want it now!
- ❖ Poor inventory may manifest itself in an increasing investment in more and more inventory with no change in backorder levels. How can this happen? If we add more to the inventory and spend more money won't that fix any problem? This attitude leads to compounded problems. The goal is to have the right stuff on the shelf in the right quantities to meet customers' requirements. If the company adds more of the wrong inventory or adds more wrong items, the number of backorders will not decrease. A careful analysis of the inventory is necessary to know what to add and how much to add to meet the customers' needs.
- ❖ Not enough inventory and/or the wrong items in the inventory produced the previous problems; having too much inventory produces different symptoms. Having too much stuff not only leads to higher inventory costs as discussed below, but also produces a shortage of storage space and the requirement to store items outside in trailers (a very expensive form of storage) or leasing additional or contract warehouse space.

## Inventory Management Methodologies

Once a company determines the answers to the four questions above, the company must decide on three basic inventory management methodologies. These three methodologies are Just-in-Time, Pull, and Push. Almost every inventory management method falls under one of these three methodologies.

- ❖ **Just-in-Time (JIT).** Although we will discuss this in detail in the next chapter, it is important to mention it here as part of inventory management. As you will see in Chapter 14, there is much more to JIT than inventory management, but many companies only see JIT as an inventory methodology. As an inventory management methodology, JIT seeks to have as little on the shelf as possible. This leaves no buffer against demand variations or lead time deviations. As the total demand for a product does not change rapidly in most cases, a company that goes to JIT as an inventory management methodology is simply passing the requirement for stockage to the next level of supply support. We will discuss this concept in detail in Chapter 14.

This is just my philosophy, but the move to just in time inventories over the past decade may have impacted the inability of the supply chain to support the panic buying of 2020. For JIT to work as an inventory methodology, someone in the supply chain has to have the inventory. The US Military saw this same phenomenon during the initial stages of Operation Iraqi Freedom in 2003, the logistical system for the Army Materiel Command and the Defense Logistics Agency moved to a JIT concept in the late 1990s – the result was the same thing we are seeing in 2020, a lack of product in the supply chain to support all customer needs.

❖ **Push.** The Push Methodology is based on the assumption that the folks at corporate headquarters know more about what an activity needs than the folks managing that activity. Most textbooks will tell you that the Push Methodology is not efficient in the long run. The fact is **Push** is not efficient in the long run or the short run. Look at the mess in Kuwait in March 2003 as a result of the Push mindset, as shown in Figure 16.6. This same mindset provided the mountains of inventory that provided the background for LTG Gus Pagonis’ book, *Moving Mountains*, from the first Gulf War.<sup>95</sup> The Push mindset is the reason for so many “Sales” at the end of a season—this coupled with poor forecasting. The Push formula is to send items forward in the supply chain based on what the higher corporate headquarters thinks should be in the stock mix.



**Figure 16.6: Inventory as a Result of the Push Method of Inventory Management**

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<sup>95</sup> Also known as Operation Desert Shield/Desert Storm

- ❖ **Pull.** This methodology is similar in nature to JIT. Both methods seek to minimize unneeded inventory. Pull means that nothing is shipped to a company or location for their inventory needs until the items are asked for. This methodology is based on the premise that the retailer, customer, or facility knows better what they need than the next level up in the supply chain.

### **Inventory Costs**

The decision on what methodology is used may very well impact the costs associated with inventory (remember, the costs of the inventory is one reason for arguments again having inventory at all). Inventory costs are driven up by poor inventory management decisions and poor inventory forecasting methodologies. An inventory cost above the value of the inventory itself includes the inventory carrying costs. Inventory carrying costs are the costs to the company to keep items on the shelf over time. The biggest percentage of inventory carrying costs is the cost of the capital tied up in inventory that could be used for other purposes in the company. This cost includes the cost of the interest that could be made if the capital is simply put in an interest-bearing account.

Other costs associated with inventory carrying costs include:

- ❖ **Taxes.** This is one of the reasons why companies have sales at the beginning of the year. If items can be sold before the annual inventory, two benefits occur. First there will be fewer items on the shelf to count during the inventory and the value of the total inventory is less, so taxes on the inventory value will be less. Also included in the taxes part of the carrying costs may be an allocated portion of the property taxes on the facility. Because of the difficulty in allocating property taxes on a facility to inventory, this is not a common practice.

- ❖ The cost of inventorying the products. This is not cheap. Someone must be paid to conduct the physical count of the items on the shelf. Then someone must reconcile the inventory count and conduct recounts, if necessary. All this costs time and money.
- ❖ There is a cost associated with obsolescence. Obsolete, excess, dormant, or aged inventory are the same thing. Regardless of what a company calls this inventory it is a liability on the books and costs the company money to continue holding these items or to dispose of the items. The better the inventory management decisions, the lower the obsolescence costs.
- ❖ Another aspect of inventory carrying costs is the insurance to cover any natural or manmade disaster. My first warehouse was destroyed by a hurricane force wind. A recent storm in the Memphis, Tennessee area did similar damage to a much larger distribution center. Without insurance on the inventory items the company would face large losses.
- ❖ Theft and pilferage. This is also known as shrinkage costs. We will discuss this in Chapter 18 when we discuss supply chain security and supply chain preparedness. Losses to distribution centers and warehouses from theft and pilferage cost supply chains, depending on the source, between \$50-\$60 billion (USD) annually in the United States alone. These costs add to the inventory carrying costs.

All of these costs added together create a cost that is usually measured as a percentage of the inventory value. The biggest problem with inventory carrying costs is that many companies have no idea what their inventory carrying costs really are. These companies use the industry average as the figure for their carrying costs. As we will see when we discuss the Economic Order Quantity as an ordering technique, not knowing what the real inventory carrying costs are



can have a major impact on funding and ordering quantities. This creates a continual problem with more carrying costs. Benchmarking studies show that inventory carrying costs may reach as high as 40% of the value of the inventory. Remember there is a flaw to managing to averages. Someone is above the average and someone is below the average. If a company does not know what their true inventory carrying costs are there are problems, but this may also be another symptom of inventory management problems. The other side of inventory related costs comes from not having enough inventory on the shelf. This leads to stockout or shortage costs. The inventory manager must find the right balance between carrying costs and shortage costs.

### **When to Order**

Now that we have established the costs of having too little or too much inventory on the shelves, it is important to determine when to order the items—remember it may be more important depending on the product to know when to order that how much.

If a company does not have a fixed interval for ordering, a reorder point is necessary to determine when to order. A fixed ordering interval simply states that at certain intervals the company will order enough to raise the inventory levels back to a pre-established maximum authorized stockage level—usually referred to as the stockage objective or maximum inventory level.

If a reorder point (ROP) is used the calculation can be a very simple calculation as shown in Formula 16-1. This calculation will work if the Lead Time is in days, weeks, or hours.

$$\text{ROP} = D \times \text{LT}$$
$$\text{ROP} = (D \times \text{LT}) + \text{SS (if safety stock is used)}$$

**D = Demand during Lead Time**

**LT = Lead Time to replenish**

**SS = safety stock**

**Formula 16-1: Reorder Point Calculation**

There are at least seven commonly used Reorder Points. Some of these reorder points are more common than the others and one is the precursor of a commonly used Just-in-Time technique. These reorder points are used for independent demand items—those items that are not dictated by the demand for another product. The opposite of independent demand is dependent demand—the inventory level of a dependent demand item is dictated by the Master Production Schedule.

- **Fixed Reorder Point.** This is also known as a periodic demand. A fixed reorder point dictates that at a set time or period a replenishment order is placed. At this predetermined period the inventory is counted and the on-hand balance is subtracted from the maximum desired inventory level. The difference between the on-hand and maximum-desired levels is ordered.

- **Variable Reorder Point.** Rather than ordering at a fixed time interval, an order is placed whenever the on-hand inventory reaches a set inventory level. At this point, the quantity ordered will take the on-hand inventory to the maximum stockage requirement.
- **Two Bin.** The Two Bin Reorder Point is the precursor to the Kanban system (see Chapter 14 for more details on the Kanban system). The Two Bin System is used for smaller parts such as nuts, bolts, screws, or washers. This system of reordering uses two bins for storage of the items. The reorder point occurs when the first bin is emptied. The quantity of each bin equals the demand during the replenishment lead time times the lead time ( $ROP = \text{Demand during lead time} \times \text{lead time}$ ). When the first bin is emptied, the necessary replenishment quantity is ordered. The theory is as long as the lead time is constant the second bin will become empty at the same time that the first bin is replenished. A variation of the Two Bin System is one bin with a line placed inside the bin. When the line is visible, it is time to reorder.
- **Card.** The Card Reorder Point is a visible card to tell the company or store that it is time to reorder. Bookstores use the Card System for books and the small carousels of book markers at the checkout line. When a bookmark is removed from the carousel, the card is visible to the clerk and a reorder or restock is made. In the books on the shelves, a card signals the checkout clerk to key in the reorder. Figure 16.7 is an example of a card reorder point.



**Figure 42.7: Card Reorder System**

- **Judgmental.** This form of reorder point is based on someone’s judgment or experience. This form of reorder point is not common except in smaller operations. For this form of reordering to be successful, there has to be a good level of experience and knowledge of the products and the sales of those products. At the US Army’s National Training Center different units would use repair parts at different levels depending on their equipment mix. The repair parts distribution center used a variable reorder point. However, when certain units were scheduled to train, judgmental increases to the stockage levels helped to prevent stockouts.
- **Projected shortfall.** Like the judgmental reorder, this form of reorder is dependent on someone’s experience and knowledge of the products. If forecasts show a projected shortfall using the normal reorder point, an additional replenishment order may be placed.
- **Min-Max.** This is the newest reorder point methodology. However, like many “new” ideas, Min-Max is just a variation of the traditional reorder point. When on-hand

inventory hits the acceptable minimum level, an order is placed to take the inventory back to the maximum desired inventory level.

### **Economic Order Quantity**

Just as the reorder point and reorder quantity may tell a company how much to order, the real purpose of the ROP is to tell the company when to order. The Economic Order Quantity calculation helps the company determine how much to order. The goal of the Economic Order Quantity is to balance ordering costs and inventory carrying costs.

$$EOQ = \sqrt{2AC_o/I}$$

**A = Annual Demand**

**C<sub>o</sub> = Cost of Ordering**

**I = Inventory Carrying Costs**

#### **Formula 16-2: Economic Order Quantity Calculation**

The Economic Order Quantity (EOQ) calculation depends on five basic assumptions in order to be useful as a tool for determining how much to order. Not all of these assumptions may be valid in today's business environment. These assumptions are:

1. The demand rate is constant and known. Demand is not always constant in today's businesses. Customers have the option of buying via the Internet and buy when they need a product. When the EOQ formula was developed the majority of

orders were placed by stores at set quantities. If demand is not constant, this assumption is not valid and therefore the EOQ calculation may not be the best methodology for a company to use.

2. There are no quantity discounts for products. Any good corporate buyer is going to try to get a discount for quantity buys. If the buyer gets the discount, this EOQ assumption is not valid and again the calculation may be flawed.
3. The entire order is delivered complete. This means no split shipments, no substitutions, and no backorders. Is this valid in today's environment?  
Substitutions and split shipments are commonplace in today's business. Sometimes the split shipment is by design because the company only needs part of the product now and part of the order later. Split shipments and backorders also occur when demand is not constant, and the supplier has a stockout. This is reality.
4. The ordering costs and the carrying costs are known. Every company should know these costs. If the company knows these costs this is a valid assumption.
5. Stockouts are not allowed as demand is constant. Look at assumption number 1; if that assumption is not valid due to variable demand patterns, then this assumption may not be valid either.

Even when all five assumptions are valid, there are sometimes when the EOQ is not needed as a replenishment calculation. If a company receives a fixed order quantity from a customer for a product and the EOQ quantity is different from the customer order quantity, then the customer order quantity should drive the company's order. If there is a limit on the size of an

order such as a fixed lot size, then the lot size or multiples of the lot size should be ordered. A third exception to the EOQ is when there is a limitation on the tool/machinery life or the shelf life of the raw materials. For example, if the EOQ calculation determines that 4,000 pounds of a raw material should be the order quantity, but the material has a limited shelf life that is shorter than the forecasted usage period, then the order quantity may be less than the EOQ.

**Annual Demand (A) = 45,000 units**

**Ordering Costs (C<sub>o</sub>) = \$50/order**

**Carrying Costs (I or C<sub>c</sub>) = 30%**

**$Q = \sqrt{((2)(45,000)(50)/.3)}$**

**Q = 3,872.98**

**Round to 3,873**

**Example 16-1: EOQ Calculation**

With the EOQ a company can forecast the number of orders that it will make each year. Example 16-2 shows the calculation to estimate the number of orders. Knowing the forecasted number of orders for a year enables a company to more accurately forecast ordering expenses for the year and when all orders are summed up, it may allow the company to forecast how many purchasing employees should be employed for the next year.

$$\begin{aligned}\# \text{ ORDERS/YEAR} &= A/Q \\ &= 45,000/3873 \\ &= 11.6 \text{ orders a year}\end{aligned}$$

Example 16-2: Calculating the Number of Orders Per Year

### Safety Stock

Safety stock is an additional insurance policy to back up the primary insurance policy known as inventory. This is simply a level of stockage above the normally calculated inventory levels to prevent against increased demands or lead times, longer than normal replenishment times or variability in demands for a product. Normal inventory levels are set to meet customer demands while safety stock insures against stockouts from variations in demand or lead times. Safety stock is also maintained in some companies as a buffer to protect the manufacturing company against forecasting errors.

Safety stock may as well be called sacred stock in most organizations. The reason for this is that many companies do not want to touch their safety stocks. One particular company actually preferred to backorder customer requests than use their safety stock and go to a stockout position to meet the customers' orders. Their rationale was that they reported SKUs that were stocked out to their Vice President and CEO, but their reports did not include backorders.

Safety stock adds costs to every location that maintains a safety stock without necessarily adding value to the ability of the inventory to support the customers. A company may better serve the customers by consolidating the safety stock for the entire distribution network at one central location. Safety stock is usually set as either a set number of days of supply above the normal stockage level or a percentage of the lead time demand.



## Inventory Turns

The most misunderstood metric for distribution centers is the measure of inventory turns. Inventory turns is a simple calculation as shown in Formula 16-3. Inventory turns provides a benchmark for companies within their industries. Comparing inventory turns calculations between different industries only creates confusion and frustration. Comparing the turns for a dairy product with a hardware store will not produce a good benchmark. For years everyone wanted to benchmark against Dell Computers even if they were not in the computer industry.

$$\text{Inventory Turnover} = \frac{\text{Annual cost of good sold}}{\text{verage Inventory Investment}}$$

### Formula 16-3: Inventory Turnover Rate Calculation

Theoretically, the following issues are associated with inventory turns. Remember, all things change when you go from the abstract to the concrete.

- Low inventory turns equates to high carrying costs and very low stockout costs. In actuality, low turns may show that there is too much inventory on the shelf which would indeed equal low or no stockout costs. However, it could also mean that there are too many of the wrong items on the shelf. If a company is stocking the wrong items on the shelf, the turns will be low but the stockouts or backorders will still be high. One company with multiple distribution centers was experiencing very low turns (less than four a year) but was also backordering a very large percentage of customer orders because the items the customers wanted were not stocked in the right distribution center.

- High inventory turns should mean lower inventory carrying costs but high stockout costs. However, if the inventory is the right size, replenishment times are stable, and the forecasts for sales are relatively accurate, a high level of turns can be achieved while keeping stockout costs to a minimum.

### **Other Performance Measures**

- **Average Inventory Investment:** The average inventory investment is calculated for the year in most cases. Comparing average inventory levels is not an effective method to benchmark between companies. This is a necessary financial metric to help companies determine how they are doing compared to previous years.
- **Days of Inventory (Days of Sales):** This metric is related to inventory turns. This measure looks at how many days of sales can be supported from the on hand inventory. In theory, the lower the Days of Inventory, the more efficient the inventory is performing.

$$\text{Days of Inventory} = \frac{\text{Average inventory Investment}}{\text{Annual Cost of goods sold}}$$

### **Formula 16-4: Days of Inventory Calculation**

#### **Inventory Analysis Using ABC Stratification**

ABC analysis has nothing to do with Activity Based Costing. ABC analysis is based on Pareto's Law—also known as the 80/20 rule. Pareto postulated that 80% of the wealth was in the hands of 20% of the population. This rule also applies to distribution centers and inventories.

The application of this principle to inventories states that 80% of the inventory value is tied up in 20% of the inventory items. By applying the 80/20 rule, inventory items can be stratified into A items (20% by value and volume), B items (25–30% of the items), and C items (50%).

ABC analysis using this methodology can dictate inventory management and inventory control measures. A items are those high value items that should be more stringently controlled and inventoried as often as once a week or once a month. B items can be inventoried a little less frequently—perhaps quarterly. C items include the small dollar items that fill up distribution centers. These items can be inventoried once a year.

There is another application of ABC—the organization of the distribution center by volume. The A items in this application are the very fast-moving items and should be placed closest to the shipping area to reduce movement and improve picking times for the fastest moving items. Further analysis may determine that in lieu of placing these items close to the shipping area, the items may be candidates for cross-docking. The C items are the slow-moving items. These items may be candidates for elimination from the stocks altogether or placed in the farthest locations from the shipping docks.

ABC analysis also applies to customers. Just as the inventory is stratified to better manage the distribution center, customers can be stratified to make sure the better customers or largest customers get better service or have priority for low volume or constrained stocks.

### **Inventory Controls**

Inventory control is the physical counting of the items and the security of the items in the distribution center. Inventory control sounds easy on paper—what comes in should be counted and what is in the center should be accounted for, and what goes out should be carefully counted and checked. Remember Clausewitz? This is another way that things change when moving from

the abstract to the concrete. If inventory control was as easy as it sounds, everyone would have perfect inventory control. And, no one would have a shrinkage problem with their inventory.

Proper inventory control starts at the receiving dock. A proper count is necessary when the items come into the distribution center, warehouse, or store. After counting the items, they must be put in the proper location. While in the location the items must be counted and when the items are picked for shipping, the items need to be counted again. If an item is stored in more than one location, this information should not be a secret. Every location has to be recorded to make sure an accurate count is possible.

There are four basic inventory counting techniques in use today. Most companies use an annual wall-to-wall inventory count, a cyclic count, a periodic count, and may also use a sensitive item inventory count. Usually a tolerance is set for the count. As long as the physical count is within the set tolerance, the count is accepted. If the count does not match the inventory record or is out of tolerance, research is necessary to determine why there is a discrepancy and when the discrepancy may have occurred.

The wall-to-wall count is the preferred method of the finance officials. This count happens once a year and every item in the facility is counted and matched against the inventory record system within the Warehouse Management System. The problem with an annual wall-to-wall inventory is that the facility is usually closed down for the duration of the count. If the counts do not match, this closure could last for up to a week. This impacts customer service if orders are not being picked during the count. One facility in South Los Angeles has a 50% employee turnover rate each year. This means that half of the employees that may have made an inventory mistake or picking error in February will not be there to help solve the problems next

January when the wall-to-wall inventory is conducted. This may impact the ability to solve the problems.

The best alternative to annual wall-to-wall counts is the cyclic inventory. Cycle counting counts each of the items at least annually but does not require shutting down a facility to do the count. A cycle count may be conducted in conjunction with routine order picking. A worker may be told to go to a location to pick an item and then count what is left and record it. Like the wall-to-wall count, this count will be matched against the inventory record for accountability. If a cycle count is properly organized, each item in the inventory will be counted at least once a year and some items may be counted more often. Cycle counting does not require closing the facility to do the count and as it is done more frequently, finding the cause of problems may be faster and much easier to identify. To prevent any complications with cycle counts, in one facility we established a third shift that did nothing but cycle counts. This facility went from 84% inventory accuracy to 99% accuracy within three months of adding this new counting shift.

A periodic inventory is an adaptation of the cycle count concept. This methodology states that a certain percentage of the items are counted each period—week, month, or quarter. The goal of this program is to count every item at least once every year.

A sensitive item inventory is another adaptation of the cycle count concept. A company that normally does annual inventory counts may choose to conduct more frequent counts of high dollar or highly pilferable items to ensure that these items do not walk out of the facility. This type of inventory count makes the insurance folks happy and helps to keep facility managers feel more comfortable about the safety of the inventory.

The ABC analysis can be applied to the inventory count methodology. The A items, those expensive or fast-moving items, may be counted monthly. The B items may be counted semi-

annually, and those low cost and/or slow-moving items may only be counted annually or when a stockout occurs.

### **Special Concerns in Inventory Management**

Inventory management is critical to the operational success and financial success of a company. There are some very real concerns that impact the quality of a company's inventory management efforts.

The first major concern is the proliferation of Stock Keeping Units in the inventory. This is a two-part problem. The first part of the problem is how a Stock Keeping Unit (SKU) number is assigned. Some companies assign a different SKU for the same item stocked in a different store or warehouse. This causes confusion. An SKU should be a unique item identifier for an item throughout a supply chain. The second part of this problem is the increase in SKUs across supply chains. AMR research recently revealed a 15% increase in the amount of products in supply chains over the past several years. Consumer pressure to produce new products contributes to this problem. The more items that a supply chain can stock contribute to the accuracy problems and the pilferage problems.

Dead/obsolete inventory is a concern for inventory managers. This is inventory that is of no value. This inventory is driven partially by the pressure to increase the number of products and the shelf life of those products. This inventory is also partially driven by forecasting inaccuracies. Dead or obsolete inventory not only takes up space and contributes to higher inventory carrying costs, but it also contributes to higher inventory turns rates while reducing profitability for companies.

Substitute and complementary items cause inventory problems. When the primary item is an out of stock item, does the company have another item that can be substituted that is

acceptable to the customer? The Department of Defense Logistics Agency maintains and publishes a listing of interchangeable and substitution items. Complementary items also create a problem if the forecasting effort does not link the items together. These items may be used at the same time such as oil and oil filters that can be placed in a kit or may be like the shirts stocked by L.L. Bean that are usually ordered together. In the fashion world complementary items may be the matching shoes and bag or suits and ties. Keeping complementary items in stock together may create challenges for inventory managers.

Repair parts and replacement parts create problems for inventory managers. Why? If everybody has repair parts how can this be a problem? Remember the discussion of independent versus dependent demand items under the forecasting discussions? Repair parts are independent demand items and therefore are much harder to forecast since end items breakdown at different rates. These items reinforce the need to have good forecasting techniques for repair parts and replacement parts in the supply chain.

Items going backward create issues and problems for inventory managers. Reverse logistics is discussed in detail in a later chapter but is important enough to mention here as one of the areas of concern in inventory management. Any resaleable item that comes backward adds to the on-hand inventory and adds to the inventory value, inventory carrying costs, and inventory turns calculations.

## **Summary**

In this chapter we have looked at why have inventory. Inventory is needed to cover the normal customer demands for products. Inventory is an insurance policy to prevent against stockouts from normal demand. On top of the inventory is another level of inventory called safety stock that prevents stockouts from variations in demand or variations in replenishment

lead times. The long running argument between operations managers and finance managers centers on the utility of inventory. Operations managers believe that much of the inventory is an asset while finance managers believe any inventory that is not cash is a liability. Both camps do agree that work-in-process inventory and obsolete inventory are indeed liabilities.

Inventory management seeks to answer four questions. We looked at three of these questions in detail in this chapter. The first question is what to order. This is driven by the Master Production Plan in a manufacturing facility. The second question is how much to order which is driven by the Economic Order Quantity which seeks to balance ordering costs and carrying costs. The third question may be the most important question of all—when to order. This is driven by the reorder point calculation. The reorder point uses demand during the replenishment time and the length of the replenishment time to prevent stockouts and determine when to order. The fourth question ties to supply chain management and location analysis: where should the product be stocked to meet the needs of the customer?

Having the right inventory on the shelf in the right quantities drives the calculation for inventory turns. Although this calculation is widely misunderstood, it is a good metric for the inventory levels necessary to support customers.

Inventory management is critical to successful operations and is important to meeting the needs of customers. Poor inventory management produces lost sales, excess stocks on the shelves, and higher inventory carrying costs. Good inventory management is important for customer service and profitability.



## Discussion Questions and Problems

1. Why do companies have inventory?
2. Is inventory an asset or a liability? Can it be both? Explain your answer.
3. Can an inventory item that is an asset become a liability? Give an example.
4. A company has an average inventory value of \$550,000,000 and their Cost of Goods Sold for the year is \$41,500,000,000. What is their inventory turn? Is this good or bad?
5. A company decides to add safety stock to its distribution centers. The company has 15 distribution centers throughout the United States. Would the company be better served to have safety stock at each location or should they consolidate the safety stock at one location? Justify your answer.
6. If JW, Inc. has a fixed lead time for replenishment of its Widget B of 10 days and an average demand of 12 Widget Bs per day, (assuming no safety stock) where should JW Inc. set their reorder point? How would this change if they set safety stock to 2 days of demand?
7. KW Industries has analyzed their inventory and come up with the following data:  
  
Inventory Carrying Costs = 12%  
  
The cost of placing an order = \$55/order  
  
Annual sales of Product X = 6,000,000  
  
Calculate KW's EOQ for Product X
8. Using the information from Question 7, how many orders will KW place in the next year?

9. Using the data from Question 7, what happens to the EOQ if the ordering costs increase to \$65/order?
10. What are the types of inventory a company may have?
11. What is safety stock and why would a company have safety stock?
12. When is the EOQ not necessary?
13. Is the EOQ calculation still valid in today's business environment when applying the assumptions of the EOQ? Explain your answer.