LEAN INVENTORY MANAGEMENT SYSTEM FOR BOEING MISSILE DEFENSE

by

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A Senior Project submitted
in partial fulfillment
of the requirements for the degree of
Bachelor of Science in Industrial Engineering

California Polytechnic State University
San Luis Obispo

Graded by: Reza Pouraghabagher      Date of Submission: June 3, 2010
Abstract

Lean inventory management is influential for business. One of the wastes businesses aim to reduce, using lean principles, is inventory. Inventory management provides the essential tools for eliminating extra inventory and cost that is tied up in capital Boeing’s Ground Based Missile Defense inventory area was failing at meeting their proprietary lean manufacturing goals. There was a need for an inventory system that included: lean principles, inventory management and user-friendly capability. The goal of this project’s inventory management database process was to minimize inventory investment while still meeting functional requirements.

The deliverables for this project met the needs of Boeing’s Missile Defense Program. Their Lean standards have been utilized and implemented In order to design a proper inventory management system; discussion on user-friendly capability was taken into consideration with an appropriate amount of technical abilities. The Access inventory management system provided accurate reports to ensure proper reordering methods. The results were analyzed on the new inventory management system through value stream maps and economic analysis. In conclusion, there was a savings of $10,466.00 which included distance saved due to improved facility design, time saved by the team member in inventory area, and the purchaser labor cost due to increased visibility in inventory.
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Introduction

Boeing’s Ground Based Missile Defense program was failing at meeting their proprietary lean manufacturing goals in their inventory area. There was a need for an inventory system that included: lean principles, inventory management and user friendly capability. A score of 3 out of 5 is desired to bring the inventory area up to standards. The lean metrics for raw materials incorporated organization through 5S, and a technical and visual reorder system. Lean has been implemented throughout the company and at sites including Vandenberg Air Force Base, California.

During my internship in the Summer of 2009, the inventory area for raw materials was presented. Guidelines and an outdated stock count were given upon arrival. According to the Boeing Lean Manufacturing Assessment (LMA), the inventory area failed in respect to both inventory organization and inventory management system. The current state of use for the area was storage with little emphasis on inventory management. There were many unidentified items, old project pieces and many other types of parts. No organization or sorting method was being implemented.

Methods used for creating a solution to the problem were analyzed using group discussions with fellow employees. It was discussed that the design needed: to have 5S incorporation, easy-to-use inventory management system that Missile Assembly Building (MAB) workers would be able to use with ease. Whether to use a manual data, Excel spreadsheet or Access database was also evaluated.

After the problem was identified and methods were analyzed, I spent more than 200 hours to design a proper solution for their needs. During this time I referenced Data Management & System Design (IME 312), User-friendly interface (IME 319), Facility
Planning and Design (IME 443) and Inventory and Control Systems (IME 410). I implemented tools from IME 312 for efficient data entry and reports, queries, macro function, and usability. I used material from IME 319 for analysis of factors influencing the efficiency of human work. I used data on the physical and mental capacities of persons, the physical environment, work organization, and the problem of aging. I incorporated knowledge of machines, operations, human computer interface and work environment to match human capacities and limitations. For the flow of the inventory I referenced IME 443. Facilities Planning and Design allowed for proper grouping of parts for optimal layout. I also utilized IME 410 for the required knowledge of inventory management and lean principles that this project relies on.

After completion of the project the deliverables included: an Access Database with personalized inventory management system, enforced 5S standardized area, and a user manual on functionality of the database and troubleshooting. The objectives also include receiving a score of 3 out of 5 on the LMA in order to gain a passing score. This report is organized by the evaluation of literature, implementation of lean principles, and design and implementation of inventory database.
**Background**

Boeing Integrated Defense Systems (IDS), based in St. Louis, is a $23-billion business with capabilities in defense, intelligence, communications, and space. As a recognized leader in providing end-to-end services for large-scale systems for global military, government, and commercial customers Boeing IDS strives for excellence. The Ground-based Midcourse Defense (GMD) System is the first and only operationally deployed missile defense program to defend the homeland against long-range ballistic missile attacks. The system provides early detection and tracking during the boost phase, midcourse target discrimination, precision intercept and destruction through force of hit-to-kill technology.

Boeing contributes to the program as prime contractor. Boeing designs, produces, integrates, tests and sustains all GMD components. Extensive ground and flight tests have demonstrated the system's successful performance against long-range ballistic missile targets. The system has achieved a total of eight successful intercept tests, including three successful intercept tests with the operationally configured interceptor.

Each interceptor is different; however, key components for the aid of manufacturing are essential to the process. It is with these key components that detail needs to be taken. Without the raw materials production could be brought to a halt. Parts like zip ties, lint free wipes and special tape are all small things that add up to the functionality of the manufacturing process.

This project is important due to the ability to manufacture the defense missile. Holding on to excess inventory is costly to not on the missile defense program but also to Boeing in general. The extra space and energy required to hold the space costs money
that could be used for further capital. On the other end of the spectrum involves stock outs or shortage. Not having enough inventory causes expensive cases like expediting or halting production. Boeing strives to effectively stock inventory to minimize inventory costs while maximizing throughput of the desired product.
Literature Review

“Inventory has been and continues to have an essential influence on companies across industries and regions; especially with increasing competition pressures, source of supply globalization, and diminishing product life cycles” (ePhiphony Incorporated). According to the survey performed in “Inventory Reduction: Getting Lean, Mean and Effective,” eighty-two percent of the senior executives who responded said that excessive levels of inventory were a major concern. Major reductions can be initiated by the use of a management system. With management, it will be likely to reduce cycle time, decrease costs, increase quality and improve customer service.

Inventory can be defined as “any good that is being held for any length of time, inside or outside the factory” (Karr). The goal of inventory management is to minimize inventory investment while still meeting functional requirements. Management techniques such as Lean Manufacturing can help reach the goal by reducing excess inventories and trim cost. Inventory management is used to create a lean system that limits excess inventory.

Inventory management can be put into a paradox as follows, “If you cannot match inputs to and outputs from an inventory, you will never control it. The better you can match inputs and outputs, the less need there is for an inventory” (Orlicky 34). This corresponds to the Lean attitude in which if the inputs (such as purchased parts, and subassemblies) do not confirm the output (finished goods) there exists a waste which Lean will attempt to eliminate.

There are two different approaches organizations can make with regard to inventory. They can assume it is just a necessary evil and start a special inventory reduction program whenever cash gets tight. Or they can make strategic decisions on the
level to carry, put an inventory management process in place to actively manage inventory and continually improve the business results (Karr Lean Inventory 57). In order to facilitate needs of inventory, strategic management tools have been developed. Simple ordering methods, mainly used for raw materials are: min/max, set time analysis, two-bin method and visual review method (Orlicky 33). These methods are based on minimal record keeping and technology. However, the constant need for strict discipline and attention to manufacturing changes can cause data inaccuracies.

Businesses today are wasting countless dollars due to their lack of a streamlined automated inventory tracking system (Wasp Barcode Technologies). To allow for an easier data management in inventory area, a database can be implemented to secure accurate data when used properly. Databases can hold information on the product such as: part number, type, location, quantity on hand, reorder quantity, and reorder details. They are easily altered to fit most situations. The major inventory management databases have functions like: adding inventory items, deleting items, log of removed items, inventory summary report, and reorder items list. These databases can use different types of mediums. For example, it can be set up with Microsoft Excel, or Microsoft Access. An example of an inventory database is a patent by: Beingreichs, Seng, Van Laethem, and Heger. Their inventory system analyzes the supply chain for a given company using inventory techniques to track and incorporate current information. The database execution, unlike the more visual techniques, can easily be updated.

Another feature that can be added to the inventory database is the ability to associate a barcode location. The barcode for location allows for ease of location identity. The barcode can also be incorporated with the database for ease of removal from
inventory. An example of a bar coding inventory system is Wasp. The associated cost of the system is rationalized by the waste that will be removed. Wasp lists the wastes as: time spent taking physical inventory, lost sales opportunities due to improper inventory overages, slow and costly purchasing process, and salary costs of employees searching for inventory. These identified wastes are incorporated into the Lean manufacturing philosophy that aims to reduce waste.

Lean is demonstrated as the elimination of waste (Womack 14). Waste, originating from the Japanese form “muda,” is the result of a non-value added activity. There are seven types of waste: overproduction, waiting, transportation, over processing, inventory, motion, and defects (McBride). Overproduction is the manufacturing before it is demanded. Waiting refers to a stationary item that is in need for the next process. According to “The 7 Manufacturing Wastes,” 99 percent of a parts life will be spent waiting due to poor production process and bottlenecks. Transportation is the moving of products or good that is not essential to the process. Over processing or inappropriate processing is caused by insufficient tooling or poor plant layout. Inventory includes raw components, work in process and finished product not being processed. Motion relates to the waste that is associated with ergonomics and extra moving of the operator. Finally defects result in waste due to the rework and resources required to fix the product. According to the Lean thinking, eliminating these wastes will eliminate non-value added steps and increase efficiency in a manufacturing setting.

A tool that is used in Lean manufacturing to simplify potential issues in wastes such as inventory, motion and over processing is 5S. The 5S process (sometimes referred to as the Visual Work Place) is about “a place for everything and everything in its place”
The term 5S came about because the original Japanese names of each of the five principles began with the letter "S". The names of the five principles are: Seiri (tidiness); Seiton (orderliness); Seiso (cleanliness); Seiketsu (neatness); and Shitsuke (discipline).

There are different interpretations of the 5S. For example, the 5S’s that have been adapted by Boeing are: Sorting, Simplifying, Sweeping, Standardizing, and Self-discipline. Sorting means to go through a designated work area and to sort out the necessary from the unnecessary. Simplifying puts everything in a designated place and to visually mark it. A good example for marking could be identified as a barcode which as stated above defines a location for the part. Sweeping means to physically clean up the work area and to deliberately pick up all parts and material that are out of place and return each to its assigned place as defined in Simplifying. Standardizing means creating standard ways to keep the work areas organized, clean and orderly and to document agreements made as part of the 5S’s if this “S” is to be successful. Self-discipline is made for following through with the 5S’s agreements. If the company doesn’t maintain the changes made with the 5S’s, the company will not maintain the gain. The typical accomplishments of a 5S program include: creation of space, reduction in lead times, reduction in cycle times, improved set-up-times, and continuous improvement (Spoore 3). 5S is a highly effective system, which when implemented properly, will simplify, standardize your operations and thereby enable measurable results in manufacturing operation.

Incorporating the Lean philosophy of eliminating waste and 5S can be a drastic improvement to manufacturing efficiency. When applying Lean principles, the value of
Reducing inventory is essential. It not only takes revenue tied up in raw material and work in process but it also takes up space. The space if not used efficiently can result in a 5S disaster. It is essential to integrate lean techniques to improve inventory management. Reductions in inventory reduce the cost of storage, increase the amount on inventory turn and reduce overall cost. Inventory turn refers to how fast a company uses up their inventory (Gibson 44). A concern with inventory exists with a lack of visibility. That is where the 5S process can be of assistance. Making the inventory visible involves everything has a place and everything is in its place.

The solution for inventory waste cannot be a one time solution. The success of inventory management is reliant on the accuracy of the data. There are many factors to be considered when inaccurate data arises. The factors range from misuse of area, lack of accountability to no system in place to regulate the inventory. A requirement for an effective inventory management system is usability. It needs to be easy to use such that the data can be updated easily. Human factors should be considered when implementing systems with importance on accurate data. According to Gibson in “Applying Lean Principles to Design Effective Supply Chains,” maintaining accuracy of inventory on hand is a fundamental prerequisite for any initiative to improve inventory management.

Inventory management is an important and costly aspect to manufacturing. Action needs to be taken in order to reduce the waste that can accumulate over time. In Boeing’s Missile Defense program, there was a need for an inventory system that would eliminate the excess inventory, sort, simplify, and standardize the raw material inventory. The management system needs to improve visibility, accuracy and fulfill the needs of Lean thinking that Boeing has set forth.
An issue with accuracy and constant flow of inventory can be maintained by an inventory database. The database includes functions tailored to the needs of Boeing. It is a user-friendly program that allows for reports and audits to be run in a moments notice. In the database, accountability is also taken into account in the functionality of the database. Each item being removed and added to the area is represented in the database. Another factor in this project is the influence represented by Lean principles. The 5S of the area will be greatly enhanced and influence the success of the inventory database. The unique purpose of this project is to create an inventory plan that incorporates an easy-to-use database that corresponds to bar coded locations that meet 5S and Lean standards set by Boeing.
Design
In this chapter an overview of the design of the project will be presented. The details about the before state of the inventory area will be analyzed. It will also describe the design characteristics used while creating the solution. To form a design, the parameters were broke them into sections. These sections defined as lean inventory set up, technical and visual reorder process, ergonomic approach and layout. Finally the proposed design will be presented along with a comparative analysis between proposed and a current system in the market called Wasp Inventory System.

The Before State
The first visit to the inventory area included a tour with both manager and team member. When entering the area, the attention focuses on the mass of boxes with no labels that are placed on shelving units. An attempt to organize the area had been made due to the sight of circular bins in the entrance. Each bin compartment had separate parts without labels, quantities or any other useful information (See Figure 1). Besides the fact there were no labels, all parts were mixed together. One circular of 40 different parts for different areas of the missiles.

Alongside the walls were storage racks full of an array of things. Everything from paint tins and hazard signs to important connectors were placed on these shelves. It was evident that organization had not been attained and also inventory management was not existent. The list of inventory given was from December 2006. It was clearly not up to date and organized in an alphabetic fashion. This made for difficult inventory counting.
and eventually led to a personal inventory count performed by myself. The area did not completely conform to any Lean metric.

The only attempted Lean metric that was in existence upon arrival were reorder cards (see Figure 2). These cards were placed in segmented bins and boxes in order for a presence of visual reordering system. It had obviously not been followed and used more as a checkmark for previous assessments. Because of the lack of Lean organization, inventory reorder knowledge, and ergonomic design to create accountability with inventory, the presented project was necessary.

![Figure 2: Example of Previous Reorder Cards](image)

**Design Parameters**

The end product of this project was presented to Boeing and initial stages of implementation occurred. It was critical for the project to provide assistance for future use of the presented area and product and detail needed to be taken for usability in the design. While evaluating the purpose of the project, broad parameters were identified, these parameters included: lean inventory setup, technical and visual management system, ergonomic approach and area layout. Within each category lies strategy to promote success of the project. Observation, team and manager input and other formal ideas were collected during each analysis of each parameter.
**Lean Inventory Setup**

The proprietary Lean Manufacturing Assessment (LMA) includes a wide range of grading factors for all areas of Boeing. However, for this given project it was only essential to perform 5S analysis on the inventory area. Other portions of the LMA are crucial for lean success; however, were not included in this project. The Lean 5S’s include: sort, straighten, sweep, standardize and sustain.

For the first S, sort, the room was thoroughly assessed for importance of each item. Things like old paint cans, outdated signs, and expired goods were all removed. This not only reduces the inventory cost but also improves the quality of goods. If the expired products were used on the missile, issues would arise. The sorting also created room for other items to eventually be group together in one specific area.

The next S, straighten, made a place for everything and put everything in its place. From the sort exercise, only remaining items needed a place. It will eventually be discussed that a barcode was also assigned to each location. This ensures a place for everything. It also prevents multiple locations for the same part. Another aspect of the straighten phase was the design of the area. A detailed design improvement can be found later in this chapter under Layout. While performing analysis on both sort and straighten, there was also an emphasis on sweeping.

The sweeping led to lots of cleaning of dust. Some items that had not been used in years had been sitting in the inventory area and collecting dust. While sorting, and straightening the area was cleaned which made sure there was a visible neatness to the area. This led me to standardizing. The area was standardized with the location barcodes and labels for each part. The labeling of each part was tedious but essential to the standardizing of the inventory area.
Finally, the fifth S, sustaining, was implemented. The main use of proposed inventory database works hand in hand with sustaining. If the database continues to be used, everything will be in its place, or assigned a new place. No more unnecessary items will be sitting in the inventory area, and checks made by the team member in charge will take accountability for sustaining the system.

**Technical and Visual Inventory Management**

As previously discussed, inventory management is crucial to time, space and costs that impact Boeing. The purpose of this project was to minimize the time, utilize their space and minimize reordering costs incurred. In initial discussions with both management and team members, there was no specific tool or interface recommended. The options presented were also provided on everyone’s computer. The interfaces presented were Microsoft Word, Microsoft Excel and Microsoft Access. Trial and error was performed which led to the end result of using Microsoft Access as the needed interface.

Before this project was presented, there was a failed attempt to have a written log of inventory taken out of the area. This was not successful due to the time and detail needed. There was also no accountability for whoever was taking the items. The Microsoft Word form was still placed on the cabinet upon arrival. The lessons learned from previous this previous design included: the less time needed the better, the less responsibility for the reorder clerk the better, and also the more knowledge the team members have of the system, the more successful it will be.

The next interface analyzed was Microsoft Excel. This would provide an easier template for the team members to fill out. However, this would also be unsuccessful due
to the time constraints. The Excel spreadsheet would consist of the part numbers and would require the team member to search in order to emulate removing inventory.

Finally the thought of using Microsoft Access was evaluated. It required more time and attention by the creator; however, both team members and reorder clerks would find the format and reports quite handy for everyday use. It would remove the writing of information and most of the analyzing. Access would perform the ordering and calculating of inventories.

**Ergonomic**

The success of this project relies on the fact that the database and interface is user friendly. With the knowledge of information capacity, minimal recollected data was needed. The font is also large enough to be visible are readable. The tabs incorporated are also user friendly. Another feature with Access, is the ability to guide the user. Buttons and text boxes are helpful to direct what is needed. I also left a handbook that describes the process taken to work the database. It will reinforce the user friendly capability of the database by easy tab manipulation.

**Layout**

The layout before this project was quite unorganized. There was no specific flow and it was evident items that were coming in were just placed on a shelf. It was then left without any form of identification. It was noted that there was extra movement by the workers to locate the part box. It was also noted that items close to the entrance were not strategically placed in order or usage (See Before Layout in Appendix B).

The often used parts are on the shelving while the rarely used objects were in the convenient circular bins. In my new layout I sorted through everything and organized it
into categories which were then organized in importance and rate of use. The new layout reduces distance traveled and time spent looking for parts. There are also signs that direct the workers to the area then within the area there is a label which clearly shows what is in the bin (See After Layout in Appendix B).

Alternative Designs

While forming alternative designs I created two scenarios for both the reorder process and also the min/max quantity for each item. The process has two options, both with pros and cons concerning efficiencies. For the min/max calculator, I used the standard Boeing equations then also implemented learnings from IME 410 to create a new min.max calculator that I feel is more accurate and better for reordering.

Process Design 1

The initial design involved the use of labels, label maker and pocket pc (See Figure 3). The labels are used for creating barcodes and labels for every item. The pocket pc had a barcode reader embedded in it to read each label. These items were all in Boeing’s possession so there was no additional costs. The process was created to minimize work for the team member to get them in and out of the inventory area as quick as possible.

The process for the worker would be:

1. Pick up Pocket PC
2. Turn on Pocket PC
3. In Excel Spreadsheet, scan the item, enter quantity taking then scan in Boeing badge barcode
The assistant purchaser below the inventory area, also known as mezzanine, will then perform these steps:

1. Take the pocket pc and place it in the doc
2. The pocket pc will then download all of the new data entered from the mezzanine worker
3. The assistant purchaser will then enter the information into the Access database.
4. While entering the database will provide notification of the need to reorder
5. The assistant purchaser will then run the reports that will list out the items needed to be reordered.

This design is very beneficial for the team member in the mezzanine. They can bring the pocket pc anywhere and easily enter in the three pieces of information.

However, this design puts a burden on the assistant purchaser. They are required to do more work. This work is not hard but it would be harder to convince the assistant purchaser to update the data often.

**Process Design 2**

For the second design the necessary items include: dedicated computer, labels, label maker and scan gun (See Figure 4). Again, these items were in Boeing’s possession. The process is similar but the team member has to do minimal additional work; however, the assistant purchase will be taken out of the process and the reports will be run by the head purchaser. The process for the worker would be:

![Figure 4: Scanner Gun](image-url)
1. Open Access database
2. Go to location of part required
3. Scan in location
4. Go back to computer and enter quantity removing
5. Scan in Boeing badge
6. Press remove items

Then all the purchaser has to do is log on to the network to view up-to-date inventories and reorder reports. The steps are not complicated for the team member. They just have to take the scan gun with them and return it when they are finishing filling out the database information. This design also lets all the sustainable steps to happen in one place. If there are new items to add to the system, the team member can stay in one location to add it to the database and create the new barcode and label.

*Min/Max Inventory Calculator Design 1 from Boeing Standards*

The standard equations from Boeing’s website involve data from: ship quantity, monthly rate used, and multiplier used by price (See Appendix C for snapshot of Boeing’s Min/Max calculation). The ship quantity used how many come in a box. This assumes there is no changing quantity size. The monthly rate is another assumption since month to month usage often changes. Finally the multiplier is calculated by price category. For example, if the price per part is between one dollar and two-hundred and fifty dollars, than the multiplier would be a 4. This emulates the idea of reducing capital cost and only holding on to more goods that cost less.

When creating inventory levels it is advisable to minimize tied up capital however, it is not of use to have capitol tied up in smaller parts. The variables used are:

Ship Quantity= Q

Monthly Rate= R
Multiplier by price= 4 if part price is between $1 and $250 
3 if part price is between $250 and $999 
2 if part price is > $999

The calculations from Boeing are:

Minimum= Q * R 
Maximum=Minimum*Multiplier by Price

The values obtained for certain parts made sense; however, some of them provided extreme values due to the multiplier of 4. This could mean there was 4 times the inventory necessary. The minimums and maximums also do not take into account lead time. The multiplier provides the buffer but does not give notice for how long the part will take to arrive to the site.

Min/Max Inventory Calculator Design 2 from IME 410 Learning’s and Research

For the second design for the minimum and maximum inventory calculator, I researched different methods. I knew the solution needed lead times since those are what cause most delays. I also wanted calculations that seemed reasonable and explainable to team members to comprehend.

In the proposed method I use some of the same variables including:

Usage in units per weeks=S
Lead time in weeks=L
Ship Quantity= Q
Safety Stock=S

I used this generic equation:
Minimum = Normal consumption during lead-time + Safety Stock

\[= S \times L + S(S \times Q \times L)\]

This equation takes into account the lead time, safety stock and the ship quantity from the previous design. The maximum equation was harder since it really comes down to how much Boeing is willing to hold on to. After discussion with my manager, Boeing Missile Defense would only like to hold on to a month’s worth of inventory. Thus my maximum equation is:

Maximum = Minimum + Month’s worth of inventory

\[= S \times L + S(S \times Q \times L) + 4(S \times Q)\]

These equations have a conservative notion. There is minimization of capital help in inventory. There might be an increase in reordering; however, the cost reduction will be encountered when there is not longer a need for rush reordering. This cost is quite high so the conservative minimum/maximum calculations should be monitored after implementation.

**Alternative System Analysis-Wasp**

After extensive research, the program called Wasp Inventory Management System (www.wasp.com) brought new insight to inventory management. According to their website with the use of their tool the company can: “Gain visibility and management of their inventory with Wasp inventory software. Reduce inventory stock outs. Manage inventory reorder levels. Check in / check out.” Their tool is quite handy and does provide a nice base for companies without Microsoft Access users. I utilized their ideas; however, created a new Access database to fit Boeing’s needs.
Initially it was brought to Boeing’s attention to simply purchase the tool and work from there. After training with the guide, it was brought to their attention that it was quite unfriendly for a user. The main form was confusing and tedious. It was not a fast process to “check out” items. This made the Wasp Inventory System not user friendly. There would be a strong push-back from the workers at Boeing for the process taking too much time. Nevertheless, Wasp’s system provided many useful reports. These reports gave the needed inventory levels and provided visibility. However, finding the needed report might not be easy. There were over twenty different reports that could be run. This takes up time for the purchaser to go through these reports and sort what he/she is looking for. The tool again shows to be useful in the beginning; however, leads to confusion for the team member in the inventory area and the purchaser.

With the cost of $595 for standard and $1,495 for the professional edition, it was clear this would not be the solution for Boeing. Those were also the costs for just the software. It was an additional $1,000 for the scanner and $1,000 for the printer. While using Boeing’s resources and my knowledge of Access database, I created the Inventory database, found their existing scanner, and used their label maker for barcodes. I also implemented a user friendly form and included only essential reports for the purchaser.
Methods

At the end of the internship, partial implementation was performed. Process Design 2 and Min/max calculator 2 was used and implemented. The Lean metrics and facility layouts were also completed. The final Access Inventory database was also designed, tested, and manipulated for errors. As seen in Figure 5, there is a visual signal for clarity in reordering. This allows for no confusion on which parts needs to be reordered. Trial runs of the process and extensive troubleshooting were performed to ensure accuracy of the database. Through discussion and a one-on-one briefing regarding the new process and usage of the database, the database and process provided a sufficient amount of detail while also user friendly. A user handbook was also left with the team for guides and troubleshooting.

The chosen method maximized effectiveness for both the team members and the purchasers. The team members were essential for the manual process of removing the inventory items, 5S and overall sustainment of the system. The purchaser was also taken into consideration due to their crucial role of reordering. They needed a fast way to see
what needed to be ordered. With the proposed method there was elimination in purchaser taking a trip to the Missile Assembly Building (MAB). In the before state, the purchaser would go to the MAB to try and identify what needed to be reordered. This not only took time but also a space in the MAB. During production, the MAB only allowed for a certain amount of people, so having the purchaser in the MAB was a bottleneck for production. The new method removed the trip and allowed for essential people to be in the MAB at all times.

Analysis was also performed using value stream maps (See Appendix D). The before state was created with a team of my manager, team member and myself. We went through the process in detail to acknowledge the bottlenecks and inefficiencies. Once the current state and kaizen bursts were gathered, action was taken to implement the kaizen ideas. After the implementation the future state was analyzed and the economic analysis was completed.
Results

The results were analyzed through value stream maps and economic analysis. The value stream maps can be found in Appendix D. As for the economic analysis, Table 1 shows the calculations performed and certain assumptions made. The savings are substantial which was expected.

There was a high cost associated with the purchaser to understand what was needed and when. There was also a large savings in labor cost due to reduced time searching for items. There was also an associated distance saved in travel for both team member and purchaser. This distance was estimated in the time saved in walking. The $10,466.67 savings per year does not include the value of the Lean improvements. The Missile Assembly Building (MAB) had high remarks in their Lean Manufacturing assessment except in their inventory area. With the Lean analysis performed this will raise the inventory area’s score and also the overall score. With regards to the financial results and

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<th>Table 1 Economic Analysis for Lean Inventory Project</th>
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<td>Average Rush Ordering Cost</td>
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<td>Rush Orders Made Per Year</td>
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<td>Cost Savings</td>
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<tr>
<td>Cost of project</td>
</tr>
<tr>
<td>Labor Cost Per Hour</td>
</tr>
<tr>
<td>Purchaser Time Spent Before (min)</td>
</tr>
<tr>
<td>Purchaser Time Spent After (min)</td>
</tr>
<tr>
<td>Purchases Per Week</td>
</tr>
<tr>
<td>Purchases Per Year</td>
</tr>
<tr>
<td>Cost Per Year Before</td>
</tr>
<tr>
<td>Cost Per Year After</td>
</tr>
<tr>
<td>Labor Savings Per Year</td>
</tr>
<tr>
<td>Total Savings per Year</td>
</tr>
<tr>
<td>One Time Inventory Reduction Savings</td>
</tr>
</tbody>
</table>
invaluable Lean improvements, I am very satisfied with the result of my lean inventory management system.
Conclusions

Boeing’s goal to obtaining Lean success includes minimizing inventory. Boeing was not successful in this due to a lack of 5S and an inventory management system. Before applying principles, I identified which major improvements were necessary. For example, there were multiple locations for the same part. This caused confusion and often unnecessary reordering due to the lack of visibility in inventory. Next, the consumables lacked labeling. It was often the case the team member needed a certain part according to the work instructions and they could not differentiate between different parts in the area. Then finally, there were unused parts from previous projects that needed to be sorted.

In order to utilize the 5S’s I straightened, swept, standardized, sorted and implemented a sustaining process. I straightened the area by assigning areas with signs. I did a sweep on the area by cleaning the shelves and making sure it had a visible neatness. I then standardized each location with a label and a barcode. This eliminated the multiple locations for one part. Then I sorted to only having essential items needed. Then the final applied “s” was sustaining. That I feel is the most important S in the fact it needed to continue on past my departure from Boeing. Nevertheless, with my design it is easy to sustain the area and is recognizable if there is something going wrong.

The other factor of my project was the design and implementation of the inventory management system. This tool is a singular location that standardizes the process and manages the inventory exchange. It is fully functional with embedded minimum and maximum calculation. The remove items feature takes the inventory out of the system and also uses a visual reorder warning to the team member. There is also an ability to add back items for more accurate accountability. For the purchaser, the reports are also very useful tool. The inventory database has a report for the items needed to be
reordered, full inventory list, activity report to read off who took what, and an inventory by location for quick inventory checks.

Results showed that there is an annual savings of $10,466.67 per year with a one time savings of $500.00. The ability to assess more inventory levels in a shorter period of time means more well informed decisions can be made when purchasing new parts. Lean manufacturing and minimizing inventory are important goals for companies worldwide, and this tool has proven it can bring the Boeing Company several steps closer operating Lean in the missile defense program.
Appendix

Appendix A: Photos Before and After Lean Analysis

Before Lean Analysis

After Lean Analysis
Appendix B: Visio Layouts Before and After Lean Analysis

Before Facility Layout

After Facility Layout
Appendix C: Snapshots of Inventory Access Database

Snapshot of Opening Form of Database

Snapshot of Visual Reordering Signal
Snapshot of Adding Items Back to Inventory

Snapshot of Editing Item Detail
Snapshot of Adding a New Item to Inventory List

Snapshot of Deleting Item from Inventory
**Inventory**

<table>
<thead>
<tr>
<th>Location</th>
<th>Item</th>
<th>Barcode</th>
<th>Part Number</th>
<th>Supplier</th>
<th>Quantity</th>
<th>Reorder Qty</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery and Misc BN</td>
<td>Hydraulic Filters</td>
<td>27</td>
<td>P871803</td>
<td>Donaldson</td>
<td>8</td>
<td>2</td>
<td></td>
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<tr>
<td>Battery and Misc BN</td>
<td>Torque Set Bits</td>
<td>17</td>
<td>T0212-1011</td>
<td>Zephyr</td>
<td>97</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Battery and Misc BN</td>
<td>Fuse 5 Amp</td>
<td>15</td>
<td>CR8-3</td>
<td>Buss</td>
<td>21</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Battery and Misc BN</td>
<td>Metric Scale</td>
<td>19</td>
<td>2-812</td>
<td>US Industrial</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
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<td>Cotton D Tips</td>
<td>20</td>
<td>548500</td>
<td>Kendall</td>
<td>600</td>
<td>50</td>
<td></td>
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<tr>
<td>Battery and Misc BN</td>
<td>Syringe Plastic, 30G</td>
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<td>75164465</td>
<td>Monarch Carr</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Battery and Misc BN</td>
<td>Inspection Mirrors</td>
<td>23</td>
<td></td>
<td></td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
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<td>Torque Set Bits</td>
<td>16</td>
<td>T0210-501</td>
<td>Zephyr</td>
<td>37</td>
<td>5</td>
<td></td>
</tr>
<tr>
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<td>26</td>
<td>375200</td>
<td>LSQ</td>
<td>750</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Battery and Misc BN</td>
<td>Alligator Cup, Large</td>
<td>22</td>
<td>BU-21D-PH 124 225</td>
<td>Mueller Electri</td>
<td>7</td>
<td>3</td>
<td>Monarch Carr = T0210</td>
</tr>
<tr>
<td>Battery and Misc BN</td>
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<td>30</td>
<td>E0108</td>
<td>Tech-Etch</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
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<td>Battery and Misc BN</td>
<td>SENCO Barer Kit</td>
<td>29</td>
<td>297631</td>
<td>Resin Formulat</td>
<td>10</td>
<td>0</td>
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<tr>
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<td>Snap on Wrist Strap</td>
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<td>TCW51</td>
<td></td>
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<td>Lithium Battery</td>
<td>31</td>
<td>GB 2002</td>
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<td>2</td>
<td></td>
</tr>
<tr>
<td>Battery and Misc BN</td>
<td>Spreader, Trowel, FL</td>
<td>32</td>
<td>17402</td>
<td>Ace Hardware</td>
<td>19</td>
<td>4</td>
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<td>Type A Tool Teather</td>
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<td>TCL2</td>
<td></td>
<td>27</td>
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<td></td>
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<tr>
<td>Battery and Misc BN</td>
<td>Ace Brushes</td>
<td>34</td>
<td>780</td>
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<td>70</td>
<td>5</td>
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<tr>
<td>Battery and Misc BN</td>
<td>Foam Q Tips</td>
<td>35</td>
<td>550</td>
<td></td>
<td>550</td>
<td>20</td>
<td></td>
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</tbody>
</table>

**Snapshot of Complete Inventory Report**
### Activity

<table>
<thead>
<tr>
<th>Date</th>
<th>Item</th>
<th>Barcode</th>
<th>Qty taking</th>
<th>Person taking</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/29/2010</td>
<td>VINYL POCKETS</td>
<td>123</td>
<td>100</td>
<td></td>
<td>11:40:16 AM</td>
</tr>
<tr>
<td>5/23/2010</td>
<td>COVER, ROUND CONNECTOR</td>
<td>79</td>
<td></td>
<td></td>
<td>2:17:20 PM</td>
</tr>
</tbody>
</table>

**Sunday, May 23, 2010**

---

**Snapshot of Activity Report**

---

**Snapshot of Inventory by Location**
To calculate Minimums and Maximums please enter the following data.

**Ship Quantity**
How many come in a package?

**Monthly Rate**
How many are used per month? You could also divide how many per year by 12.

- Enter parts used per year: 
- Parts per month: 

**Multiplier by Price**
Enter 4 if part price $1-$250
Enter 3 if part price $251-$999
Enter 2 if part price > $1000

**Minimum**
Update for this barcode:

**Maximum**

Update the Reorder Quantities

---

**Snapshot of Minimum and Maximum Calculation Design 1**

**Lead Time (in Weeks)**: 2
**Ship Quantity**: 10
**Weekly Rate**: 2

How many come in a package?

- Enter parts used per year: 100
- Parts per week: 2

**Minimum**: 56
**Maximum**: 104

Barcode of Item: 123

---

**Snapshot of Minimum and Maximum Calculation Design 2**
Appendix D: Value Stream Maps for Current and Future States

Value Stream Map for Current State with Kaizen Bursts

Value Stream Map for Future State
Appendix E: Mezzanine Inventory Database User Manual

Mezzanine Inventory Database How-to Guide

Danielle Partridge
Summer Intern 2009
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How to Open...........................................Page 3
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How to Run Reports.................................Page 5
How to Calculate Min’s and Max’s..............Page 5
Troubleshooting.......................................Page 5
5S Standards...........................................Page 5
**Reason for Use:**

The use of this database is not to be a burden but a resource for knowing exactly what we have and when to reorder. Less time will be needed to remove items from the mezzanine. There is also no longer a need for a paper log. It will also provide an accurate list of inventory.

Within the program is also a min/max system. The minimum (reorder point) is visible for every item. When the quantity hits that minimum there is a message box displaying the need for reorder. It is very useful and a perfect example of good LEAN characteristics and Just-in-Time manufacturing.

**How to Open:**

Double click on the MAB_CONSUMABLE_INVENTORY icon.

In the Security Warning message box Click OPEN.

This will open to the Home page where you can instantly start removing items.

How to Open if you close the HOME.
Under MAB_CONSUMABLE_INVENTORY there are several buttons. One says Forms. Click on Forms then double click on HOME.

If all else fails. Close and reopen.

**How to Remove Items:**

After opening the database, you should be under the Remove Item tab.

Scan in the barcode. It is either on the item or scan the location barcode.

Enter the quantity taking in the Taking text box.
Press enter.

Scan Badge with your BEMSID barcode

Click REMOVE FROM INVENTORY
If the item has not hit the minimum then it will process as planned. If it has hit the minimum then a message box will appear letting you know it has hit minimum. Please alert MMO that this part needs to be ordered.

How to add Items:

Click on the upper tab that is labeled Add Item.

Then click on the Add Item Button.

This will lead you to a screen where you enter the information

Click the Add Item Button

Click Exit Screen

*If you would like to go through the products you can click Next and Previous Item to go between

How to Delete Items:

Click on the Delete Items Tab

Find the associate barcode number (also at the location) and enter it in the text box.

Click the Delete Item button
How to Run Reports:

Click on the “Reports” tab.

Select which report you would like to open and click on the corresponding button.

How to Find Min’s and Max’s:

Follow the instructions on the screen.

Troubleshooting:

This Access database is based off of a list. The list is set up similar to an excel spreadsheet. If there are any mistakes made in the Form (HOME) then you can open the table (Found by clicking on INVENTORY LIST under the Table button in the MAB_CONSUMABLE_INVENTORY window).

If there are any questions please ask, email: dpartrid@gmail.com

5’s Standards

Please enforce labeling everything that is coming into the Mab Mezzanine. The parts not only need a label but a barcode. They also need to be entered into the database using as much information possible. This will make it easier to reorder. Thank you!
Bibliography


