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Inventory Management Improvement Techniques

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Inventory Management Improvement Techniques

BY

James Lanman

THESIS

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DEDICATION

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Abstract

An inventory management system that does not ensure inventory record accuracy greatly reduces the ability of a company to control inventory levels and fulfill customer requirements. This study investigated how two principles of inventory management affected three business metrics: on-time delivery, inventory record accuracy, and inventory level management.

Eight manufacturers of aircraft parts and equipment in northeastern Illinois responded to a survey created to analyze the effects of ABC classification of inventory and cycle counting techniques on inventory management. Survey data were collected via teleconference with a representative of each manufacturer.

Half of the manufacturers reported using ABC inventory classification and/or cycle counting techniques for inventory accuracy. The most common ABC inventory classification system reported was both the dollar value and usage/movement methods. The random selection method was the most preferred method of cycle counting.

Not all companies had information about their on-time delivery ratings before implementing an inventory management technique. Responses were variable for those that did have this information. Two out of four manufacturers reported unchanged on-time delivery ratings after implementing an inventory management technique, while one reported a decrease and another reported an increase.

Inventory accuracy data also proved difficult to collect. Those companies providing inventory accuracy information, however, typically indicated dramatic increases in their accuracy ratings after the implementation of an inventory management technique.

Contrary to expectations, an obvious decline in inventory was not reported by most companies after the implementation of an inventory management system. Because most participants had difficulty providing relevant data, whether or not an increase or reduction in inventory levels was related to inventory management philosophy or to business growth or decline could not be determined.

Limitations of the present study, as well as directions for future research were discussed.

Chapter 1

Introduction

"Where did it go?" "The system says that we have plenty of these parts to complete the order." These are some common phrases that may be heard in a company that does not have a good method of ensuring inventory record accuracy. Maintaining inventory record accuracy is just as important to a company as is maintaining quality assurance, employee safety, and customer service. Inventory record accuracy initiatives require the support from every employee of the company and must be regarded as everyone's responsibility. This initiative must be supported from top level management to the floor personnel.

Manufacturing is becoming more and more competitive everyday. Gaither and Frazier stated that "a country's borders no longer provide protection from foreign imports. Competition has become intense and is increasing" (1999, p. 14). For years, large and small manufacturing companies have been searching for ways to stay ahead of their competitors. Organizations can improve their competitiveness through gaining an understanding of their inventory levels and implementing processes to reduce these levels.

Companies must strive to reduce inventory levels. By reducing inventory levels, businesses will experience benefits that show up directly on the bottom line. Less inventory equates to less money tied up and can enable funds to be allocated to other improvement initiatives.

Inventory record inaccuracies can lead to many issues within the organization. In the production environment, line down, or forced change over situations could occur as a result of record inaccuracy. In the purchasing department, expedited shipments or costly buys for material could occur as a result of record inaccuracies. The scheduling department is also affected by record inaccuracy, in the sense that scheduled tasks are delayed due to stockout situations. Record inaccuracies affect all aspects of the organization and should be investigated promptly to eliminate causes. ABC analysis and cycle counting are two methods that enable organizations to have more confidence in inventory numbers.

ABC Inventory Classification is a proven method to obtain understanding and reduce levels of inventory. Williams (2003) stated that "a company implementing the ABC strategy will carry 33% less inventory than a company that maintains the same inventory level for all items" (p. 7). ABC analysis has been around for years and utilizes Pareto's Law that 80 percent of the problems come from 20 percent of the items or activity. Brooks and Wilson (1995) described the Pareto Principle as "A heuristic rule which states that where there are a large number of contributors to a result, the majority of the result is due to a minority of the contributors (the 80/20 rule). The basis of ABC analysis" (p. 166). ABC analysis aids companies by allowing them to visualize where to prioritize their efforts. The primary goal of ABC inventory classification and cycle counting is to find errors in the process and through root cause analysis, identify and eliminate the cause of the errors.

Cycle counting activities is another initiative that can aid a company in improving inventory record accuracy. The Institute of Management & Administration (IOMA) (2003) reported that "cycle counting is number three of the best practices for reducing inventory" (p. 1). ABC analysis and cycle counting usually go hand in hand. Cycle counting methods verify the system counts by physically counting the on-hand inventories. Organizations must be able to trust the system information in order to make many business decisions.

Statement of Purpose

The purpose of the present study was to investigate the effectiveness of cycle counting and ABC inventory classification as inventory management systems. Because ABC Inventory Classification techniques and cycle counting can be utilized to ensure inventory record accuracy and pin-point problem areas that need more attention, through the use of these inventory management methods, a company should be able to improve many aspects of the organizations inventory control procedures. It is expected that a company that implements ABC inventory classification and cycle counting practices will report significant increases in inventory accuracy, which in turn lead to reduced inventory levels and improved on-time delivery to customers.

Statement of the Problem

An inventory management system that does not ensure inventory record accuracy greatly reduces the ability of the company to control inventory levels and fulfill customer requirements. To reduce inventory levels and improve on-time delivery, organizations must first possess a good understanding of where and what inventory levels presently exist and how well the reporting system portrays this information. Information about how well inventory management systems provide companies with this information is vital.

Definition of Terms

ABC Classification: The ABC classification system considers inventory parts in descending order of annual dollar volume or some other criterion. This array is subdivided into classes, A, B, C. Class A parts are those with the highest dollar volume (or other criterion) and receive the closest attention. Class C contains the lowest dollar volume items. The classification method is used to focus limited attention on highest priority parts (Brooks and Wilson, 1995).

ABC Cycle counting: A cycle counting technique that is explicitly biased toward parts that represent a greater inventory investment. The ABC cycle counting process puts an explicit emphasis on the samples to reflect the monies invested in inventory. Simply explained, the "A" class parts (the 20 percent of the parts that represents 80 percent of the total monies spent per year on inventory) are counted more frequently than the "B" and "C" class parts, which account for lesser expenditures (Brooks and Wilson, 1995, p. 163).

***Addresses*:** Name given to a row of racks or bins, then a name to each vertical rack opening or stack of bins within the row; and finally the shelves themselves (Brooks and Wilson, 1995, p. 79)

***Backflushing*:** The deduction from inventory of the component parts used in a parent by exploding the bill of materials by the production cost of parents produced (Brooks and Wilson, 1995, p. 163)

Bill of Materials: A listing of components, parts and other items needed to manufacture a product, showing the quantity of each required. (Brooks and Wilson, 1995, p. 163)

Cycle counting: Any process that verifies the correctness of inventory quantity data by counting portions of the inventory on an ongoing basis

Demand During Lead Time (DDLT): The amount of material that will be demanded while waiting for an order of material to arrive and replenish inventory (Gaither and Frazier, 1999, p. 369)

Inventory Process: Includes the receiving of parts, putting them away, and their storage, withdraw, issue, and movement through work-in-process, while simultaneously tracking their movement and maintaining records of those events and their effects (Brooks and Wilson, 1995, p. 165).

Inventory Record: Hard copy or electronic document that reflects how much and what kind of inventories a company has on hand, committed (allocated) to work in process, and on order (Brooks and Wilson, 1995, p. 164).

***Lead time*:** Length of time required to replenish the inventory for a material from the time that a need for additional material is sensed until the new order for the material is in inventory and ready to use (Gaither and Frazier, 1999, p. 824).

Material Requirements Planning (MRP): An approach to calculating material requirements not only to generate replenishment orders but also to reschedule open orders to meet changing requirements. Once viewed as an inventory ordering technique, MRP is thought of today as more of a scheduling technique (Brooks and Wilson, 1995, p. 165)

***On-hand Balance*:** Quantity of an item shown in the inventory records as being physically in stock (Brooks and Wilson, 1995, p. 166).

Order Point (OP): Point when an order is placed for a material in a fixed order point inventory system; expected demand during lead time plus safety stock (Gaither and Frazier, 1999, p. 826).

Point of Use Storage: Lean Manufacturing practice that requires components or material used in the manufacturing process be within a predetermined distance from the work area where the components are needed.

Safety stock: Quantity of material held in inventory to be used in time periods when demand is greater than expected or when supply is less than expected (Gaither and Frazier, 1999, p. 829).

SKU: Stock Keeping Unit stands for a specific identifying numeric or alpha-numeric identifier for a specific item (Muller, 2003, p. 4).

Stockout: Reduction of a material's usable inventory level to zero (Gaither and Frazier, 1999, p. 830).

Expectations

It is expected that a company that increases its level of inventory record accuracy will be able to reduce inventory levels and improve on time delivery. Because ABC classification of inventory and cycle counting are systematic ways to increase inventory record accuracy, companies using these methods should have more accurate inventory records, reduced inventory levels and better on-time delivery records.

Limitations

Two important limitations to this study included:

- The data for the present study came from a self-report, interview format and were not verified.
- The level of expertise of the respondents also was not verified.
- Companies' willingness to share information about their inventory structure.

Delimitations

Only manufacturers of aircraft parts and equipment were surveyed. The 2004 Illinois Manufacturers Directory was used to identify manufacturers in northeastern Illinois having 20 or more employees. The counties in this section of Illinois include:

Research Questions

This research is guided by the following questions:

1) Can improvements in inventory management improve on-time delivery ratings?

2) What are best practices in the use of ABC inventory classification?

3) What cycle counting method is best practice?

4) Can improved inventory management aid in achieving reduced inventory levels?

5) Can improved inventory management increase inventory record accuracy?

Chapter 2

Literature Review

Inventory Carrying Cost

For most companies, inventory is their largest asset on the books. Despite this, many companies overlook the costs that are incurred by inventory. Companies that hold excess inventory encounter inventory carrying costs. Hurlbut (2003) explained that

> "Most companies evaluate the productivity of their inventories through such yardsticks as inventory turn, gross margin return on investment, gross margin return on square foot and the like. These are all valuable tools in assessing inventory productivity, but they are all limited by the fact that they use inventory at cost as the cost basis in their analysis…The true cost of inventory extends far beyond just inventory at cost or the cost of goods sold. The cost of managing and maintaining inventory is a significant expense in its own right, but the true cost of inventory doesn't even stop there. The full cost of inventory, in fact, is actually buried deep within a number of expense items below the gross margin line, almost defying any executive, manager or cost accountant to pull them out, quantify and actually manage them".

Some areas of inventory management that contribute to the total cost of inventory include:

- inventory finance charges;
- opportunity costs;
- inventory insurance and taxes; and

- material handling expenses.

Businesses that deal with offshore suppliers view inventory levels in a different manner. When dealing with offshore suppliers, companies have to take into account the transit time. A shipment from China requires 30 – 45 days from the time it leaves the dock in China until it arrives at the dock in the United States. The 30 to 45 days includes the time that it takes to get the boat across the ocean, the time required to clear customs, and the transit time to deliver the product from the port to the end user. Knowing that there is a 30 – 45 day lead time, companies have to hold at least that much inventory. In some cases, companies will hold 60 days of inventory in case some catastrophic event happens, like the boat sinks, or the freight is stolen. Companies that hold excess inventory for these reasons encounter inventory carrying costs.

In order to calculate inventory carrying costs, a company must first understand what is included in the equation. According to Tersine (1982), carrying costs include capital cost, taxes, insurance, handling, storage, shrinkage, obsolescence, and deterioration. The usual range of annual holding cost is 20 – 40% of the inventory investment. LaMacchia (2004) also reported that the cost to store inventory generally runs 20 – 40% of the cost of goods sold (COGS) per year. Companies need to understand the impacts of holding excess inventory and initiate plans to reduce inventory. Having accurate inventory records can help organizations better understand inventory needs, which will allow for reduced inventory levels.

Inventory Record

What are inventory records? Brooks and Wilson define inventory records as "hard copy or electronic documents that reflect how much and what kind of inventories a company has on hand, committed (allocated) to work-in-process (WIP), and on order" (1995, p. 4). Inventory records are important to an organization for many reasons. Inventory records are used to make decisions on when and what to receive, order or sale. Inventory records allow the organization to know what and how much inventory is on-hand at any given time without having to physically count the inventory. Inventory records track and document every transaction made on inventory, from receiving, to WIP, and finally, shipping. Accurate inventory records are important to an organization when making decisions of material purchases, production schedules, and sales agreements. Brooks and Wilson stated that companies with inaccurate inventory records "are forced to either make decisions based on questionable inventory records, or conduct time-consuming physical inventory checks before moving forward" (p. 6). A delay in decision making could cause the organization to miss an opportunity to capture new customers and lose valuable market share.

Williams (2003) reported that a key element that separates successful companies from companies that are not as profitable is how inventory levels are determined. A company must first gain an understanding of where and how much inventory is in the system in order to effectively determine appropriate levels of inventory needed to sustain production and not have excess inventory. This knowledge can be obtained by analyzing what type of demand the company is experiencing.

Inventory Demand

Two basic types of inventory demand systems are independent-demand and dependent-demand. Tersine (1982) described independent-demand as "when no relationship exists between the demand for an item and any other item" (p. 14). An example of this would be ordering a spark plug for retail sales purposes. The spark plug can be sold independent of any other components. Tersine goes on to define dependent-demand as "the requirement for any components necessary to make some other item" (p. 14). An example of this could also be a spark plug that is used to assemble an engine at an automobile manufacturer. The engine is not complete without the spark plug, so the engine assembly is dependent on the spark plug to function properly. Dependent and independent items must be handled with different methods of reordering in order to maintain inventory levels.

Economic Order Quantity

For many companies reordering or maintaining inventory levels of their independent-demand items is accomplished through the use of Economic Order Quantity (EOQ), which is an equation used to determine how much product to buy. EOQ was developed in 1915, by F.W. Harris of General Electric (Muller, 2003). According to Gaither and Frazier (1999, p. 360), the basic equation for EOQ or Model I, is as depicted in Figure 1:

Muller (2003, p.127) also points out that the EOQ formula allows a company to determine the following:

- the optimal quantity to order,
- when it should be ordered;
- the total cost;
- the average inventory level;
- how much should be ordered each time; and
- the maximum inventory level

Assumptions

1. Annual demand, carrying cost, and ordering cost for a material can be estimated
2. Average inventory level for a material is order quantity divided by 2. This implicitly assumes that no safety stock is utilized, orders are received all at once, materials are used at a uniform rate, and materials are entirely used up when the next order arrives.
3. Stockout, customer responsiveness, and other costs are inconsequential.
4. Quantity discounts do not exist.

Variable definitions

D = Annual demand for a material (units per year)
Q = Quantity of material odered at each order point (units per order)
C = Cost of carrying one unit in inventory for one year (dollars per unit per year)
S = Average cost of completing an order for a material (dollars per order)
TSC = Total annual stocking costs for a material (dollars per year)

Cost formulas

Annual carrying cost = Average inventory level X Carrying cost = $(Q/2)C$
Annual ordering cost = Orders per year X Ordering cost = $(D/Q)S$
Total annual stocking cost (TSC) = Annual carrying cost + Annual ordering cost
$= (Q/2)C + (D/Q)S$

Derivation of the Economic Order Quantity Formula

The optimal order quantity is found by setting the derivative of TSC with respect to Q equal to zero and solving for Q:

1. the formula for TSC is: $TSC = (Q/2)C + (D/Q)S$

2. the derivative of TSC with respect to Q is: $d(TSC)/d(Q) = C/2 + (-DS/Q^2)$

3. set the derivative of TSC equal to zero and solve for Q:

$$C/2 + (-DS/Q^2) = 0$$
$$DS/Q^2 = C/2$$
$$Q^2 = 2D/C$$
$$Q = \sqrt{2DS/C}$$
$$EOQ = \sqrt{2DS/C}$$

Figure 1 EOQ Model I. (Gaither and Frazier, 1999, p. 360)

EOQ equations are used in a fixed order size system, also known as perpetual inventory system. Perpetual inventory systems work off the premise that the demand rate is constant and that the same number of units are ordered once the inventory level reaches a reorder point.

Materials Requirements Planning

Materials Requirements Planning (MRP) is a method that businesses use to determine inventory levels for dependent-demand items. MRP was introduced in 1975 by Joseph Orlicky (Muller, 2003). This method works off the principle of receiving exactly what is needed at the exact time that it is needed. MRP is set up in such a manner that predetermined reorder points are not required. MRP reorders components as they are used in production operations. As a finished unit is claimed from production, MRP references the Bill of Materials (BOM) for the unit and backflushes the system. Backflushing removes all the components, and quantities listed on the BOM, from the available inventory. When an item is allocated to a sales order and no longer available for future production needs, MRP uses this activity as a reorder signal. MRP is more concerned with manufacturing needs, rather than customer needs.

There are several methods of determining inventory levels that are beyond the realm of this study. No matter which method is utilized, manufacturers need to ensure that every aspect of inventory management is taken into account.

Replenishment Lead Time

Another aspect of inventory management that must be analyzed is replenishment lead time. Replenishment lead time is the actual time necessary to replenish the stock once an order has been made. Every order for an item takes a predetermined amount of time to process. Tersine (1982, p. 15) illustrates a simple equation used to determine the lead time for inventory items:

$$L = T_1 + T_2 + T_3 + T_4 + T_5 = \text{lead time.}$$

T_1 = in-house order preparation time

T_2 = order transmittal time to supplier

T_3 = manufacture and assembly time

T_4 = goods transit time from supplier

T_5 = in-house goods preparation time

Gaither and Frazier (1999) also expressed that the organization must understand the demand during lead time (DDLT). "Demand during lead time (DDLT) means the amount of a material that will be demanded while we are waiting for an order of a material to arrive and replenish inventory" (Gaither and Frazier, 1999, p. 369). Gaither and Frazier go on to emphasize the importance of understanding the variation in demand during lead time. As stated by Gaither and Frazier (1999, p. 369)

> "The fluctuation in demand during lead time comes from two sources. First, the lead time required to receive an order is subject to variation. For example, suppliers can encounter difficulty in processing orders, and trucking companies can have equipment failure or strikes that delay deliveries. Second, daily demand for the material is subject to variation. For example, customers' demands for finished products are known to be subject to great daily variation, and production departments' demands for raw materials can vary because of changes in production schedules. What makes this variation in demand during lead time particularly worrisome to operations managers is that this uncertainty hits them when they are most vulnerable – when they are waiting for an order of materials to arrive and inventory levels are low".

Due to the fluctuation in demand and supply, some companies are forced to hold safety stock to ensure that they do not encounter a "stockout" situation. It is important to note that safety stock is expensive if you carry too much. "If we carry too much safety stock, the cost of carrying these materials becomes excessive; however, when too little safety stock is carried, the cost of stockouts becomes excessive. Operations managers want to balance these two costs as they set order points" (Gaither and Frazier, 1999, p. 369). Gaither and Frazier also offered an equation to help determine order points:

Order point = Expected demand during lead time + Safety stock

$$OP = EDDLT + SS$$

The same equation can be used to establish optimal safety stock. Once an organization has good estimated DDLT and order points it can start to reduce safety stock:

$$SS = OP - EDDLT$$

Businesses need to have a profound understanding of the lead times of every part that they are supplied. Companies that analyze lead times and initiate actions to reduce them will be better equipped to meet and exceed customer requirements. Companies must keep in mind that even the most methodical inventory management systems will fail, without accurate inventory records.

Inventory Record Accuracy

Inventory record accuracy affects a company's ability to respond to customer needs. Brooks and Wilson (1995) stated that "if a company's inventory records are inaccurate, that company cannot really know the status of its inventory assets. And without that knowledge, its ability to schedule or deliver what its customers want is significantly impaired" (p. 4). Businesses need to be confident that inventory records are accurate. Million dollar decisions are made daily based on information about inventory levels. Companies must ensure that this information is as accurate as possible. One method of ensuring inventory records are accurate is through cycle counting.

Piasecki (2003) defined cycle counting as "any process that verifies the correctness of inventory quantity data by counting portions of the inventory on an ongoing basis" (p. 81). There are several types of cycle counting systems. Muller (2003, p.178) offered the following types of cycle counting methodologies:

- control group;
- location audit;
- random selection;
- diminishing population;
- product categories; and
- A-B-C categorization.

It is important to understand that each organization is different and will require cycle counting methods that are best suited for the organization.

ABC Inventory Classification

ABC Inventory Classification utilizes Alfredo Pareto's theory that 20% of the population contributes 80% of the use or cost of the population. Greene (1970) indicated that there are three basic questions that an inventory system must answer. The first question is on what items should the system devote its control efforts? The next consideration should be how much of an item should be requested when an order is placed? The third question an inventory system should address is when should the item be reordered? EOQ and MRP systems help to answer the later two questions. ABC analysis of inventory will assist in answering the first question by exemplifying items that represent high activity. Greene (1970) also quoted J. M. Juran, who stated in an article in *Management Review* (1954), that

> In any series of elements to be controlled, a selected small fraction in terms of numbers of elements always accounts for a large fraction in terms of effect. A few percent of the quality characteristics account for the bulk of the customers' complaints and the bulk of the scrap and rework. A few percent of the various piece parts entering the final product account for the bulk of the scheduling and delivery date failures. A few percent of the purchase orders account for the bulk of the credit losses and the bulk of unjustified returns. A few percent of the decisions made account for the bulk of the total effect of all decisions. (p. 16).

Juran went on to say, 'it is important to any control system or any management planning that the 'vital few' be separated from the 'trivial many'" (Greene, 1970, p. 16-3). Greene also stated that it was H. Ford Dickie, "who applied Pareto's law to inventory and developed the general concept of ABC analysis" (1970, p. 16-4). "The idea of distribution of value for inventory stratification in neither a system nor at technique; it's a fundamental management principle with universal application potential" (Greene, 1970, p. 16-4).

ABC analysis distributes an inventory population into three major categories (A, B, or C) based on use or cost. Category A items are the highest users (top 20 percent) or fastest movers and account for approximately 80 percent of total inventory usage or cost.

Category B items are the next highest users. Category C items are slow moving items that are used less frequent. Some companies go as far as a category D for the low volume sluggish items, such as service items. Greene (1970) corroborated this by stating "Where the A, B, and C lines are drawn in not of critical importance. A common approach is to consider the first 20 percent of the items to be A items, then the next 30 percent to be B items, and the next 50 percent to be C items" (p. 16-4).

Once the items have been placed in appropriate categories, count frequency must be determined. The basic idea behind the frequency of counts is that the A items will be counted more frequently than the B items and so on. Cycle count frequency will vary by company and by goals. Piasecki (2003) stated that, "count frequency should be relative to the frequencies of errors and the impact of the errors on operations. As accuracy improves, cycle count frequency should decrease" (p. 87). When determining the frequency of counts, a company must take into consideration the number of items that will need to be counted and the time and resources that will need to be allocated to complete the task. Businesses must first calculate the number of counts that will be required each year. This is accomplished by multiplying the number of items in a given category by the number of counts per year per category. The next step is to calculate back the total number of counts per year to the number of counts required per day to achieve the total yearly counts.

For example, if a company has 1,000 items that need to be counted, of those items, 200 are A items, 300 are B items and the remaining 500 items are C items. If a company decided to count A items 6 times per year, B items 4 times per year and C items 2 times per year, that would equate to 3,400 counts to be conducted throughout the year.

Based on a calendar of 200 working days per year, the cycle counters would have to count 17 items per day (3,400 ÷ 200). If the counting activity requires 15 minutes per part to count, the company would have to allocate 255 minutes, or 4.25 hours, per day to the cycle counting program. This could be done by one employee working part time. But if the counting activity required 30 minutes per part to count, the company would have to allocate 510 minutes, or 8.5 hours, per day to the cycle counting program.

The previous example illustrates the factors that must be taken into consideration when determining cycle count frequency. Businesses must recognize the requirements and analyze availability of resources needed to conduct cycle counting activities.

Implementation Resources

Organizations that implement cycle counting initiatives will sometimes incorporate an Inventory Accuracy Team. This group of cross-functional individuals will aid in the planning, implementation, training, monitoring, and all other stages of the cycle counting program. The team will help design the process, define the metrics to be measured, and communicate to the rest of the organization about the successes or failures of the program. The team will also be responsible for collecting, tracking, analyzing and documenting data obtained from the cycle counting program, as well as to educate the organization on the importance of cycle counting procedures. The organization must support the team and give them any and all resources necessary to be successful.

Training is yet another resource that must be devoted to ensure a successful cycle counting program. Organizations must incorporate training into the implementation plans. Piasecki (2003) indicates that:

> Cycle counters must be trained on procedures, acceptable counting methods, use of counting equipment and technologies...cycle counters must also be trained when cases must be opened and counted versus accepting case quantities, when inventory must be moved to verify obscured inventories, and how to verify questionable items. (p. 109).

Training initiatives can be outsourced or conducted by employees of the organization. There is still a cost no matter which method of training is conducted.

Counting Methods

Two of the common methods used for counting inventory include hand counting and scale counting. Most companies use a combination of hand and scale counting to accomplish their daily counting activities. Hand counting is very simply counting each item by hand, but there are several techniques that can be used to increase accuracy and productivity when manually counting inventory (Piasecki, 2003). "These include organizing materials so they can be counted in even layers, hand counting in multiples of twos or fives, counting large quantities in smaller batches, and counting from one container to another (Piasecki, 2003, p. 248). Scale counting utilizes scales that can be programmed to convert a counted sample into a unit weight and use the unit weight to covert the total weight back into a piece count (Piasecki, 2003). Piasecki (2003, p. 200) stated that "A counting scale is simply combining a series of measurements with some simple math to convert weight to pieces." The accuracy of the process is dependant upon the following:

- The sensitivity of the scale relative to the piece weight of the items being weighed;
- the accuracy of the tare weight;
- the accuracy of the sample count;
- the consistency in the unit weight of materials being weighed; and
- the relationship of the sample count to the total count.

Scale counting is very common when dealing with small components. It is very important that the sample count be accurate and that that size of the samples be a good representative of the total quantity to be counted (larger quantity = larger sample size). Figure 2 shows an example of a scale counting procedure and how to determine sample sizes for accurate counting.

Quantity to Count	Procedure
100 or less	Count by hand
101 – 300	Count a sample of 50, weigh sample, count another 50, add to scale and verify that scale reads 100, if not 100 you must recount samples and possibly go to higher sample. If scale reads 100, reweigh at sample 100 and then add remaining product.
301 – 1,000	Count a sample of 50, weigh sample, count another 100, add to scale and verify that scale reads 150. If not 150 you must recount samples and possibly go to higher sample. If scale reads 150, reweigh at sample 150 and then add remaining product
Over 1,000	To weigh very large quantities, use the previous procedure to obtain a verified sample of 150, and then add product until scale reads 1,000, reweigh at sample 1,000 and then add remaining product.
Very light items	For some very light items you may need larger sample sizes. It's imperative that you always check you original sample with another sample of at least the same quantity as the original. Moving air and vibrations can also affect the proper weighing of very small items.

Figure 2 Example of procedure for determining sample sizes (Piasecki, 2003, p. 203)

Root Cause Analysis

As stated previously, ABC analysis of inventory will help the organization visualize where the "vital few" pieces of inventory exists, but does nothing to facilitate the correction of the errors in record accuracy. Inventory error identification and correction is another facet of the ABC analysis that businesses must comprehend. "The idea here is to determine root causes for each variance encountered during the cycle counting process, and then use root cause analysis to focus process improvement efforts" (Piasecki, 2003, p. 84). Brooks and Wilson (1995) also made it clear that "like quality management programs, the cycle counting system's greatest value is its ability to find errors so that their causes can be revealed and remedied. This is the most effective way to maintain record accuracy once it has been established" (p. 135).

Tools for problem solving and root cause analysis can be utilized in reconciling inventory inaccuracies. Pareto analysis is used to classify the items in the organization, but could also be used to segment errors by type and frequency. Cause and effect diagrams and brainstorming techniques can be utilized to help determine causes of inventory inaccuracies and their effects on the organization. Control charts can be used to monitor the cycle counting process from day to day. Tally charts and histograms also can be used to help identify what errors are happening and in what frequency the errors occur. Piasecki (2003) reported "a commonly used phase that a 'cycle counting program should be self-eliminating,' in that by improving processes to eliminate the root causes of errors you will ultimately increase accuracy to a point where cycle counting in no longer necessary" (p. 82). Cycle counting is a great way to keep actual (on-hand) inventory levels in line with the numbers that are illustrated in the organization's inventory database. However, organizations that do nothing to identify and correct the causes of the errors in record accuracy will never fully know the impact of record inaccuracies.

Measuring Inventory Record Accuracy

For an organization to improve inventory accuracy, it must first understand how to measure the accuracy of the inventory system. Potter (2002) stated that "inventory record accuracy is based upon a physical count of an individual item's on-hand quantity and physical location compared to the computer record" (p. 4). A physical count is taken and compared to the value that the inventory management system claims is on-hand. These data are accumulated on an inventory record accuracy sheet, which lists all the items to be counted. Also included on this sheet is a column for the physical count value and the system value (the computer generated value). Next to this column is usually a column depicting the tolerance that will be allowed. The fifth column is titled Hit/Miss; this column is used to tally the results of the comparison between the physical count and the system value. Figure 3 shows an example of an inventory record accuracy sheet.

Inventory Accuracy Tolerances

Tolerances are usually established for counting error. As a rule, the higher the usage an item experiences, the higher the tolerance allowed for error. And likewise, items with lower usage levels will require a lower tolerance allowance (Brooks & Wilson, 1995). It is not uncommon for items with low usage to have a tolerance level of ± 0. For example; if a physical count was taken and produced a value of 10,000 and the system stated a value of 10,325, then this would be a miss on accuracy, unless a tolerance for counting error was established. For this example, assume a tolerance of ± 5 percent was depicted. This would allow for a count value of 9,500 – 10,500 and still attain a hit on the accuracy sheet. This activity is completed for every part in the system, as depicted in Figure 3. Once all the parts have received a rating of hit or miss, the counter would rate the inventory accuracy level of the organization. Record accuracy is calculated using the following equation:

$$\text{Record Accuracy} = \frac{\text{total accurate records}}{\text{total records checked}} \times 100\%$$

Inventory record accuracy of 95% or greater will enable an organization to better understand the level of inventory that is needed to sustain productivity, while reducing inventory levels.

Inventory Record Accuracy Sheet

Date ____ **Counter** ________

Part #	Inventory Record	Physical Count	Tolerance	Range		Hit	Miss
1	100	99	± 2%	98	102	X	
2	100	95	± 2%	98	102		X
3	100	92	± 2%	98	102		X
4	100	94	± 2%	98	102		X
5	100	99	± 2%	98	102	X	
6	100	98	± 2%	98	102	X	
7	100	102	± 2%	98	102	X	
8	100	103	± 2%	98	102		X
9	100	105	± 2%	98	102		X
10	100	98	± 2%	98	102	X	
11	100	102	± 2%	98	102	X	
12	100	100	± 2%	98	102	X	
13	100	96	± 2%	98	102		X
14	100	97	± 2%	98	102		X
15	100	106	± 2%	98	102		X
Totals 15	**1500**					**7**	
						47%	**Accurate**

Figure 3 Example of Inventory Record Accuracy Sheet

The real challenge that exists for manufacturers is determining what method to use to measure accuracy. There are several methods for measuring accuracy. Some of the more common methods of measuring accuracy include:

- good count bad count;
- net piece variance;
- gross or absolute piece variance; and
- average absolute variance.

Good count bad count methodology is the most commonly used method of measuring record accuracy (Piasecki, 2003). This method is very similar to the previous example, in which tolerances are assigned and reported accuracy is defined by the number of good counts divided by the total number of counts.

Net Piece Variance method views the system as a whole. The reported accuracy is defined by the variance of the sum of the counted values compared to the system values (Piasecki, 2003). For example, if a cycle count yields a value of 20 for item A and 65 for item B and the system states that the values should be 24 and 63, respectively, then the net variance would be -2 (-4 + 2). The net variance is divided by 87 (the sum of the system values), which yields a net variance percentage of -0.02 percent. This number is then subtracted from 100 to give the net piece accuracy percentage, which in this case would equal 99.98 percent.

Gross or Absolute Piece Variance method compares the sum of the absolute piece variances to the sum of the system values (Piasecki, 2003). Referring to the previous example, this method defines the reported accuracy by calculating the absolute piece variance of 6 (4 + 2) divided by the sum of the system values of 87. This equates to an absolute piece variance percentage of 0.06 percent. Again this number is subtracted from 100 to obtain an absolute accuracy percentage of 99.93 percent. "Absolute accuracy measurements are a much better means of showing operational accuracy than net accuracy measurements" (Piasecki, 2003, p. 155). Average Absolute Variance method is similar to Absolute Piece Variance except the total absolute variance is divided by the number of variances (not including good counts) (Piasecki, 2003).

Benefits of Inventory Classification

ABC Inventory Classification is a good management philosophy and can help an organization gain a better understanding of its inventory levels. Some of the benefits of ABC analysis include identifying the "vital few" items that account for the majority of the problems, aiding in providing tolerance ranges for various levels of inventory, providing a systematic approach to inventory management, allowing for prioritization of items in a system, and enabling an organization to distribute the population into more manageable portions and create a plan for each of those portions. Like any other system, the ABC method does have limitations.

Limitations of Inventory Classification

Some areas in which the ABC approach may be deficient include focusing on the high volume items and ignoring the low volume items, which does not account for the specific characteristics of items, and it does not consider the impact of errors on operations (Piasecki, 2003). ABC analysis focuses on the high volume, fast moving items and assumes that the fast moving items will encounter more transactions, which equates to more opportunity for error. ABC analysis also does not take product lead- time into consideration. These limitations should be kept in mind when using the ABC method of classifying inventory.

Summary

Organizations are encountering a more competitive environment than ever before. Companies need good sound management philosophies in place to address the issues that arise in a competitive atmosphere. This requires businesses to analyze and fully understand every aspect of the organization. Inventory is present in every industry and must be explored to find enhanced methods of ensuring accuracy. Inventory record accuracy is just as important to an organization's livelihood as is quality. Inventory inaccuracies affect companies' ability to perform and to deliver to their customers' expectations. Organizations need to allocate resources to ensure that records depicting the status of inventory are as correct and as accurate as possible. Improvements in inventory accuracy can result in improvements in a company's profitability because they allow for reduced inventory levels, freeing up cash for other expenditures.

In order to maximize success, therefore, companies must understand the impact that inventory has on the bottom line. The use of systematic methods of improving inventory record accuracy will enable companies to reduce inventory levels. ABC inventory classification and cycle counting are two systematic approaches to better understanding inventory levels. By using these systematic approaches for understanding inventory levels, organizations can position themselves to better satisfy their customers.

Chapter 3

Research Methods

Participants

The 2004 Illinois Manufacturers Directory was used to identify manufacturers in the aircraft parts and equipment category. This category is depicted by the U.S. Government's Standard Industrial Classifications as S.I.C. 3728. Only companies with more than 20 employees located in northeastern Illinois were asked to participate. Although 12 companies were identified as meeting the selection criteria, only eight (67%) agreed to participate.

A person highly knowledgeable about each company's inventory system answered the survey questions, including three company presidents, two vice presidents, and three purchasing managers.

Materials

In order to uncover best practices in inventory control, a survey was developed that addressed the research questions for the present study. Using 18 questions in a multiple-choice format, the survey asked about the inventory management philosophy of each organization, date of implementation of cycle counting process, current inventory accuracy percentage, initial inventory accuracy percentage, time required to implement inventory control, resources allocated to the cycle counting process, reduction in inventory levels, metrics used to analyze system, and procedures of conducting cycle counting activity.

In order to validate the survey questions, the survey was circulated to three experts (Appendices B and C) in the field of inventory accuracy for review. The expert candidates were chosen because they met the following criteria:

-- Experience with cycle counting;

-- Experience with ABC inventory classification;

-- Experience with implementation of either cycle counting or ABC inventory classification;

-- Actively working in an inventory management capacity; and

-- Posses a thorough knowledge of inventory systems.

The panel of experts was asked to review the survey based on their knowledge in the field and to offer any suggestions for improvement. Their suggestions were incorporated into the final survey instrument. See Appendix D for a copy of the survey questions.

Procedure

In April and May, 2005, the 12 manufacturers meeting selection criteria were contacted. As mentioned earlier, eight of the 12 agreed to participate. Responses to the survey questions were gathered via the telephone with the representative from each company.

Data Analysis

The researcher utilized the tools included in Microsoft Excel software to analyze the data. For each question, the researcher determined which response was more frequently chosen. The response with the highest frequency was considered the best practice for this study.

Chapter 4

Research Results

A representative from eight companies that manufacture aircraft parts and equipment in northeastern Illinois responded to a survey about their inventory management practices. The survey used a multiple-choice format for recording responses and descriptive statistics are used for presenting the results.

Questions 1, 2, and 3: (Number of people indicating each choice in parenthesis)

(1) Number of employees?

A. 1-25 (4)	D. 76-100 (1)
B. 26-50 (1)	E. 101-125 (1)
C. 51-75	F. >126 (1)

(2) Number of different components produced?

A. 1-25 (1)	D. 76-100	G. 151-175
B. 26-50 (1)	E. 101-125	H. 176-200 (1)
C. 51-75	F. 126-150 (1)	I. >200 (4)

(3) Number of customers?

A. 1-15 (2)	D. 46-60	G. 91-105
B. 16-30 (4)	E. 61-75	H. 106-120
C. 31-45	F. 76-90 (1)	I. >120 (1)

The eight companies participating were located in Cook, Dupage, or Kane counties in Illinois. Half of the companies employed 25 or fewer people; two companies had over 100 employees. Five of the companies or 63 percent indicated that they produced 176 or more components; two (25%) produced 50 or fewer components. The majority of respondents (six of the eight or 75%) reported having 30 or fewer customers; only one manufacturer indicated over 120 customers. Appendix A describes the companies

Questions 1 through 3 on the survey asked about number of employees, number of components produced, and number of customers. Results to these questions are also presented in the Participants' section of the Research Methods chapter.

Questions 4 and 5:

(4) Does the company utilize cycle counting techniques for inventory accuracy?

A. Yes (4) B. No (4)

(5) During which decade did the company implement the cycle counting program?

A. 1950 (1) D. 1980 (1)
B. 1960 (1) E. 1990
C. 1970 F. 2000 (1)

Fifty percent of the respondents (n = 4) indicated that they used cycle counting techniques for inventory accuracy. All four of these companies produced 176 or more components and three of the four reported having 76 or more employees. Number of customers was more variable, ranging from less than 15 to more than 120. The decade when they first began cycle counting varied widely from company to company, the first being in the 1950s and the most recent in the 21st century.

Questions 6, 7, and 8:

(6) Does the company utilize the ABC inventory classification?

A. Yes (4) B. No (4)

(7) During which decade did the company implement ABC inventory classification?

A. 1950 D. 1980
B. 1960 E. 1990 (1)
C. 1970 (2) F. 2000 (1)

(8) Which method of ABC inventory classification best describes your company?

A. The company uses the dollar value to categorize inventory (1)
B. The company uses the usage or movement to categorize inventory
C. The company uses both the value and usage to categorized inventory (3)

Fifty percent of the respondents indicated that they used ABC inventory classification. Seventy-five percent (n = 3) of those using ABC inventory classification also reported using cycle counting techniques on question 4. Companies reporting the use of ABC inventory classification all produced 176 or more components and three of the four (75%) had 76 or more employees. Number of customers ranged from less than 15 to more than 120.

The decades that ABC inventory classification was first implement by the various companies was not quite as varied as it was for cycle counting techniques. Fifty percent reported first using ABC inventory classification in the 1970s; one company began ABC inventory classification in the 1990s and another one recently began in the 2000s.

For those companies reporting the use of ABC inventory classification, 75% (n = 3) indicated that they used both the dollar value and usage or movement to categorized inventory. One company used only the dollar value and no one selected the usage or movement category alone for categorizing inventory.

Questions 9 and 10:

(9) How many resources (people) did the company allocate to start up the inventory accuracy project?

A. 1-3 (3)	D. 10-12
B. 4-6 (1)	E. 13-15
C. 7-9	F. >16

(10) Did the company use teams to drive the initiative?

A. Yes (1)	B. No (3)

Responses to questions 9 and 10 indicated that most companies allocated few resources to start up inventory accuracy projects and did not use teams to drive the initiative. Seventy-five percent (n = 3) of respondents to question 9 stated that only one to three people were allocated to the project and that they did not use teams to drive the initiative. The one company allocating between four to six people to start up the inventory project also used teams to drive the initiative and was the company reporting the greatest number of customers. The respondent for this company indicated that they began using cycle counting and ABC inventory classification as tools to avoid annual inventory counting.

Question 11:

(11) How many months did it take the company to reach their goal of inventory accuracy?

A. 1-3	D. 10-12	G. 19-21
B. 4-6 (1)	E. 13-15	H. 22-24
C. 7-9	F. 16-18 (1)	I. >24 (1)

Although only three companies had data related to how long it took to reach their goal of inventory accuracy, the range in months reported was considerable. One company reported that it only took four to six months and another reported more than two years to reach its inventory accuracy goal.

Interestingly, the company reporting four to six months to reach its goal indicated that it had not implemented cycle counting techniques in question 4, while the other two companies did report the use of cycle counting. All three companies reported the use of ABC inventory classification.

The company that reported it took between 16 to 18 months to reach their goal of inventory accuracy was the company that allocated more than three people and used teams to start up and drive the inventory initiative.

The company that reported it took over two years to reach its initiative was the company with the most employees (over 100 employees).

(12) Which cycle counting techniques are utilized at your facility?

A. Control Group	D. Product Group Counting
B. Location Counting (1)	E. Random Selection Grouping (4)
C. Transactional Counting	F. Other (*briefly explain)*

Eighty percent (n = 4) of those responding to question 12 listed random selection grouping as the cycle counting technique used at their facility. The only other selection was one respondent (20%) who mentioned location counting and this was the company with the fewest number of employees (<25) and customers (<30), producing over 200 components. The other four companies also reported producing from 176 to over 200 components.

Questions 13 and 14:

(13) What was the company's inventory accuracy rating at the beginning of implementation?

A. 10-20%	D. 41-50%	G. 71-80%
B. 21-30%	E. 51-60%	H. 81-90%
C. 31-40%	F. 61-70% (2)	I. 91-100% (1)

(14) What is the company's current inventory accuracy rating?

A. 55-60%	D. 71-75%	G. 86-90%
B. 61-65%	E. 76-80%	H. 91-95%
C. 66-70%	F. 81-85%	I. 96-100% (3)

Inventory accuracy data was difficult to collect. Only three respondents could provide inventory accuracy data. Two of the three respondents, however, indicated dramatic increases in their inventory accuracy rating since the implementation of an inventory management technique.

Questions 15 and 16:

(15) How much inventory (in thousands of dollars) did the company carry prior to implementation?

A. up to 200	D. 400-500	G. 700-800
B. 200-300 (1)	E. 500-600	H. 800-900
C. 300-400	F. 600-700 (1)	I. >900 (2)

(16) How much inventory (in thousands of dollars) did the company carry after implementation?

A. up to 200	D. 400-500 (1)	G. 700-800
B. 200-300	E. 500-600	H. 800-900
C. 300-400	F. 600-700	I. >1 million (2)

One person responding to question 15 did not have an answer for question 16. Of the remaining three respondents reporting on inventory before and after implementation of inventory monitoring techniques, only one reported a decrease in inventory (from 600-700 to 400-500); two companies indicated increases in inventory (one from 200-300 to over 1 million and the other from >900 to over 1 million).

Questions 17 and 18:

(17) What was the company's on-time delivery rating before implementation?

A. 55-60%	D. 71-75% (1)	G. 86-90% (1)
B. 61-65%	E. 76-80%	H. 91-95%
C. 66-70%	F. 81-85%	I. 96 -100% (2)

(18) What was the company's on-time delivery rating after implementation?

A. 55-60%	D. 71-75%	G. 86-90% (3)
B. 61-65%	E. 76-80%	H. 91-95% (2)
C. 66-70%	F. 81-85% (1)	I. 96-100% (2)

Although not all companies had data about their on-time delivery ratings before implementation of an inventory management technique, for the four companies that did report both before and after implementation data, one reported an increase in on-time deliveries (from 71-75 to 96-100%), one reported a decrease (from 96-100 to 91 to 95%), and two remained unchanged (one in the 86-90% range and the other in 96-100% range).

Chapter 5

Conclusions

Manufacturers of aircraft parts and equipment in a Midwestern state responded to a survey assessing their inventory control techniques. One caution must be mentioned before discussing the conclusions of this research: Results were based on the reports of few companies. Of the 12 companies that met the selection criteria for the present study, only eight agreed to share their inventory information. This small sample size makes generalization of present findings very difficult. This is also discussed in the next chapter on recommendations for future research.

The conclusions from the findings of the present study will be discussed based on the original research questions that guided this research.

Research Question 1: Can improvements in inventory management improve on-time delivery ratings?

Most of the companies sampled could not provide information about their on-time delivery ratings before the implementation of an inventory control technique. The few companies that could provide pre- and post-inventory control data related to on-time delivery indicated mixed results. One company reported a decrease in on-time delivery rating, another reported an increase, and two indicated no change. The present results, therefore, do not provide enough evidence to conclude that an improvement in on-time delivery rating resulted from the use of an inventory management system.

Research Question 2: What are best practices in the use of ABC inventory classification?

The companies producing the most components indicated that they used ABC inventory classification. Companies producing fewer than 150 components did not report the use of ABC inventory classification. Of the companies reporting the use of ABC (n = 4), three of the four (75%) had 76 or more employees. Number of customers was not related to the use of ABC inventory classification.

The companies using ABC inventory classification were most likely to report also using the cycle counting method.

The combination of both dollar value and usage was the most popular ABC inventory method reported by respondents. The one respondent who mentioned the use of only dollar value indicated that they used ABC inventory classification mainly as a tool to avoid annual inventory counting.

Overall, based on the limited sample in the present study, large companies, based on components produced and employees, seem most likely to use the ABC inventory classification method, preferring the combination of dollar value and usage methods. They also are likely to be using an additional inventory method as well.

Research Question 3: What cycle counting method is best practice?

Similar to the results found for ABC inventory classification, companies with the most employees and components produced indicated the use of cycle counting. The number of customers served was not related to cycle counting. Three-fourths of those using cycle counting also reported the use of ABC inventory classification. There was no clear pattern related to which inventory method was put in place first. One company began using ABC inventory classification first before adding cycle counting, another company started cycle counting first, and a third put both inventory management methods into place in the same decade.

Random selection grouping was the cycle counting method endorsed by most manufacturers. The only organization to use a different cycle counting method, location counting, was the company with few employees and customers. How this practice generalizes to other manufacturers today cannot be determined based on the current study.

Research Question 4: Can improved inventory management aid in achieving reduced inventory levels?

The manufacturers responding the survey in the present study did not seem to have inventory reduction as a goal. This may be due, at least in part, to the nature of aircraft parts and equipment manufacturing. Several respondents indicated that they worked off of contract buys for individual projects that were not related to ongoing inventories.

Although there were some examples of dramatic increases in inventory accuracy after the implementation of an inventory monitoring method, only one company reported a decrease in inventory. Because survey data did not provide enough relevant details, it could not be determined if an increase, decline, or no change in inventory levels was related to inventory management philosophy or to business growth or decline.

Research Question 5: Can improved inventory management increase inventory record accuracy?

Inventory accuracy data proved hard to collect. Companies, in general, reported devoting few resources to their inventory accuracy project, and how long it took them to reach their accuracy goal was highly variable, from a few months to years. Two out of three respondents did report dramatic increases in their inventory accuracy rating since the implementation of an inventory management technique. Due to the limited sample how representative they are of others in similar settings is unknown.

Summary

In one Midwestern state, approximately one-half of aircraft parts and equipment manufacturers responding to a survey reported using inventory management techniques. Larger companies, based on number of employees and number of components produced, were most likely to endorse the use of inventory management, and those using cycle counting were also likely to be using ABC inventory classification. Due to a limited sample size, best practices were difficult to determine, but random selection grouping was the most frequently used form of cycle counting and a combination of both dollar value and usage was the most popular ABC inventory classification method reported by respondents. For the most part, companies reported allocating few resources to the implementation of inventory management practices. Although inventory accuracy and on-time delivery data proved difficult to collect, examples of dramatic increases in accuracy ratings after the implementation of an inventory management technique were found. Contrary to expectations, no clear pattern of changes in on-time delivery was found. Inventory reduction did not appear to be a major reason for the use of inventory management. Because of limited data, it was difficult to determine whether any reported changes in inventory were due to inventory management or to some other factor, such as business growth and decline.

Chapter 6

Recommendations for Future Research

While results from the present study add to the body information about inventory management systems, future research is needed. The limitations of the present research highlight areas for future research.

The limited number of respondents greatly hindered the ability to generalize the results of the present study to other manufacturers of aircraft parts and equipment. Information from a much larger sample size is needed to better understand the effects of inventory management on this industry. Rather than telephone interviews, sending out questionnaires to all relevant companies would be one method of contacting many more manufacturers.

This study focused only on the aircraft parts and equipment industry in one portion of one state. Results from this industry may not be relevant to other manufacturers. For instance, some respondents indicated that their inventory focused on contract buys for individual projects. This focus on contract buys is not universal to all manufacturers. Future studies could be conducted utilizing another industry. The automotive industry, for example, would be a good candidate for a future study of the benefits of inventory management systems.

The participants in this study were all located in a northeastern location of one Midwestern state, limiting any possible generalization to other states and locations. Future research can be conducted in other states and areas to better understand the possible benefits and limitations of cycle counting and ABC inventory classification.

No information on product demand was collected from respondents in the present study. Because demand can influence inventory, future research could investigate how demand affects the success of various inventory management methods. It may be that some practices are more or less practical based on demand characteristics. Only future research could confirm or disconfirm this possibility.

Participants in the present survey often had difficulty providing some relevant information. A more in-depth review of company records seems to be necessary in order to determine in what contexts and for what types of manufacturers inventory management affects inventory accuracy, on-time delivery rates, and inventory level.

Time was a constraint to this study. A case study that followed five companies through implementation would take one or two years to complete, but would enable the researcher to thoroughly analyze the improvements that these inventory management tools can offer. One could establish metrics that would be analyzed throughout the implementation, to uncover the true benefits of ABC Inventory Classification and cycle counting practices. Each of the five companies could implement a slightly different version of the management tools and this would allow the researcher to analyze and report which method yielded the best results.

This study added to the knowledge of inventory control, but also highlights future areas that need to be investigated. There still are many questions that need to be answered in order to determine the best practices of inventory management.

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APPENDIX A

List of Participants

Subjects	Type of Products	County	Contact Position
A	Aerospace actuators, compressors, pumps	Dupage	Vice Pres.
B	Precision aircraft components, gears	Cook	Purchasing Manager
C	Aircraft & Aerospace components	Cook	Vice Pres.
D	Aircraft instrument components	Kane	Purchasing Manager
E	Explosive actuated devices, escape systems	Dupage	Purchasing Manager
F	Aircraft body parts	Dupage	Pres.
G	Aircraft electronic equipment	Cook	Pres.
H	Household electronics & avionics	Cook	Pres.

Appendix B

Panel of Experts

Expert 1:

Ron Tupper
Owner/President
DAPCO Industries

DAPCO Industries is a manufacturer of parts from screw machines and CNC machines. DAPCO implemented ABC Classification and cycle counting in the early 1990's

Expert 2:

Rick Ross
Materials Manager
Rockford Spring Co.

Rockford Spring Co. is a manufacturer of springs and wire forms. Rockford implemented cycle counting in the late 1980's

Expert 3:

Charles R. Bovard
Operations Manager
Total Quality Warehouse
A Division of Agracel, Inc.

Total Quality Warehouse is a company that offers warehouse service to local manufacturers. Charle gained his knowledge of ABC Classification with Sherwin Williams in Effingham, IL.

Appendix C

Letter to Panel of Experts

Gentlemen,

I have spoken to most of you on this topic, but some of you I have not. I am currently working to finish my Thesis for my Masters Degree requirements. I have chosen to do my Thesis on inventory management. I am contacting you because of your expertise in inventory management. I have attached two files (survey instrument) that I would like for you to review and give me your honest feedback.

Just a little back ground so that you understand the purpose of the instrument. I have chosen to research Aircraft Parts and Equipment manufactures in Northeastern Illinois. I am researching whether or not they use ABC Classification of inventory and cycle counting and if through the use of this management style they have seen improvements in their inventory accuracy and on-time delivery to their customers.

I will keep your names anonymous if so desired, but I want to take the feedback that you provide to improve on the survey instrument prior to sending to prospective survey subjects. Please review the documents and provide any and all feed back that you can.

Thank you in advance for your help with this issue. I am almost done with this thing and need your responses by April 18th if at all possible.

Please respond to confirm that you received this message and feel free to contact me with any questions or concerns.

Thank you
James M. Lanman

Appendix D

Survey Questions

General Questions

1) Number of employees?

A. 1-25
B. 26-50
C. 51-75
D. 76-100
E. 101-125
F. > 126

2) Number of different components produced?

A. 1-25
B. 26-50
C. 51-75
D. 76-100
E. 101-125
F. 126-150
G. 151-175
H. 176-200
I. > 200

3) Number of customers?

A. 1-15
B. 16-30
C. 31-45
D. 46-60
E. 61-75
F. 76-90
G. 91-105
H. 106-120
I. > 120

4) Does the company utilize cycle counting techniques for inventory accuracy?

A. Yes
B. No

5) During which decade did the company implement the cycle counting program?

A. 1950
B. 1960
C. 1970
D. 1980
E. 1990
F. 2000

6) Does the company utilize ABC Inventory Classification?
A. Yes
B. No

7) During which decade did the company implement ABC Inventory Classification?

A. 1950
B. 1960
C. 1970
D. 1980
E. 1990
F. 2000

8) Which method of ABC Inventory Classification best describes your company?

A. The company uses the dollar value to categorize inventory
B. The company uses the usage, or movement to categorize inventory
C. The company utilizes both the value and the usage to categorize inventory

Implementation

9) How many resources (People) did the company allocate to the start up of the project?

A. 1-3
B. 4-6
C. 7-9
D. 10-12
E. 13-15
F. > 16

10) Did the company use teams to drive the initiative?
A. Yes
B. No

11) How many months did it take the company to reach their goal of inventory accuracy?

A. 1-3
B. 4-6
C. 7-9
D. 10-12
E. 13-15
F. 16-18
G. 19-21
H. 22-24
I. > 24

Cycle Counting Techniques

12) Which cycle counting techniques are utilized at your facility?

A. Control Group
B. Location Counting
C. Transactional Counting
D. Product Group Counting
E. Random Selection Counting
F. Other *(Briefly Explain)*

Inventory Accuracy

13) What was the company's inventory accuracy rating at the beginning of implementation?

A. 10% - 20%
B. 21% - 30%
C. 31% - 40%
D. 41% - 50%
E. 51% - 60%
F. 61% - 70%
G. 71% - 80%
H. 81% - 90%
I. 91% - 100%

14) What is the company's current inventory accuracy rating?

A. 55% - 60%
B. 61% - 65%
C. 66% - 70%
D. 71% - 75%
E. 76% - 80%
F. 81% - 85%
G. 86% - 90%
H. 91% - 95%
I. 96% - 100%

Inventory Levels

15) How much inventory (in dollars) did the company carry prior to implementation?

(In Thousands of Dollars)

A. < 100 – 200
B. 200 – 300
C. 300 – 400
D. 400 – 500
E. 500 – 600
F. 600 – 700
G. 700 – 800
H. 800 – 900
I. > 900

16) How many annual inventory turns does the company currently have?

(In Thousands of Dollars)

A. < 100 – 200
B. 200 – 300
C. 300 – 400
D. 400 – 500
E. 500 – 600
F. 600 – 700
G. 700 – 800
H. 800 – 900
I. > 900

On-time Delivery

17) What was the company's on-time delivery rating before implementation?

A. 55% - 60%
B. 61% - 65%
C. 66% - 70%
D. 71% - 75%
E. 76% - 80%
F. 81% - 85%
G. 86% - 90%
H. 91% - 95%
I. 96% - 100%

18) What was the company's on-time delivery rating after implementation?

A. 55% - 60%
B. 61% - 65%
C. 66% - 70%
D. 71% - 75%
E. 76% - 80%
F. 81% - 85%
G. 86% - 90%
H. 91% - 95%
I. 96% - 100%

Appendix E

Survey Responses

	Subjects	A	B	C	D	E	F	G	H
Questions	1	E	F	A	B	D	A	A	A
	2	I	I	I	I	H	F	A	I
	3	F	A	B	B	I	A	B	B
	4	A	A	B	A	A	B	B	B
	5	D	B		A	F			
	6	A	A	B	B	A	B	B	A
	7	C	C			F			E
	8	C	C			A			C
	9	A	A			B			A
	10	B	B			A			B
	11	I	0			F			B
	12	E	E	E	B	E			
	13	F				I			F
	14	I				I			I
	15	B	I			I			F
	16	I				I			D
	17	D			I	I			G
	18	I	G	F	H	I	G	H	G