THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF SUPPLY CHAIN AND INFORMATION SYSTEMS

A PRACTICAL APPROACH TO SUSTAINABLE ASSET MANAGEMENT FOR THE BOROUGH OF STATE COLLEGE

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ABSTRACT

Proper asset management is critical to any organization's success. Inventory represents the stock required to fulfill all business needs, but it carries a large cost. Poor inventory tracking can lead to unnecessary costs, unnecessary use of space, and poor life cycle management. The Borough of State College's municipal repair shop warehouse was experiencing serious downfalls due to a lack of asset management. Many parts in inventory had become obsolete: some parts had been in inventory so long that they could no longer be used, and some parts exclusively serviced vehicles that had been discontinued by the Borough. This case demonstrates the need for an inventory management system, how to implement a basic and effective such system, and the possible benefits that this system can provide. This case will prove that utilizing effective asset management can limit unnecessary costs and improve sustainability.

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Chapter 1

Introduction to Case/Literature Review

Introduction

Inventory tracking is vital to any organization's success. Inventory represents money that is tied up; The money has already been spent, but no value has been recognized or recognized yet. Properly tracking and understanding the inventory on hand can have significant benefits for an organization. The better the inventory aligns with actual product flow, the more efficient a supply chain can be. If inventory matches product flow, many unnecessary costs can be cut, and the organization can save a lot of money. In order to maintain and support proper inventory levels, a proper inventory management system must be utilized.

In August 2013, the Borough of State College approached Penn State's Sustainability Institute, seeking help with an inventory management problem. They knew that they had lost sight of their inventory at their municipal repair shop warehouse. The Borough had a lot of money tied up in inventory, but had little idea of what types of inventory they had, inventory counts, and costs of inventory on hand.

When a team, led by this author (see lead paragraph in Chapter 2 or Appendix A for team details), was asked to assist with improving the Borough's inventory management process, they knew that they would have to start from the ground and move their way up. The staff had been operating on an outdated card system, which they admitted was not accurate. Now, well into the twenty-first century, it was time that they make the switch to an electronic system. If effective, this system could give them an accurate record of the inventory in the warehouse at any time, as

well as a cost analysis and life cycle analysis for the in-house items. Additionally, if the system could function on barcodes, it could be especially efficient and accurate.

This project explores and demonstrates how to set up a basic, free electronic inventory management system. The system will be adaptable other similar organizations, and can easily be duplicated and implemented. Additionally, this project should demonstrate the benefits of implementing an inventory management system by showcasing the problems that can be uncovered at the time of implementation. It should serve as a showcase to any reader that inventory management is always possible, and can significantly improve product availability and cut cost. This project was undertaken in order to effectively demonstrate that, with some effort, inventory tracking can be implemented and it can alleviate problems that may or may not have been known about the warehouse.

Though it may be surprising, it is possible to find organizations that operate with little or nothing in the way of inventory management. The explanation of this project should highlight the benefits of an inventory management system, and suggest cost savings that can be recognized by tracking inventory. Additionally, it will show that anybody with any supply chain insight can incorporate inventory tracking into his or her organization. The case of the Borough of State College's municipal repair shop warehouse can be used as a model situation to explain why inventory management is vital for an organization's success, how to build and implement a basic inventory management system, and how it can benefit the organization. Through this paper, it will be explained how the team built the system, the problems that were discovered, and what the team recommended the Borough do moving forward.

Literature Review

> In a literal sense, inventory refers to stocks of anything necessary to do business. These stocks represent a large portion of the business investment and must be well managed in order to maximize profits. (Barnes, Davis, Whybark 1)

The quote above is taken from the beginning of a textbook written by Frank Barnes, Edward Davis, and D. Clay Whybark, entitled Inventory Management (1989), and it is the beginning of a discussion about the importance of inventory management. Inventory should be thought of as a cost, as it is the money that a firm has spent to prepare for the ability to sell a good or provide a service. With inventory, money has been spent, as reported on the balance sheet, but no value has yet been recognized in the form of revenue and reported on the income statement. No matter how effective the sales end of a firm may be, the firm cannot survive without effective inventory management. The quote from above continues on to say:

> In fact, many small businesses cannot absorb the types of losses arising from poor inventory management. Unless inventories are controlled they are unreliable, inefficient, and costly…Successful inventory management involves simultaneously attempting to balance the costs of inventory with the benefits of inventory. Many small business owners often fail to appreciate fully the true costs of carrying inventory- which include not only direct costs of storage, insurance, taxes, etc., but also the cost of money tied up in inventory. The total annual cost may amount to fifteen to twenty-five percent. Inventory also ties up capital, which may strain a business and lead to a severe crisis. (Barnes, Davis, Whybark 1)

Large scale mistakes can and have been made in neglecting inventory management. Lack of an inventory management system can lead to overstocking or understocking. Overstocking, or purchasing more product than can be used in a reasonable period of time, can be a strain on a warehouse because it demands a lot of space. Additionally, if overstocking is very dramatic, it

can lead to products becoming obsolete while still on the shelves, meaning that the firm would have to assume the cost of the item without gaining any benefit. Understocking, when an inventory runs out before being replenished can back up the operations of a firm and make them spend more money trying to speed up the delivery of the product. In either case, costs rise dramatically simply due to a poor inventory management system.

On page 2 of the textbook Essentials of Inventory Management (2003), author Max Muller displays a list of costs associated with inventory. He states:

> Inventory brings with it a number of costs. These costs can include:
>
> - Dollars
> - Space
> - Labor to receive, check quality, put away, retrieve, select, back, ship, and account for
> - Deterioration, damage and obsolescence
> - Theft
>
> (Muller 2)

As Muller sees it, costs can include a lot more than money. Keeping stock requires a few scarce resources, and opens the door for a few risks. Inventory levels should be kept in check and tracked carefully, as to not waste money or other resources. This increases the importance for a firm to have the right level of inventory, not just a level that fits for one reason or another.

The discussion in Muller's book changes a few times, and settles on a topic of dead stock. Dead stock is inventory that is no longer useful the firm, and is now simply sitting on a shelf and taking up space. Muller explains three possible reasons for why dead stock may exist in a warehouse:

1. It's already paid for.
2. We might use it someday.
3. We might sell it someday.
   (Muller 32)

He explains the necessity toward getting rid of dead stock by explaining that it would save space in the warehouse, and probably bring back some money to the company, as the products may have some salvage value. He explains seven approaches to disposing dead stock, all of which are good ideas for nearly any business:

- Sell at net price
- Temporarily raise commissions for salespeople
- Discount the price
- Return to vendor
- Donate it
- Write it off
- Auction
  (Muller 38)

These seven approaches can help save any organization a lot of money, and avoid the headache of overstocked shelves. Tracking inventory is a great first step, but managing that inventory leads to even greater benefits. Further, any organization, large and small, can benefit from these inventory management principles.

Local municipalities certainly have the need to track and manage inventory. Despite having deep taxpayer pockets to cover costs, it is a municipality's responsibility to keep inventory in check. This can limit the number of products necessary to purchase and cut the budget for the warehouse, which can lead to a better appropriation of taxpayer funds or even a tax cut. In his article, "Coming of Age: Strategic Asset Management in the Municipal Sector" written in the Journal for Facilities Management, Pierre Joilcoeur noted:

> The primary intent of the municipal asset management concept is to support decision making related to the acquisition, remediation or disposal of municipal property in a cost-effective manner… (Jolicoeur)

Jolicoeur continues and explains the importance of life cycle management. Keeping track of products' life cycles and their positions within them can help maximize the effectiveness of inventory management. Knowing how and when to rid your warehouse of aging materials is necessary for a warehouse to run as cost-effectively as possible. Surplus or obsolete materials should be auctioned off or recycled when unnecessary to the function of the warehouse. If not, inventory, and all of the associated costs, can get out of hand.

The Borough of State College was not alone with their inventory management shortcomings. As explained by Alan Phelps in his paper, "Municipal Property Asset Management – A Comparative Study of UK and Russia" from the Journal of Strategic Property Management, the public sector led the way with asset management systems. Public companies recognized that they could not sustain themselves by throwing away costs in inventories. Not feeling quite the cost constraint, municipalities were not quite as quick to catch onto the trend. Slowly, many municipalities began tracking their inventory. Phelps states, "Although local government owns a significant property it generally has been the least managed of its resources… For most countries municipal property represents a significant area of management concern." This was very clearly the case with the Borough of State College's municipal repair shop warehouse.

Phelps noted a poor direction of thought for local government in terms of inventory management. Their actions, in general, were based on holding inventory to provide and maintain property, as a "stewardship role" rather than looking at them as a strategic business holding.

Attempting to provide reasoning for municipalities' neglect for asset management, Phelps wrote:

> Property assets have not been given the strategic attention they warrant for a variety of reasons. These include: lack of policy direction; because their management was traditionally seen as a technical matter, and because assets were viewed as illiquid and thus unable to contribute to annual financial or medium term political cycles of local government. Thus property was a neglected resource with little executive attention and general ignorance of property costs, value or performance. (Phelps)

In his research, Phelps noted a distinct cultural difference in attitudes and cultures of local governments with and without asset management systems. People working at municipalities that did not practice inventory tracking tended to be complacent and passive about their jobs. This countered the culture in municipalities with good asset management systems, where workers were heavily engaged in their work and carried self-pride in their working environments.

Implementing a basic inventory management system that can function properly is a start, but a few quick and easy improvements can make a huge difference. Barcodes, for example, are easy to use and can save a lot of time. Additionally, a system with barcodes will see many fewer errors than one that has a manual input system. Muller shares his thoughts on barcodes by saying:

> Errors and time increase dramatically the more often a human being is involved in identifying an object, inputting that information into a database, and then modifying the knowledge to keep track of changes in location, pack size, quantity, and so on. (Muller 89)

Muller goes on to explain the numbers behind why barcoding is so superior to its alternatives. According to his research, a given twelve-character field will take an average person six seconds to type, and they will make a mistake for one in every three hundred entries.

In contrast, barcode scanning would take that same person between three tenths of a second and two seconds, and there will be an error for one in every 15,000- 36,000,000,000 characters entered. As effective and easy to implement as they are, barcodes should be heavily utilized in inventory management systems.

Clearly, the disadvantages of poor inventory tracking are great. Implementing an effective inventory management system would be a responsible action for a municipality to become more sustainable and properly utilize taxpayer funds. With everything in mind, it was time for the Borough of State College's municipal repair shop warehouse to get an inventory management facelift.

Chapter 2

Original Situation

In August 2013, the Director of Purchasing and Risk for the Borough of State College approached Penn State's Sustainability Institute seeking help with an inventorying problem. They had very little feel for what was being stored in the Borough's municipal repair shop warehouse, the repair shop that services police, snow removal, leaf removal, and waste management trucks for the town. The Sustainability Department contacted the Penn State Department of Supply Chain and Information Systems, who contacted the author of this paper, and the project was initiated. To complete this project, this author compiled and led a team of himself, three Penn State Smeal Sapphire students (a leadership program run through the College of Business), and one fifth-year senior student pursuing his masters in accounting.

The team's first step was to fully understand the problem, and to do this, they took a tour of the facility in question. Upon touring the facility, the team was led to an upstairs loft overlooking the repair shop. They found a series of ten double-sided shelves, each about twenty feet long with a huge variety of items seemingly scattered throughout. Some items were new, others were covered in measurable layers of dust. Some items were in fresh boxes, others looked like they may have been used. Some items were clearly and descriptively labeled, others were undecipherable to the average layman.

As the team dug around, they asked questions to the staff, which was pleasantly knowledgeable. They learned that the products were organized in the warehouse mostly by vehicle, with other special areas for common items (such as air filters, which can be used in many different vehicles). The team learned that mechanics fill out work forms for each job that

they complete that can loosely and imperfectly track what is left in the warehouse. The Administrative Assistant at the warehouse takes these work forms, compiles the data as well as she can, and orders new parts. When she orders and receives new inventory, she organizes the data in a card filing system. The card filing system in use was a series of cards with product information on them, describing what was in the warehouse at a given time. The Administrative Assistant admitted to having very little faith in the accuracy of this system.

It is crucial to note the importance of the warehouse, its inventory levels, and its proximity to the repair shop. The vehicles being serviced are critical to the town's civility. If a police car needs a new filter, it is imperative that the vehicle is repaired quickly so the vehicle can be back on the roads as quickly as possible. Even more importantly, if a snow plow needs a new plow arm before a big snow storm, it needs to be repaired quickly or it could have a large negative effect on children's commutes to school and adults' commutes to work.

Because of the importance of the repair shop, it is imperative that the warehouse is always stocked properly. The Borough cannot simply hold large stocks of each product because that would cost an unnecessary amount of money, and would require a much larger warehouse than available. Many similar warehouses would take advantage of economies of scale and order infrequently, but in large quantities. While it would save on ordering costs, this strategy is usually coupled with long lead times, which artificially inflates the likelihood of stock-outs. This is a risk that the Borough simply cannot take.

Upon leaving the warehouse after the team's first visit, the Director of Purchasing and Risk for the Borough of State College alerted them of his biggest fear with the situation. "If the warehouse ever burned down," he stated, "we would not have any idea how to find a monetary value to the property and products that we lost." Finding this answer would become a key to this

project. The team set out to create a new, easy method to keep track of the warehouse's inventory levels at all times, keep track of the active lifecycles of the products in the warehouse, and keep track of costs of the individual items and the overall value of the warehouse.

Chapter 3

Methodology

Operating a warehouse without tracking inventory can lead to significant inefficiencies. Without an inventory system, it is impossible for staff to know what products are in-house. This can lead to shortages or overages of products. Building an inventory system is no easy task; it takes a bit of time to get started, and includes a high attention to details. However, the benefits outweigh the costs. Without an inventory tracking system, any organization will inevitably face overstocking or understocking. Overstocking would lead to a problem with product obsolescence, and the firm would have to incur the costs of purchasing products that it would never be able to use. In the case of understocking, the firm's operations would get backed up and the firm would have to incur the cost of getting expedited shipping for a product that is not in inventory. In either case, the saved costs from operating an inventory system will make the efforts to building the system worth it.

Given the size of the project and time it would command, it was important for the team to set goals and objectives. Additionally, a plan with set steps would make the plan easier to carry out. Without a plan and set goals, the project would probably become overwhelmingly large and complicated, and results would be hard to come by. Finally, the team realized the necessity to keep the inventory system simple and keep all of the data in Excel. The Administrative Assistant requested a simple system, and if she would feel uncomfortable using the system, it would have very little value. It was very important that the team make the system as user friendly as possible.

This project was hindered by a few limitations. First, the team lacked the ability to locate a computer programmer that was able to help. Their Excel knowledge provided for the best

possible Excel system. If a computer programmer had been available, the system may have been written in more user friendly manner, while maintaining operational simplicity. Additionally, the students involved the project lacked any relevant knowledge about automobile parts. The team's work ended up complete, though many fewer questions would have needed to have been asked, had they possessed knowledge about automobile parts. This could have sped up the process. A final hindrance to the project was a lack of time. This paper has been written shortly after the implementation of the system. With more time to observe results, this paper may have been able to provide more precise details on the long-term results of the project.

This paper will describe the goals and steps taken by the team. It will describe the details of the system, as well as the manner in which it was written. It will explain a list of recommendations for the Borough of State College, as well as an implementation plan. It will state the problems that were revealed by the implementation of the system. Due to an implementation shortly before the writing of this paper, it will not include much detail on the long-term results, but will simply suggest projections.

Chapter 4

Problems/Goals

Inventory management is essential for all warehouses, regardless of how big or small they are, what they service, or whether they are publically or privately operated. Proper inventory management systems can lessen the frequency of stock-outs, minimize excess inventory, and minimize the number of items that become obsolete on a warehouse's shelves.

Three major problems existed in the Borough of State College's municipal repair shop warehouse: lack of knowledge of the quantity of products in the warehouse, lack of life cycle awareness, and lack of asset value awareness.

Without an accurate inventory tracking system, it is extremely hard to know when new items need to be ordered. This can lead to stock-outs or overstocking. If stock-outs occur, vehicles will not be able to be serviced, and congestion can occur in the repair shop. As more vehicles come in for repairs, queues may form, and long wait times for repairs may appear. Everything in the shop can become backed up, and the lack of in-service municipal vehicles could hinder the town.

If overstocking would occur, the warehouse would run out of shelf space for all of its inventory. Additionally, if too much inventory is ordered, products can be left on the shelves for longer than their active lifecycles last. If this occurs, products could become obsolete while still sitting on the shelves, and the money associated with their purchase would be wasted. That is, the item would have been purchased for a given amount, but the item never would have been utilized.

Knowing the clear penalties associated with stock-outs, the repair shop staff tended to over-stock and allow their inventory to become obsolete. Further, based on the dust that the team had observed on some of the products, it was clear that they were unaware that they possessed as many items as they did. The team realized early on that tracking the inventory could save the borough, and therefore taxpayers, a lot of money. Maintaining a life cycle analysis is crucial in an inventory tracking system

A good inventory tracking system should also contain a cost analysis for each product. In this case, the Administrative Assistant should always be able to check the value of goods stored in inventory. She should have easy access to the prices paid for individual goods, as well as a total asset value of the warehouse.

With these problems clearly in front of us, the team set four goals to improve the status in the warehouse:

- *Find out what products are actually in the warehouse.* This would involve a count of every unit in the warehouse.
- *Track the product flow in and out of the warehouse.* The team would set out to create an electronic inventory tracking system that could tell the staff what was in the warehouse at any given time.
- *Track cost.* With the new inventory management system, all products in the warehouse would be linked with an associated purchasing cost.
- *Manage life cycle.* The database attached to the inventory management system would also include suggested life cycle lengths of each product. The database will warn the Administrative Assistant when products on the shelves are too old for use. For products

that would become unusable for the Borough after a period of time, plans and recommendations would be suggested to limit the financial and environmental impact.

Chapter 5

Steps/Sub-Projects

To complete this project, the team knew that they would need to build a specific, goal oriented plan. The team organized the project into six different steps, to be completed in order. The steps, as well as what the team learned along the way, were as follows:

1. *Meet with the employees at the repair shop to discuss ideas and define specifics that they would like to see.*

This project was to be completed in order to make the Borough's staff's jobs easier. Keeping this in mind, the team would be open to all suggestions from the staff. It was at this point that the team was alerted of the need for a cost analysis of the products. The Borough asked that the system track the inventory quantities, as well as item costs and some information on lifecycle. Further, the Administrative Assistant asked that, if possible, the team keep the information in Excel, as she would have to learn how to use any other information-tracking system.

2. *Visit the warehouse and track what is on the shelves.*

This was to be completed in the shortest possible span of time as to avoid changes in inventory over time. The team searched the warehouse for all products and tracked the brand, name, description, and quantity of each unique item. The team of five used net books (borrowed from the University) to input all of the data into an Excel sheet. The team found this to be more difficult than originally planned due to the diversity of the products. Nobody on the team had

any background in auto-mechanics, and their lack of knowledge led them to ask the warehouse mechanics about the names and uses of many of the products. Ultimately, it took about forty man-hours to record the information for the entire ten-aisle warehouse. Before cleaning up the data, the team found 890 different types of items, and 2909 total units.

3. *Collect data on each unique item's cost and life cycle.*

After collecting all of the different types of items, the team had to research more data about them. This author broke the research down to sub-projects. Marc-Elie, a fifth-year Masters of Accounting student and member of the team, and this author took on the cost analysis. They researched each item and recorded prices of each item that was publically available. In most cases, they cross-referenced the data with a secondary source to ensure accuracy. The two students looked specifically at some vendor sites, as well as mass retailers like Amazon.com and eBay.

Two of the Smeal Sapphires, Amy and Karen, were tasked with researching life cycle data. Their primary goal was to find how long products could sit on shelves without becoming obsolete. If this could not be found, they found data on how long products would last if they were in use.

4. *Combine the data into single sheet, clean the data, and write formulas for system to work appropriately.*

Naturally, the data collected from the warehouse, as well as from the two sub-teams, was dirty. This author spent several hours cleaning up typing errors, rearranging the data to be clear and concise, and combining the three sets of data. A series of vlookups and advanced formulas

were written into the system to make it work properly and effectively. As items were scanned in, their information would be pulled from a data source onto a master page, so all relevant information could be seen at once. Also, the act scanning in and out would control the total quantity of each product as represented in the database.

5. *Create a book of bar codes for scanning products in and out of the warehouse.*

In order for the project to be effective, the team needed to set up a system in which the Borough could track the inventory coming in and going out of the warehouse. This author created a book that lists all of the products, with brief descriptions. Each product in the book was assigned a unique code and barcode. When products are brought into the warehouse or used by the mechanics, an employee is to search the book, which is arranged in alphabetical order by brand name, and scan the product. The data in the scanner will be input into an Excel spreadsheet, which will track product inventory levels. From this sheet, vlookups will pull the product data, so it can be easily interpreted.

6. *Teach the warehouse crew how to effectively use the barcode book and database.*

Toward the end of April, the team set back out to the Borough to present the project and to teach the Borough staff how to utilize the new inventory management system. The team presented the barcode system to the Borough, and they seemed ecstatic. The Borough staff seemed eager begin to use it, and recognized how much of an improvement it would be. The team presented that the warehouse had 803 unique types of products, and 2,691 individual types of units. This came out to a total warehouse current value of $149,935.50. Upon stating the numbers, the Director of Risk and Purchasing became excited, because he knew that he would be able to accurately report how much money he had held up in inventory- something he never could have done before.

The Borough staff seemed very happy with the work, which made teaching them the finer points of the system fairly easy. They were happy to learn the advance formulas and conditional formatting that makes the system run properly. There were a lot of details to cover, but the team was able to get through the system in about two hours. This author gave to them and described a list of recommendations that he had come up with regarding their continuing operations, as well as an implementation package that he had devised. (The recommendations can be seen in Chapter 7 and the implementation package can be seen in Chapter 8.) At the end of the meeting, the team lead passed future of the project to the third Smeal Sapphire, Jacob. Any ongoing problems would be run through Jacob, as the team lead would soon graduate, while Jacob would still be local.

Due to its great impact on the Borough of State College, a reporter from The Daily Collegian (the Penn State on-campus newspaper) attended the team's meeting with the Borough. He wrote an article that ran in the newspaper a few days later. This article is included in Appendix A.

Chapter 6

Building the Inventory System

In one of the first conversations, the Administrative Assistant alerted the team of her concern with use of certain computer programs. She expressed that she was very comfortable with Microsoft Excel, but not comfortable with Access. The team knew that keeping the system in Excel would be difficult due to the large volume of data and the complicated formulas. However, the team recognized that the system would be of little value if the Administrative Assistant could not easily manipulate it. The team decided that it was at least worth a try to keep everything in Excel.

The first use of the Excel system was to collect the data. This author created several sheets with four simple headings across the first four columns: Brand, Part, Description, and Quantity. These sheets were used as the team walked around the warehouse and collected data. This author knew that with these key pieces of data, the team could research everything else that was necessary to know. This data, originally 8 lines, was condensed and cleaned, and resulted in 890 lines of data. As described in the previous chapter, the sub-teams took the data and researched life cycles and costs for each of the unique products.

The Excel document is a compilation of three individual sheets, labeled “Scan In”, “Scan Out”, and “Data”. The Scan In sheet is to be used when items are being added to the virtual inventory. When an item is brought into the warehouse, one of the employees should search the barcode book to find the product being added. The employee should make sure that the first empty cell in the “A” column of the Scan In sheet is selected, then scan the barcode that corresponds to the appropriate item. This column must be formatted so that the information

contained in the cells is displayed as “text” or the zeros at the beginnings of codes will not appear. Excel will read the code and place it in the highlighted cell. The next four columns in that sheet are coded with vlookups so that they will display the brand, part, description, and quantity of the item which’s barcode has been scanned. This is shown in Figure 1.

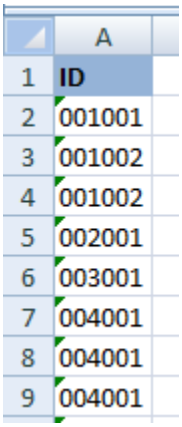
	A	B	C	D	E
1	ID	Brand	Part	Description	Cost Per Unit
2	001001	AC	sealed beam lamp	7630k	$ 44.99
3	001002	AC	sealed beam lamp	7680k	$ 44.99
4	001002	AC	sealed beam lamp	7680k	$ 44.99
5	002001	AcDelco	Switch Commutateur	0	$ 57.04
6	003001	Allison	Relays	27177K	$ 208.26
7	004001	Apollo	male adapter	92-7081	$ 4.75
8	004001	Apollo	male adapter	92-7081	$ 4.75
9	004001	Apollo	male adapter	92-7081	$ 4.75
10	004001	Apollo	male adapter	92-7081	$ 4.75
11	004001	Apollo	male adapter	92-7081	$ 4.75
12	006001	Arrow	fan clutch	E3AZ-19A706-A	$ 38.26
13	006001	Arrow	fan clutch	E3AZ-19A706-A	$ 38.26
14	006001	Arrow	fan clutch	E3AZ-19A706-A	$ 38.26
15	006001	Arrow	fan clutch	E3AZ-19A706-A	$ 38.26
16	006001	Arrow	fan clutch	E3AZ-19A706-A	$ 38.26
17	006002	Arrow	lamp cover	FT-105	$ 4.00
18	006002	Arrow	lamp cover	FT-105	$ 4.00
19	006003	Arrow	lamp/light	SP-405	$ 13.59
20	006003	Arrow	lamp/light	SP-405	$ 13.59
21	006004	Arrow	triple bar marker lamp	4W7Z-14028-AAA	$ 16.33
22	006004	Arrow	triple bar marker lamp	4W7Z-14028-AAA	$ 16.33
23	006004	Arrow	triple bar marker lamp	4W7Z-14028-AAA	$ 16.33
24	006004	Arrow	triple bar marker lamp	4W7Z-14028-AAA	$ 16.33
25	006004	Arrow	triple bar marker lamp	4W7Z-14028-AAA	$ 16.33

SCAN IN | SCAN OUT | Data | Input

Figure 1.

The second sheet, “Scan Out” should be used when a mechanic is using a product from the shelves. The mechanic should make sure that the first available cell in the “A” column is selected. Then, he should find the appropriate bar code in the book and scan it into the worksheet. This column must be formatted so that the information contained in the cells is

displayed as “text” or the zeros at the beginnings of codes will not appear. This is shown in Figure 2.



	A
1	ID
2	001001
3	001002
4	001002
5	002001
6	003001
7	004001
8	004001
9	004001

Figure 2.

The “Data” sheet serves multiple purposes, as it houses all of the data for the workbook. All of the products, with their life cycles and costs, are listed in this sheet. The first column displays a unique code for each individual type of product. In the six-digit code, the first three numbers are linked to the manufacturer of the product, and the next three are linked to the individual product type. The next column, which should remain hidden for purposes of simplicity, is a duplicate of the first column, which is used to make some of the formulas run smoothly.

Columns C, D, and E are used to show all products’ brands, descriptions, and costs. Columns F and G are the researched life cycle and cost data associated with each product. Many of the original prices have been lost, due to insufficient tracking and product obsolescence. The cost shown is a combination of information that could be collected. In most cases, this was a combination of the original price, the market value, and the current market value of a similar product.

Columns H and I should also be left hidden for the sake of simplicity. Column H includes a formula that adds up all of the times that each item has been scanned in and subtracts it by the amount of times that the product has been scanned out. This should be an accurate track of how many items have been brought to or taken from the shelves, beginning on the day that the system begins use. Column I is a quantity count of each item from the original inventory counts. Column J is a sum of the two previous columns, giving a total quantity for each product in the warehouse. If the quantity in Column J is less than 2, the sheet will highlight it in red, indicating that a new inventory may need to be ordered.

Column K is a multiplication of the cost of each item and the quantity of each item, which gives the amount of money that the Borough has tied up in each type of item. The lone occupied cell in Column L is the total warehouse value, calculated by adding up all of the costs in Column K. This sheet is shown with all cells unhidden in Figure 3.1 (Columns A-F) and 3.2 (Columns G-L), and only appropriate cells showing in Figure 4.

	A	B	C	D	E	F
1	**Code**	**Code**	**Brand**	**Part**	**Description**	**LifeCycle**
2	001001	001001	AC	sealed beam lamp	7630k	N/A
3	001002	001002	AC	sealed beam lamp	7680k	N/A
4	002001	002001	AcDelco	Switch Commutateur		N/A
5	003001	003001	Allison	Relays	27177K	N/A
6	003002	003002	Allison	Filter	LF-568	N/A
7	003004	003004	Allison	Filter	Black Belt, 160024C92	N/A
8	003005	003005	Allison	Filter		N/A
9	004001	004001	Apollo	male adapter	92-7081	N/A
10	006001	006001	Arrow	fan clutch	E3AZ-19A706-A	N/A
11	006002	006002	Arrow	lamp cover	FT-105	N/A
12	006003	006003	Arrow	lamp/light	SP-405	N/A
13	006004	006004	Arrow	triple bar marker lamp	4W7Z-14028-AAA	N/A
14	006005	006005	Arrow	lens/light cover	5L1Z14529BA	N/A
15	008001	008001	Baldwin	Filter	9W7Z-9E926-A	N/A
16	009001	009001	BalkAMP	Hose Clamp	F6AZ9D289-AA	N/A
17	010001	010001	Beckett	detector CAD cell	2W73-8A080-AA	N/A
18	010002	010002	Beckett	interrupted ignition oil primary control	6W1Z-7E395-A	N/A
19	010003	010003	Beckett	electorde insulator	6F2Z-1A189-A	N/A
20	010004	010004	Beckett	electronic igniter	raio	N/A
21	012001	012001	Belex	Police Light	box	N/A
22	013001	013001	Browning Bearings	Bearing		N/A
23	014001	014001	Buyers	hour meter	4 headlamp system 4001	N/A
24	014002	014002	Buyers	hub spinner	4505	N/A
25	014003	014003	Buyers	Latch, T-handle	4416R	N/A

SCAN IN | SCAN OUT | Data | Input

Figure 3.1

G	H	I	J	K	L
Cost	Quantity Equation	Original Quantity	Total Quantity	Total Cost	Overall Warehouse Value
44.99	0	2	1	$280.09	$149,935.50
44.99	0	1	2	$130.23	
57.04	0	8	2	$6.00	
208.26	0	7	3	$33.08	
25.21	0	1	2	$20.00	
25.21	0	7	7	$35.00	
120	0	8	1	$7.00	
4.75	0	4	2	$1.00	
38.26	0	2	1	$3.00	
4	0	2	1	$63.36	
13.59	0	4	1	$39.85	
16.33	0	1	1	$64.98	
5.485	0	1	1	$41.80	
8.06	0	1	1	$7.22	
6.015	0	3	10	$1,919.40	
4.25	0	1	1	$138.78	
49.33	0	1	1	$2.00	
17.475	0	1	1	$7.13	
29.995	0	1	1	$80.73	
175.875	0	1	2	$348.00	
23.33	0	7	1	$8.74	
84.38	0	1	1	$44.66	
22.74	0	2	1	$48.49	
23.49	0	1	1	$0.50	

Figure 3.2

	A	C	D	E	F	G	J	K	L
1	Code	Brand	Part	Description	LifeCycle	Cost	Total Quantity	Total Cost	Overall Warehouse Value
2	001001	AC	sealed beam lamp	7630k	N/A	44.99	1	$280.09	$149,935.50
3	001002	AC	sealed beam lamp	7680k	N/A	44.99	2	$130.23	
4	002001	AcDelco	Switch Commutateur		N/A	57.04	2	$6.00	
5	003001	Allison	Relays	27177K	N/A	208.26	3	$33.08	
6	003002	Allison	Filter	LF-568	N/A	25.21	2	$20.00	
7	003004	Allison	Filter	Black Belt, 160024C92	N/A	25.21	7	$35.00	
8	003005	Allison	Filter		N/A	120	1	$7.00	
9	004001	Apollo	male adapter	92-7081	N/A	4.75	2	$1.00	
10	006001	Arrow	fan clutch	E3AZ-19A706-A	N/A	38.26	1	$3.00	
11	006002	Arrow	lamp cover	FT-105	N/A	4	1	$63.36	
12	006003	Arrow	lamp/light	SP-405	N/A	13.59	1	$39.85	
13	006004	Arrow	triple bar marker lamp	4W7Z-14028-AAA	N/A	16.33	1	$64.98	
14	006005	Arrow	lens/light cover	5L1Z14529BA	N/A	5.485	1	$41.80	
15	008001	Baldwin	Filter	9W7Z-9E926-A	N/A	8.06	1	$7.22	
16	009001	BalkAMP	Hose Clamp	F6AZ9D289-AA	N/A	6.015	10	$1,919.40	
17	010001	Beckett	detector CAD cell	2W73-8A080-AA	N/A	4.25	1	$138.78	
18	010002	Beckett	interrupted ignition oil primary contr	6W1Z-7E395-A	N/A	49.33	1	$2.00	
19	010003	Beckett	electorde insulator	6F2Z-1A189-A	N/A	17.475	1	$7.13	
20	010004	Beckett	electronic igniter	raio	N/A	29.995	1	$80.73	
21	012001	Belex	Police Light	box	N/A	175.88	2	$348.00	
22	01300	Browning Bearings	Bearing		N/A	23.33	1	$8.74	
23	014001	Buyers	hour meter	4 headlamp system 4001	N/A	84.38	1	$44.66	
24	014002	Buyers	hub spinner	4505	N/A	22.74	1	$48.49	
25	014003	Buyers	Latch, T-handle	4416R	N/A	23.49	1	$0.50	
26	015001	CarQuest	Dome Lamp	4579	1-5 yr	4	1	$30.33	
27	015002	CarQuest	rubber piping	4435	N/A	974.22	22	$689.70	
28	015003	CarQuest	Thermostat	4w	N/A	120.45	1	$162.00	
29	015004	CarQuest	belt	Black Belt	N/A	18	2	$780.76	
30	015005	CarQuest	belt	140-2897	200 hr	18	1	$3.76	
31	015006	CarQuest	brake rotor	12 050 01 S	N/A	288.5	1	$5,062.50	
32	015007	CarQuest	Filter	Black Switches, 9528	N/A	103.7	1	$244.95	

SCAN IN | SCAN OUT | Data | Input

Figure 4.

The Excel workbook should work tightly, so that there is always an accurate count of each product in the warehouse, as well as a cost associated with each product.

The barcode book works closely with the Excel workbook. The barcode book can be recreated at any time by copying Columns C, D, and E into a Microsoft Word document, then adding Column A next to the previous three. This will create a book that displays Brand, Part, Description, and a code number. The user can then highlight the column with the codes and change the font to the barcode font. A description of the process to download the barcode font is described in the Implementation Package. If done properly, the barcode book will work in synch with the Excel workbook. The barcode book should be updated periodically, as new items are added to the Excel document. The barcode book is shown in Figure 5.

Brand	Type of Product	Description	Code
AC	sealed beam lamp	4414	
AC	sealed beam lamp	5001	
AcDelco	Switch Commutateur	3778C4	
Allison	Relays	29535907	
Allison	Filter	29539579	
Allison	Filter	11P0301X	
Allison	Filter	11P8988X	
American Valve	ball valve		

Figure 5.

Chapter 7

Recommendations

The following contains several recommendations for the Borough of State College future success of their inventory management system:

- Utilize a first-in-first-out (FIFO) system to manage inventory. This means that when a mechanic picks an item off of a shelf, he should take the item that has been there the longest. Doing this will lessen the problem that the warehouse faces with obsolescence. The oldest items will be used before they become obsolete, and fewer items will go unused before the end of their usable shelf life.
- Look through the current inventory in the warehouse. As college students with little knowledge about automotive parts, the team did little cleaning of the warehouse, and did not remove much inventory from the shelves. Not knowing the specifications of many of the parts, they did not know what parts could still be used, despite an apparent old age or dust covering. This team suggests that someone with knowledge look through the warehouse and collect the obsolete items.
- For any products that are beyond use for a municipal vehicle, the Borough should look into selling it in auction through Pennsylvania Supplies and Surplus Operations. The Commonwealth of Pennsylvania periodically runs auctions where they sell goods that they can no longer use. Many of these items are surplus goods, and many are beyond the valuable life for the state, but not beyond the lifecycle for public use. The Borough of State College should look to get involved in these auctions. This would bring in a little

money for items that would otherwise be thrown away. Additionally, this can act as a recycling system, in which items can be used longer than they would have, had they simply been thrown away. By going through the Commonwealth's auctions, the Borough can decrease their environmental impact and make some money on salvaging products. The supplies and surplus auction is run by the Commonwealth's Department of General services and can be contacted at http://www.dgs.state.pa.us/portal/server.pt/community/supplies_and_surplus_operations/1393 or by phone at (717) 787-6159.

- Keep updating costs as new parts are ordered. Costs change frequently, and though the changes may be small, many small changes can lead to large changes in the big picture. Also, cost tracking can quickly become overwhelming if it is not taken care of frequently.
- Keep an eye on life cycles. It costs a lot of valuable space to keep obsolete items on the shelves. Further, the earlier that the Borough can identify an item that is too old for them to use, the more money they may get back in resale.

Chapter 8

Implementation Package

Here are some important notes that should be referenced when working with the new inventory management system:

Barcode Book

- Begin by downloading the barcode font at http://www.dafont.com/barcode-font.font. Other barcode fonts may not read as the standard language, and will read differently with standard scanners.
- Transfer the first four columns of the Excel file to a word document and size to preference.
- Change the font of the "barcode" column to the barcode font.
- For the barcodes to be read properly, they must contain start and stop characters. In the language utilized in this system, the character is an asterisk (*).
    - To add an asterisk to the beginning and end of each of the codes, click Ctrl+f , and move to the "Replace" tab. In the "Find what:" bar, type: <*>. In the "Replace with:" bar, type *^&*. Press enter and the codes should be updated. This can be seen in figure 6.

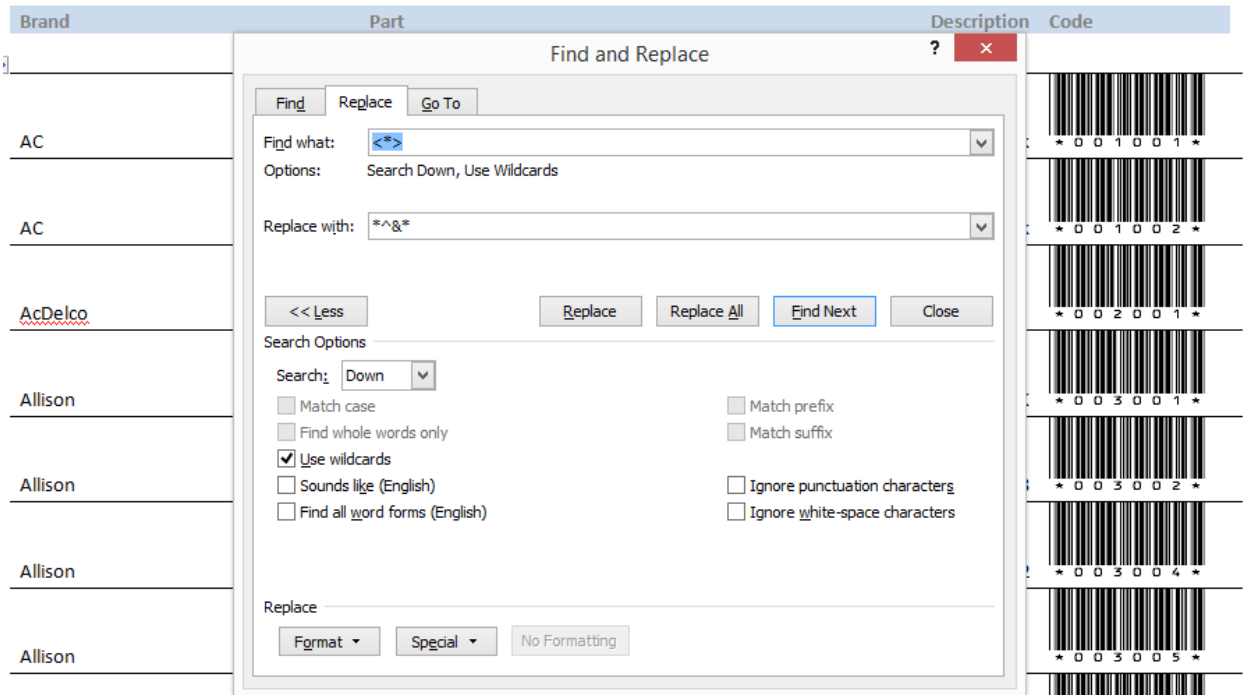


Figure 6.

New Item Insert into Excel

- Make sure to write the new product name, product type, description, life cycle (if applicable) and cost in the Excel sheet
- Assign a 6 digit code to the “code” column the worksheet.

System Use

- Make sure that the “codes” column in the Excel sheet is on “text format”. If it is not on text, the zeros at the beginning of the code may not appear.
- Codes are organized so that the first three numbers indicate the company, and the final three numbers indicate the unique product.

- When scanning a product into the system, make sure that the first empty cell in the A column of the “SCAN IN” tab is selected.
- When scanning a product out of the system, make sure that the first empty cell in the A column of the “SCAN OUT” tab is selected.
- In the “SCAN IN” tab, information from the “DATA” tab is pulled in using VLookups.
- Values in the “Cost” column are a combination of original purchasing price and current salvage value. That is, the costs have depreciated from their original costs, and now cost somewhere between their original cost and what one could sell them for today.
- Make sure to save a backup of the document frequently, as it is a large file, which may lead to data corruption.

Chapter 9

Results/Conclusion

This case shows just how imperative it is that inventory is tracked properly from the beginning of any project that deals with warehousing. Many products in the warehouse were old, and some were even layered with thick dust. Many products had lost their labels or were long removed from their boxes. When looking through the warehouse, our team had a lot of trouble determining what all of the products were, which would later hinder our ability to research the products. Further, many of the items in the warehouse were discontinued by the manufacturer. Even if the item could have been properly identified, it may still be hard to research the product's current cost or life cycle. 323 of the original 890 unique products had to be searched more than twice by two different people in order to find information on the product. That means that 36% of the data was "dirty" and could not be searched. This was due to an inability to determine the product, or the product line being discontinued. For many of these products, we had to record costs and lifecycles based on similar products, because the actual products themselves could not be found.

The recommendations that I put forth to the Borough will allow them to operate a closed-loop supply chain. The management system alone will prevent them from purchasing too many items, which will cut down on product obsolescence. The FIFO system will help even more to cut down obsolescence, as the oldest available products will always be used. Finally, when a product does become obsolete, the staff will be able to realize it, and they will know how to properly dispose or recycle it. The system as a whole will help to identify potential overstocks or understocks, and save the costs associated with both. Additionally, it will fight against products sitting on shelves beyond their useful life cycles and becoming obsolete. A simple

implementation of this type of inventory management can seriously cut costs for the organization in the long-run.

As widespread and affordable current technology is, every firm should be operating an electronic inventory management system. It does not need to be a complex system, but almost anything on a computer will be easier to use and manipulate than any manual system. Barcodes are easy to use and can save staff a lot of time by utilizing them. Further, scanning barcodes leads to much less frequent error than would occur if a person was typing everything into a spreadsheet.

At this given time, the new inventory management system has just been turned over to the Borough, and they are beginning to utilize it. It is exciting to think of how much better of a grasp they already have on their inventory, and how much more that will grow as they master the system and add their own touches to it. The Borough is now functioning with an inventory system that allows them to have a good handle on their product mix at all times. The system will also provide them with an on-demand cost analysis and data that will allow them to effectively manage a closed-loop supply chain. With effective use of the system, the Borough can use effective inventory management to minimize inventory on hand, minimize the space needed for the inventory, and cut costs of holding inventory.

The Borough has learned a lot, and they should soon realize great benefits to utilizing an inventory management system. Overall, this case should provide a good understanding of the fundamentals to an effective inventory management system, and convince anybody without a system to invest the time and/or money to obtain and utilize one. The system that I created for them and described in this paper can be easily adapted to fit any similar organization, and it can be done for free. By implementing this type of system, an organization can better match its

inventory with its product flow. Simply knowing and tracking inventory can save a firm a lot of money, and keep it profitable for a long time. Through the demonstration of this project, all should be convinced that implementing an inventory tracking system is worth the effort, and can bring forth many short-term and long-term benefits

Appendix A

Article from the Daily Collegian

Below is the article written and run by The Daily Collegian about our warehouse inventory management project (2014):

Team of Penn State students assisted the borough with an updated inventory system

By Clayton Over | Collegian Staff Writer Clayton Over can be reached at **cso5042@psu.edu** or (814) 865-1828. Follow him on Twitter at @ClaytonOver. | Posted 3 days ago

The inventory system at the State College Public Works Service Facility, 330 S. Osmond St., got an overhaul Monday with the help of a team of Penn State students.

Students assigned each type of item in the facility warehouse a barcode, put all of them in an inventory book and linked the book to a Microsoft Excel spreadsheet. The new system allows borough employees to check items in and out using a scanner, team leader Jordan Schaeffer (senior-supply chain management) said.

"It's pretty clear that this is going to be a big improvement and should save us an ample amount of time," borough Public Works Department Operations Manager Eric Brooks said.

Schaeffer presented the system for use to borough staff members and the project was a part of his senior honors thesis. The team also consisted of three Smeal Sapphires and an accounting student conducting an independent study, Schaeffer said.

The project took the team close to two semesters to complete and was divided into three phases, Schaeffer said.

The first portion required the team to inventory every item in the warehouse, which holds the parts for the borough's fleet of municipal vehicles, Schaeffer said.

The inventory took 40 man hours to complete, Schaeffer said. The team found there were more than 800 types of products and around 2,600 total items in stock, and had a value of $149,000, he said.

The second part was writing the system for Excel, Schaeffer said, and the third phase occurred Monday, when the program was handed over for actual use.

The old system required writing items checked in and out on a card and then ordered numerically in a file, clerk Tammy Rinehart said.

“It’s pretty ancient,” Rinehart said.

After everything with the new system is worked out, Rinehart said the updated method would save time and be neater.

Besides ease of use and efficiency, Borough Chief Mechanic Steve Duck said the program could help manage size of inventory and costs.

“Not overstocking on certain things probably would help with keeping the overhead down,” Duck said.

Schaeffer, who graduates at the end of the semester, said he is relieved to be done with the project and feels a sense of accomplishment.

“I don’t care if people read my thesis, but I wanted to, with that amount of time, do something productive,” Schaeffer said. “I think I’ve done something that’s been productive.”

The project was a part of the Sustainable Communities Collaborative, a partnership between the university and the borough of State College.

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