THE OPTIMAL WAREHOUSE LOCATION FOR CAL POLY'S CAMPUS DINING

BY

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Executive Summary

The Cal Poly Corporation and Campus Dining face the challenge of meeting the growth of students and dining venues on campus with the limited space capacity of their warehouse in building 19. Given a $250,000 budget, Campus Dining has an option to keep the warehouse at the current location at building 19 or moving the warehouse to building 82 off Mt. Bishop Road. Each warehouse location has its benefits as building 19 is in the center of campus and building 82 has much more shelving space than building 19. The objective of this project was to select the better choice for the warehouse location in order to meet the growing number of students and dining venues by comparing the efficiencies between the two choices.

In order to accomplish the objective, the warehouse processes were defined as receiving, storing, picking, loading, and delivering to the dining venues. A small amount of time studies were taken from building 19 for the five warehouse processes and were analyzed to create a linear regression line, which led to using a random number generator and the computer program Stat:Fit to find the best distribution function for each process. This information was inputted into ProModel, a simulation software that was used to simulate both warehouse locations. The information for building 82inputted into ProModel was logically altered from the data from building 19. The simulation was run for 160 hours with 10 replications, which is roughly the amount of time the warehouse runs per year. The important output from the simulation was the average time in system, which signifies the amount of time the inventory was not sitting in permanent storage. In other words, it details the efficiency of each building's warehouse.

A statistical comparison was run between the two models using a two-sample t-test because of the small sample size. The null hypothesis was that the buildings' average time in system was equal and the alternative hypothesis was that they were different. With 95% confidence, the buildings' average time in system was not equal and building 19 actually had a lower average time in system, proven by the 95% confidence interval of the difference between the two as (-50 minutes, -37 minutes). This means the warehouse in building 19 is more efficient with the handling of the product. However, building 82 has a greater shelf space than building 19 and therefore larger inventories are handled, which leads to its greater average time in system.

An economic analysis was run between the two buildings as well by calculating net present value over a 25 year period. The present worth of building 82 of is -$2,591,876 and building 19's is -$3,817,747, which means building 82 is of greater value over the period of 25 years. One of the reasons for this is the number of vendor deliveries is cut in half because of the potential of building 82 to hold more inventory.

The final recommendation from this project was to move the warehouse location out to building 82 to meet the growing number of students and dining venues on campus.

Introduction/Background

In 1955, Cal Poly had approximately 5,000 students enrolled in classes. The number of food venues correlated with the number of students and did not require much inventory. To meet the number of students and their food demand, Cal Poly built the foodservice warehouse location in the Campus Dining complex, building 19. (See map in Appendix A) The goal of this location was to meet the nourishment demand presented by the students and the dining venues serving them. The warehouse's purpose was to store the entire inventory required by the dining venues. Cal Poly decided on building 19 as the primary warehouse because it's location is in the center of campus. Also, by being located in building 19, the main dining complexes in the University Union would have their resource needs met quickly since transportation time was very short. At the time, the warehouse in building 19 was an essential and ideal choice to meet the dining needs for Cal Poly's students and to store enough inventories to limit deliveries, while accessing the dining complexes rather quickly.

Fast forward to the 2009-2010 school year at Cal Poly. Cal Poly has over 19,000 enrolled students and a growing number of faculty, to keep the student to faculty ratio as low as possible to increase the students learning potential. With the increase in both students and faculty, Campus Dining has increased the number of available dining venues to over 20. In addition to the 20 plus food locations, the Avenue consists of five different "fast-food" style venues with each venue offering a different cuisine. With the increasing number of food venues offering a great assortment of food, Campus Dining has to order a variety of ingredients and supplies to match the demand required by students and dining venues. Also, many of these dining complexes do not have any storage areas in their complexes. To overcome the

lack of space, building 19 is used to store dry goods, cold goods, frozen goods, and the supplies needed to cook them and package them. The warehouse has a width of 43 feet and length of 70 feet with a total of 3010 square feet available for storage. If you give an average amount of space to each of the 18 venues, then they would get 167 square feet of space within the warehouse. However, even though this sounds like quite a bit of space, it does not account for walking space, cart space, and door space, which are all required and essential to a warehouse. Also, with the high number of items and the variety of meals being served, the inventory for each venue needs quite a bit of space to be stored effectively and efficiently. However with the very limited amount of space in the warehouse, the ability to store a large inventory for each venue is diminished. For this reason, many deliveries are needed each day to meet daily demand.

Along with the warehouse area, the cooler and freezer are over capacity. The cooler is stationed in the room right next to the warehouse, but also contains inadequate space to meet the growing demand of students and food venues. A walkway is located right down the middle of the cooler, which splits the storage space into half. Along with that, since there is a limited amount of space, many pallets, crates, and boxes are placed on the ground, which blocks access to the racks along the wall. The amount of time for picking and storing is increased dramatically with the requirement of moving items around to reach another item. With the very limited space in the cooler, the process of picking and storing will not be efficient. The freezer also faces the same problem, but is more severe than what the cooler faces. The freezer space is smaller than the cooler and the layout is more complex as there are two walkways that divide the storage racks. However, since there is very limited space, one of the walkways is

completely blocked with moving carts, which would require the process of moving each one of the carts to another part of the freezer in order to reach the desired item. This takes substantial time and again the process of picking and storing will not be efficient with the limited space and current layout.

Another constraint that to having the warehouse in the current location is the closure of South Perimeter Road. With the road closure, access to the warehouse for vendors has been made more difficult. Along with the vendors, intra-campus deliveries to the dining venues face difficulties. The efficiencies of delivering items to these locations decrease since it is harder to drive around campus. With the limited food storage already, the number of intra-campus deliveries was high, but with the added road closures, the time to deliver now increases.

Overall, the major problem Campus Dining faces is that the warehouse, cooler, and freezer, have not evolved with the growth of students, faculty, and number of eateries. With the limited space in these locations, the processes involved with supplying the food venues with their resources is not an efficient one. Also, with the continuous growth in students, faculty, and number of dining venues, building 19 will become even more over capacitated and will face even larger problems. An example of the overcapacity in building 19 can be seen in Figure 1. Cal Poly's administration has to approve of a way for Campus Dining to more efficiently meet Cal Poly's food needs in a way that is cost effective.

Figure 1: Building 19's dry storage area overcrowded

One possible solution that Campus Dining can implement is moving the main warehouse, cooler, and freezer to building 82. Building 82 contains a much larger freezer and more than 5000 square feet of available storage space. Also, in building 82, the ceiling is higher, which allows for an extra set of racks to be added, which would increase the potential storage capacity. An example of building 82's increase in space can be seen in Figure 2. Building 82 is located on the outskirts of campus with the nearest entrance being California Blvd. This would allow vendors to make deliveries any time of the day without having to drive into the heart of campus and not having to face the foot traffic of students, which delays arrival times. With the larger storage space, Campus Dining will be able to hold more inventories, which would decrease the amount of needed deliveries from vendors. Also, with the potential increased storage space, picking and storing should be a lot easier and quicker. The efficiency of this process should increase with the move to building 82.

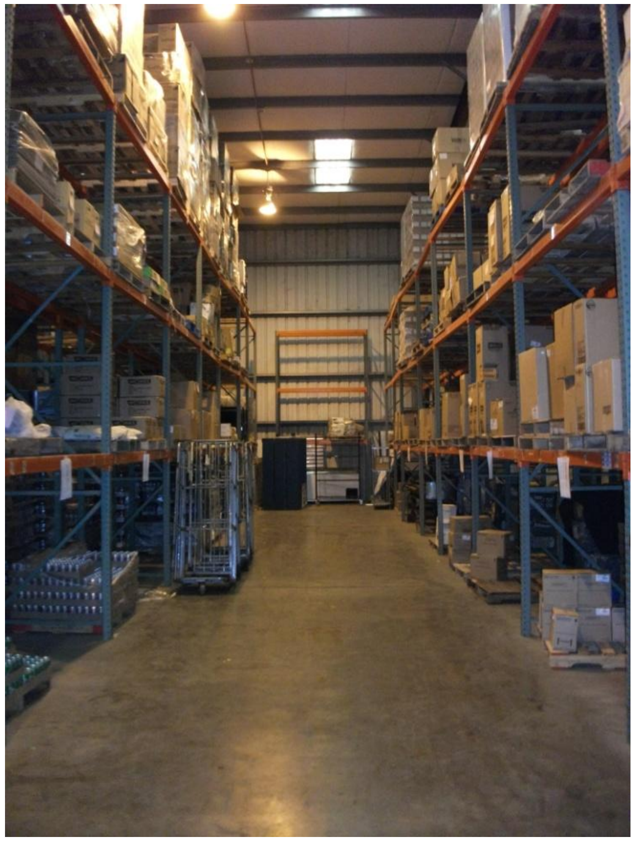


Figure 2: One aisle in building 82's dry storage area

An alternative possible solution to the previous one is that Campus Dining can redesign the layouts for the warehouse, cooler, and freezer to try and meet the increased demand of food resources more efficiently than the current layouts. This solution will be chased if the previous solution is not attainable.

The purpose of the project is to find the best warehouse location for Campus Dining with the options being building 19 or building 82. Facility designs, warehouse processes, financial information, and time studies will be analyzed in the choosing of the optimal location.

Interest in Selected Senior Project

There were many reasons why I was interested in working on this project. After completing most of the required major course needed to graduate, I wanted to utilize the

Industrial Engineering skills I acquired. This project presented the opportunity to use these skills. In order to successfully complete the project I had to use different topics including times studies, efficiency, project management, simulation, statistical analysis, facility layouts, and more. This project presented the “learn by doing” opportunity that Cal Poly pushes and allowed me to see firsthand the results that my project may produce. By producing a successful project, I could help Cal Poly change its warehouse location that is has been in use for over 50 years. By implementing the results, Cal Poly can be saving money and can successfully meet the growth of students, faculty, and food venues.

Another reason I had a lot of interest in this project is that is represents a real world situation. Working on this project simulates what a project will be like when I hold a career position using my Industrial Engineering skills. I was in charge of completing this project individually and in the process of completing I facilitated with many different people including operations managers, mechanics, advisors, and warehouse employees. This project gave me a great experience in how to communicate effectively with those associated, meeting deadlines, using different techniques and skills I have learned, and how to solve a real life problem

Solving a problem for Cal Poly is a great way to give back to the college. By having the fortunate opportunity of studying at the number one ranked undergraduate Industrial Engineering program in the nation, I have felt a need to find a way to give back to the university. By solving this problem, I fulfilled the need to give back to the university that has given me so much.

What People Have Done

It is unknown if any senior projects have been done on this exact problem that Campus Dining and Cal Poly faces. I have been in contact with Greg Yeo, the Operations Manager of Campus Dining, and he has stated that he has tried to have the administration move the warehouse before, but did not have the evidence to support his case. However, Dr. Jose Macedo's IME 223 class will also worked on certain processes in the warehousing operation. I worked with them in collecting data and coming up with solutions to improve the efficiency and productivity of the warehouse. The IME 443 Facilities class has also worked on developing new facility layouts for buildings 19 and 82, but has not actually compared the warehouses statistically or economically.

I also worked with my advisor, Liz Schlemer, to use the correct techniques in determining the optimal solution for Campus Dining and Cal Poly. I had constant communication with Greg Yeo and other Campus Dining employees to understand the day to day operations of the warehouse and to effectively define the processes involved.

Hopefully, when I am done with this project, Campus Dining and Cal Poly will be able to implement my recommendations. After the project, another student may be able to pick it up and take it even farther and help Campus Dining with other existing or future problems.

Literature Review

With the large scope of the senior project, a large variety of sources and references were used. This project incorporated many of the Industrial Engineering skills taught in IME classes, which meant using a few textbooks as references to try and use their ideology in

solving the Cal Poly Foodservice Warehouse Location problem. On top of the textbook resources published books and journals as well as websites were used as references to obtain the top theoretical ideas on solving this problem.

Since this project was a lot of work, a systematic procedure was followed in developing a solution and completing the project. Specifically, Dr. W. Edwards Deming's process ideology of Plan-Do-Study-Act was followed. According to Deming's teachings, "plan means to plan ahead and analyze and predict the results; do is to execute the plan, taking small steps in controlled circumstances; study is to check and study the results; act is to take action to standardize or improve the process." [Value Based Management.net] This plan would be a solid establishment to follow as it lays out a procedure that would act as the foundation to follow in order to complete the project. Also, by following this philosophy, there was a systematic procedure to prevent getting out of order.

Supply chain networks consist of all parties involved in fulfilling a customer request. The players involved in sending the product to the customer include the manufacturer, suppliers, transporters, warehouses, retailers, and the customers. The objective of every supply chain network design is to maximize the supply chain surplus, or profitability. In the supply chain network, warehouses are usually involved with the distribution area in the overall process. The distribution network influences the following measures that affect customer service: response time, product variety, product availability, customer experience, time to market, order visibility, and returnability. In the distributor storage with last-mile delivery distribution design, the product is shipped from factories to distributor/retailer warehouses, and finally shipped to the customer. With this design, "last-mile delivery requires the distributor warehouse to be much

closer to the customer…From an inventory perspective, warehouse storage with last-mile delivery is suitable for relatively fast-moving items for which some level of aggregation in beneficial." [Chopra 2010] The supply chain network design applies to the Cal Poly Foodservice Warehouse location as well. Campus Dining's warehouse is part of the distribution process within the network. In particular, it follows the distributor storage with last-mile delivery distribution design with Campus Dining using carts and small charts to deliver the inventory to the final restaurant destinations.

Warehouses serve a major purpose in many distribution networks. Often times their existence is to store inventory used to balance and cushion the variation between production schedules and customer demand. Another mission of a warehouse is to accumulate and consolidate products from various manufacturers for a combined shipment to a customer. Also, warehouses are often located where they are to shorten the transportation distances to offer rapid response to changing customer demands. For almost all warehouses, the process of receiving and shipping material is very similar. The process usually contains the following operations: receiving, prepackaging, put-away, storage, order picking, packaging and/or pricing, sortation and/or accumulation, packing and shipping, cross-docking, and replenishment. Not every warehouse follows each one of these activities, but all warehouses use most of them in their process. In the design process of a warehouse dealing with receiving and shipping, several steps have to taken to calculate the space needed. These steps include determining what needs to be received and shipped, the number of docks needed and what type is needed, and the receiving and shipping area requirements inside the facility or building itself. When all of these steps are found, then an optimal solution for amount of space needed can be found. The

last one of these steps includes offices, personnel convenience (break rooms), and maintenance areas. Finally, the goals of warehouse and storage operations are to maximize the utilizations of space, equipment, and labor as well as maximizing the accessibility and protection of all materials and employees. [Tompkins 1996] With a potential change in warehouse location and size, the new warehouse location has to be designed to optimize performance for day to day and weekly operations. With an added dock and more floor space, the warehouse will be able to hold more inventories as well as take deliveries at the same time. Also, all processes within the warehouse operations to supply the dining venues will be more efficient.

In the process of receiving and shipping for warehouses, storage is an important activity for inventory.

> "Temporary storage or delay indicates a delay in the sequence of events: for example, work waiting between consecutive operators, or any object laid aside temporary without record until required. Permanent storage indicates storage in which material is received into or issued from a store under some form of authorization, or an item is retained purposes." [Kanawaty 1992]

Flow process charts are often used to provide detailed accounts of sequences or processes dealing with workers, materials, and equipment. They are useful in obtaining information such as times and distances traveled of a certain task or an overall process. Another useful tool in observing and studying processes is a flow diagram, which is often used to present a visual of a process over an entire layout. From this, you could see how much travel is needed for employees to create a process as well as developing solutions of a better layout for the process. According to Kanawaty, a

> "time study is a work measurement technique for recording the times of performing a certain specific job or its elements carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for an operator to carry it out at a defined rate of performance." [Kanawaty 1992]

Time studies can be used for just about any process for a warehouse operation. In order to proceed with a time study, defining the process is vital. After the process is defined and studied and consent of the employee or employees is given, a time study can be completed. From the results, solutions to increase efficiency and worker or machine utilization can be completed. For the building 19 warehouse, the flow process charts were used, when evaluating the daily operations needed to run the warehouse effectively. After defining the processes, time studies were taken of the employees receiving, storing, picking, loading, and delivering the goods and were able to identify how efficient the current process is. In these time studies, obstacles such as walking over and pulling a ladder to the needed location, which will add time for that activity, were identified.

Many processes can be recreated on a simulation model to be further examined and studied. "A simulation is the imitation of a dynamic system using a computer model in order to evaluate and improve system performance." [Harrell 2004] Using the simulation computer software ProModel allows the user to watch an artificial simulation with real numbers used and allows the user to come up with valid design decisions. In using the software, you cannot just jump right in and start entering data. You need to study the system and define it. You need to determine if the system deals with static or dynamic, stochastic or deterministic, and discrete or continuous simulations. According to Harrell, the simulation procedure consists of, "Step 1:

Define objective, scope, and requirements; Step 2: Collect and analyze system data; Step 3: Build the model; Step 4: Validate the model; Step 5: Conduct experiments; Step 6: Present the results." [Harrell 2004] After the simulation model is created, the program submits output data such as utilizations and time for products to enter and leave the system. This numerical data allows the user to make decisions on the design of the system to meet their goals. For this project, the simulation models will be very valuable as the ProModel program will develop overall process times for building 19 as well as times for building 82. The building 82 model will be built by using the same activities and processes, but with a larger space for inventory, which means easier processes for the employees. Also, the data from the ProModel will help draw conclusions for the project and will either justify or not justify the move to building 82.

Once results are developed from the ProModel software, they have to be compared somehow. "Both mean and standard deviation output can be compared between the samples to determine if a difference is large enough to be statistically significant." [Breyfogle III 1992] In order to run the comparison tests between the two samples like Breyfogle states, a null hypothesis and an alternative hypothesis must be created. These hypotheses state what is being compared and the null hypothesis will be if they are equal with the alternative hypothesis stating that the samples are not equal, one is greater than, or one is less than the other sample. A proper sample size must be used as well to improve the results of the comparison. For this project, ProModel allows the user to choose how long the process will be run (i.e.: 5 hours or 20 days). By doing this, a larger sample size should be obtained, which would increase the value of the results of the comparison test of overall time between building 19 and building 82.

A very important idea of Industrial Engineering is safety and designing a process for the user. This idea applies to the employees in a warehouse as well. The goal of human factors is to increase performance, safety, and user satisfaction. In warehouses, items and areas have to have displays for users and employees to identify rather easily. This includes using contrasting colors, a large sized font, and at a level that is easy for the user to read. Anthropometrics play a big part in a design of a process as well. According to Wickens, "Anthropometric data are used to develop design guidelines for heights, clearances, grips, and reaches of workplaces and equipments for the purpose of accommodating the body dimensions of the potential workforce." [Wickens 2004] By designing a process for the user correctly, the safety of the user is increased and minor and major injuries can be avoided. Also, the biomechanics of the user is just as important as the design. The user and employee needs to be taught the proper techniques in handling materials, equipment, and machines so that they do not obtain any unnecessary injuries. With limited space in building 19, safety for the employees is of the upmost importance. By climbing ladders and walking through crowded aisles as well as walking on slippery floors in the cooler and cooker, the severity of injury increases. For this reason, the processes have to be designed and adjusted very carefully in order to promote a safe work environment in building 19 and potentially in building 82. However, human factors was not part of the scope of the project.

In the design of operations for the receiving, storing, picking, and shipping of inventory, several practices can save the company both time and money while increasing the efficiency of each process. For the receiving and shipping processes, there are a few practices that may improve the efficiency of the activities involved. The idea of putting away items immediately

after receipt can clear the staging area as well as enable the company to start picking orders as soon as the items are placed in their identified storage areas. Another practice of combining the shipping and receiving functions in one area can maximize dock usage, save space, and enable cross-docking. Smaller volume orders must be used in order to incorporate this method. Obtaining advance shipping notices for inbound deliveries may enable the use of scheduling of dock usage as well as know what the content is and the quantity of content being received. For the storage of inventory process, there are a few practices that will improve the performance of the organization. The practice of cross-docking, which is immediately sending the received inventory to the shipping dock for immediate departure to its final destination, may eliminate receiving and storing activities altogether for some inventory items. Assigning unique location codes to all inventory storage locations would make it easier for employees to locate items for storing and picking. Having a universal code for different aisles and then another code for specific racks will allow employees to easily find the locations of inventory immediately regardless of experience. Allocating specific warehouse space for specific customers would allow employees to store and pick orders rather quickly for specific customers. For the picking process, there are also practices that will improve performance for the organization. Grouping single-line orders and picking in order by location would increase the efficiency of the picking process and would decrease the amount of movement and time required. Implementing forward picking may decrease the amount of time needed to pick in crowded and smaller warehouses because it limits the number of employees required to pick. However, it requires more space because the inventory is separated by delivery order in another area after it forward packed. [Bragg 2004] Many of these practices could be

implemented for both warehouse locations in buildings 19 and 82. With the limited amount of space in building 19, clearing the staging area, the use of cross-docking, assigning location codes, and grouping single-line orders for picking would be useful practices to implement as it would decrease overall times as well as properly utilize the limited space and capacity of inventory. Since there is more space in building 82, more of the practices mentioned above would be able to be implemented in order to increase dock utilization and increase the efficiency of the receiving, storing, picking, and shipping operations for inventory.

The use of a refrigerated storage area and larger freezer are a must for food warehouses. The desire for a door to eliminate ice buildup while being energy efficient and limits the refrigeration loss is there. With the creation and design of refrigerators and freezers, the door is one of the most important components because the wrong selection can increase operational costs as well as decrease efficiency. The AirSeal Air Door is an automated door that can be opened hundreds of times per day and still eliminate the ice and frost buildup on the bottom of the door. Also the door adjusts to the temperature and humidity changes in the environment in order to conserve energy. [Frozen Food Age 2005] With the potential move to building 82, the design of a cooler and freezer is essential. The operating costs of the door used have to be considered. The design may incorporate a sliding manual door large enough for forklifts, but is susceptible to ice and frost at the bottom as well as increasing energy costs. The other option is an automated door like the one mentioned in the article above. It may cost more up front, but may improve the energy efficiency as well as keeping ice and frost off the door.

Although many warehouses face capacity and space constraints, there are ways to improve the existing operations to maximize the usage in those warehouses. The most popular design of warehouse aisles is having rows upon rows of parallel storage racks with a few perpendicular racks involved. This design is straightforward and easy to configure as well as set up in a warehouse. However, in warehouses that have limited space and quite a bit of inventory, an alternative method for storing excess inventory is needed. According to the article "New Article Warehouse Designs", two Industrial Engineering professors from different universities have created two different designs that would reduce the average warehouse travel distance. In both designs they incorporated a "V" layout, meaning that the aisles will no longer be parallel, but have a vertex with one of the aisles being slightly angled. One of the designs is a little more complicated with one aisle connected at the other horizontally, but angled a bit, which creates a "fish-bone" look. The first design reduces the average travel distance by eight percent and the second design reduces the average travel distance by up to 20 percent. [Industrial Engineer 2009] These designs would be great to use if they can reduce the average travel distance, which would increase efficiency. However, with building 19, it would be rather complicated to implement this design since much of the space does not utilize racks. Also, with the limited space, and already "tight" aisles for carts and ladders to fit through, the design may be too complicated to configure. More research would have to be done on this warehouse layout to conclude if this is the best way to design warehouse aisles for a small warehouse with a large volume of inventory.

In the article "Better Warehouse Inventory Management: Storage Systems Provide Solutions for Handling a Proliferation of SKUs", the beverage industries are increasing their

number of products, which in turn increases the amount of SKUs, about 600 to 700, they are carrying in stock in their warehouses. To meet the increased amount of SKUs, the beverage companies have adapted their warehousing storage and picking systems. They have begun to use automated voice recognition systems, which enables the user to tell the system which inventory needs to be stored and picked, and the robotics will take care of the rest. Also, some of the beverage companies no longer use forklifts as they have one or two cranes stationed on each aisle which pick up the contents and store them on the racks. Other companies use conveyer belts to efficiently move pallets across the warehouse. [Beverage Industry 2008] The Cal Poly Foodservice Warehouse also possesses hundreds of SKUs as they send out many different products to the campus dining locations. They too face the limited space and capacity that the beverage companies are facing, but do not possess the financial and technological resources to implement some of the automated machinery that the beverage companies own and use. The aisles in building 19 do not have enough space to incorporate a crane in each aisle or if at all since the ceiling height is not very high either. Also, with such a small warehouse, a conveyer belt would not improve the efficiency. An automated voice recognition system would make the warehouse technologically advanced, but would be very costly and is not realistic with robotics.

Worker safety is of the upmost importance in any warehouse in any industry. OSHA, the Occupational Safety and Health Administration, has introduced a four step ergonomics initiative which helps warehouse increase the safety. The four steps are identify existing and potential problems, train and educate correctly, establish an effective injury-response program, and earn continuing support for compliance. On top of this program, OSHA is trying to communicate

with warehouse managers more effectively to build a partnership, which will increase the safety of warehouses. [Logistics Management 2005] Regardless of which building Campus Dining moves the warehouse to, safety has to continue to have its major importance in the operations. The four steps are a solid guideline in building a safe environment and it is up to the warehouse managers and Campus Dining to enforce safety measures. The activities performed to ensure daily performance is being met must be designed to be ergonomically safe for the warehouse workers. However, OSHA requirements are not part of the scope of the project.

In Operations Research, inventory theory is one of the key topics taught. In the class and book, the formulation of a mathematical model describing the behavior of inventory systems as well as finding of an optimal inventory policy is taught. The setup cost, unit production cost, holding cost, ordering cost, and shortage cost are all taken into consideration within the formulation model. From these costs and demand rate, an optimal reordering schedule with lead times can be calculated. [Hillier 2005] Although Operations Research is a great tool in finding optimal solutions in inventory theory, it is not useful in this project. I did not reorganize Campus Dining's methods in inventory control.

Linear regression is often used when there are two variables, the dependent variable and the independent variable. A relationship needs to be found between the two variables and the first step is assuming that the dependent variable is linearly related to the independent variable. A line of means is created which describes the average value of the dependent value for a given independent value. The principal of least squares is used to minimize the distances of the points to the fitted line. The best-fitted line can have the slope and intercepts calculated

from it and then used in statistical calculations. [Mendenhall 2006] The use of the linear regression model was useful for this project as there was variability in the amount of items and the times needed to store or pick those items. The independent variable in this case was the number of items being received, stored, picked, or shipped. The dependent variable was the amount of time needed to complete those processes. After using the linear regression model, I was able to limit the variability of the data and can run the necessary statistical analysis needed to complete the project.

More often than not, decisions must be made with certainty and risk in the picture. Risk could be defined as when there are two or more observable values for a parameter and there is a possibility to estimate the chance of each happening. Uncertainty is when there are two or more values is observable, but the chances of them happening cannot be estimated. However, despite these two variables, decisions must be made. For decision making under risk, you could try expected value analysis or simulation analysis to help make the decision easier as some favorable results may come out from them. For decision making under uncertainty, you can make the assumption that the chance that both values are equal, which would reduce this to decision making under risk. [Blank 2005] Decision making under risk and uncertainty applies to this senior project because although a statistical analysis was completed, there was still doubt if the location chosen was the ideal choice.

Design

In this section, the problem definition, project scope, as well as the overall process in developing an answer to the problem is elaborated on. Also, a description of the tools used in the project is included. Deming's procedure of plan, do, study, act was used throughout the project with planning being the design and observing stage; do being the simulation model, and the statistical and economic analysis; study being the analyzing of the output from the statistical and financial information; act being the final recommendation for Campus Dining.

Definition of Problem and Scope

To approach this problem, a problem definition and the possible solutions was developed. The problem was defined as the Cal Poly Corporation cannot maintain efficient operations with the limited space in the building 19 warehouse while facing the increase in students and dining venues in the future. After establishing the problem definition, the project scope was defined as justifying moving the main warehouse to building 82 or keeping the warehouse in its current location in building 19. The scope does not include the actual redesign for building 19 or 82.

Customer Requirements

In the design of the project, the customer requirements placed on the project were considered. These requirements included taking into consideration the reduction of vehicles on campus, the location of the warehouses on campus in regards to deliveries, and the $250,000 proposal for the move to the warehouse in building 82. These requirements showed that the campus is trying to decrease the amount of deliveries for Campus Dining and that the Cal Poly Corporation is only willing to spend a certain amount for the move. These requirements were

incorporated into the simulation model as well as the economic analysis. A map of where each building's location on campus can be seen in Appendix A.

Warehouse Processes

Since the problem dealt with efficiencies, costs, and having to choose one solution over another, the key tools used to analyze were a simulation model, an economic justification by using the net present value, and a statistical analysis of the output from the simulation model. Before going to take time studies right away, the process of building 19 was defined. The identified steps in building 19 were receiving, storing, picking, loading, and shipping.

In receiving, the outside vendors entered the system at the intersection of California Blvd. and Foothill Blvd. The reason for this is that there is an overhead pass on Highland Drive, which limits trucks from traveling on it because it is too low. For this reason, campus deliveries start at the intersection mentioned above. The campus deliveries then enter campus at Campus Way off of California Blvd. and proceed to Cuesta Ave. and make a right on S. Perimeter Road. The University is trying to limit the amount of vehicle traffic on campus, so there are detouring bumps at the entrance of S. Perimeter Road, which gives smaller vehicles difficulty in entering the road. The vendors face pedestrian and bike traffic on S. Perimeter Road until they make a left into the parking lot for building 19. There they wait until a dock space clears up, unless they have a smaller load, which they then use the hydraulic lift. They drop off their contents in the staging area, where one of the three full-time employees verifies the delivery contents and inputs that into the inventory system, Eatec. The vendor then exits the system.

Since the staging area is quite small, the warehouse tries to institute the principal of cross docking as much as they can. However, since both docks are often used at the same time by outside vendors, the cross docking philosophy takes up quite a bit of space as pallets stay in staging until they are shipped off to their final destinations. The orders that aren't destined for cross docking are broken up by student employees and taken into the storage areas from staging.

The process of taking the inventory from the staging area to the storage areas is known as storing. The student employees divide the contents from staging by its storage areas which are dry storage, cooler, and freezer. They use pallet jacks and hand trucks to transport the inventory to the three storage areas. The dry storage area has barcodes placed where the inventory is supposed to be stored. The cooler is quite small and is pretty disorganized so wherever there is open space is where the inventory is stored. Access to the shelves is blocked by pallets and cartons laying on the floor, which leads to the tedious task of moving items to reach the shelves and then moving the items back into their place. There are two freezers used in building 19, the front freezer and back freezer. Both freezers are impacted by limited space requirements and often times items need to be moved to store the incoming inventory.

The next process identified is the picking. The dining venues on campus call in there order to the building 19 warehouse and tell them the ingredients and materials they need. This creates an order requisition which is used by the student employees to pick the orders. The student employee then grabs a cart or pallet jack to store the items on while picking. Since the dry storage area's space is quite limited, the carts and pallet jacks have a very difficult time making their way through the aisles, so often times they are left in the front of the dry storage

area while the student employee walked back and forth carrying a few products at a time, which is very inefficient. The student employees try picking the heaviest products first so they could build their pallet or cart correctly in order to decrease the chance of crushing any items. Also, by using this procedure, the pallet or wagon will be able to hold more items. The pickers start in the dry storage area, then move to the cooler and freezers to pick so the food will not spoil if the requisition is large. After picking, the order goes to staging for loading.

From loading, the order is delivered to the final destination, which is one of the twenty plus dining venues on campus. Venues close to the warehouse are often delivered to by golf carts with wagons attached to them. The venues upstairs from the warehouse are delivered to by carts and pallet jacks through the freight elevator in the warehouse. The two box trucks deliver pallets to multiple venues per trip when scheduled correctly. Once the order is delivered the vehicles and employees come back to the building 19 warehouse and the process starts over again.

Currently, the warehouse in building 82 is shared by El Corral Bookstore and Campus Dining. Campus Dining has access to 3.5 aisles with a freezer. The racks are currently stocked with old appliances and furniture, pallets of records, and one week's worth of inventory. There are no employees from Campus Dining stationed in building 82.

Documents Analyzed

To further analyze the process more, Campus Dining warehouse documents were analyzed. These documents included a day's worth of order requisitions, and the AutoCAD drawings of the layouts in buildings 19 and 82.

As shown in Figure 3, the day's worth of requisitions included 72 different requisitions, with a majority of the orders ordering more than two times a day. This shows that the dining venues are ordering when they run out of stock on an item and don't really have a standard operating procedure (SOP) to coordinate with the warehouse. This causes problems with the warehouse in building 19 trying to fill the order immediately with the student employees crossing paths and dropping other things they are working on. These requisitions also contained the number of items ordered, which is a good estimate of a typical day's number of requisitions and number of items ordered. These numbers are used instead of random numbers to develop a linear regression trend line because there is such a small sample size to begin with. Also, in order to have an accurate simulation model, using over 20 points is necessary in Stat:Fit in ProModel. This will be explained in greater detail later on. An example of an order requisition is shown in Appendix E.

Units: # of items

Date	Venue	# of Orders	Shortage
1/26/2010			
1	19 M Fields of Greens	3	0
2	19 M Grab N Go	2	1
3	19 M Grill	3	1
4	19 M Homeward Bou	2	1
5	19 M Pasta Stop	1	2
6	19 M Roundtrip Fare	1	0
7	Ave Yougurt/Salad Bar	2	0
8	Backstage Pizza	1	2
9	Bakeshop	2	2
10	Campus Market	1	0
11	Catering Production	1	0
12	Chick-Fil-a	1	0
13	Childerns Center	1	0
14	City Deli	1	0
15	Curbside Grill	2	0
16	Custodial	1	0
17	Dexters	1	0
18	Einstein's Bagels	1	0
19	Etcetera	4	4
20	Fusion Bowl	2	0
21	Julian's Jr.	1	0
22	Julian's Patisserie	1	2
23	Kitchen	4	3
24	Lucy's	1	2
25	Market Deli	2	1
26	Market Grill	6	1
27	Market Pizza	3	2
28	Salad Room	3	5
29	Sandwich Factory	5	7
30	Slyders	3	1
31	Starbucks	2	0
32	Tacos To Go	1	0
33	TapangoSpr	1	0
34	VG Café	5	6
35	Village Market Retail	1	0
	Total	72	43

Figure 3: Day's worth of order requisitions

The current layouts of buildings 19 and 82 from the AutoCAD drawings were obtained from Greg Yeo, Operations Manager of Campus Dining. From these the derivation of the size of

the warehouses was found and the Microsoft Visio was used to draw up the current operational layout in each building. These documents showed that the carts and loaded pallet jacks had a hard time fitting through the small aisle widths, which proved to be inefficient as employees had to walk back and forth carrying a couple items at a time. Also, from the Visio drawings, the difference between shelf space in buildings 19 and 82 was calculated. In Figures 4 and 5, you could see the difference between the layouts of the dry storage areas in buildings 19 and 82.

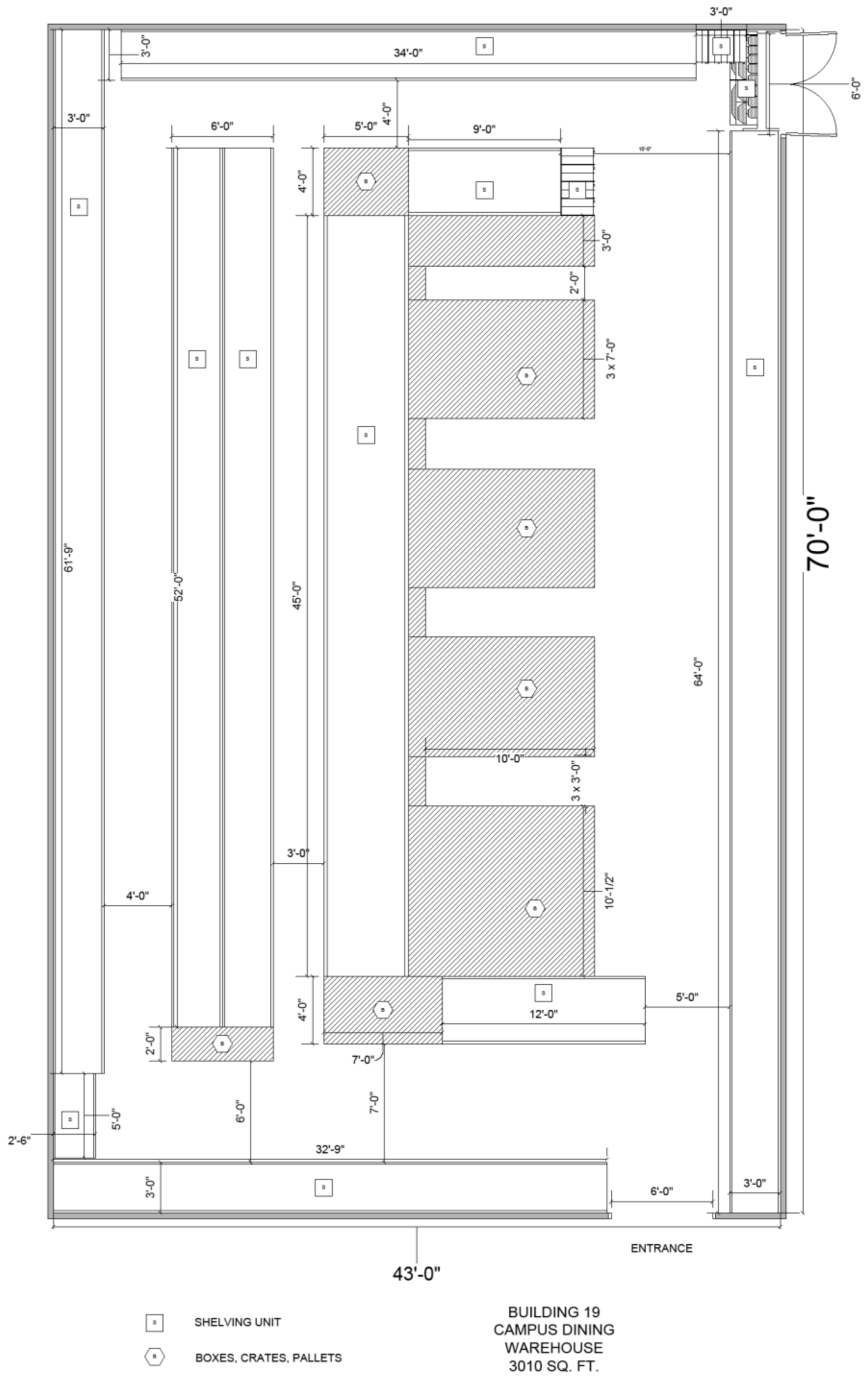


Figure 4: Current building 19 dry storage area

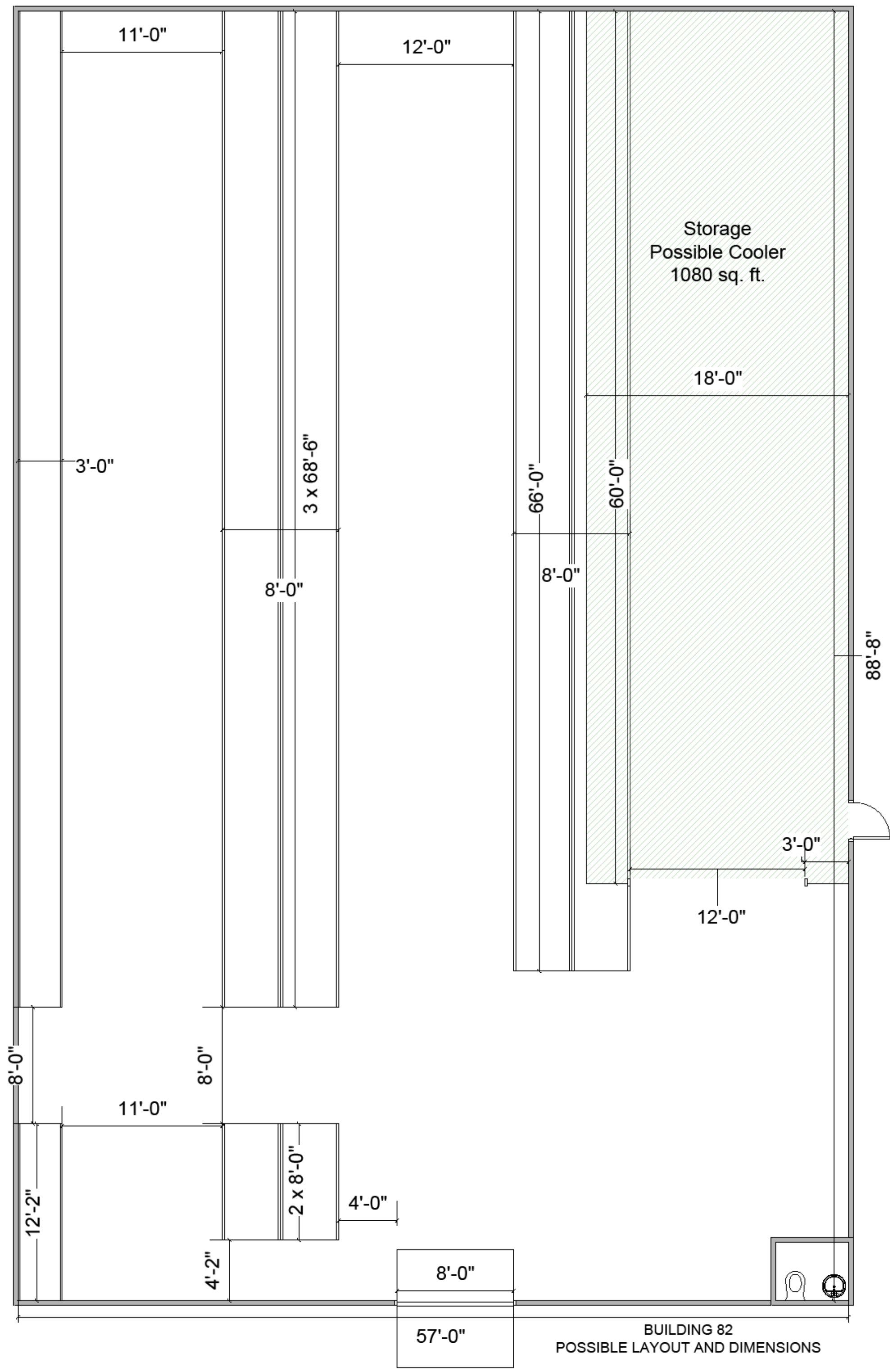


Figure 5: Building 82 layout

Time Studies

In order to test the efficiencies between the current operations in building 19 and the possible operations in building 82, I took time studies of the various operations that would take place at either warehouse. These time studies would be entered into Minitab to calculate a linear regression trend line. I took three time studies each from the receiving process, storing process, picking process, loading process, and delivery process, which gives me a small sample size for each of the processes. I also tried to take time studies dealing with different off campus vendors for receiving and different dining venues for picking and delivering. I simulated driving from the intersection of California Blvd. and Foothill Blvd to both buildings 19 and 82 at 20 mph and took the times from them. This simulated a off campus vendor delivering an order through pedestrian traffic to arrive at the destination. I took these time studies in different parts of the hour to obtain an accurate reading of how long it takes to reach buildings 19 and 82. An example of a flow process chart can be seen in Figure 6.

Flow Process Chart

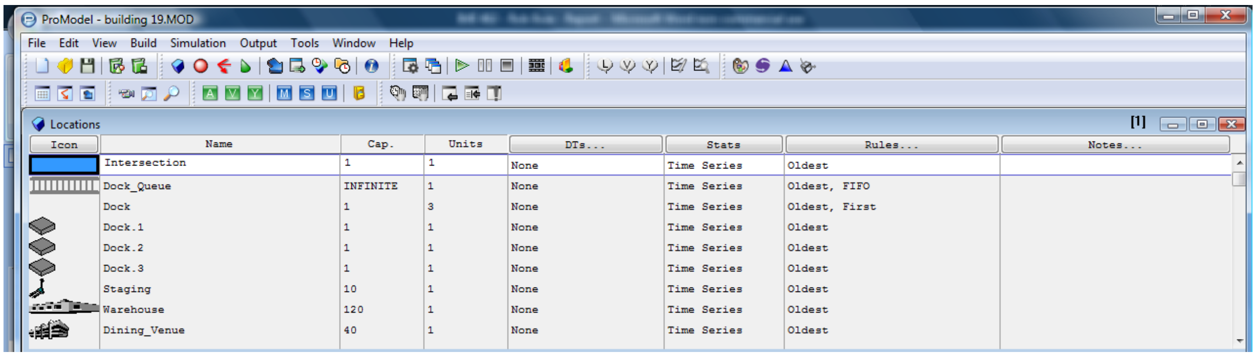
Location: **Building 19 Warehouse**	**Summary**			
Activity: Prodcuer's Dairy - Delivery	**Event**	**Present**	**Proposed**	**Savings**
Date: 1/8/10	Operations			
Operator: Analyst: Group 4	Transport			
Circle Appropriate Method and Type	Delay			
Method: Present Proposed	Inspection			
Type: Worker Material Machine	Storage			
Remarks:	Time (min)			
	Distance (ft)			
	Cost			

Event Description						Time (min)	Dist (ft)	Notes/Method Recommendation
Truck arrives to parking lot		●				0:00:13		
Truck waits for open dock/space			●			0:08:54		
Driver picks order in truck	●					0:02:13		10 cartons
Driver moves order to hydraulic lift		●				0:00:19		
Driver uses hydraulic lift		●				0:00:07		
Driver moves order to staging		●				0:00:08		
Driver waits for Rick			●			0:00:36		
Sam verifies order and signs				●		0:01:56		
Driver moves to truck		●				0:00:16		
Truck leaves	●					0:00:07		
Total =						0:14:49		10 cartons

Figure 6: Flow Process Chart for a Producer's Dairy delivery

Simulation Model

A simulation model was created for buildings 19 and 82 to compare the times and efficiency between the two layouts. Both layouts will have the same locations, arrivals, entities, and processing. An example of the locations can be seen in Figure 7.



Icon	Name	Cap.	Units	DTs...	Stats	Rules...	Notes...
	Intersection	1	1	None	Time Series	Oldest	
	Dock_Queue	INFINITE	1	None	Time Series	Oldest, FIFO	
	Dock	1	3	None	Time Series	Oldest, First	
	Dock.1	1	1	None	Time Series	Oldest	
	Dock.2	1	1	None	Time Series	Oldest	
	Dock.3	1	1	None	Time Series	Oldest	
	Staging	10	1	None	Time Series	Oldest	
	Warehouse	120	1	None	Time Series	Oldest	
	Dining_Venue	40	1	None	Time Series	Oldest	

Figure 7: The locations built in ProModel for both buildings

The data from the time studies and flow process charts was used to create a linear regression line. The order requisitions were used as well as a random number generator for plugging into the linear regression line to enter data into ProModel's Stat:Fit, which then created a statistical fit to plug into the simulation. The difference between the two buildings would be the times inputted into the linear regression line as building 82 would not have the inefficient process of walking back and forth without a cart as well as not having to use a ladder. An example of the vendor delivery regression equation and line can be seen in Figure 8. The regression line's equation for vendor deliveries was time = 10.2 + .315*number of items. An equation and regression line was created for each of the five processes. The data and results of the simulation model can be seen in the methodology section.

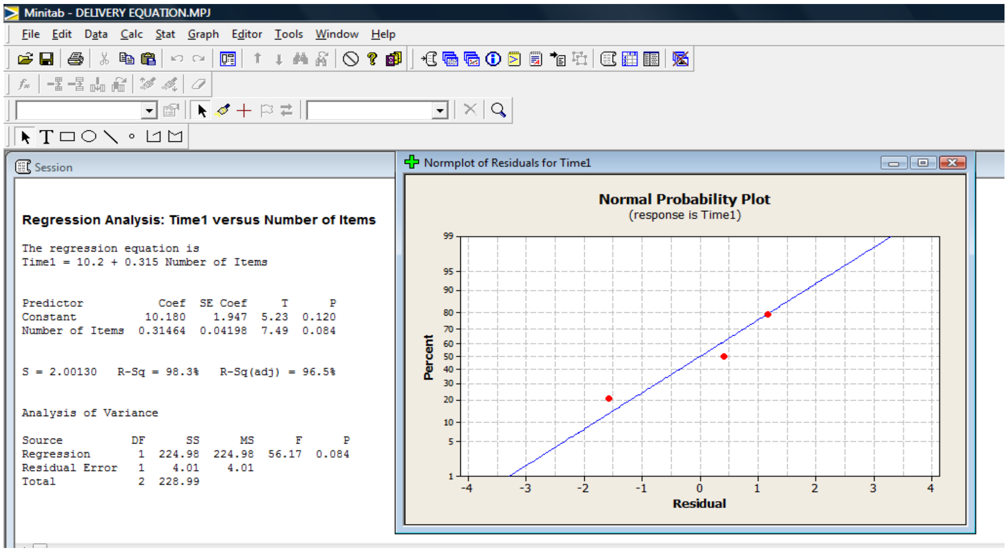


Figure 8: Regression line with equation for vendor deliveries

Statistical Analysis

After running the simulation for both buildings 19 and 82, the output results were compared them in Minitab. The total timer per entry by a pallet was used, which took into account the delivery time, storing time, picking time, and delivery time to the dining venue. These times reflected the efficiency of the process in each building. The data and calculations in the statistical analysis will be elaborate on in full in the methodology section.

Economic Analysis

In order to get an accurate reading on the plausibility of using building 82 as the warehouse or to stay in building 19 for the future, An economic comparison using the present worth of the planned costs was run. The initial cost of $250,000 for building 82 was given by Greg Yeo, which would include the installation of a 60' x 18' cooler, all of the electrical wiring needed, the installation of an office, and other miscellaneous items needed to run a warehouse out of building 82. Obtaining other financial information about the Cal Poly Corporation or Campus Dining other than the initial cost of building 82 was not possible. Logical assumptions

of yearly costs and improvement costs for building 19 were made because of the age and limited space properties. For yearly costs, each vendor delivery cost was $100 was assumed as well as that Campus Dining receives deliveries five days a week for 52 weeks a year. Rick, a full time warehouse employee explained that building 19 receives on average, 16 vendor deliveries a day. An assumption was made that the number of vendor deliveries would be cut in half if moved to building 82 because there is much more storage space. Also, for building 82, an assumption was made that the additional yearly costs should include the added electricity/logistics costs, which would be about $50,000 a year. An estimation that the life of building 82 was made to be about 25 years and the life of building 19 to be 5 years. Every 5 years, building 19 would need a $10000 investment to expand the life another 5 years. A minimum attractive rate of return of 10% was used because that is an average amount used in calculating the net present value. The result of the economic analysis is in the results section of the report.

Methodology

The two possible solutions were compared using a statistical analysis and an economic comparison. In order to obtain the data for the statistical analysis a simulation model using the program ProModel was completed.

Simulation Model

The simulation model was built to compare the efficiency between buildings 19 and 82 warehouses. The model used in this project can be seen in Figure 8. The model built in ProModel simulation software was used for the simulation of both warehouses. The reason for this was the fact that the warehouse would still have the same day to day operations, and the same processes of receiving, storing, picking, loading, and delivering to the dining venues. The starting point of the simulation was the intersection of California Blvd. and Foothill Blvd. because regardless of where the warehouse moves on campus, the vendor trucks must come in through that entrance as they cannot fit under the overpass on Highland, and traffic is restricted going through campus. The only thing that was different between the two warehouses in building the model was the capacity. The reason for this is that building 82 can hold more inventories and has a larger staging area, which gives it a larger capacity than building 19.

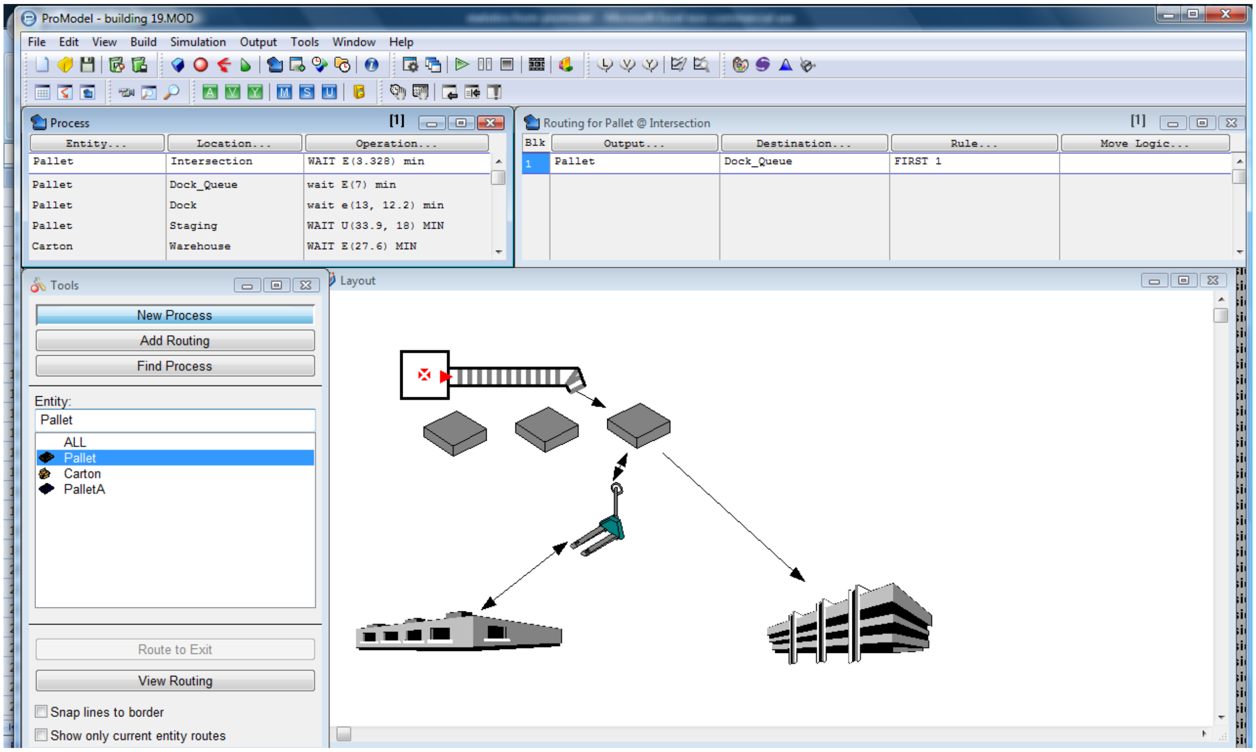


Figure 9: ProModel used for buildings 19 and 82

In running the simulation, times had to be inputted into the processing function in order to have an accurate simulation. These times came from the time studies taken from observing the building 19 warehouse operations. They were inputted into Microsoft Excel and then into Minitab, a statistical analysis software. A linear regression was used, which gave an equation of the regression line. The regression line was copied to Excel and random numbers were plugged into the equation. The random numbers were created by the random number generator in Excel and were between a certain two points, which logically relates to the number of orders and items used by Campus Dining. The data was then inputted into Stat:Fit, a program affiliated with ProModel, to develop a Goodness of Fit, also known as a distribution function that fits the data the most accurate. The Stat:Fit ranks the best distributions that fit the data given and this distribution was inputted into the processing for the simulation model.

The simulation model was run for 160 hours with 10 replications, which represents the approximate of hours a month for 10 months a year, and simulates the warehouse running for an entire school year. Both simulations created output data that included the average time per each process as well as the utilization of each location and the number of entrances and exits of the entities, which were the pallets. An example of the data can be seen in Figure 9. The data was exported into Excel and the average time in the system was calculate and transferred into Minitab to compare the results.

building 82.rdb - Output Viewer 3DR - [General Report (Normal Run - All Reps)]

File View Tools Window Help

Views: <undefined view>

General | Locations | Location States Multi | Location States Single | Failed Arrivals | Entity Activity | Entity States

building 82.MOD (Normal Run - All Reps)

Name	Replication	Scheduled Time (HR)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization
Intersection	1	160.00	1.00	160.00	3.21	0.05	1.00	1.00	5.36
Intersection	2	160.00	1.00	160.00	3.26	0.05	1.00	1.00	5.43
Intersection	3	160.00	1.00	160.00	3.22	0.05	1.00	1.00	5.36
Intersection	4	160.00	1.00	160.00	3.21	0.05	1.00	1.00	5.35
Intersection	5	160.00	1.00	160.00	3.23	0.05	1.00	1.00	5.38
Intersection	6	160.00	1.00	160.00	3.25	0.05	1.00	1.00	5.41
Intersection	7	160.00	1.00	160.00	3.25	0.05	1.00	1.00	5.42
Intersection	8	160.00	1.00	160.00	3.27	0.05	1.00	1.00	5.45
Intersection	9	160.00	1.00	160.00	3.18	0.05	1.00	1.00	5.30
Intersection	10	160.00	1.00	160.00	3.24	0.05	1.00	1.00	5.39
Dock Queue	1	160.00	999999.00	159.00	22.16	0.37	2.00	0.00	6.91
Dock Queue	2	160.00	999999.00	159.00	20.65	0.34	2.00	0.00	6.44
Dock Queue	3	160.00	999999.00	159.00	23.22	0.38	2.00	1.00	7.25
Dock Queue	4	160.00	999999.00	159.00	19.73	0.33	2.00	0.00	6.16
Dock Queue	5	160.00	999999.00	159.00	19.35	0.32	2.00	0.00	6.04
Dock Queue	6	160.00	999999.00	159.00	17.90	0.30	1.00	0.00	5.59
Dock Queue	7	160.00	999999.00	159.00	24.71	0.41	2.00	0.00	7.71
Dock Queue	8	160.00	999999.00	159.00	24.85	0.41	3.00	0.00	7.76
Dock Queue	9	160.00	999999.00	159.00	23.17	0.38	2.00	0.00	7.23
Dock Queue	10	160.00	999999.00	159.00	20.96	0.35	2.00	0.00	6.54
Dock.1	1	160.00	1.00	114.00	68.99	0.82	1.00	1.00	81.92
Dock.1	2	160.00	1.00	111.00	69.73	0.81	1.00	1.00	80.62
Dock.1	3	160.00	1.00	120.00	67.70	0.85	1.00	1.00	84.62
Dock.1	4	160.00	1.00	119.00	62.60	0.78	1.00	1.00	77.60
Dock.1	5	160.00	1.00	116.00	66.02	0.80	1.00	0.00	79.77
Dock.1	6	160.00	1.00	130.00	58.12	0.79	1.00	0.00	78.71
Dock.1	7	160.00	1.00	119.00	67.71	0.84	1.00	0.00	83.93
Dock.1	8	160.00	1.00	114.00	71.48	0.85	1.00	0.00	84.89
Dock.1	9	160.00	1.00	109.00	74.60	0.85	1.00	0.00	84.70
Dock.1	10	160.00	1.00	109.00	72.38	0.82	1.00	1.00	82.18
Dock.2	1	160.00	1.00	111.00	64.14	0.74	1.00	0.00	74.16
Dock.2	2	160.00	1.00	111.00	63.64	0.74	1.00	1.00	73.58
Dock.2	3	160.00	1.00	111.00	65.43	0.76	1.00	1.00	75.66

Ready | Database Loaded - c:\program files\promodel\output\building 82.rdb

Figure 10: Output from ProModel for building 82

Statistical Analysis

The sample size taken from ProModel was 10 because there were 10 replications conducted. The average time in system was compared because this shows how long the pallets were involved in the five processes mentioned above, receiving, storing, picking, loading, and

delivery to dining venues. The average time in system also describes how efficient each warehouse is in running the processes mentioned, which leads to the comparison of the efficiency between the buildings. The time the inventory is stored is not taken into account because that does not deal with efficiency.

The two samples were compared in a two-sample t test, which compares the difference between two means taking into account the standard deviation. The data from the 10 samples/replications can be seen in Figure 10. The reason the t-test is used is because there are only 10 samples, which is not enough to be concluded as being “Normal”, which means following the distribution from the Normal distribution. The t-test, which tests the null hypothesis, was also completed using 95% confidence and the output was the p-value. The null hypothesis of the comparison test was that there was no difference in the average time in system and efficiency between buildings 19 and 82. The alternative hypothesis was there is a difference in the average time in system and efficiency between the two buildings. The results from the two sample t-test are in the results section of the report.

Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	Bldg 19 Avg Time in System (MIN	Bldg. 82 Avg Time in System (MI			
1	105.625	155.559			
2	105.731	155.952			
3	117.698	157.589			
4	106.984	150.389			
5	118.414	153.327			
6	111.882	141.315			
7	103.651	158.149			
8	109.637	159.101			
9	128.899	159.227			
10	105.273	159.077			

Current Worksheet: Worksheet 1

Figure 11: Average Time in System of 10 replications from ProModel

Results

Statistical Analysis

After running the statistical analysis, the null hypothesis was rejected as there was a difference between the average time in system and efficiency between buildings 19 and 82. Building 19 had a mean average time in system of about 111 minutes while building 82 had a mean of almost 155 minutes. The standard deviations of both were 8 minutes and 5.5 minutes respectfully. The two-sample t-test had a p-value of 0.000, which means that with 95% confidence, there is a difference in the efficiencies between the buildings. Also given was the 95% confidence interval of the difference between the two buildings, which ended up being (-50 minutes, -37 minutes). This confidence interval shows that the building 19 warehouse is more efficient in terms of the five processes mentioned in the methodology sections. The results from Minitab can be seen in Figure 11.

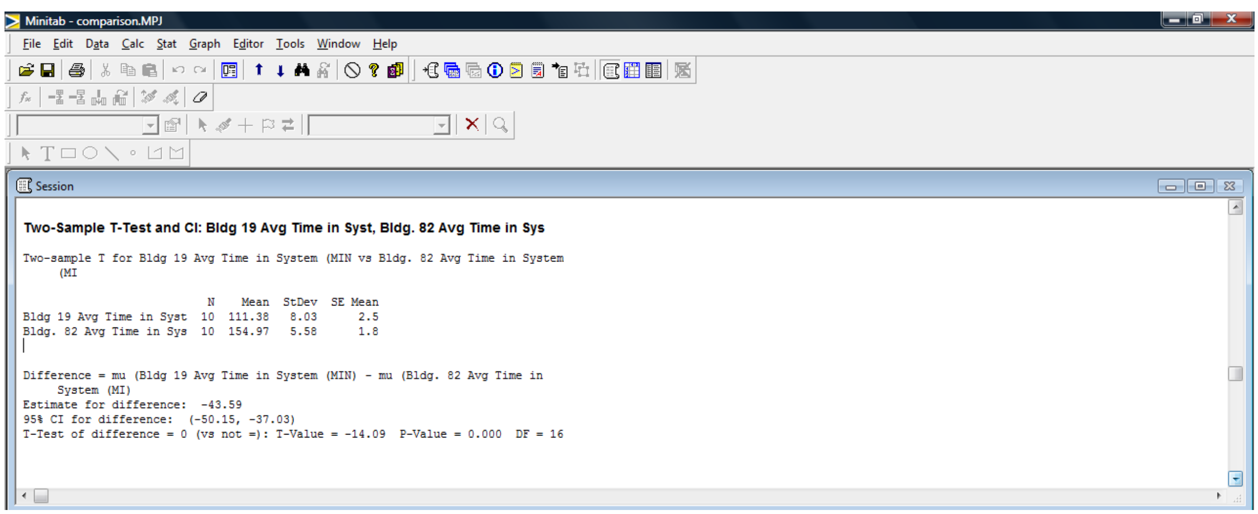


Figure 12: Two-Sample T-Test between buildings 19 and 82

Economic Analysis

The results from the economic comparison were in building 82's favor. With the initial costs and yearly costs of both buildings mentioned above in the design section, the net present value/present worth was calculated over a 25 year period of time. The present worth of building 19 is -$3,817,747 and the present worth of building 82 is -$2,591,876. The income for Campus Dining was not obtainable, so the present worth with the least negative value is the better financial option. Building 82 has a lower negative present worth over 25 years, which makes it a better financial option than building 82 over the long run. The reason for this is the lower yearly costs, due to fewer deliveries. The economic analysis run in Microsoft Excel can be seen in Appendix B. The economic analysis included the initial cost for building 82 with an annual cost of $258,000 which includes eight vendor deliveries a day for 52 weeks a year. The building 19 warehouse has an initial cost of $10,000 to upgrade the warehouse and to extend the life of it for another five years. Also, building 19 had an annual cost of $416,000 which was based on 16 deliveries a day for 52 weeks a year. The economic analysis does not take into account the payroll of the warehouse employees, fuel costs for driving on campus, or potential income.

Conclusion

In the final analysis, Campus Dining faces the challenge of meeting the increase in students and dining venues with the space constraints in building 19 for its warehouse operations. They have a $250,000 budget to work with and have the option of moving to the building 82 warehouse or staying at the current warehouse in building 19. Building 82 has more shelf space than building 19 and therefore can hold more inventories. However, building 82 is located on the outskirts of campus while building 19 is a centralized location.

A simulation model, statistical comparison, and economic analysis were completed in order to figure out the best warehouse location for the future of Campus Dining. Time simulation model used the data from a linear regression line calculated from the time studies taken from building 19. The data for building 82 was logically depicted from the data of building 19. The statistical comparison used the average time in system, which is another measure for the efficiency, and a two-sample t-test was taken from the 10 samples of each building. The two-sample t-test showed that the data was significant enough to show that the building's efficiency was not equal and that the building 19 warehouse is actually more efficient by more than 37 minutes. The p-value of 0.000 confirmed this result, which was a bit surprising at first, but made sense because although building 82 has more space to operate in, the employees have to handle more inventories because Campus Dining would like to use all of the extra space, which would lead to the longer average time in system. The economic analysis showed a different result with moving to building 82 being a better financial option. The net present value over a 25 year period resulted in building 82 having a present worth of -

$2,591,876 and building 19 having a present worth of -$3,817,747. This calculation only took the costs for each building into account as income information was not obtainable.

Although the t-test favored building 19, the recommendation is to move to building 82 because of the large increase in space to meet the continued growth in students and dining venues on campus. However, there must be other policies put into place to maximize the potential of building 82 such as updated standard operating procedures for ordering and picking as well as possibly instituting night picking in order to maximize efficiency. These topics could be further researched in other senior projects and would be a benefit to Campus Dining.

References:

http://www.valuebasedmanagement.net/methods_demingcycle.html

Chopra, Sunil. *Supply Chain Management*. 4th ed. Boston: Prentice Hall, 2010. Print.

Tompkins, James A. *Facilities planning*. New York: Wiley, 1996. Print.

Kanawaty, George. *Introduction to work study*. 4th ed. Geneva: International Labour Office, 1992. Print.

Harrell, Charles. *Simulation using Promodel*. 2nd ed. Boston: McGraw Hill, 2004. Print.

Breyfogle, Forrest W. *Statistical methods for testing, development, and manufacturing*. New York: Wiley, 1992. Print.

Wickens, Christopher D. *Introduction to human factors engineering*. Upper Saddle River, N.J: Pearson Prentice Hall, 2004. Print.

Bragg, Steven M. *Inventory Best Practices (Wiley Best Practices)*. New York: Wiley, 2004. Print.

"Opening the Right Door: Choosing a Door System for a Refrigerated Warehouse is No Easy Task." *Frozen Food Age*, 53.l 2005, v53 i9 (2005): 39.

"New Warehouse Aisle Designs." *Industrial Engineer: IE*, 41.3 (2009): 52.

Strzelecki, Molly. "Better Warehouse Inventory Management: Storage Systems Provide Solutions for Handling a Proliferation of SKUs." *Beverage Industry*, 99.2 (2008): 54.

Lacefield, Susan. "OSHA's New Approach to Warehousing: The Federal Agency is Choosing Collaboration over Confrontation when It Comes to Improving Warehouse Ergonomics." *Logistics Management (Highlands Ranch, Co.)*, 44.3 (2005): 57.

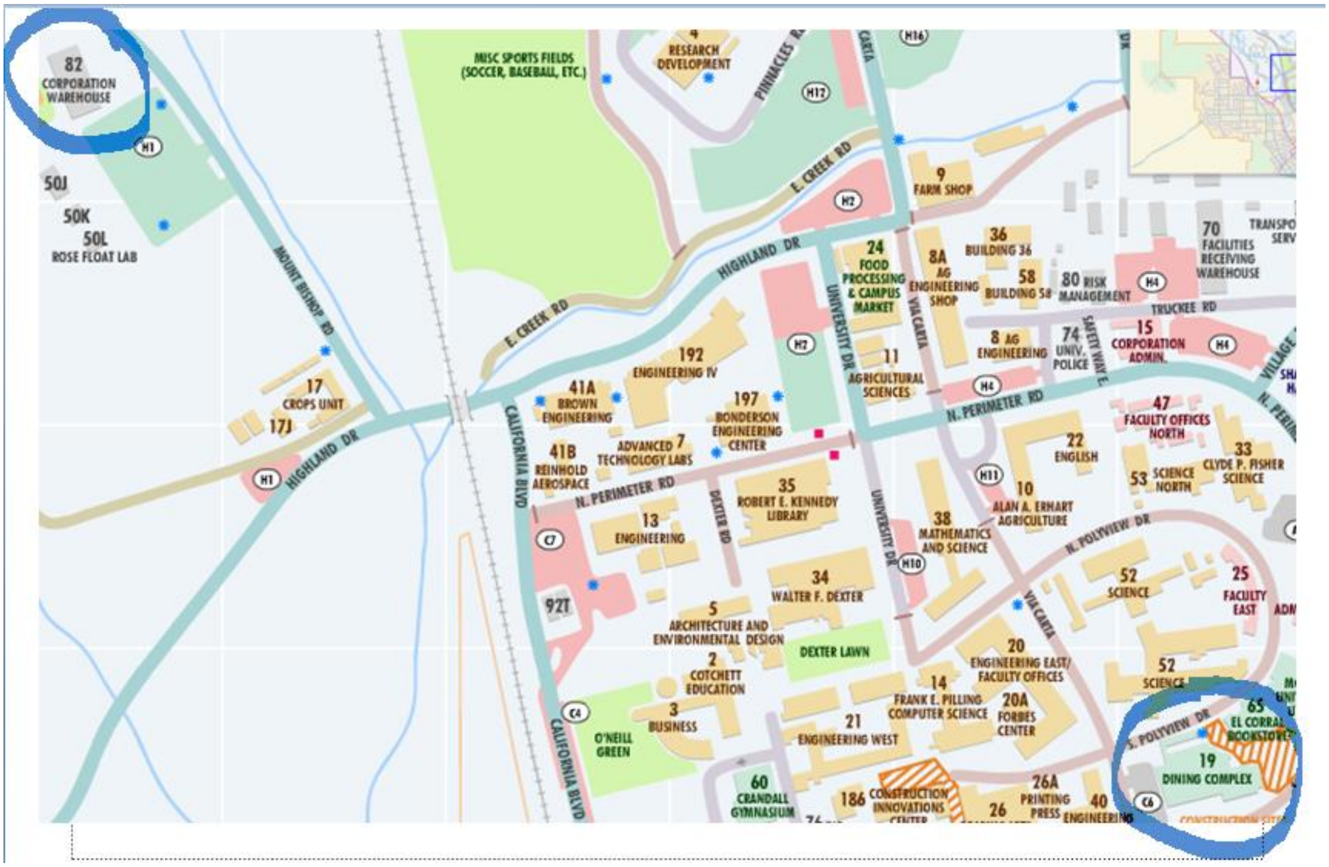
Hillier, Frederick S., and Gerald J. Lieberman. *Introduction to Operations Research and Revised CD-ROM 8*. New York: McGraw-Hill Science/Engineering/Math, 2005. Print.

Mendenhall, William. *Introduction to Probability and Statistics*. Australia. Duxbury, 2006. Print.

Blank, Leland T. *Engineering economy*. Boston: McGraw-Hill, 2005. Print.

Appendix

Appendix A: Map of Cal Poly with warehouse locations identified



Appendix B: Economic Analysis

Net Present Value for Buildings 19 and 82 over 25 years						
	Plan A: Move to Bldg. 82	Plan B: Stay in Bldg. 19				
Initial Cost ($)	-250000	10000				
Annual Operating Cost ($)	-258000	-416000		82: Assuming $100/delivery, deliveries cut in half, $		
Salvage Value ($)	20000	5000		19: Assuming $100/delivery, 16 deliveries a day, $10		
Life, Years	25	5				
MARR =	10%	10%				
NPV Comparison Over LCM = 25 Years						
	Plan A		Plan B			**NPV values over 25 years:**
Year	Investment	Annual CF	Investment	Annual CF		NPV of Plan A
25-yr NPV	$ (250,000)	$ (2,341,876)	$ (41,699)	$ (3,776,049)		$ (2,591,876)
						NPV of Plan B
0	$ (250,000)	$ -	$ (10,000)	$ -		$ (3,817,747)
1		$ (258,000)		$ (416,000)		
2		$ (258,000)		$ (416,000)		
3		$ (258,000)		$ (416,000)		
4		$ (258,000)		$ (416,000)		
5		$ (258,000)	$ (10,000)	$ (416,000)		
6		$ (258,000)		$ (416,000)		
7		$ (258,000)		$ (416,000)		
8		$ (258,000)		$ (416,000)		
9		$ (258,000)		$ (416,000)		
10		$ (258,000)	$ (10,000)	$ (416,000)		
11		$ (258,000)		$ (416,000)		
12		$ (258,000)		$ (416,000)		
13		$ (258,000)		$ (416,000)		
14		$ (258,000)		$ (416,000)		
15		$ (258,000)	$ (10,000)	$ (416,000)		
16		$ (258,000)		$ (416,000)		
17		$ (258,000)		$ (416,000)		
18		$ (258,000)		$ (416,000)		
19		$ (258,000)		$ (416,000)		
20		$ (258,000)	$ (10,000)	$ (416,000)		
21		$ (258,000)		$ (416,000)		
22		$ (258,000)		$ (416,000)		
23		$ (258,000)		$ (416,000)		
24		$ (258,000)		$ (416,000)		
25		$ (258,000)		$ (416,000)		

Appendix C: Pictures from building 19 warehouse

Appendix D: Examples of flow process charts form building 19

Flow Process Chart

Location: Building 19 Warehouse
Activity: Backstage - Picking
Date: 1/11/2010
Operator: Analyst: Group 4
Circle Appropriate Method and Type
Method: Present Proposed
Type: Worker Material Machine
Remarks:

Summary			
Event	Present	Proposed	Savings
Operations			
Transport			
Delay			
Inspection			
Storage			
Time (min)			
Distance (ft)			
Cost			

Event Description						Time (min)	Dist (ft)	Notes/Method Recommendation
Review order						00:23		
Grab pencil						00:07		
Move to warehouse						00:12		
Grab cart						00:55		
Move cart to soda area						00:43		
Walk to stacked sodas						00:11		
Back to cart						00:09		
Grab dolley and move						00:21		
Grab 1 box and put on dolley						00:21		1 box
Move dolley to cart						00:19		
Grab 1 box and put on cart						00:11		
Look at list						00:39		
Move to back of warehouse						00:14		
Instruct new employee						00:49		
Grab 2 Boxes						02:07		2 boxes
Travel back to cart in front						00:23		
Put 2 boxes into cart						00:17		
Look at list						00:34		
Instruct new employee						01:29		
Move dolley to right side of wh						00:18		
Grab 0 boxes						00:46		out of stock
Walk to back of wh						00:06		
Grab 1 box						00:07		1 box
Back to dolley						00:06		
Grab 1 box						00:31		1 box
Dolley back to cart						00:22		
Move 2 boxes into cart						00:13		
Look at list						01:52		
Move to left side of wh						00:20		
Grab ladder and bring around						03:02		ladder doesn't fit under aisle 2
Grab 1 box						00:21		1 box
Back to cart						00:25		
Look at list						00:15		
Instruct new employee						00:50		
Move to cooler						00:28		
Grab 1 Box						01:05		1 box
Move to freezer						00:06		
Grab 1 box						00:31		1 box
Back to cooler						00:20		
Back to freezer						00:12		
Move 4 carts out way						00:18		
Grab 1 box						00:01		1 box
Move 4 carts out way						00:07		
Back to cooler						00:10		
Back to cart						00:32		
Instruct new employee						00:56		
Put items into cart						00:16		
Look at list						00:09		
Move cart to hydraulic lift						00:41		
Instruction from chef						00:35		picking mistake
Bring back item to wh/grab 1 item						01:53		
Cart back to staging						00:20		
Grab new cart at dock						00:25		
Instruct new employee						00:55		
Cart to back freezer						01:11		
Move cart out of way						00:11		
Grab 5 boxes						00:48		5 boxes
Look at list						00:08		
Grab 10 boxes						02:19		10 boxes
Instruct new employee						00:22		
Rearrange cart						00:44		
Move cart to staging						00:57		
Instruct new employee						00:24		
Move to cooler						00:10		
Grab 7 boxes						03:09		7 boxes
Grab clipboard in cooler						00:18		
					Total =	40:39		31 boxes
						06:09	time that should be subtracted in 82	

Flow Process Chart

Location: Building 19 Warehouse		**Summary**			
Activity: Family Tree Produce Delivery		**Event**	**Present**	**Proposed**	**Savings**
Date: 1/8/10		Operations			
Operator:	Analyst: Group 4	Transport			
Circle Appropriate Method and Type		Delay			
Method: Present Proposed		Inspection			
Type: Worker Material Machine		Storage			
Remarks:		Time (min)			
		Distance (ft)			
		Cost			

Event Description						Time (min)	Dist (ft)	Notes/Method Recommendation
Truck arrives to parking lot	○	⇨	D	□	▽	0:00:10		
Truck sits idle waiting for open dock	○	⇨	D	□	▽	0:11:27		
Truck arrives at dock	○	⇨	D	□	▽	0:00:11		
Ramp down	○	⇨	D	□	▽	0:01:07		
Driver picks order in truck	○	⇨	D	□	▽	0:00:10		10 Cartons
Move product to staging	○	⇨	D	□	▽	0:00:20		10 Cartons
Looks through product in truck	○	⇨	D	□	▽	0:00:15		
Moves to staging	○	⇨	D	□	▽	0:00:05		
Driver grabs pallet jack	○	⇨	D	□	▽	0:01:03		
Driver moves back to truck	○	⇨	D	□	▽	0:00:13		
Rick starts forklift	○	⇨	D	□	▽	0:00:04		
Driver moves pallet to end of truck	○	⇨	D	□	▽	0:00:54		1 pallet
Rick drives forklift to end of truck	○	⇨	D	□	▽	0:00:19		
Rick transports pallet to staging	○	⇨	D	□	▽	0:00:29		1 pallet
Rick parks forklift	○	⇨	D	□	▽	0:00:16		
Rick moves to staging	○	⇨	D	□	▽	0:00:03		
Rick cuts saran wrap	○	⇨	D	□	▽	0:00:35		
Rick helps someone	○	⇨	D	□	▽	0:04:18		Instruction to another vendor about getting to Campus Market
Rick verifies order	○	⇨	D	□	▽	0:11:49		75 cartons
Rick signs driver's delivery	○	⇨	D	□	▽	0:00:02		
Driver walks to truck	○	⇨	D	□	▽	0:00:11		
Truck turned on and leaves	○	⇨	D	□	▽	0:00:18		
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
Total =						0:34:19		Total: 75 cartons

Flow Process Chart

Location:	Building 19 Warehouse
Activity:	Loading for Backstage
Date:	1/11/2010
Operator:	Analyst: Group 4
Circle Appropriate Method and Type	
Method:	Present Proposed
Type:	Worker Material Machine
Remarks:	

Summary

Event	Present	Proposed	Savings
Operations			
Transport			
Delay			
Inspection			
Storage			
Time (min)			
Distance (ft)			
Cost			

Event Description						Time (min)	Dist (ft)	Notes/Method Recommendation
Move cart to hydraulic lift						00:37		
Lift down						00:24		
Dolley to golf cart						00:22		
Rerrange golf cart						00:21		
Back golf cart to hydraulic lift						00:12		
Attach golf cart to picking cart						00:41		
Leave						00:10		
Total =						02:47		

Location:	Building 19 Warehouse					**Summary**			
Activity:	DPI West - Delivery					**Event**	**Present**	**Proposed**	**Savings**
Date:	1/11/2010					Operations			
Operator:			Analyst: Group 4			Transport			
Circle Appropriate Method and Type						Delay			
Method:	Present	Proposed				Inspection			
Type:	Worker	Material	Machine			Storage			
Remarks:						Time (min)			
						Distance (ft)			
						Cost			

Event Description						Time (min)	Dist (ft)	Notes/Method Recommendation
Truck arrives at dock	○	⇨	D	□	▽	0:01:02		
Driver moves to computer station	○	⇨	D	□	▽	0:01:22		
Driver asks Rick question	○	⇨	D	□	▽	0:04:18		
Driver moves to truck	○	⇨	D	□	▽	0:00:11		
Driver picks order in truck	○	⇨	D	□	▽	0:02:28		
Driver moves order to truck edge	○	⇨	D	□	▽	0:00:26		
Rick gets forklift	○	⇨	D	□	▽	0:00:41		
Rick drives forklift to truck	○	⇨	D	□	▽	0:00:07		
Rick picks up pallet	○	⇨	D	□	▽	0:00:14		
Rick moves pallet to staging	○	⇨	D	□	▽	0:00:12		
Rick parks forklift	○	⇨	D	□	▽	0:00:15		
Rick walks over to staging	○	⇨	D	□	▽	0:00:10		
Rick removes wrap from pallet	○	⇨	D	□	▽	0:00:13		
Rick verifies order	○	⇨	D	□	▽	0:01:03		27 boxes
Rick gets forklift	○	⇨	D	□	▽	0:00:22		
Rick moves pallet to truck	○	⇨	D	□	▽	0:01:21		Delivery to wrong place (C.M.)
Driver gets instruction from Rick	○	⇨	D	□	▽	0:01:45		
Driver moves to truck	○	⇨	D	□	▽	0:00:22		
Truck leaves dock	○	⇨	D	□	▽	0:00:38		
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
	○	⇨	D	□	▽			
Total =						0:17:10		27 boxes, driver error

Location:	Building 19 Warehouse		
Activity:	Storing - Milk		
Date:	1/8/2010		
Operator:		Analyst: Group 4	
Circle Appropriate Method and Type			
Method:	Present	Proposed	
Type:	Worker	Material	Machine
Remarks:			

Summary

Event	Present	Proposed	Savings
Operations			
Transport			
Delay			
Inspection			
Storage			
Time (min)			
Distance (ft)			
Cost			

Event Description	○	⇨	D	□	▽	Time (min)	Dist (ft)	Notes/Method Recommendation
Sam gets cart	○	⇨	D	□	▽	0:00:13		
Sam moves cart to staging	○	⇨	D	□	▽	0:00:18		
Sam packs 10 cartons on cart	○	⇨	D	□	▽	0:00:26		10 cartons
Sam verifies amount	○	⇨	D	□	▽	0:00:20		
Sam transports milk into cooler	○	⇨	D	□	▽	0:00:31		
Sam moves another cart	○	⇨	D	□	▽	0:00:17		Another cart in way
Sam moves cart into place	○	⇨	D	□	▽	0:00:47		
Sam leaves cart	○	⇨	D	□	▽	0:00:10		
					Total =	0:03:02		10 cartons of milk

Appendix E: Examples of order requisitions from the building 19 warehouse

156791

REQUISITION

REQUISITION NUMBER: 112311
Ref: Jason
Requisitioning Location: Slyders
Supply Location: Warehouse

Remarks:
Date Required: 1/26/2010

Bin Number	Ingredient Number / ID		Unit	Pack Sz	Req Qty	Qty Sent
F/Q4	601037	Buns/Hamburger/Plain/Mini/12dz/SLyder	CS	144.00 EA	1.00	1
FF3	38016	CornDogs/Chili-Cheese	CS	36.00 EA	3.00	3
FF3	38005	CornDogs/Jumbo/Turkey-spc	CS	72.00 EA	3.00	3
F/H1	57555	Fries/Tater/Gems	LB	1.00 LB	30.00	30
F/G1	575674	Fries/Micro-Brew/5-16	LB	1.00 LB	90.00	Ø
T1	51484	Salsa/El Pato/Jalapeno/Hot	CS	12.00 CN	4.00	Ø
60116.8	601168	Tortilla/Wrap/Flour-14"	DZ	12.00 EA	10.00	10

Signature

Day Goods

1/26/2010 BTCHRQCP90.rpt

REQUISITION

15678

REQUISITION NUMBER: 112302
Ref: saul
Requisitioning Location: Chick-Fil-A
Supply Location: Warehouse

Remark: TUES order
Date Required: 1/26/2010

Bin Number	Ingredient Number / ID		Unit	Pack Sz	Req Qty	Qt
F/I1	575676	CFA/Fries/Waffle/New/#51835	CS	30.00 LB	5.00	5
FL1	340060	CFA/Chicken/Fillet/Seasoned/#030002	CS	36.00 LB	2.00	2
FL1	340062	CFA/Chicken/Fillet/Tenderloin/#43459	CS	36.00 LB	1.00	1
FM1	340120	CFA/Chicken/Nugget/#030003	CS	36.00 LB	2.00	2
W1	591408	CFA/Coater #030007	CS	40.00 LB	1.00	1
X2	592125	CFA/Sauce/Chick-fil-a/#43545	CS	360.00 EA	1.00	1
X2	592121	CFA/Dip/BBQ/#030038	CS	360.00 EA	1.00	1
W3	791553	CFA/Cup/8oz/Squat/#32421	CS	500.00 EA	1.00	1
NN1	601036	Buns/Hamburger/White/4"/Earthgrains#1195	PK	12.00 EA	30.00	30
F/P5	601033	CFA/Buns/Golden/Wheat/#51210	CS	96.00 EA	1.00	1
W1	591462	CFA/Oil/Peanut/#030076	CTN	35.00 LB	1.00	2

Signature ____________

JB

1/25/2010 156723

REQUISITION

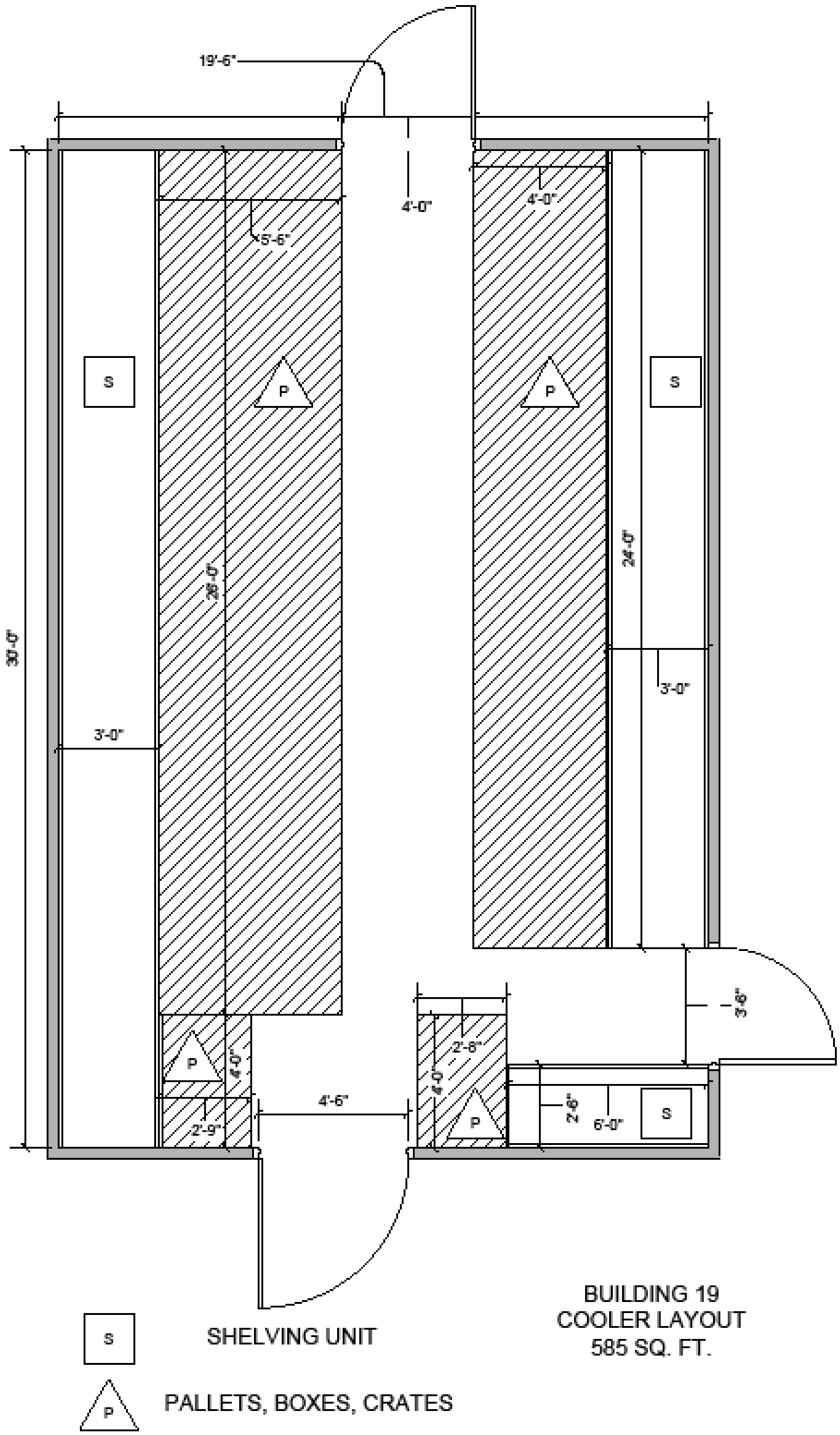
REQUISITION NUMBER: 112300
Ref: shannon
Requisitioning Location: Julian's Patisserie
Supply Location: Warehouse

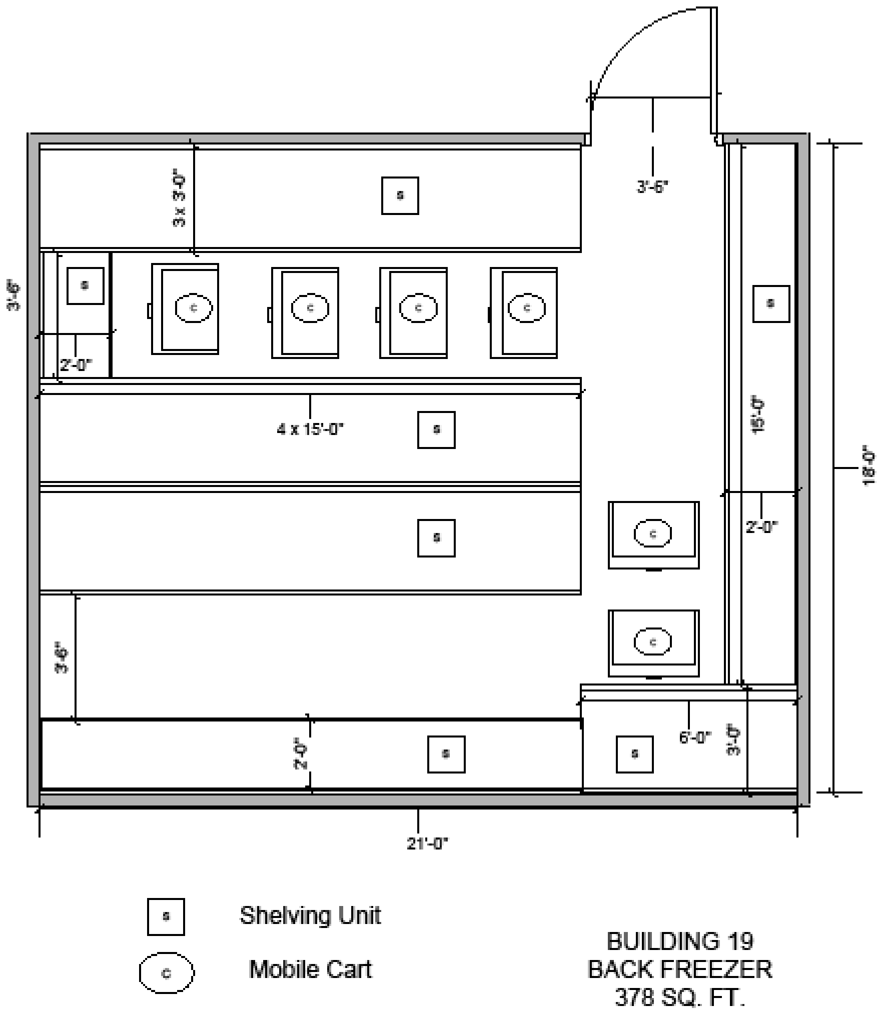
Remarks:
Date Required: 1/25/2010

Bin Number	Ingredient Number / ID		Unit	Pack Sz	Req Qty	Qty Sen
C/A1	40003	Milk/Whole-1/2Gallon/#114 C	EA	1.00 G/2	60.00	60
C/A1	40021	Milk/Nonfat 1/2Gallon/#244 C	EA	1.00 G/2	36.00	36
C/A1	410410	Half&Half/Qt/#335 C	QT	1.00 QT	24.00	24
CC1	531292	Chai/Tazo	CS	12.00 QT	1.00	1
TT1	530039	Juice/MinuteMaid/Orange/15.2oz(Coke)	CS	24.00 BT	1.00	1
TT1	530036	Juice/MinuteMaid/Apple/15.2oz(Coke)	CS	24.00 BT	1.00	1
SS1	530254	Water/20oz/Dasani(24-1/case)(Coke)	CS	24.00 EA	2.00	2
GG1	720871	Lid/International/White/Eco#64706	CS	1,000.00 EA	1.00	1
AA1	720872	Sleeve/Coffee/Geopack	CS	1,000.00 EA	1.00	1
A3	402201	Creamer/NonDairy/pc	CS	1,000.00 EA	1.00	Ø
B5	72021	Bags#25/Julian's/Logo	CS	2,000.00 EA	1.00	Ø

Signature [signature] 0

Appendix F: Building 19 cooler and freezer layouts





BUILDING 19
BACK FREEZER
378 SQ. FT.