Design of a Fulfillment Pack Area for a Pet Supply Company Experiencing Steady Growth

by

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ABSTRACT

With the pet industry expanding to over $38 billion dollars in 2006, according to the American Pet Products Manufacturers Association (APPMA), it is of no surprise that companies within the industry are experiencing growing pains. This study concentrates on the design of an additional pack area for a pet supply company that is experiencing steady growth.

The basic principles of ergonomics, capacity analysis/profiling, work measurement and facilities design/layout were applied to the data collected from this company to produce an area that could meet their needs for the next five years at a 12.5% growth rate. This paper explains the data collection methods and the ergonomic and capacity considerations for the design. The final result was a layout and workstation recommendation that could meet their capacity needs, hold all the supplies needed for the area, improve process cycle times and improve the overall condition of the pack environment for the worker.

Acknowledgments and Dedication

Thank you to Dr. Thomas Lacksonen for being an excellent advisor and available for questions at almost anytime. His advice was greatly appreciated.

Thank you also to Drs. Foster & Smith, Inc. and my manager, Ron Sasek who have been extremely supportive of furthering my education.

A special thank you to my husband, Steve, and children, Samantha and Kyle for allowing me the time to spend on my studies and work and being supportive of my efforts.

Finally, I'd like to dedicate this paper to my father, Ed who died of amyloidosis in January, 2006. He was very proud that my brother and I were finishing our Master's degrees and wanted to be healthy enough to see each of us graduate and finish. I know that even though he never got the chance to see this finished, he knew it was coming and was proud. Thank you Dad for always teaching us to work hard for what we want.

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Chapter I: Introduction

Drs. Foster & Smith, Inc. started over 20 years ago by two veterinarians, Dr. Rory Foster, and Dr. Marty Smith. They operated four animal clinics in Northern Wisconsin and their clinics were the first in the nation to offer free rabies vaccinations and free spay/neutering. In 1983, they founded the company and distributed their first informational product catalog, a 16-page flyer sent to 1,500 customers. In 1985, they opened their first catalog facility dedicated to pet supplies and catalog products. Third shift staff members were added in 1991 to increase customer service. They built their current facility in 1992. Since 1992, the facility has almost doubled in size, currently containing almost 200,000 square feet of space with the offices and warehouse. The warehouse comprises about 100,000 square feet of that space. The campus also contains a retail store, returns building, Coral Farm (Aquaculture) Facility, and a fully licensed pharmacy. In 2003, a new conveyor system and Warehouse Management System was implemented. With the pet industry expanding to over $38 billion dollars in 2006 (American Pet Products Manufacturers Association, 2006), it is of no surprise that companies within the industry are experiencing growing pains.

Statement of the Problem

Drs. Foster & Smith, Inc., had grown immensely over the last few years. With that growth, the warehouse is rapidly expanding its duties and product output. However, the current system was only designed to handle five years and a lower growth rate, and being already three years into that plan, it is starting to experience problems at busy times. This study was to review the current pack methods at the order fulfillment facility and provide a plan to redesign and improve the methods, the workstations, and the conveyor system in the area to handle the growth over the next few years.

Purpose of the Study

The goal of the implementation of the study was to increase the output of the pack operations and accommodate a 12.5% growth rate for the next five years. This study looked at current flow into the pack stations, the projected flow in the future, and the amount of stations needed to handle the increased volume.

Also, the current pack stations are large and bulky and not sized to hold the proper balance of supplies to meet the pack outputs. This study also provided alternatives for workstations to maintain approximately an eight-hour supply of most necessary items (excluding boxes) and provide sufficient workspace to hold the computers and items needed to pack an order.

It was imperative that this situation was studied within this facility at this time. With the projected growth rates, and the current amount of pack stations, the facility would not be able to handle the increased growth beyond the year 2007.

Assumptions of the Study

It was assumed that the new mezzanine structure of the warehouse is available to expand pack operations. An addition was put on the mezzanine in January of 2006, to handle future packing stations and provide more space. Currently, some other operations are using some of the space, but it was assumed that they can be moved.

It was also assumed that capital will be available to meet the recommendations of this study. Each item recommended will be evaluated cost-wise before implementation to provide a working, cost-effective solution.

The pack methods were assumed to remain the same throughout the study except for changes proposed in the study.

The pack lane routing was looked at and held constant during the study times to ensure that there was not an additional factor producing variation. A model was developed to predict the pack lane 1routing current flow.

Definition of Terms

Container – A storage or transportation device for products. Aliases: tote, pallet, carton, box, envelope, etc. (ASAP Automation, 2000)

Ergonomics – The study of the interaction between human beings and the objects they use and the environments in which they function. (Pulat, 1992)

EXACTA – Third-party warehouse management system currently in operation.

Label – A barcode with optional human readable text that is printed and adhered to the product or container for tracking the movement or storage within the warehouse. (ASAP Automation, 2000)

Pack – Placing the items into an outer case in preparation for shipping. May also include pack list printing and application of a shipping label. (ASAP Automation, 2000)

Pack Workstation – Configuration dictates packing methods used: order pack vs. carton pack. Optional value added processes can be performed. The operator manually validates the picked product and its quantity against the work order. (ASAP Automation, 2000)

Packing List – Prints as an operator closes each shipping carton or last carton for the order in the WMS. Contains details on each item and quantity packed into the container. The packing list is placed inside the shipping carton. (ASAP Automation, 2000)

Product ID – Fixed barcode with optional human readable text that is marked on the product by the supplier. Aliases – item ID, item number, part number, SKU. (ASAP Automation, 2000)

Shipping Container – A carton containing products packed for delivery to the customer. Aliases: carton, box, envelope. (ASAP Automation, 2000)

Shipping Label – printed for the freight carrier. Barcode with human readable text that is printed by Exacta and is applied (generally to the top) of the shipping container. It contains the order number, shipping container number (4^{th} of 5 cartons), ship-to address, freight carrier and type of freight service. May also contain manifest tracking number, carton identifier, and return address. The shipping label is applied to the outside of the shipping carton so the carrier can properly deliver the carton to its destination. (ASAP Automation, 2000)

WMS – Acronym for Warehouse Management System

Work Order Number – number to identify each work order. It must be unique within the WMS system. (ASAP Automation, 2000)

Zone – A storage location or a work location. A storage zone encompasses a physical area and is normally defined by the storage device used. A work zone is defined by the activity performed at the workstation present, e.g. pack workstation, management workstation, etc. (ASAP Automation, 2000)

Limitations of the Study

The study was limited by the amount of data available. Current pack rates are only available in the system for a period of 30 days. They were being collected from January, 2006 to May, 2006, but if data was not on the reports collected, it could not be acquired and time studies had to be done to determine what the expected outputs would be.

Secondly, the spur mentioned in the analysis was designed but not implemented at the time of the study. Any assumptions and analysis of that line had to be done using system data and drawings rather than actual observation.

Thirdly, the addition of pack stations and conveyor will be limited not only by the current conveyor and stations in place, but also by the software logic already in place in the WMS. The system was programmed by a third-party company and changes in the logic can be done to add pack stations, but any substantial change in processes and logic will be hard to accomplish. If there are substantial changes, they will have to be cost/time justified.

Chapter II: Literature Review

Ergonomics

Ergonomics was the first category for review on this project for many reasons. First, it was very popular in the mid-nineties as a buzzword for many manufacturing companies and for many companies trying to sell equipment for offices, pack stations, and other uses. Due to the overemphasis on the area, many people have been turned off by the word and the field and often ignore it. However, it is a vital part of any project done in a warehouse, no matter how technical or mechanical it may appear. "Ergonomics is an interdisciplinary science that deals with the interaction of people with the objects they use. In many cases, human beings take for granted the inefficiencies that may exist in such an interface. In many cases, poor design of workplaces leads to a drop in production efficiency." (Pulat, 1992). By taking into account the people in the system from the onset, putting yourself in their shoes and thinking about flow and function, you gain great advantages throughout the project in design time, future efficiencies, and overall satisfaction.

According to Pulat (1992), experience shows that there are many potential ill effects that can be expected if ergonomics is ignored during design:

1. Less production output
2. Increased loss time
3. Higher medical costs
4. Higher material costs
5. Increased absenteeism
6. Low-quality work

7. Injuries, strains
8. Increased probability of accidents and errors
9. Increased labor turnover
10. Less spare capacity to deal with emergencies

Potential gains of ergonomics are the reverse of the above. In addition to the tangible gains, there are many intangible benefits. One can count increased job satisfaction and work acceptance as two important intangible gains of considering the human being when undertaking system design.

The main area of ergonomics that was focused on for this project was work area design. According to Pulat (1992), several generic design principles/conventions apply to all workstation/workspace design cases.

1. Consider functional requirements. System requirements with respect to needed functionality filtering all the way down to human and equipment tasks must be adhered to. The resulting design must allow the operator to carry out the required tasks in the sequence called for. Specific equipment needs for each task must be considered.
2. Consider visibility. Visibility of primary and adjunct displays, controls, other equipment, other workers, task area, and so on, is of primary importance. Making sure that everything that the worker must be able to see is visible in the best conditions is one of the primary tasks of the designer. After all, human performance will be degraded significantly if signals and information of interest cannot be seen.

3. Consider clearances. Clearances for the trunk, the legs, the head, the knees, the feet, and so on, are essential in any design to be used by human beings. Access and egress space must be provided at each work area. Proper clearances will allow for comfort and ease in grasping and operating equipment and controls. They are especially helpful to a person in moving around to relieve static loading and other discomfort. Finally, clearances isolate the worker from potential injury.
4. Consider reach and manipulation requirements. These determine dimensional factors with respect to the operation of controls, equipment, seat adjustments, and the like. Such requirements can be based on 5^{th} percentile reach characteristics of the user population. Other items that may be reached are parts bins, tools, parts, fixtures, cabinets, and manuals. A good rule of thumb is to locate the most frequently used items within the normal work area, and all others within the maximum work area.
5. Investigate possibility for standardization. Benefits of standardization are numerous. Savings in hardware development and training time are some. Furthermore, there is lessened chance for operator error. Naturally, a poor design repeated many times is more detrimental than different designs. Hence the prototype of standardized work areas must be evaluated carefully.
6. Consider the total system. Each work area must be designed with the total system in mind. Operational relationships in the system define relative locations of the various work areas. Such relationships also define the equipment needs at each work position.

7. Design for maintainability. Any work area must be maintainable. Work benches, equipment, and tools require periodic maintenance. While human engineering the work area, the designer should not complicate the maintenance person's task.
8. Minimize safety hazards. Accident potential at the work area must be minimized.
9. Consider fixed locations for work components. Fixed locations for tools, materials, and controls will eliminate ineffective motion elements such as search and select.

By considering the principles listed, it helped to ensure an effective design while minimizing trouble in those areas in the future. In the current pack operation, monitors are fixed to locations on the pack station and not adjustable for those who may need to tilt it for glare or other reasons. There are excessive reaches all over the current pack stations which cause stretching, twisting, or stepping to get items. Some items on the pack stations are standardized, but other items are placed wherever a packer likes to put them. The stations are very hard to clean and maintain and access to any computer equipment for repair is very difficult.

Capacity Analysis/Profiling

Capacity Analysis/Profiling was a second major topic studied in the project. Frazelle (2002), provides a great scenario to emphasize the important of understanding capacity and profiling. Image you are sick and went to the doctor. When you arrived, your doctor already had a prescription waiting for you, without even talking to you, looking at you, examining you, etc. Much reengineering in warehouses and layout projects commence without any understanding of the main cause of the problems and without looking at all the real opportunities for improvement.

Warehouse activity profiling is the systematic analysis of item and order activity (Frazelle, 2002). The profiling process is designed to quickly identify root causes of material flow problems and find areas of opportunity for process improvements. Looking at the data and profiling helps to stimulate creative thinking on the topic. As people look at the data and profiles, creativity flows and the person or team start making decisions and creating new ideas.

One way to profile is to figure out what is common for the industry/environment being studied and important to them and design based on that profile. Some companies may find movement of a product to be more important in a profile, while others make consider size more pertinent to gaining advantages in their processes. In this study, data was profiled by box (shipping container) size. This gained distinct advantages for supply of materials to the stations.

Work Measurement

According to Niebel (1993), when methods studied are made to improve the existing method of operation, experience has shown that to achieve maximum returns, analysts should follow a systematic procedure similar to that advocated for designing the initial work center. Westinghouse Electric Corporation's Operation Analysis program advocates these steps to assure the most favorable results:

1. Make a preliminary survey.
2. Determine the extent of analysis justified.
3. Develop process charts.

4. Investigate the approaches to operations analysis
5. Make motion study when justified.
6. Compare the old and the new methods.
7. Present the new method.
8. Check the installation of the new method.
9. Correct time values.
10. Follow up the new method.

Methods engineering scrutinizes the direct and indirect operations to find improvements making work easier to perform and allowing work to be done in less time. The real objective of methods engineering is profit improvement.

Time study is often referred to as work measurement. Time study can use several techniques to establish standards. These can include stopwatch time studies, standard data, work sampling, estimates based on historical data and computerized data collection. Time standards developed based on the measurements make allowances for fatigue and personal and unavoidable delays such as breakdowns in mechanical equipment. Good analysts must know when it is best to use a certain technique. This study will use stopwatch study to develop the standard data/times, process charting (not as a flow chart, but listed in the labor worksheet), and estimating based on historical data of the current pack process.

Facilities Planning/Design

The final major topic considered was facility planning and design. The objectives of facilities planning are to improve material handling and housekeeping, effectively utilize people, equipment, and space, minimize capital investment, provide flexibility and ease of maintenance and provide for employee safety. Some of the key parts of the facilities design process according to Tompkins and White (1984) are to define the objective of the facility, specify the primary activities to be performed, determine the space requirements for all activities, and to select a facilities plan.

The selection of a facilities plan often requires compromise among several important areas. According to Tompkins and White (1984), the decision maker's value system is not necessarily the same as the facilities planner's. The facilities plan needs to provide for a proper amount of space for each of the operations and equipment, be cost effective for the company, and where possible, provide for future expansion or changes. Often one of these criteria is traded to accomplish another, but not without careful consideration of the impact of the decision. The most common problem is the future getting traded for cost savings without considering the time value of money and the cost to redo the area in the future. The design proposed in this study meets the proper amount of space for each of the operations and equipment, is cost effective based on improvements made and capacity gained and provides from some changes and expansion. The design would only lack if growth figures were excessive high over the next five years or if the design was to be stretched far beyond the five year time frame. At that point, however, other areas of the facility would have to change also.

Chapter III: Methodology

Introduction

The goal of the implementation of the study was to increase the output of the pack operations and accommodate a 12.5% growth rate for the next five years. In studying the line, many areas had to be looked at. The current capacity of the line had to be determined, and what the future flow, and capacity would be expected to look like.

Pack station design was looked at as a subcomponent, however knowledge of the pack rates was needed in order to determine some overall capacity numbers and create the right zones and stations at the right place. Pack rates were also helpful to determine where inefficiencies in design or layout occurred and help gain some additional benefits to the system.

The problem was looked at mainly using system data, time studies of current operations (current output), and expected growth figures. Current pack operation data was used to determine the current output of the pack stations and determine the amount of stations needed in the future. For recommendations made to the current methods, time standard were created to determine the expected change in output in comparison to the current methods. The input into the pack area was determined by studying the current flow and speeds and combining that with a look and the drawings and system data to determine what impact the spur would have on the area.

Workstations were evaluated as a subcomponent of this project to make sure we were not just increasing capacity, but providing a good area for the workers to function in. By improving ergonomics and the workstation layout, there would be increases in the output at the stations.

Subject Selection and Description

The data to be used in analyzing the flow of the line had to be selected with some consideration. A significant amount of history had to be pulled to better determine what the future would be expected to look like. However, such factors as seasonality of products, lifespan of the current WMS system and conveyors, company acquisition, and customer sales had to be considered. To just pull data and look at it without understanding its source and what factors affected it would do a disservice to the whole system and the company. The past helps predict the future, but an understanding of its ebb and flow is needed so conclusions make sense.

In 2001, Drs. Foster & Smith, Inc. purchased Pet Warehouse, which changed the focus of the company from mainly dog and cat products, to dog, cat, fish, pond, bird, and reptile products. The addition of fish and pond products dramatically changed the quantity of SKUs in the warehouse and fulfillment areas and also changed the make-up of the "typical" order. The number of lines per order increased and the dollar total of the orders also increased. The physical size of the packed order also increased.

Data Collection Procedures

A query was written in Pick Basic to gather data out of the current server and back-up tapes pulling orders and their headers and characteristics for January, 2006 – June, 2006. Items gathered included order date, order time, number of lines, box sizes and product weights. Also included, where applicable, is what zones the product was routed to at the time for picking based on the inventory files. Data was put into SQL Server 2000 for analysis and calculation purposes using SQL Query Analyzer and Excel

2003. Knowledge of the system and order profiles made the selection of that time span adequate to predict the future that needed to be looked at for this project.

For the pack data, reports were pulled from a SQL database using Crystal and then printed. Older data had to be taken from the printouts and manually entered. Productivity data in the WMS was only kept for a four-week period so foreseeing that issue and collecting data as it occurred, the printouts provided the data needed.

Chapter IV: Results

The main goal of this study was to increase the output of the pack operations. This was mainly done by determining the capacity needed, applying the current output of the pack stations and increasing them to meet the future needs at a 12.5% growth rate. All volume data has been modified by a factor to protect the actual company information and rates. It also looks at a specific area of the company rather than the total amount.

Future Growth

In 2005, the company had a total order volume of 1,987,659 orders for the year or 6,371 orders per day in a six day work week for the specific area studied only.

Table 1

Projected Future Order Volume at 12.5% Growth

Year	Total Orders	Orders per Week	Orders per Day (6)
2005	1,987,659	38,224	6,371
2006	2,236,116	43,002	7,167
2007	2,515,631	48,374	8,063
2008	2,830,084	54,425	9,071
2009	3,183,845	61,228	10,205
2010	3,581,825	68,881	11,480

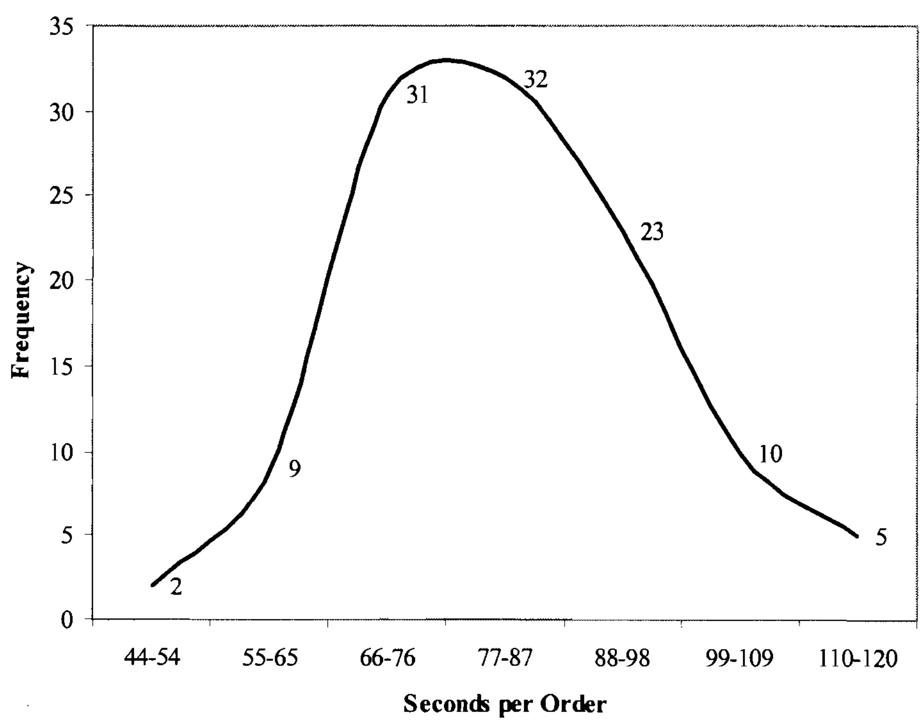
For the year 2010, the expected amount of orders per day is expected to be 11,480 or an increase of 80.2%.

Pack Rates

There were two ways chosen to look at the pack rates. One is by actual data out of the system on productivity, the other is by looking at the standard times. For this study, both were used in order to make sure there was a good understanding of the step-by-step processes involved before design and also to help find any tasks that were being done outside of the ordinary processes set that could be eliminated in the future for improvements.

When looking at the system data for a four month period, it looks similar to a normal distribution (see Figure 1 below), with a mean of 84, median of 81 and standard deviation of 16.85. The range was 109.

Figure 1. Line Graph of Pack Rates (January-May, 2006)



When standard rates were looked at for the same process, stopwatch times were used to establish the standard. The total time for the whole pack operation for a single item order with no taping or bagging was determined to be 84 seconds by productivity data, 70 seconds by time standard data. The process steps and times can be found in Appendix A. The discrepancy revealed the inefficiencies occurring in the current pack operation and the variations in orders. Variations between the data gathered from the system from productivity reports and between the stopwatch time studies can be attributed to multiple items in an order, and items needing to be taped, bagged, or wrapped to protect the product. The data shows that to make improvements to the cycle time of the pack process, steps in the process can be improved or eliminated. The main limiting factor of the process is making the box to put the products in. By eliminating this step entirely, the pack process can be sped up by 10 seconds. By improving the workstation design, the times to accomplish several other steps will be reduced.

Order Profiling

Based on the knowledge of the company and the current WMS, it was determined that the best way to profile orders and gain efficiency in pack was to profile the orders by the size of box that they would go in at the end. This helped accomplish some of the goals of profiling mentioned by Frazelle, (2002) such as identifying material flow problems and finding areas of opportunity for process improvement. When looking at the order data by boxes (details can be found in Appendix B), it could be seen that almost thirty percent of orders go into a box size of #5. Time and productivity savings can be achieved by making all of those boxes with the currently available box machine and also by supplying another machine to handle the volume of making #3 boxes, #2 boxes and tri boxes. The profile also shows that the #15 and Med boxes comprise together less than one percent of the volume. It is suggested to eliminate these boxes altogether to reduce storage and handling space, time to manual fold and tape them and time to acquire them. By reducing folding and taping alone at the previous standard of 10 seconds, significant savings can occur. To calculate the savings, the following equation was used:

$$\text{Savings in hours} = \frac{(\text{6 months of orders for box size in Appendix B}) * 2 * 10 \text{ sec.}}{3600 \text{ sec/hr.}}$$

This would save 43.4 hours for the year for boxes #15 and Med. By automating the #5 folding and taping, it would save 1827.65 hours for the year or almost a year's work for one employee. The #2 box savings would be 682.32 hours. The #3 box savings would be 914.72 hours and the tri box savings would be 487.8 hours. This is a total of 3,912.49 hours for the 4 boxes, or almost 2 employees for a year. A box machine that can handle these 4 sizes of boxes costs approximately $45,000. With the amount a worker would be paid in a year with benefits, the 2 employees saved would justify the machine within a year's time. When the entire list is profiled and analyzed in this way, the justification for automating the process becomes apparent.

Additional benefits for the company for profiling by box size are to reduce the number of supplies at many of the pack stations, and provide some consistency for the employees. According to the data, eleven different boxes are needed at each pack station in various quantities. With all orders going to any line, all these items have to be stocked at each station and there is no consistency as to what box is needed. By looking at the data, we can see that almost thirty percent of the overall orders go in a #5 box, so it would be beneficial to dedicate about thirty percent of the pack stations to take the orders in #5 boxes and provide a supply of pre-made boxes to those stations. Other lines in the older area can also have allocations in a similar fashion to reduce the variety of boxes needed there and save space.

Additional Capacity Needed

To determine the capacity needed for the future, just use a combination of all the data we have compiled so far. First, to identify the maximum number of pack stations needed, use the most conservative rates for pack, and determine the daily capacity of a station if manned. The most effective way to do this is to reuse the Labor Worksheet and input the time for the total operation to determine the daily capacity at the station. It is nice to reuse the Labor Worksheet because it already has made sure that allocations for lunches, breaks, clean-up and downtime are considered. See the results of a daily capacity of 522 for an eighty-four second pack cycle time in Appendix C. The capacity is calculated using the following formula:

Daily Capacity = net run time (after allowances) / minutes per cycle

By using the more conservative pack times, the system will not be low on capacity if the orders would increase above projection or if a box maker was broken down and the packer had to hand tape the orders. The number of stations needed is calculated using the following formula:

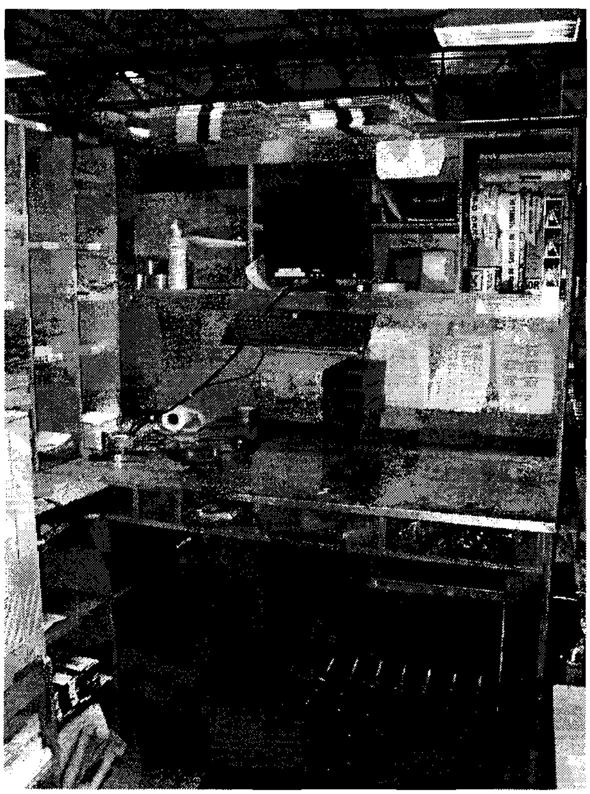
Stations needed = Orders per Day / Daily Capacity

For this scenario, we take the total orders per day of 11,480 in 2010 from Table 1 and divide by the capacity of a station of 522. This calculation results in 22 stations. The current facility has up to 16 stations available at the present time, so we need to add at least 6 to accommodate the additional volume.

Pack Station Design

The current pack stations in the facility in this area are large, bulky, hold too much of certain items, lack on space for others, and are quite cluttered. They also have quite a bit of distance on many of the reaches for materials. An example is shown below in Figure 2.

Figure 2. Current Pack Station



The large frame, L-shaped design with no adjustability presents with many ergonomic issues and many opportunities for improvement. Table 2 shows a list of many of the item locations in Figure 2, along with the distances and some of the problems encountered with each item.

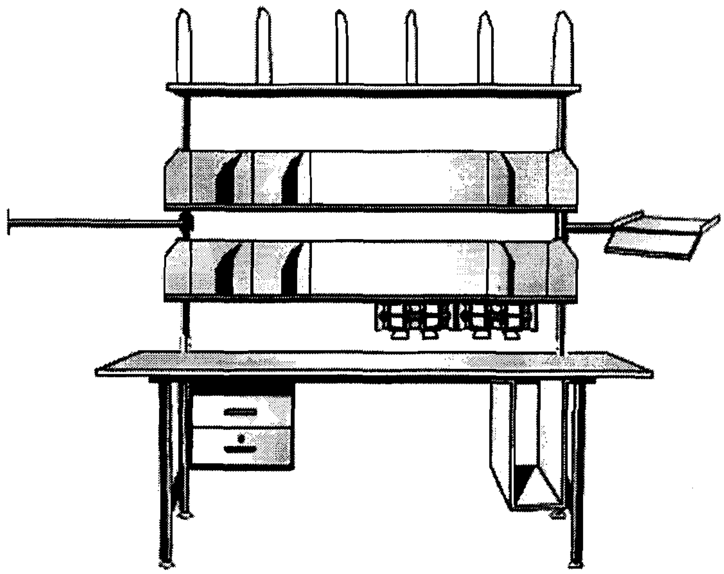
Table 2: Current Pack Station Issues

Item	Location in Fig.2	Reach Distance	Ergonomic Issue(s)
Scan Gun	Work Surface	44"	Excessive Reach
Catalogs	Left Compartments	32"	Reach/Twist/Lot of Product
Labels	Upper Right	36"	Two-handed excessive reach
Printer	Left Foreground	40"	Twist/Step/Reach
Boxes	Center Above	73"H/24"D	Reach up and back

The mouse and scan gun are located far away from the conveyor where the tote would be scanned, making them hard to use. The reach is also beyond the ergonomic recommendations. There is a lot of twisting motion to get the catalogs on the left and the station holds up to a week's supply of some catalogs, taking space away from other necessary items. Open, unorganized spaces add to the clutter, distraction and difficulty to maintain the equipment. Labels are beyond recommendations for reaches and take 2 hands to grab and apply. On the top is about the only location for boxes, but they are too high for most operators to reach.

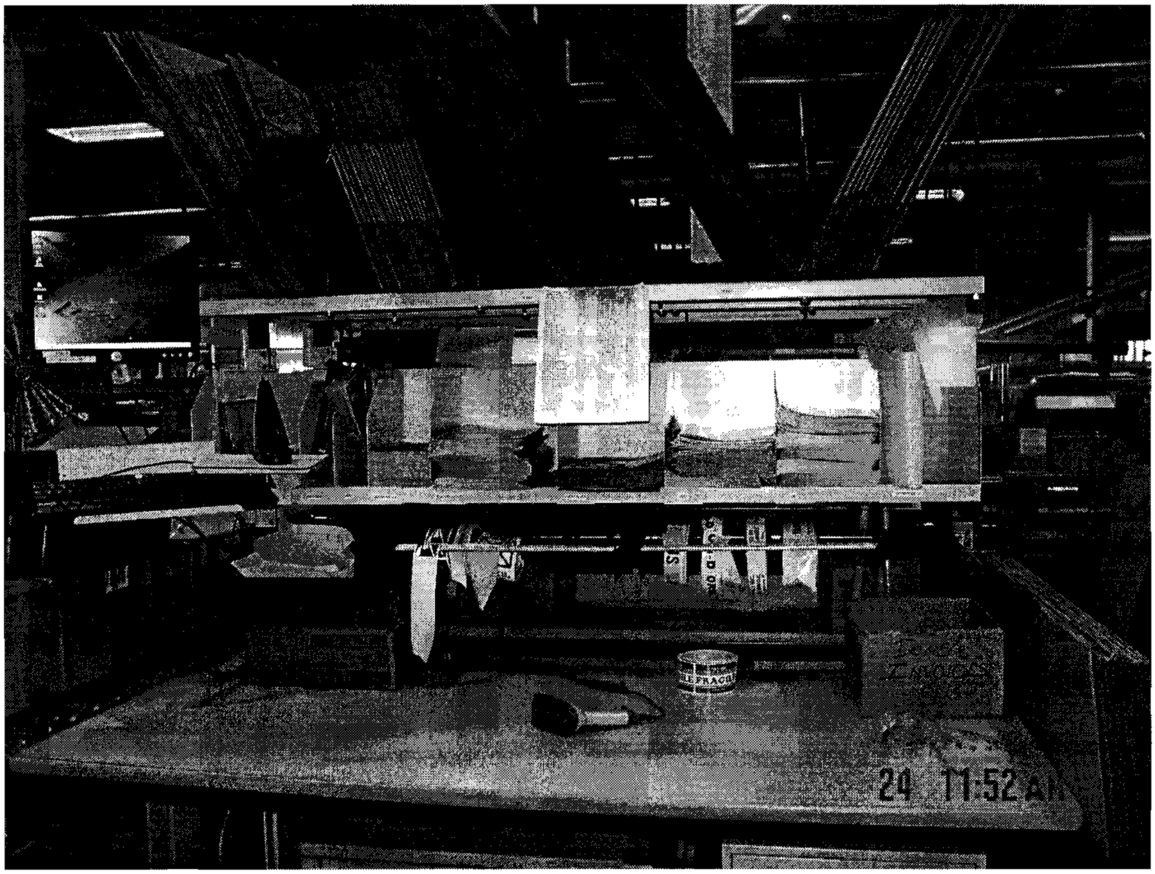
An improved pack station would look similar to the one in Figure 3. There is a clear space for the computer and peripherals on the right side where the line is. This considers the functional requirements of that equipment as emphasized by Pulat (1992). The monitor can be adjusted in and out and also up and down to reduce glare and improve vision which considers the visibility of the operator. Also, the catalogs and flyers can be placed directly in front of the operator within reach. The dividers are adjusted to size the supply to an eight hour shift based on volume of each item. The label dispensers allow for one handed operation to get and place a label when needed.

Figure 3. Proposed Pack Station.



Boxes when not supplied in an already folded and taped fashion can be stored overhead within reach of the operator. Another design feature is that there is purposely no excessive storage space or crevices for items to hide in. This also aids in maintaining the equipment and the cleanliness of the station. Each item also has a fixed location for storage to eliminate searching around for items needed. Figure 4 shows a similar pilot station currently in use. It still needs a few containers for items on the work surface, but shows how the pack area is much cleaner, supplies are reachable and it is easy to maintain and clean.

Figure 4. New Pack Station in use.



In addition to meeting general ergonomics standards, many distances and reaches were reduced that will aid in improving the overall process time. The changes in distances can be found in Appendix D: Pack Station Distances. According to Niebel (1993), the maximum reach for a woman in the horizontal plane is 24.3". On the old stations, every reach exceeded this distance which caused an extra step or stretch to get the item. On the new stations, every reach has been brought within this standard. This provides for significant savings in the operation cycle time of the packers. After doing a revised Labor Worksheets, using stopwatch studies, the new station, and supplied boxes. The savings in standard time totaled 16 seconds. Since one applied 10 of those seconds previously to our box making justification, one can attribute 6 to the improvements in the work station design. This was applied to the orders in 2010 of 11,480, using the following equation:

$$\text{Savings in hours} = \frac{(\text{1 year of orders for 2010 in Table 1}) * \text{Savings per cycle(sec.)}}{\text{3600 sec/hr.}}$$

The result was 19.1 hours per day or well over a person a day with 12.2 available hours of run time after allowances. In addition, there are benefits to reduce the strain and the fatigue on the worker that are not easy to quantify, except when injury occurs.

Layout Design

For the layout of the new area, limited space was available. The design was based mainly to accommodate the old system. There is already a feed with a pack sorter heading across the mezzanine. Space is available to place 50/50 pushers along that line to divert to the pack stations (see Appendix F). With the space available overall of 53'x 77', and 53'x 47' for pack, 4 incoming lines holding two stations each can be added. This meets the goal of 6 stations and also provides two additional. Also already inherent in the system riding alongside the incoming line (labeled in Appendix F) is a tote return line. This is vital to the pack area because all of the orders come in on a line in totes, the totes cannot head to the tapers in this area, and they must get back to the beginning of the line. That tote return line can extend across into this area and resides under the incoming pack lines for the packer to put their tote on when finished.

The outgoing, shipping containers are pushed by the packers into a takeaway line that heads to one of two tapers new tapers. One taper would be allocated to up to 4 pack stations. There is flexibility to provide manpower to one or both tapers depending on the volume experienced. When the volume is higher, the outgoing packages will alternate between the two machines for taping. When only one is needed, all packages can be diverted to that lane only via the WMS. The taper line then will merge into the current line headed down to the ship sorter.

An added feature that will greatly increase productivity as mentioned previously is a box machine for the area. This is labeled on the left of the drawing. This area can be set to handle a single box size for orders (preferably the #5 box). By suspending a hook conveyor system over the packer's head and stations, it can deliver the pre-made boxes to the packers at the eight new stations and they just have to reach up to grab one. There is also an additional box machine drawn in to provide capacity to other areas of the facility or in case the main one breaks down.

Chapter V: Discussion

This study was to review the current pack methods at the order fulfillment facility and provide a plan to redesign and improve the methods, the workstations, and the conveyor system in the area to handle the growth over the next few years.

It was imperative that this situation was studied within this facility at this time. With the projected growth rates, and the current amount of pack stations, the facility would not be able to handle the increased growth beyond the year 2007.

Conclusions

By providing additional capacity for 6 stations, the growth over the next five years can be met. The main advantage of the overall new layout is that is also provides some additional capacity above and beyond the estimated needs to accommodate potentially more growth. A common mistake of many businesses is to market and grow then not be able to meet their customer needs. Drs. Foster & Smith, Inc. strives to have excellent customer service, therefore, it is important to allow them to continually meet their customer needs. The cost of the additional two stations is minimal compared to the benefits gained.

The change in the pack stations meets several design principles put forth by Pulat (1992). They consider functional requirements, by allowing an increased functional workspace for the actual packing operation, and room for supplies needed to do the job. They consider visibility but putting the computer, monitor, and many supplies right in front of the operator, and allowing for adjustability of the monitor depending on the high of the operator. The monitor arm can also swing in and out if it needs to come closer to a worker. The pack stations also consider clearances, and reach and manipulation requirements. The reach distances in Appendix D showed the various items improved along with Appendix E showing the labor savings. They considered investigating the possibility for standardization, all supplies and catalogs now have a specific labeled home. They considered the total system by allowing for totes to be returned back to the beginning of the line, and provided means for the shipping containers to progress to their next destination. The stations are designed for maintainability. Access to equipment is now available and they can be cleaned fairly easily also. They also minimize safety hazards by reducing reaches and lifts. Finally, they considered fixed locations for work components. This reduced cycle time of the process by 6 seconds, and also benefits the workforce to reduce fatigue and strain.

The work measurement helped show the activity that was taking up the most time in the pack area, making boxes. By providing automated means for making and delivering boxes, the reduction in the process time by 10 additional seconds is achieved. Stations can also have orders of specific box sizes delivered to them to reduce any clutter of needing all the box sizes stored at each one.

Recommendations

First, it is recommended that the new pack area be implemented including all the conveyor systems, pack stations, box machine, and box delivery system as shown in Appendix F. The capacity is needed for the future, and the labor savings help justify the purchase of much of the equipment.

Second, it is recommended that the company look at the older, similar operations and evaluate the 16 old pack stations and box method supply in those areas to achieve similar benefits to the new area. In addition, a plan for continuous housekeeping should be established and implemented. Training on the new area needs to occur to show the benefits of the new stations and to emphasize the methods so the standard times are continually met. It is also important to show the adjustability of the computers and monitors so the packers feel free to adjust to meet their specific needs.

Third, it would be recommended to assign someone specifically to supply products and supplies to the workers and to do housekeeping. By stocking the stations with an eight hour supply, the need to go get materials is reduced and capacity increased, however, by assigning someone specifically to those tasks, the packers could reduce the downtime of 15% shown in the process in Appendix A and potentially gain some more benefits. Also, by having someone specific to that area, the stock of boxes for the box machines and the workers can be better controlled and maintained.

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Doctors FOSTER & SMITH

Labor Worksheet (LBRW)

Part #	One item order	Date (originated)	10/7/2003
Part Name		Date (revised)	7/7/2006
Department	QC/Pack	Work Center	Mezzanine
Mfg. Facility	Rhinelander	Revision #	2
Prepared by	Janet R. Siefert	Authorized by (signature)	JRS

SHIFT ALLOWANCES		MINS / SHIFT
GROSS :	MINS/SHIFT	960.00
LESS :	PAID LUNCH	40.00
	BREAKS	40.00
	MEETINGS	0.00
	CLEAN-UP	20.00
	OTHER	0.00
	AVAILABLE RUN TIME	860.00

MFG. SYSTEM PARAMETERS	MINS / SHIFT	% RATE	ROUTING ALLOW. %
CHANGE-OVERS	0.00	0.00%	0.00%
DOWNTIME	0.00	0.00%	0.00%
SCRAP	0.00	0.00%	0.00%
OTHER	129.00	15.00%	17.65%
SUBTOTAL LOSSES	129.00	15.00%	17.65%
NET RUN TIME	731.00		

OPERATION DESCRIPTION	NUMBER OF		CYCLE TIME						PCS/SHIFT CAPACITY		STD
	OPER'S	MACHS	SECS/ CYCLE	MINS/ CYCLE	PCS/ CYCLE	LOCKS/ BLISTER	BLIS./ DISP.	MINS/ PIECE	PER MACHINE	TOTAL OPERATION	HOURS / 1000 PCS
Grab tote and move or turn to scan.	1.00	1.00	4.0	0.0667	1.00	1.00	1.00	0.0667	10,965	10,965	0.7296
Scan tote (grab gun, scan, and set down gun)	1.00	1.00	4.0	0.0667	1.00	1.00	1.00	0.0667	10,965	10,965	0.7296
View Screen to determine box size	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
Make box (grab box, fold, grab taper, tape) put taper b	1.00	1.00	10.0	0.1667	1.00	1.00	1.00	0.1667	4,386	4,386	1.8240
Pull items out of tote to scan/view	1.00	1.00	10.0	0.1667	1.00	1.00	1.00	0.1667	4,386	4,386	1.8240
View Screen to determine catalog/flyers	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
Reach, grab and place catalog in box.	1.00	1.00	5.0	0.0833	1.00	1.00	1.00	0.0833	8,772	8,772	0.9120
Pack Complete in system (click function key)	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
Place items in box	1.00	1.00	8.0	0.1333	1.00	1.00	1.00	0.1333	5,483	5,483	1.4592
Grab invoice, tear shipping label off and place on box	1.00	1.00	5.0	0.0833	1.00	1.00	1.00	0.0833	8,772	8,772	0.9120
Fold and place invoice in box	1.00	1.00	4.0	0.0667	1.00	1.00	1.00	0.0667	10,965	10,965	0.7296
Pull old style invoice out of tote	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
Place old invoice in pile	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
Push box back on line (other totes usually in the way)	1.00	1.00	5.0	0.0833	1.00	1.00	1.00	0.0833	8,772	8,772	0.9120
Place tote under conveyor	1.00	1.00	5.0	0.0833	1.00	1.00	1.00	0.0833	8,772	8,772	0.9120
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
NO. OF OPERATIONS	15.00		LIMITING MINS/PC					0.1667			
		Total Time	70.0								

Notes:

Improvements can be gained by eliminating making the box in the pack process.

Additional time is added when items have to be taped, bagged, or wrapped.

Appendix B: Orders by Box Size

Orders by Box Size

Box Size	Number of Orders*	Percent of Total
#5	328,977	29.42%
Mlr	286,412	25.62%
#3	164,650	14.73%
#2	122,818	10.98%
Tri	87,804	7.85%
#11	52,140	4.66%
Sm	24,791	2.22%
Mug	23,157	2.07%
Env	19,497	1.74%
#15	5,204	0.47%
Med	2,608	0.23%

*Data is for the mezzanine area only from January 1, 2006 – June 30, 2006.

Doctors FOSTER&SMITH

Labor Worksheet (LBRW)

Part #	Capacity Analysis	Date (originated)	10/7/2003
Part Name		Date (revised)	7/14/2006
Department	QC/Pack	Work Center	Mezzanine
Mfg. Facility	Rhinelander	Revision #	1
Prepared by	Janet R. Siefert	Authorized by (signature)	

SHIFT ALLOWANCES		MINS / SHIFT
GROSS :	MINS/SHIFT	960.00
LESS :	PAID LUNCH	40.00
	BREAKS	40.00
	MEETINGS	0.00
	CLEAN-UP	20.00
	OTHER	0.00
	AVAILABLE RUN TIME	860.00

MFG. SYSTEM PARAMETERS	MINS / SHIFT	% RATE	ROUTING ALLOW. %
CHANGE-OVERS	0.00	0.00%	0.00%
DOWNTIME	0.00	0.00%	0.00%
SCRAP	0.00	0.00%	0.00%
OTHER	129.00	15.00%	17.65%
SUBTOTAL LOSSES	129.00	15.00%	17.65%
NET RUN TIME	731.00		

OPERATION DESCRIPTION	NUMBER OF		CYCLE TIME						PCS/SHIFT CAPACITY		STD
	OPER'S	MACHS	SECS/ CYCLE	MINS/ CYCLE	PCS/ CYCLE	LOCKS/ BLISTER	BLIS./ DISP.	MINS/ PIECE	PER MACHINE	TOTAL OPERATION	HOURS / 1000 PCS
Total Pack Operation	1.00	1.00	84.0	1.4000	1.00	1.00	1.00	1.4000	522	522	15.3215
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
NO. OF OPERATIONS	1.00		LIMITING MINS/PC					1.4000	CAPACITY	522	

Total Time 84.0

Notes:

Improvements can be gained by eliminating making the box in the pack process.

Additional time is added when items have to be taped, bagged, or wrapped.

Appendix D: Pack Station Distances

Pack Station Distances

Description	Old Station	New Station	Change
Overall Depth	38"	33"	-5"
Overall Length	56"	83"	+27"
Reach to Catalogs	32"	24"	-8"
Reach to Labels*	36"	16"	-20"
Reach to printer**	40"	12"	-28"
Ground to Monitor***	70"	64"	-6"
Reach to boxes	73"H/24"D	64"H/24"D	-9"H/0"D
Reach to hand taper	32"	24"`	-8"
Reach to scan gun	44"	18"	-26"
Functional Space	41"Lx24"D	83"Lx24"D	+42"L

*Old method is step and reach with 2 hands, new method is reach with 1 hand

** Old method is a step, twist and reach, new method is a reach down.

*** Old station is not adjustable, new is adjustable in 4 directions.

Appendix E: Labor Worksheet for a One-Item Order – New Process

Doctors FOSTER & SMITH

Labor Worksheet (LBRW)

Part #	One item order (new process)	Date (originated)	7/7/2006
Part Name		Date (revised)	7/7/2006
Department	QC/Pack	Work Center	Mezzanine
Mfg. Facility	Rhinelander	Revision #	2
Prepared by	Janet R. Siefert	Authorized by (signature)	JRS

SHIFT ALLOWANCES		MINS / SHIFT
GROSS :	MINS/SHIFT	960.00
LESS :	PAID LUNCH	40.00
	BREAKS	40.00
	MEETINGS	0.00
	CLEAN-UP	20.00
	OTHER	0.00
	AVAILABLE RUN TIME	860.00

MFG. SYSTEM PARAMETERS	MINS / SHIFT	% RATE	ROUTING ALLOW. %
CHANGE-OVERS	0.00	0.00%	0.00%
DOWNTIME	0.00	0.00%	0.00%
SCRAP	0.00	0.00%	0.00%
OTHER	129.00	15.00%	17.65%
SUBTOTAL LOSSES	129.00	15.00%	17.65%
NET RUN TIME	731.00		

OPERATION DESCRIPTION	NUMBER OF		CYCLE TIME						PCS/SHIFT CAPACITY		STD
	OPER'S	MACHS	SECS/ CYCLE	MINS/ CYCLE	PCS/ CYCLE	LOCKS/ BLISTER	BLIS./ DISP.	MINS/ PIECE	PER MACHINE	TOTAL OPERATION	HOURS / 1000 PCS
Grab tote and move or turn to scan.	1.00	1.00	4.0	0.0667	1.00	1.00	1.00	0.0667	10,965	10,965	0.7296
Scan tote (grab gun, scan, and set down gun)	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
View Screen to verify box size	1.00	1.00	3.0	0.0500	1.00	1.00	1.00	0.0500	14,620	14,620	0.5472
Pull items out of tote to scan/view	1.00	1.00	10.0	0.1667	1.00	1.00	1.00	0.1667	4,386	4,386	1.8240
View Screen to determine catalog/flyers place catalog	1.00	1.00	3.0	0.0500	1.00	1.00	1.00	0.0500	14,620	14,620	0.5472
Pack Complete in system (click function key)	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
Place items in box	1.00	1.00	8.0	0.1333	1.00	1.00	1.00	0.1333	5,483	5,483	1.4592
Grab invoice, tear shipping label off and place on box	1.00	1.00	4.0	0.0667	1.00	1.00	1.00	0.0667	10,965	10,965	0.7296
Fold and place invoice in box	1.00	1.00	4.0	0.0667	1.00	1.00	1.00	0.0667	10,965	10,965	0.7296
Pull old style invoice out of tote	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
Place old invoice in pile	1.00	1.00	2.0	0.0333	1.00	1.00	1.00	0.0333	21,930	21,930	0.3648
Push box back on line (other totes usually in the way)	1.00	1.00	5.0	0.0833	1.00	1.00	1.00	0.0833	8,772	8,772	0.9120
Place tote under conveyor	1.00	1.00	5.0	0.0833	1.00	1.00	1.00	0.0833	8,772	8,772	0.9120
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
			0.0					0.0000	0	0	0.0000
NO. OF OPERATIONS	13.00		LIMITING MINS/PC					0.1667			

Total Time 54.0

Notes:

Improvements were made by removing box making and moving materials to combine operations.

Additional time is added when items have to be taped, bagged, or wrapped.

Appendix F: New Layout