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Redesign of Talley Farm's "Fresh Harvest" Produce Program

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REDESIGN OF TALLEY FARM'S "FRESH HARVEST"

PRODUCE PROGRAM

by

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Executive Summary

Fresh Harvest, a Central Coast Community Supported Agriculture (CSA) program run by Talley Farms located in Arroyo Grande, CA, has a rapidly growing customer base. They harvest, package, and deliver boxes of fresh quality produce to almost 3000 subscribers. However, Talley Farms' space for production and processing is limited and at times required for other aspects of business. This results in a problem where Talley Farms current processing system of produce for the Fresh Harvest program is not suitable for the forecasted growing demand. This report addresses the need to prepare for continued significant growth to the demand for Fresh Harvest produce boxes.

The objective of this project is to analyze and improve the procedures of the current Fresh Harvest processing system. By increasing the capacity of the system in place, Talley Farms can take full advantage of potential demand growth.

The systematic approach to methods engineering was the structure the team implemented in order to address the problem statement successfully. The steps included were defining the problem, collecting data and relevant information, data analysis, generating alternative solutions, analyzing the solutions, and selecting the best solution and providing recommendations. These steps help to not only offer suitable solutions, but also encourage multiple iterations of a solution to be created. This allows the solution to be improved, and therefore allows a solution to be better designed to address the problem statement.

To improve the production process, the team redesigned the current approach to packaging for short term benefits. Overall, it is projected that with these improvements, capacity of the current space has the potential to increase from about 2000 boxes per week to 3000 boxes per week. After evaluation of four facility alternatives, a comprehensive layout design is proposed with features including a prewashing area, two processing lines, with space which can be utilized for both pre-packing and packaging, an employee area for a desk, refrigerator, bathroom, and employee personal

belongings, an independent loading dock so pallets of finished boxes can be directly loaded for shipment, and a cooler designed for only Fresh Harvest produce storage. Along with this facility, Standard Operating Procedures for new proposed pre-packing and packaging set ups are included. These new process designs should not only boost productivity for the new facility, but should also help to increase the production capacity of the current area.

Lastly, an economic analysis and recommendation is included for both the short term approach to the program, and a long term approach to the program. Overall, the team proposes an implementation and investment in the facility design included in this report. With a facility implementation, the team estimates a capacity improvement from the current limitation of 2000 boxes per week (400 on average per day) to a capacity of 6000 boxes per week (1200 per day). If the subscriber total increases to 5000 boxes per week as the Fresh Harvest program suggests, the payback period on the total proposed facility investment of $210,000 would be paid off in approximately 0.55 years.

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Introduction

In the first class meeting for the Senior Project course, Karen Bangs, the senior project facilitator, described the process of selecting a Senior Project topic. During this class, she also mentioned local companies looking for analysis and that they could offer interesting topics as well. One of the interested companies, Talley Farms, had questions about a production aspect of a recently created program. The program, Fresh Harvest, focuses on delivering high quality local produce to customers along the Central Coast.

The purpose of this senior project was to develop a redesign of the Talley Farms "Fresh Harvest" produce program. The "Fresh Harvest" program offers boxes containing top-quality, local produce that they deliver to convenient pick up locations along the central coast. Fresh Harvest boxes contain 9-12 different fruits and vegetables. The current Fresh Harvest program supports a demand that is forecasted to grow within the next year. However, management wants to determine possible options and improvements to support a doubling of current demand.

In order to effectively design and propose good alternatives for this project, a strong general understanding of the Fresh Harvest operating procedure is crucial. Also, the "tribal knowledge" required to run a produced company is very important to many aspects of solution design.

The Systematic Approach to Methods Engineering is an effective way to finding the best solution for the redesign of the Talley Farms Fresh Harvest Program. The systematic approach to methods engineering is broken down into a series of six steps: define the problem and objectives, analyze the problem, formulate alternatives, evaluate alternatives and select the best option, implement the best method, and audit the study.

The intention of this project is for the team involved to learn sufficient information about produce, current packaging systems in place, and utilize industrial engineering concepts to generate and propose a set of solutions to address meeting future demand by the Fresh Harvest program.

Some of the main deliverables for the end of this project will include the following:

- Facility Layout
- Standard Operating Procedures
- Simulation of current packaging procedure
- Simulation of proposed packaging procedure
- Inventory and Production Planning schedule analysis using Operations Research
- Economic Analysis of possible options to address problem statement

To meet these objectives, an effective project schedule will be maintained to plan the completion of tasks effectively; weekly deliverables given to our Technical Advisor will ensure that our progress remains on track.

Throughout the progression of this project some analyses will not be included with our deliverables. Economic analysis with Return on Investment as well as detailed facility design costs will not be included. Also, shipping as well as the routing logic for the program will not be analyzed in detail. Regardless of suggestions made for this project; shipping as well as routing will need to be altered to account for the continuous growth of the program. For example, in the future one company Fresh Harvest truck will not be able to make the deliveries required with forecasted future demand

Background

Talley Farms is a mid-sized farm located in Arroyo Grande Valley on California's central coast. Oliver Talley founded the company in 1948 and has passed down the Talley family business generation after generation. Over three generations of Talley families have been growing, packing, and shipping high quality fruits and vegetables. Talley Farms is a part of the Community Supported Agriculture (CSA), which is way that allows consumers to support local, seasonal food that comes directly from the farmer. When community members come together to support local farmers they are not only supporting the farmer directly but also eliminating the need for a middle man, reducing packaging, supporting the local community, and receiving fresh, nutritious locally grown food. Talley Farms strives on a day-to-day basis to follow the company's vision for "Excellence in Everything."

A new program created by Talley Farms called Fresh Harvest was started in June of 2012 to sell locally grown produce to the local people. Customers of the Fresh Harvest program can register either receive their boxes weekly or bi-weekly, which are delivered to specified drop-off locations. These boxes cost $26 each, and no week has the same exact produce as another for the entire year.

Talley Farms supplies the produce for the boxes for two different ways:

- They grow 50% to 75% of each box on site, and harvest just enough to meet box order demand for the week.
- They purchase produce from local farmers, and include them in the box

In order to add value to some produce items in the box, they must be bagged to a certain weight. For example, English peas must be bagged to about one pound for each box sold to the customer. This process is described by Talley Farms as "Pre-Packing", the process of prepping certain produce so it is ready to be packaged into boxes for customers.

Once all produce is prepared for final packaging, the produce items are palletized and put into coolers. On the day orders are shipped, all pallets of produced are aligned and boxes are packaged and palletized for shipping. Talley Farms calls this process “Packaging”. This process is crucial, since it must be completed efficiently on the day of shipping. If not, orders will not be completed in time for getting to drop off areas.

Since Fresh Harvest has started, it has grown at an impressive rate. In order to take advantage opportunities for the growth of the program, Talley Farms must continue to find ways to keep the capacity of their Fresh Harvest program production large enough to meet demand requirements.

The implementation of this project is necessary due to the constraints and specifications unique to the Talley Farms Fresh Harvest program. Based on Randy, production manager, and Andrea Chavez, the program manager, previous experience with program that offer local produce boxes to customers, it is evident that this business model is difficult to profit from. Box variations, front door delivery, excessive inventory, and outsourcing a significant amount of produce boxed can lead to overly complex system designs and limited profit margins.

Ultimately, the project team is optimistic about the success of Talley Farms with the Fresh Harvest program. The extensive experience of Talley Farms as a commercial produce provider, the business experience of Randy and Andrea with this business model, and the unwavering commitment to a high quality product all contribute to the rapid growth of the Fresh Harvest program. With this foundation, demand for “Fresh Harvest boxes” will continue to rise, and capacity of the program must be improved.

Literature Review

Lean Six Sigma

Before implementing Lean Six Sigma into a company, it is important to know the importance and effectiveness of having a lean enterprise. Lean manufacturing sparked industries after the book publication of *The Toyota Production System.* The USA Motorola company started the Six Sigma approach about 30 years later. The integrated approaches of Lean and Six Sigma have been recognized as “a business strategy and methodology that increases process performance” (Nicoletti 2013). Lean Six Sigma (LSS) incorporates both approaches by combining Lean’s philosophy on reduction of cycle and lead times, as well as Six Sigma philosophy on reduction on the amount of defects and variation outputs.

Lean thinking focuses in the elimination of waste, unevenness, and overburdens (Nicoletti 2013). Determining what a value added activity is for the customer is the first step to eliminating waste in a process (Nicoletti 2013). Waste can be broken down into seven different types (Nicoletti 2013): overproduction, processing, defects, waiting, transportation, motion, and inventory. Some of the main benefits of incorporating lean thinking into a company are quality improvement, cost reduction, flexibility, supplies reduction, lead time reduction, customer satisfaction improvement, and productivity increase (Nicoletti 2013).

“LSS is regarded as a holistic improvement methodology addressing the flow of information and materials through processes as well as the enhancement of value-adding process-steps to create the product for the customer” (Timans 2012). The Lean Six Sigma and Digitize Methodology is broken down into several different macro-phases shown in the figure below.

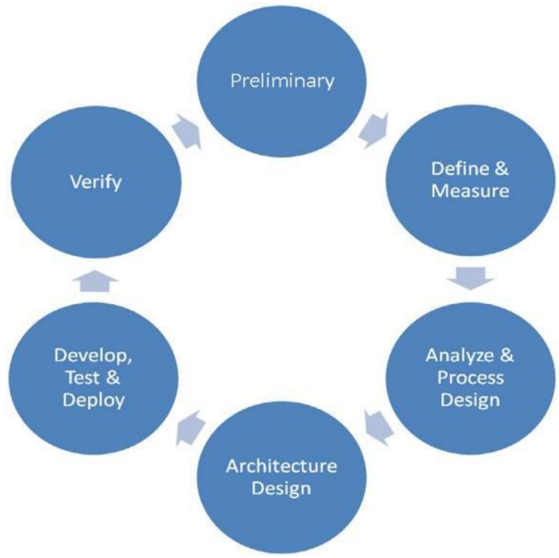


Figure 1: The Lean Six Sigma and Digitize Method (Nicoletti 2013)

The six step process stated by (Nicoletti 2013) is further explained below:

1. Prepare - Defining the context, vision, and strategy of the company.
2. Define and Measure - Understand what metric should be used to measure, monitor, and improve the process. Determine what information will be sufficient to validate the need and measure the potential benefits of the new process.
3. Analyze and Process Design - Discover wastes and non-quality that is in the current state process and redesign activities to eliminate waste.
4. Architecture Design -Analyze the functional and technical characteristics of each activity to create a continuous and connected flow between each activity leading all the way to the final customer.
5. Develop Test and Deploy - Considered the build phase that focuses on the execution on the pilot to see if it is beneficial and if the coming is on board with upcoming changes in their process.
6. Verify - Is an on-going act to verify the new process, and always looking to continuously improve, tweak, and expand on the implemented process. Having a clear understanding that the process must be continually monitored.

Although the Lean Six Sigma process can be applied in just about any industry, especially larger companies, for this project a closer look on implementing LSS in small- and medium-sized manufacturing enterprises (SMEs) would be beneficial. For a company to be classified as SME, the cut off on the total number of employees ranges from 200 to 300. For LSS to be successful in SMEs, "management involvement and participation, linking the program to customers and linking the business strategy are the highest ranked critical factors "(Timans 2012). Some of the main critical success factors (CSFs) for lean manufacturing within SMEs is leadership and management, financial capability skills, and expertise and organizational culture (Kundu 2012). In smaller companies there are various enablers and inhibitors when implementing LSS. Some of the enablers for SMEs are: active leadership, commitment to improve, and focusing on simple and practical improvements. On the other hand, some of the inhibitors to consider within SMEs are: resistance to change by employees when they have their own way of doing things, lack of professional training in LSS techniques, and generating actions that don't take into account the company's "culture." Management leadership in SMEs must believe that the new process will work, have a willingness to learn, cultural readiness, communicate the importance of lean to employees and patience in the long term view of the results. Along with management leadership in SMEs, organizational culture is another important success factor in implementing LSS. The organizational culture is what "defines the core beliefs, values, norms, and social customs that govern the way individuals act and behave in an organization" (Kundu 2012).

Facility Design Literature

Integrating facilities planning and ISO 14000

Before starting a facility design, taking action on environmental issues and understanding their impact on facilities planning will eliminate the chance of a crisis in the middle of the project. Looking at environmental self-audits, such as ISO 14000 series and the US Environmental Protection Agency (EPA), before diving deep into facilities planning can reduce the operating cost and increased profit (Deaver

1998). Deaver (1998) explains in the article how a planner had no knowledge that there was a leaking underground storage tank right where the expansion of the facility was going to take place. Not having prior knowledge of the problem before the planning caused the company a significant loss of money (Deaver 1998). Using an environmental audit can help adequately prepare and understand the significant environmental issues before starting to plan. Once an environmental audit has been performed, the next step is to evaluate the issues exposed by the audit and establish goals and objectives for the environmental plan. The ISO 14000 audit created a process to form an environmental management system (EMS), which is stated as follows:

1. Policy – Management has an environmental statement that is recognized throughout the company.
2. Planning – Creating a detailed plan to apply the policy.
3. Operation and Implementation- Ensure the planning objectives and the coordination of daily activities are being met.
4. Checking and corrective action- Document corrective actions and audit the activities to document the overall achievement of the plan.
5. Management review - Management reviews EMS on a regular basis.

It is very important to identify the environmental problems and one way to ensure that the EMS is established is by going through the plan-do-check-act (PDCA) cycle. Figure 2 below shows a continuous and repeatable cycle. By blending the EMS with the facility planning, it can reflect the overall project to be completed much faster, reduce compliance problems, and potential cost avoidances.

Figure 2: The continuous environmental improvement program.

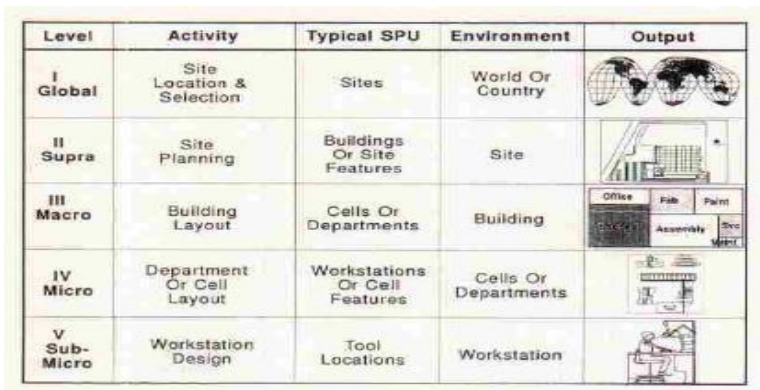
Framework for Facilities Design

To effectively design a facility for a company, one must undergo several steps to ensure success in the final product. Overall, facility design proceeds from the general to the particular – from global site location to workstation (Lee 1997). Space planning requires five levels. The descriptions of each level are listed below:

- Level 1: Global site location – The firm decides where to locate facilities and determines their missions. A facility mission statement is a concise summary of products, processes, and key manufacturing tasks.
- Level 2: Supra-space plan – Includes number, size, and location of buildings as well as infrastructure such as roads, water, gas, and rail. The plan should look ahead to plant expansions and eventual site saturation.
- Level 3: Macro-space plan - Most important level of planning. The designers define and locate operating departments and determine overall material flow.

- Level 4: Micro-space plan – The location of specific equipment and furniture is determined in the micro-space plan. The emphasis shifts form gross material flow to personal space and communication.
- Level 5: Sub-micro-space plan – Individual workstations and workers are the concern. The focus is design for efficiency, effectiveness, and safety.

Each level of space planning has a space planning unit (SPU) and environment associated with it (Lee 1997). These associations along with output are briefly described in Figure 3.



Level	Activity	Typical SPU	Environment	Output
I Global	Site Location & Selection	Sites	World Or Country	
II Supra	Site Planning	Buildings Or Site Features	Site	
III Macro	Building Layout	Cells Or Departments	Building	
IV Micro	Department Or Cell Layout	Workstations Or Cell Features	Cells Or Departments	
V Sub-Micro	Workstation Design	Tool Locations	Workstation	

Figure 3: Levels of Space Planning (Lee 1997)

Although the elements of facility space plans are simple; execution of the tasks required to develop them is not. Rarely do the tasks neatly correspond to the development as described above (Lee 1997). At each level of design, the approach changes to accommodate the amount of detail, available information, and the dominant issues.

The primary levels that apply to the facility design project for Talley Farms are level 3, 4, and 5. The stakeholders are mainly concerned in the material flow of the produce as it's packaged, the layout of the equipment and furniture, and finally ensuring the design of workstations that allows for efficiency, effectiveness, and safety. Some concepts of level 2 space planning such as designing layouts for future expansion should also apply for this facility design. Since forecasting demand can never be entirely accurate, stakeholders must plan a flexible layout that accounts for a greater than estimated demand.

Facilities Planning Textbook

The current production process at Talley Farms requires all raw materials to move efficiently, and standardization of this procedure could be a major improvement to their ability to package more effectively. According to the text “Facilities Planning”, there are ten main material handling principles to consider when designing a facility (Tompkins 2010):

1. Planning Principle
2. Standardization Principle
3. Work Principle
4. Ergonomic Principle
5. Unit Load Principle
6. Space Utilization
7. System Principle
8. Automation Principle
9. Environmental Principle
10. Life-Cycle Cost Principle

Of these ten principles, the Unit Load Principle will be a major component of standardizing Fresh Harvest’s packaging and pre-packing processes. The definition is included below (Tompkins 2010):

“A *number of items, or bulk material, so arranged and constrained that the mass can be picked up and moved as a single object too large for manual handling, and which upon being released will retain its initial arrangement for subsequent movement.”*

Because Talley Farms frequently is moving produce manually from one stage of processing to another, transportation unit load size as well as the frequency they move these loads are important to consider. By finding the ideal unit load size for easy transportation and maximum efficiency, the prepacking and packaging processes will improve.

Along with ideal item size, palletizing produce boxes and harvesting totes is a critical part of Fresh Harvest. With this in mind, effective stacking principles must be used for both safety of employees as well as for maintaining product quality. For example, effective stacking principles can keep boxes that are palletized from falling over, and also pack them with better density so they take less space in trucks when brought to customers. As seen in Figure 4, there are some stacking configurations from the text that could be considered. (Tompkins 2010)

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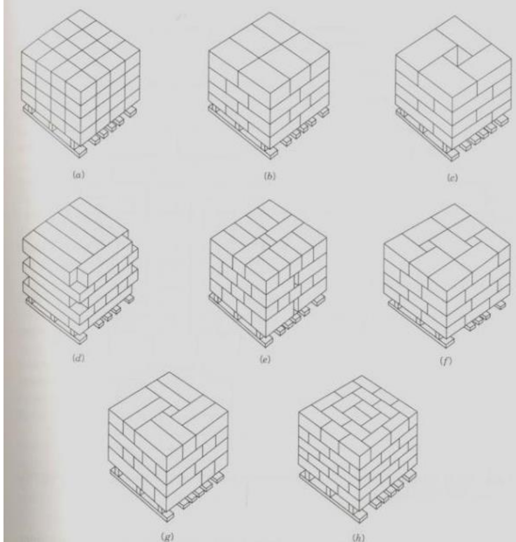

Figure 5.9 Stacking patterns for different pallet sizes. (*a*) Block pattern. (*b*) Row pattern. (*c*) Pinwheel pattern. (*d*) Honeycomb pattern. (*e*) Split-row pattern. (*f*) Split-pinwheel pattern. (*g*) Split-pinwheel pattern for narrow boxes. (*h*) Brick pattern. (From [7] with permission.)

material handling equipment and the physical configuration of the storage facility. Further, the utilization of both the warehouse and highway trailer (or intermodal shipping trailer) is affected. The focus on unit load design is therefore warranted.

The specific operations included in this example are the following:

- Finished goods are packaged using closed-top cardboard cartons.
- The cartons are transported to a palletizer via a belt conveyor.
- The pallet loads are formed using a mechanized palletizer.
- The full pallet loads are then stored in the finished-goods warehouse using a powered lift truck. This lift truck is used exclusively for warehouse operations

Figure 4: Pallet Configurations (Tompkins 2010)

Along with palletizing, Aisle size and orientation of the packaging facility must allow for employees, pallets, and the equipment to move those pallets to flow effectively. There are standards and guidelines for these aisle sizes in the text, and they are included below (Tompkins 2010). Overall, it is clear that many different components of the textbook “Facilities Planning” will be utilized for this project.

Recommended Aisle Widths for Various Types of Flow

Type of Flow	Aisle Width (feet)
Tractors	12
3-ton forklift	11
2-ton forklift	10
1-ton forklift	9
Narrow aisle truck	6
Manual platform truck	5
Personnel	3
Personnel with doors opening into the aisle from one side	6
Personnel with doors opening into the aisle from two sides	8

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Table 5.4 *Recommended Aisle Widths for Facility Design*

Equipment Type	Pick Aisle	Cross Aisle
Three-wheel counterbalance	9′–10′	10′
Four-wheel counterbalance	10′–12′	12′
Reach truck	8′–6′	10′
Double-deep reach	8′–6′	10′
Order picker truck	5′	10′
Turret truck	5′	12′
Swing-mast truck	5′–6′	12′
Side loader	6′	15′–20′
Fixed-mast truck	5′	20′
Counterbalance w/attachment	12′	14′–20′
Manual pallet jack	6′	8′–10′
Powered pallet jack	7′–8′	8′–10′

Figure 5: Recommended Aisle Widths (Tompkins 2010)

Facilities Design for Lean Manufacturing

The primary focus of lean is for a facility to operate with minimum waste. Focusing on smaller engines with variable output to match a company's daily customer demand each day would make a building generate more cash and grow the business (Duggan 1998). In general, the two measures that can focus a factory toward successful operation are throughput and capacity (Duggan 1998).

There are several tools that are identified to promote lean manufacturing. One of these tools is the use of a *process map* (Duggan 1998). Factory processes are listed across the top and its products are listed down the left side. For this process, a user would go through each product and place an X in the process column if the product calls for that process (Duggan 1998). This tool reveals patterns that show which products follow similar manufacturing processes (Duggan 1998).

	Processes												
Products	**Casting**	**Polishing**	**Threading**	**Assembly**	**Bend**	**Drill**	**Wash**	**Plating**	**Welding**	**Paint**	**Stamping**	**Riveting**	**Final Pack**
787	X			X		X	X	X		X	X	X	X
4210	X	X	X	X									X
909	X			X	X	X	X	X	X	X	X		X
6211	X	X	X	X									X
2528	X		X	X		X	X		X	X	X		X
3798						X	X			X	X	X	X
5736	X		X	X									X
806	X			X	X		X	X	X	X	X		X

Figure 1. A process map reveals patterns that show which products follow similar manufacturing processes.

	Processes												
Products	**Casting**	**Polishing**	**Threading**	**Assembly**	**Bend**	**Drill**	**Wash**	**Plating**	**Welding**	**Paint**	**Stamping**	**Riveting**	**Final Pack**
4210	X	X	X	X									X
5736	X		X	X									X
6211	X	X	X	X									X
2528	X		X	X		X	X		X	X	X		X
3798						X	X			X	X	X	X
909	X			X	X	X	X	X	X	X	X		X
787	X			X		X	X	X		X	X	X	X
806	X			X	X		X	X	X	X	X		X

Figure 2. Group the products with similar patterns to determine the number of manufacturing cells required.

Figure 6: Process Maps (Duggan 1998)

The process map could serve as a useful tool for most facilities design. However, in the case of Talley Farms, only one product is being manufactured for the purpose of the current facility design. If

other products are incorporated into the design of this facility, then a process map would then be utilized.

Another tool to be considered when designing a facility is the use of *shared resources* - a process or piece of equipment that supplies multiple cells with parts. These shared resources need to be set up to run the various parts needed to feed different cells (Duggan 1998). As shown in the figure below, shared resource needs to have direct flow to as many cells as possible. Placing a shared resource in the center of the factory where it can feed as many cells as possible provides the least material movement as well as more visibility to the shared resource.

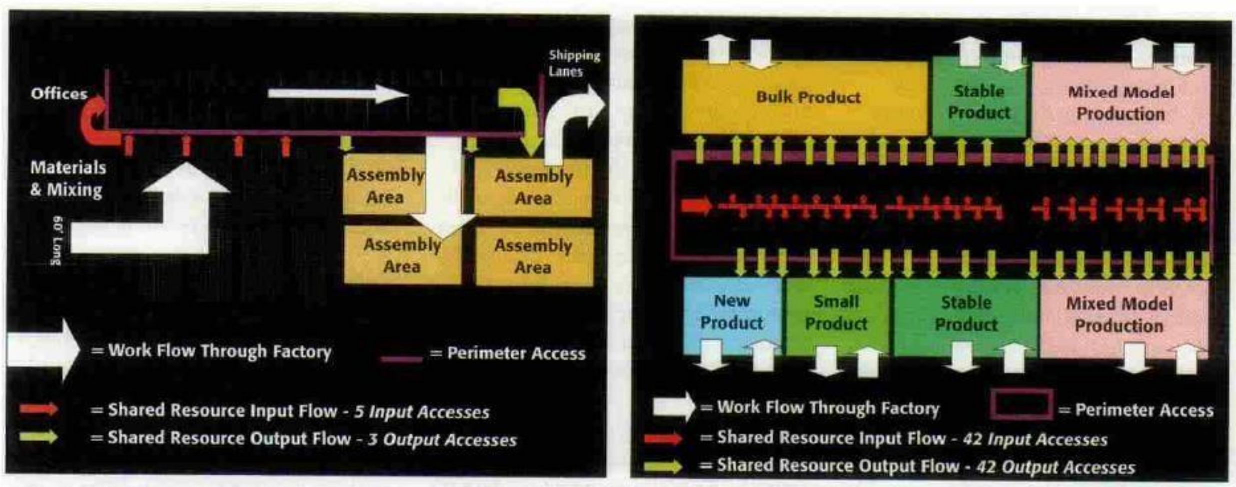

Figure 3. A traditional facility flow map (left) reveals little perimeter access, while a lean facility map (right) shows the flexibility afforded by process-based cells.

Figure 7: Traditional Facility Flow Map

The primary application of the shared resource tool is in the prepacking process at Talley Farms. An example of the shared resource is the pallet that carries the produce that needs to be weighed and bagged. Its placement in the center of four workstations allows it to feed multiple cells and minimize material flow. The current state of prepacking involves unnecessary movement of the workers.

LEED Programs in California Communities

There are many communities in California that have adopted or are currently adopting green building standards. The Leadership in Energy and Environmental Design (LEED) rating system serves as the green building standard of interest. There are many benefits associated with creating green buildings. Some of the benefits according to the United States Green Building Council (USGBC) are:

Environmental:

- Green buildings enhance and protect surrounding ecosystems and biodiversity.
- Green buildings improve air and water quality compared to traditional building methods, and also greatly reduces solid waste production.
- Green buildings conserve previous natural resources by using alternative materials.

Economic:

- Green buildings have reduced operating costs compared to conventional buildings.
- Green buildings optimize lifecycle economic performance.

Health:

- Green buildings improve the indoor quality of a building, including the air, acoustic, and thermal conditions.

Several case studies were done on this report to showcase barriers and lessons learned by the personnel involved in the implementation of LEED buildings. The case studies below are quick snapshots of the results (Ciccone 2014):

Case Study 1: Primary barrier for implementation of LEED buildings is state budget. Start a building with the LEED process, so it becomes a major factor and not just an afterthought.

Case Study 3: Education about sustainable buildings in necessary for any course of implementation. Use the term sustainable rather than green, the terms sounds more professional.

Case Study 4: Primary barriers were members of city council wanting definitive proof of the cost benefits of LEED before implementation. The primary sources of support for LEED in San Jose came from members of the public. Educational seminars and training promote awareness of sustainable buildings ultimately gathering more support.

LEED Certifications

Currently, there are six sets of LEED rating standards for different types of construction, according to the state of California LEED Certified Buildings department.

These include:

- LEED-NC (LEED for New Construction) - is designed to guide and distinguish high-performance commercial and institutional projects, including office buildings, high-rise residential buildings, government buildings, recreational facilities, manufacturing plants and laboratories.
- LEED-EB (LEED for Existing Buildings) - helps building owners and operators measure operations, improvements and maintenance on a consistent scale, with the goal of maximizing operational efficiency while minimizing environmental impacts. LEED for Existing Buildings addresses whole-building cleaning and maintenance issues (including chemical use), recycling programs, exterior maintenance programs, and systems upgrades.
- LEED-CI (LEED for Commercial Interiors) - is applied to tenant improvements and used for certifying high-performance green interiors that are healthy, productive places to work; are less costly to operate and maintain; and have a reduced environmental footprint.

- LEED-CS (LEED for Core and Shell) - is a green building rating system for designers, builders, developers and new building owners who want to address sustainable design for new core and shell construction. Core and shell covers base building elements such as structure, envelope and the HVAC system.
- LEED-H (LEED for Homes)
- LEED-ND (LEED for Neighborhood Development)

Simulation

Inventory Management of Multiple Items with Irregular Demand

There are several steps in identifying the best method for modeling demand. One of these steps involves understanding the different types of demand. Several descriptions exist, such as erratic, intermittent, lumpy, and slow-moving (Nenes 2010). The following definitions are listing (Nenes 2010) the different types of demand:

- Erratic – highly variable demand size
- Intermittent – it appears randomly with many time periods having no demand
- Lumpy Demand – both intermittent and erratic
- Slow-moving – have intermittent demand with each demand size equal to one item or very few items

In addition, there are terms that are frequently used interchangeably. These are listed below (Nenes 2010):

- sporadic and intermittent
- lumpy and irregular
- intermittent and irregular

Discrete event simulation case study

In the *Journal of the Operational Research Society* article "The Role of Discrete Event Simulation Techniques in Finite Capacity Scheduling", some effective and valuable approaches to scheduling and production planning are highlighted.

Delivery Performance

When focusing on production scheduling, delivery performance and system efficiency are critical. According to the article, two critical areas of performance are the reliability of the system, and the speed at which the system can produce (Roy 1995). When evaluating reliability as a metric, the article focuses on evaluating the percentage of jobs delivered on time. Also, when addressing scheduling, it is beneficial to schedule jobs using the completion time as the main driver (Roy 1995). In this way, inventory as well as crucial tools can be balanced to serve the most urgent orders (Roy 1995). However, it is also important to factor in allowances in order to produce and prepare for variability; allowances smooth the process before it has been started. At times, systems try to smooth productions mid process, which inevitably leads to higher WIP times or late jobs (Roy 1995).

Throughput

When referring to throughput, Roy and Meikle focus on bottleneck resources as well as production flow. When evaluating the limits of a production system, bottleneck resources are the functions that hold back the performance of the system. Therefore, it is crucial to make sure that the bottleneck resources always are cycling as close to the demand rate as possible; the goal of a production system is to match demand over the planned manufacturing lead time (Roy 1995).

To help production flow, the article highlights possible solutions like smaller transfer batch sizes, shorter set-up times, and cellular layouts that do not require employees to leave their work area.

However, some production processes require components to be tied together, and also need some resources to be utilized at very high levels; in these cases other factors must be considered. The focus should always be on addressing bottlenecks to maximize the capacity of the process as needed (Roy 1995). In this way, the metrics of individual stations may not be as important as the overall priority of matching production rate with demand rate (Roy 1995).

Operating Expenses

When referring to operating expenses, the common expenses to be aware of according to the article are inventory and overtime (Roy 1995). However, as related to a produce providing company, the loss of perishable material would be an operating cost as well. The production procedure will need to move product fast enough through the system in order to not lose perishable produce (Roy 1995).

Modeling Technique

In this article, Discrete Event Simulation's main advantages are showcased. Four mentioned are shown below (Roy 1995):

- Discrete Event Simulation schedules and outputs are not easy skewed by small changes in the parameters of a manufacturing system. It creates more stable schedule results and usually do not need to be too detailed to offer valuable insight
- It enables models that are useful to be made efficiently, especially in production settings where lean principles are being utilized.
- DES can be used before implementation to give more insight on the design of a manufacturing system.

- Because DES can be very visual and easy for non-technical personnel to understand, the ideas and processes shown to employees as a simulation can make procedure changes easier to accept for employees.

Although DES has some positive attributes, the article also highlights some negative ones. DES uses estimates and decisions at each time interval, without including possible trends and correlations of one processing time with another (Roy 1995). It is also only as effective as the way in which it represents the real manufacturing limitations; false constraints or overlooking key factors of the process make DES invalid (Roy 1995).

Experimental Tool

As for experimentation and adjustments made to the original simulation design, it is suggested in the article that the main goal of experimentation is to identify areas where capacity is constrained and processes are delayed (Roy 1995). To combat and help bottleneck processes or resources, multiple solutions are mentioned. One, input control, is highlighted effectively by the authors with this chart (Roy 1995).

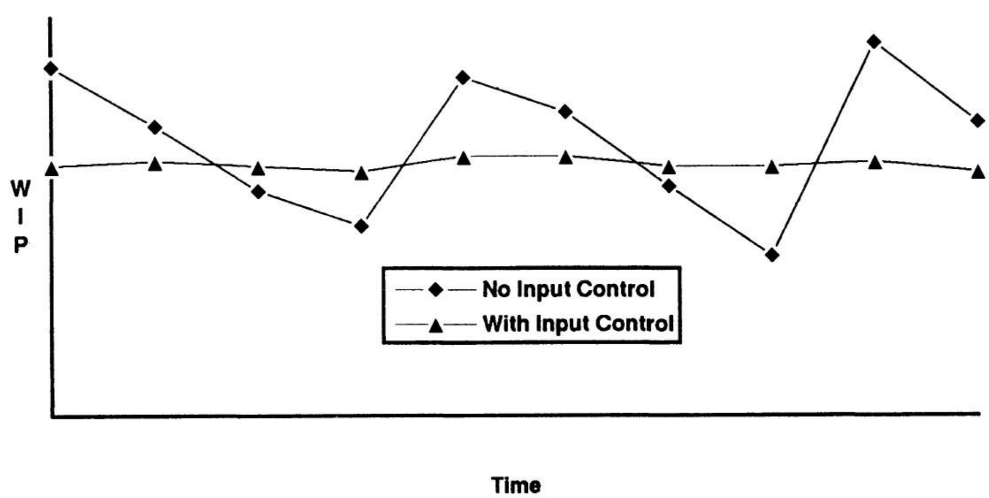

Figure 8: Effects of input control on smoothing WIP (Roy 1995)

Simulation can be an effective tool is by identifying rates as well as bottleneck resources so that WIP can be minimized, while maximizing throughput (Roy 1995). Again, one suggestion made by the authors is to limit processing of stations immediately before bottlenecks so that queues are minimized, but the bottleneck is always operating (Roy 1995).

Implementation

When referring to implementation of a designed system, insightful and applicable phases were addressed.

According to the article, the first phase of the implementation should be focused on fully understanding the current system, its limitations, and collecting quality data that can be used in analysis (Roy 1995). One main concern mentioned is using existing data collected by employees within the company. Data received from employees through their knowledge or personal data collection may not be valid for DES or other analysis, since they could have personal biases with their data collection and results (Roy 1995).

In the second phase, analysis of the data as well as financial justification of all alternatives is considered (Roy 1995). In this phase, the simulation to determine and identify bottleneck resources is completed. A full evaluation of the current system is completed (Roy 1995).

In the final phase, the authors describe taking the results of the simulation and attempting to gain acceptance of the data from personnel and management. The article highlights the importance and common issue of finding useful information from simulation scheduling tools, but not having a company commit and accept the results (Roy 1995). If the simulation tool is to be used iteratively to schedule production, this phase also focuses on training employees to use the software effectively (Roy 1995).

Overall, this article highlights many essential concepts of using a simulation to make influential conclusions about a process, while also focusing on the goal of finding ways to apply the results to help company success (Roy 1995).

Safety

PrimusGFS Audits

In the agricultural industry, food health and safety is the priority, and abiding by government regulations is crucial for all produce providers. Primus Global Food Safety Initiative is a company that benchmarks food safety within companies, and completes audits of facilities and production frequently. Talley Farms has provided two separate Audit forms that any new facility design must be able to adhere to (PrimusGFS). These Audits will serve the project well, since adhering to the laws and regulations of the industry will allow any suggestions or recommendations to be implemented for the company's gain. Module #1, the Food Safety Management System Audit Form, focuses on the system process interactions as a whole (PrimusGFS). The following bullet points are a summary of requirements generated from the audit (PrimusGFS):

- There must be a documented food safety policy detailing company commitment to food safety.
- A food safety manual as well as a management system scope statement that includes food safety must be available.
- A Food Safety Standard Operating Procedure must be in place.
- If contamination occurs, a Corrective Action Procedure needs to be enacted and available.
- Routine self-inspections should be completed periodically as the company sees fit. Documentation also needs to be included.
- Products that are held or rejected after inspection must be processed independently. Released products and rejected products must be recorded.

- A Daily Incidence Report must be maintained by management of the facility.
- A scheduled testing program in all phases of production should be in place, along with data collection of the tests conducted.

Module #2, the Good Agricultural Practices Audit Form, focuses on Harvesting Employee Activities & Sanitary Facilities. The following bullet points are a summary of requirements generated from the audit (PrimusGFS):

- No food, drinks, or tobacco products are allowed inside the facility
- Disposable, latex free gloves must be provided and used by employees for every operation where produce is handled. These gloves must be removed and disposed of before other activities are completed.
- No jewelry can be worn by employees that can lead to contamination while handling produce, except for single rings on hands.
- A hand washing station needs to be provided so that employees may wash their hands between activities as well as before and after processing steps. It must be within 5 minutes walking distance.
    - Hand soap, single use towels, and employee washing reminders must be present.
- Toilets must be provided for all employees within 5 minutes of walking distance.
    - These toilets cannot be in a location where produce could be contaminated.
    - One employee is necessary for every 20 employees.
    - There must be signs in both Spanish and English to remind employees to wash their hands after using the restroom.
    - Toilet maintenance and toilet supplies must be monitored and maintained regularly.
- Drinkable water and single use cups must be available for employees.

- A First Aid Kit must be accessible to all production areas.
- A standard operating procedure for contamination of any kind must be available. (Blood, Animal, Human)
- Garbage must be disposed of properly, with containers designed to prevent leakage of postharvest contamination.

Ergonomics

Ergonomics and the NIOSH Lifting Equation

When observing both the prepacking and final packaging processes for the Fresh Harvest program, it is clear much of the procedure relies on heavy manual labor. For example, totes of harvested produce weighing more than 25 pounds are frequently lifted, with some totes being palletized to over 5 feet. With all analyses and recommendations made through this project, employee safety and Human Factors must be considered as the priority. With this in mind, Ergonomics is included as an aspect of the solution so that future production and procedure can prevent employee injuries. One key metric, the Lift Index, will be used in this project to evaluate the weight lifted by workers on a regular basis. Suggested and supplied by Lecturer Virginia Callow-Adams, the NIOSH Lifting Equation is an effective way to evaluate the safety of a manual labor step (Waters 1994). Below an outline of the procedure and used terms for the equation is included in Figure 9 below.

1.1.1 Recommended Weight Limit (RWL)

The RWL is the principal product of the revised NIOSH lifting equation. The RWL is defined for a specific set of task conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (e.g., up to 8 hours) without an increased risk of developing lifting-related LBP. By ***healthy workers***, we mean workers who are free of adverse health conditions that would increase their risk of musculoskeletal injury.

The RWL is defined by the following equation:

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

Load Weight (L) Weight of the object to be lifted, in pounds or kilograms, including the container.

Horizontal Location (H) Distance of the hands away from the mid-point between the ankles, in inches or centimeters (measure at the origin and destination of lift). See Figure 1.

Vertical Location (V) Distance of the hands above the floor, in inches or centimeters (measure at the origin and destination of lift). See Figure 1.

Vertical Travel Distance (D) Absolute value of the difference between the vertical heights at the destination and origin of the lift, in inches or centimeters.

Asymmetry Angle (A) Angular measure of how far the ***object*** is displaced from the front (mid-sagittal plane) of the worker's body at the beginning or ending of the lift, in

The LI is defined by the following equation:

$$LI = \frac{\text{Load Weight}}{\text{Recommended Weight Limit}} = \frac{L}{RWL}$$

1.1.2. Terminology and Data Definitions

The following list of brief definitions is useful in applying the revised NIOSH lifting equation. For detailed descriptions of these terms, refer to the individual sections where each is discussed. Methods for measuring these variables and examples are provided in Sections 1 and 2.

Lifting Task Defined as the act of manually grasping an object of definable size and mass with two hands, and vertically moving the object without mechanical assistance.

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Lifting Task Defined as the act of manually grasping an object of definable size and mass with two hands, and vertically moving the object without mechanical assistance.

Load Weight (L) Weight of the object to be lifted, in pounds or kilograms, including the container.

Lifting Frequency (F) Average number of lifts per minute over a 15 minute period.

Lifting Duration Three-tiered classification of lifting duration specified by the distribution of work-time and recovery-time (work pattern). Duration is classified as either short (1 hour), moderate (1-2 hours), or long (2-8 hours), depending on the work pattern.

Coupling Classification Classification of the quality of the hand-to-object coupling (e.g., handle, cut-out, or grip). Coupling quality is classified as good, fair, or poor.

		METRIC	U.S. CUSTOMARY
Load Constant	LC	23 kg	51 lb
Horizontal Multiplier	HM	(25/H)	(10/H)
Vertical Multiplier	VM	1-(.003 |V-75|)	1-(.0075 |V-30|)
Distance Multiplier	DM	.82 + (4.5/D)	.82 + (1.8/D)
Asymmetric Multiplier	AM	1-(.0032A)	1-(.0032A)
Frequency Multiplier	FM	From Table 5	From Table 5
Coupling Multiplier	CM	From Table 7	From Table 7

Figure 9: NIOSH Lifting Equation and Term Definitions (Waters 1994)

This equation can be used against the OSHA guidelines for lifting weight in order to see if both the current procedure and the recommended procedure are appropriate for the safety of employees (Tompkins 2010). By utilizing this metric, any results and suggestions made through the project will not overlook worker comfort. Because of the repetitive nature of the tasks involved, as well as the weight of the produce moved in the process, ergonomics and the NIOSH Lifting Equation will be critical for all final recommendations made for this project.

Ecological Economics

In recent years, locally produced foods have become an increasing interest to consumers. Grebitus (2013) focuses on the questions how much to consumers really want *local foods* and why are these products desired? The article emphasizes on how the consumers' willingness to pay (WTP) for food can vary depending on the number of miles traveled for food. To many consumers the distance the food has traveled (food miles) has a huge impact on the freshness, taste, environment, health, and local economy (Grebitus 2013). Food miles are defined by the distance in which the food travels from the location it is grown to the location it is consumed in (Grebitus 2013). In the US, on average, about 1500 miles of traveling occurs for fresh produce before reaching the consumer, while processed food averages about 1300 miles (Grebitus 2013). Many consumers believe that local foods are the healthiest for the body and planet because they are considered fresher, better tasting, and has a higher nutrient value (Grebitus 2013). Not only is it considered healthier, but local foods are better for the environment due to the decrease in the energy used and the distance traveled. Surveys have shown that freshness and quality of produce are two of the most important things to consumers (Grebitus 2013). Purchasing local foods is considered to also help the local economy and supporting the local family farmers (Grebitus 2013).

Grebitus (2013) performed an auction experiment on 47 participants to test if displaying the food miles on four different bags of apples and one without a label on the bag, would affect the participants WTP for the local food. The results indicated that the WTP was dependent on the distanced traveled and that the people preferred the produce that had the closest mileage (Grebitus 2013). But when they tested consumers on a non-perishable item, wine, the consumer didn't depend as much on the distance traveled (Grebitus 2013). For perishable produce, the results indicated that the longer the transportation distance is then the lower the WTP for the products (Grebitus 2013). The results also indicated that females are willing to pay more than males for the distance traveled, considering the local foods are

more expensive than foods transported from further away (Grebitus 2013). This article could be used as an effective marketing strategy to consider for Talley Farms. For example, the program could label the transportation miles for the produce.

Randy and Andrea Chavez

Throughout the course of this project, Andrea Chavez and Randy Chavez have been key contributors of industry knowledge. Andrea is the Program Manager, while Randy is the Production Supervisor. Through their extensive years in the produce business, they have acquired a lot of "tribal knowledge" as well as valuable experience. Included in this Literature Review is the knowledge so far accumulated from conversations with them. This list is in no way exhaustive, since more and more information will be utilized from them as the project progresses.

Andrea Chavez

- Fruit and Vegetable prices fluctuate very frequently, and changes cannot be forecasted.
    - For example, blueberry availability can be lost overnight, and prices can fluctuate incredibly since markets are so sensitive.
- Products within Fresh Harvest are 50% to 75% grown on Talley Farms property; the rest of the produce is purchased from local growers.
- 9 to 12 items of produce are included in every box.
- All items are seasonal and very fresh; item lists change week to week.
- All produce harvested ideally follows this schedule:
    - Harvested, put in totes and palletized
    - Washed (if Necessary)
    - Cooled (Either wet or dry)
    - Pre-Packed

- Cooled in Napa Cooler
- Packaged in Boxes next day

- They currently have over 2500 customers in the program.
- The current space occupied by the packing area cannot be utilized for 3 months, since it is used for storage for Bell Peppers.
- Largest bottleneck is perceived to be Pre-Packing.
- Utilization of the coolers they currently have is extremely important; including a cooler installation is not a cost effective option.
- Current proposed area for a new facility would be located south of the vacuum cooling machine.
- Strong consideration for the company to include Buellton as a possible customer source.
- Fresh Harvest may include a produce market downtown. A new facility may need to serve its needs as well.
- Routing and transportation routes remain the same every week, regardless of fluctuations in order numbers.

Randy Chavez

- Priority of procedural steps is on the safety for the workers.
- Not all employees are available to work, and the size of the work force for a week varies consistently.
- Each truck carries 480 boxes.
- They project 5000 independent customers in two years (their customer base would need to double).
- Jose does all deliveries alone, with days reaching almost 500 orders.

- The main concern of the project should be on standardization and keeping procedure simple.
- Delivery style at drop off locations and the standard style of the box are keys to success
- Former businesses Andrea and Randy have encountered did not have the same success with delivery and product packaging styles
- Wet floors as well as heavy boxes are common concerns with produce packaging, and the recommended facility design should incorporate solutions to these issues.
- There must be significant flexibility in the recommended design and procedure; variability in material cost and material availability is unavoidable.
- Boxes made to order for each individual customer would increase operating costs and defeat the purpose of the program: options for the customer would cause too complex of a processing situation.
- Cardboard boxes from suppliers used in Pre-Packing are not usable after being received.
- Pre-Packing is usually completed for the boxes shipped the following day. Fresh Harvest limits only one to two items per week to need to be pre-packed.
- More intuitive and specific procedure will limit the variability of the set up and production time, since employees at times do not keep repeatable procedures.

Design

The team utilizes a problem solving approach that is taught in the Senior Project class at Cal Poly San Luis Obispo. The methodology involves a series of steps that is also iterative to promote flexibility in problem solving. The steps for the problem solving approach are listed below.

Problem Solving Methodology

1. ***Define the problem*** - The initial step is dedicated to identifying a problem that is to be addressed. This step ensures that there is an existing problem that needs to be solved. In addition, it is during this phase that scope of the problem is defined. Limiting the scope identifies what the team covers in the project along with what will be out of scope. Furthermore, this step avoids scope creep ensuring that the project stays within the time and resources of the team involved.
2. ***Collect data and relevant information*** – With the problem statement in mind, collection of data is then conducted. Different methods of collection take place. Data collection is also the first step of the iterative process. This means that at any time new data needs to be collected after this step has been passed, the team returns to this step and follows the steps in series.
3. ***Analyze data*** – After enough data has been collected, sort through the data and identify patterns or red flags that might lead to identification of root causes. If at any point the team needs more data, return to the data collection step and iterate.
    a. *Identify root causes* – This is the end goal of analysis of data. The root causes show what ultimately needs to be addressed to generate a resolution for the problem or problems defined.

4. ***Generate alternative solutions*** – When meticulous analysis of data has been undertaken, solutions are generated. Multiple solutions will be generated while reserving judgment on the positives and negatives of each solution. This step is focused on generating quantities of ideas.
5. ***Analyze solutions*** - This step involves listing the pros and cons of each alternative. This step is usually accompanied by an economic analysis. If at any point the team needs more data, return to the data collection step and iterate.
6. **Select the best solutions and give recommendations** – A final solution is selected along with a justification usually in the form of an economic analysis.

Define the Problem

Problem Statement

The problem statement to be addressed throughout this program is:

- The current processing system of produce for the Fresh Harvest program may not be suitable for forecasted growing demand.

In order to address this problem statement and propose an influential, useful solution, the systematic approach to methods engineering was utilized.

Objective

The objective of this senior project was to develop and redesign the Talley Farms "Fresh Harvest" produce program. The "Fresh Harvest" program offers boxes containing top-quality, local produce that they deliver to convenient pick up locations along the central coast. Fresh Harvest boxes contain 9-12 different fruits and vegetables. The current Fresh Harvest program supports a demand that

is forecasted to grow within the next year. However, management wants to determine possible options and improvements to support a doubling of current demand.

Scope

For this project, a controlled scope helped to focus the team on the areas of the system that can best address the problem. The scope of this project is focused on the processes of washing, pre-packing, packaging, and their interactions. No analysis of the routing logic of the program, and the necessary capacity for transportation is included. In addition, neither analysis about material cost nor analysis about suggested box size is mentioned in this project. Also, in depth aspects of the facility design, including but not limited to plumbing, wiring, lighting, and drainage are not included in the final proposed solution.

Overall, the scope of our project focuses on addressing the capacity and improved design of the Fresh Harvest system so that possible growth in demand can be capitalized on.

Deliverables

In order to fulfill the requirements for this project as well as for the client, the team has created a set of deliverables. The main deliverables for this report include the following:

- System analysis with process improvement
- Standard Operating Procedures
- Facility Layout
- Economic analysis of possible options to address problem statement

These deliverables will give sufficient analysis for Talley Farms to better understand the state of the Fresh Harvest program.

Collect Data and Relevant Information

The collection of data for this project helped the team to make the best analysis and proposed solution to address the problem statement. Three main methods to collecting data for this system

included time studies, literature reviews, and employee interviews.

- *Time Studies*
    - For analysis of capacity as well as efficiency, videos were taken of pre-packing, packaging and washing throughout the quarter. These time studies served well in allowing the team to collect and analyze as much data in the limited time given.
- *Interviewing/Tribal knowledge*
    - The most beneficial and critical aspect to data collection for this project was informally interviewing of Randy, Andrea, Adam, Ron and other Fresh Harvest employees. The extensive experience and tribal knowledge acquired by these employees is essential to every solution proposed by the project team.
- *Literature Reviews*
    - As a supplement to the data collection included in this project, the team extensively reviewed articles and textbooks on the concepts that could be utilized throughout the quarter. More knowledge on concepts such as lean manufacturing, shared resource utilization, 5S implementation, and effective flow design helped to design and propose the best solution possible.

Below are selected detailed processes used to collect data that is essential to developing the solution and its benefits.

- *Building measuring approach*
    - Throughout early meetings at Talley Farms, the team used 25 foot tape measurers and recorded the system process as it currently operates. This was a critical aspect to the project critical approach; understanding the current space occupied was essential to justifying new layout space requirements.

- *Pallet size*
    - Pallet sizes and the number required represent significant space and storage factors in facility design. Consistently, the pallets used by the Fresh Harvest program are 48" X 40". This standard is utilized for pallets of produce from suppliers, pallets of produce that have been pre-packed, and pallets of Fresh Harvest boxes after they have been packaged. The proposed layouts focus on efficiently orienting the pallets so that facility floor space is conserved, while still being functional.
- *Unit load*
    - Because the pallets in the Fresh Harvest facility are utilized in every phase of processing, how pallets are packaged and stored must be considered. For example, pallets of produce can hold different unit quantities of produce, which can vary significantly. A pallet of lemons, for example, can serve far more Fresh Harvest boxes than a pallet of Napa cabbage. Since these pallets take up the same amount of facility floor space but contribute different resource quantities to the packaging line, suggested designs must account and make up for the variation. This is necessary because restocking and set up orientations must consider the space pallets of supplied produce require. This way, the way pallets are stacked and how high they are stacked can be analyzed to increase the output of the system.
- *Tote Size*
    - Frequently, totes 24" X 20" are used to store prepackaged products, products before washing, products after washing, and products that are stored onto pallets used for packaging Fresh Harvest boxes. Similar to unit load, the tote size and capacity is relevant to this project; can only hold certain quantities of types of produce.

- *Box Sorting/Rearranging*
    - A significant portion of causes in delay or stoppage of the line is the rearrangement of boxes/totes that contain produce that are served into the line. A conservative average of 30 seconds gets added to packaging a box when rearrangement or sorting takes place before placing produce into it.

Analyze the Data

For the current Fresh Harvest System, there are five main processes to consider:

1. **Purchase** or harvest of the produce
2. **Prewash** the produce when necessary
3. **Prepack** the produce when necessary
4. **Pack** the order number of boxes
5. **Ship** boxes to appropriate drop off locations.

Again, for the scope of this project, the main processes analyzed were pre-packing and packaging.

Pre-Packing

Currently, pre-packing takes place in the narrow "Pre-packing" room just outside the main packaging floor utilized by Fresh Harvest. Pre-packing is necessary for produce that the Fresh Harvest program does not want freely packed into the consumer box. Items for pre-packing include snap peas, potatoes, stone fruits, and broccoli. Pre-packing is almost always packed to a desired unit weight. For example, snap peas for a box may be packed to be 1 lb.; the interval that is acceptable for the product being pre-packed varies for each produce item.

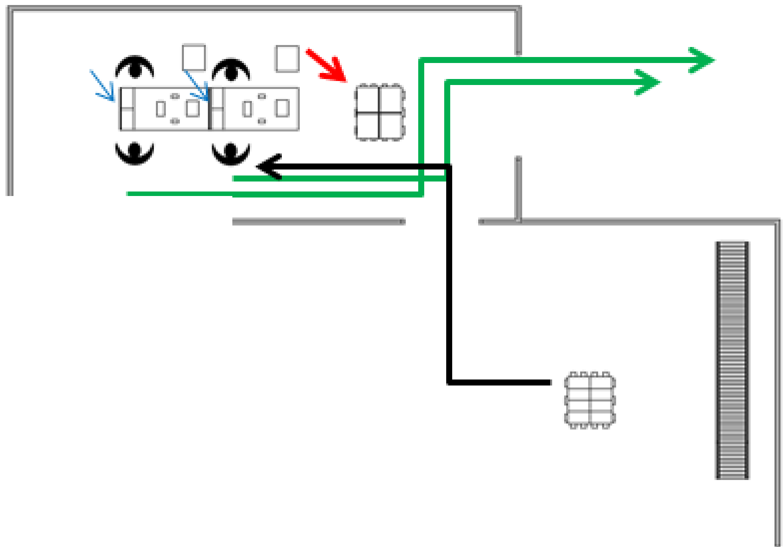

Figure 10: Current Pre-packing

Figure 10 displays the current Fresh Harvest layout. The employees bag the produce, weigh it to a certain total, tie off the bag, and put it in a tote. The tote is filled to a certain quantity, and as the red arrow in the diagram describes, the tote is palletized for the next morning's packaging line. The blue arrows show where boxes of produce from the supplier are located on their table; this is the location where the employee takes produce and bags it. Since the produce boxes only hold 15 to 25 pounds of produce, these boxes must be replaced regularly throughout the process. When the boxes are empty, they must be thrown away outside on the loading dock; the green arrow represents this path. Finally, the black arrow represents the path the employees must take in order to grab and refill their bagging stations. The frequency of employees leaving the workstation is high and transportation time is excessive.

Points of Improvement

Figure 11 and 12 below were taken from video recordings of Pre-packing during the quarter. The diagrams and analysis below showcase the main points of improvement for the current procedure followed by the program.

Figure 11: Current Pre-packing Trial 1

A. Space Limitations for the area that is used for pre-packing create a non-ergonomic environment. In this image, the employee with the red hat must work around a cabinet in order to carry a box out of the area. Also, the cable in Figure 11 that crosses the aisle is unsafe.
B. With pre-packing in this area, employees must move their empty box of produce from their station, put it outside, and grab the next box from the adjacent room. This leads to excessive transportation times, ranging from 45 seconds to 1 minute of idle working time per box.
C. Since boxes stored with ice, drip while they warm above freezing, the floor in this room can get wet. With no rubber mats, the floor could cause somebody to slip.

Figure 12: Current Pre-packing Trial 1

D. In Figure 12, Mateo must lift a heavy box of broccoli. To prevent worker injury, lifting this tote should not be done for long distances. With this layout, Mateo would walk all the way around the right of the image to place the tote on the pallet.

E. Since the totes in this procedure are shared, employees must keep count together in order to ensure that each tote has the right number of pre-packed bags. Once the employee leaves with the tote, his partner for the tote must wait, or restock another empty tote in order to continue. This lapse in time can lead to increased mistakes, and more time spent recounting.

Packaging

The current packaging line takes place inside a facility that contains a cooler. The packaging line operates at the space where the pre-packing exit and the entrance to the cooler intersect. Before packing of produce takes place, the boxes used for packaging are already folded as they are usually in a collapsed state. This folding process usually takes several hours and is done before packaging setup. Folded boxes are stacked and usually placed behind the conveyor line as shown in Figure 13.

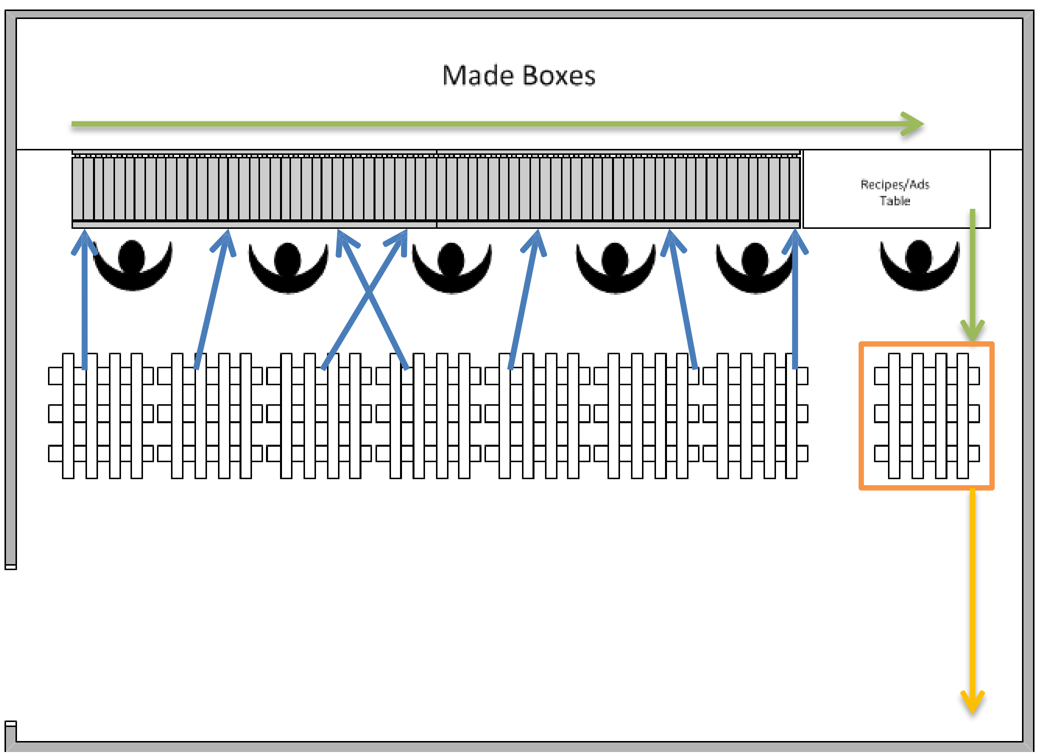

Figure 13: Current Packaging

The packaging line starts when the worker on the leftmost section of the conveyor takes a box from the pile of premade boxes. The worker then takes the first box, places it on the conveyor, and tears a plastic bag then places it in the box. The worker then puts produce from a pallet located behind them. This step is repeated several times as the box moves along the conveyor. In Figure 13, the blue arrows roughly indicate taking a produce from a pallet and placing it into the box, while the green arrows indicate the flow of a box within the system. The produce on the pallet are usually contained in totes or boxes provided by the supplier. The worker at the end places advertisements and recipes into the box, closes the box, and places it into the pallet highlighted orange shown in Figure 13. The last two workers sometimes switch on who puts a specific item in a box. After the pallet of completed boxes reaches around 63 boxes, a worker takes the pallet via pallet jack and puts it into the cooler or truck as indicated by the orange arrow.

Points of Improvement

Figure 14: Current Packaging Trial 1

A. Reaching over pallets is not ergonomic. The higher the tote, the more strained a worker is in reaching into the pallet. The current configuration does not accommodate the comfort of workers that are of shorter height.

B. As a result of higher stacked totes, quality inspection for each produce is conducted less. Items located at the top totes are not seen until picked; hence more time is wasted sorting through the produce. In addition, the height of the tote disables the picker to determine whether a tote is empty and needs to be removed.

C. The current line has several instances wherein two workers are directly working with a box. This results in some confusion where workers are not sure what is already put into the box. As a result, time is wasted in checking and rechecking the current contents of the box. There is no clear progression of the box along the conveyor.

D. Due to the irregularity of the current packaging line, some boxes end up idle or in queue before the next worker.

E. There is an inventory of pre-punched boxes that are not adding any value to the process. These stacks of boxes take up valuable space and do not contribute significantly to the throughput or speed at which boxes spend in the current packaging system.

Figure 15: Current Packaging Trial 1

F. Empty boxes of produce from the replenishment line take up space among the filled boxes. Workers have to maneuver around these boxes to get to picking produce. This adds several seconds for each instance they have to rearrange the boxes. The cumulative result is a reduction in throughput.

G. In this instance, an empty tote is taken out of the line by a worker since their size is not easily rearranged within the replenishment line. Hence, a worker has to leave the packaging line causing their corresponding workstation to be idle. A worker leaving the line adds a significant amount of time in the processing of each box. As a result, the workstations before this worker develop a queue of boxes, and workstations after end up being idle. When the worker comes back from removing the tote from the line, several seconds are additionally spent in checking which boxes need to be filled. Although there are instances where other workstations take up the "slack" from the worker leaving, the workstation who tries to help end up slowing their portion of the line.

H. Stacks of flattened boxes save space but should not be placed within the replenishment area as it interferes with the picking process. When the pile of flattened boxes is greater in number, a

worker eventually takes this pile and leaves the line. The result of this worker leaving is similar to the instance where a worker leaves to take out a tote (letter G in the figure 15 above).

I. Idle box within the packaging system, as a result from worker leaving for rearranging of piles of empty boxes and totes. This box will require double checking to verify what has been placed in the box.

Root Causes

The problem being addressed throughout this entire project is finding key improvements in which the Fresh Harvest program will be made suitable to meet forecasted growing demand. After meticulous analysis of the data collected, a significant number of opportunities for improvement have been identified. The recurring issues that occur in the pre-packing and packaging systems are the lack of standardization, the practice of push manufacturing, minimum regard for ergonomics, and inflexible system designs.

Lack of Standardization

In both pre-packing and packing systems, the lack of standardization exists throughout the entire process. This issue is exhibited during the setup phase of production. Although the workers have a general idea of how to set up before production, there is a lack of immediate direction as there is a lack of information. The first step of setting up usually involves getting production information such as number of produce to prepack, amount of boxes to pack, and a produce list of what gets stored in the boxes. However, there were several instances where workers would start setting up the pallet production line without verifying the sequence on the produce list, or what produce gets packed for that shift. As a result, rearrangement of setup becomes common and valuable time is wasted.

During the operation of pre-packing produce, each worker has a different method of picking, weighing, and bagging produce. As a result of this inconsistency, it is often difficult to track the number of bags of produce pre-packed and additional time is required for verifying bag count. For packing

produce into the boxes, a similar trend of inconsistency is present. Workers do not have assigned produce to place into the box as it travels through the conveyor. Hence, some boxes travel along the conveyor while missing produce from workers in the earlier sequence of the line. This causes workers to have to recheck the contents of a box to ensure no produce items are missed. This adds more time a box spends on the conveyor and contributes to longer lead times.

Push Manufacturing

The production line currently practices a variation of push manufacturing, which is producing batches of product. An example of this manufacturing concept is pre-folding boxes and stacking them across a wall to make available for a later shift or the next day. As a result piles of boxes take up valuable space within the already cramped facility. During the operation of the produce packing process, workers continually place produce into as many boxes possible with minimal regard for queues forming in the later stages of production. As a result, it is common to have high work in process boxes within the entire packing line and contributing to boxes have longer lead times. Batch manufacturing also causes a sense of having to rush when queues start developing and this leads to more mistakes within the production line. An increase in demand will lead to a greater number of mistakes.

Ergonomics Issues

After observing both pre-packing and packing systems, it is apparent that some ergonomic issues need to be addressed. Some totes contain enough produce to weigh over 50lbs yet are lifted and transported a great distance by a single individual. In addition, boxes and totes of produce are stacked at a height that requires repetitive reaching or produce is placed in deep bins that requires tiresome bending to reach the product. The act of reaching and bending several hundred times during production causes an enormous strain on the bodies of the workers. Regularly being exposed to these working condition damages the overall physical health of these workers. If production ramps up to meet growing demand, workers will experience more discomfort and eventually have physical injuries based on the current system designs.

Inflexible System

There are a number of variables that exist to disrupt the current pre-packing and packing systems. These variables are the changing number of produce in the list for packaging, unpredictable number of workers for a shift, and workers leaving the line during production for various reasons. Although, the pre-packing and packaging systems in place meets the current demand even with the existence of these variables, the delays experienced during these operations would not be acceptable to a forecasted demand that is significantly greater. For example, the current packing system does not have standardized workstations; as a result workers have an inconsistent role in determining what produce to pack. This leads to mistakes down the line and increases when the types of produce increase in number as variation of what to pack increases. Each mistake contributes to a delay in the time demand is met. In addition, the variable of not having a reliable number of workers places a strain on the inflexible packing system. When there are fewer workers in the line, they experience more stress in having to pack more produce without a standard guideline. More workers added to the line do not effectively get utilized as throughput of finished boxes does not significantly increase. Finally, when any worker leaves the packaging line during operations, the system fails to adapt accordingly or takes a significant amount of time to recover. When a worker leaves to place an empty box or tote outside the line, several boxes become idle, queues develop, and produce is not placed accordingly causing a series of inspections. In an environment of greater demand, such disruptions would not allow the packing system adapt accordingly. The three variables discussed may be addressable by the current system, but any significant increase in demand will not be met if the system is not altered to be more flexible.

Methods

Proposed Design of Pre-Packing

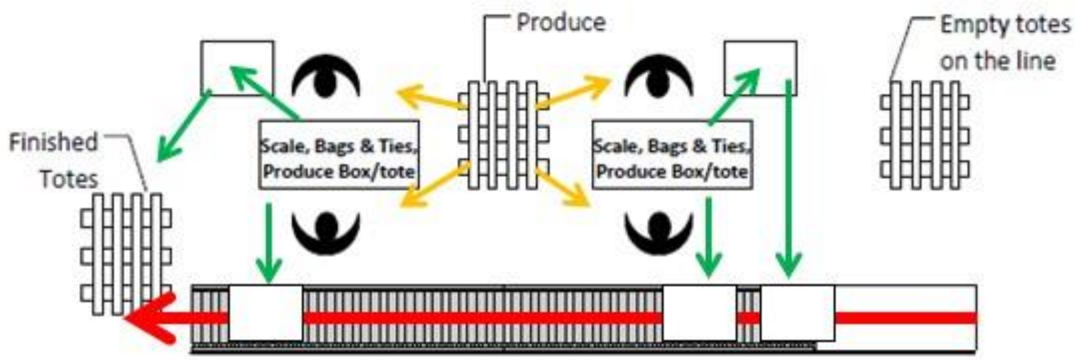

Figure 16: Proposed Pre-Packing Design

The proposed pre-packing layout Figure 16 is to take place in the current location where boxes are being packed. This layout allows flexibility in utilizing current equipment like the conveyors, tables and rubber matting. The boxes of produce to be pre-packed are placed between the four workers and are a shared resource. Each worker will have their corresponding tote where weighed bags will be placed and counted. The yellow arrows indicate the flow of produce to be bagged. After the produce is weighed, bagged and zip tied, it will be placed in the tote closest to each worker. The green arrows indicate which tote the corresponding bag goes to. Those closest to the conveyor will turn around and move the filled totes along the conveyor to avoid heavy lifting. The red arrow indicates the flow of filled totes along the conveyor ending at the finished totes pallet. The workers away from the conveyors will have their totes directly beside them. Once their totes are full, they will move the totes to either the conveyor or pallet for finished totes, whichever one is closer. This layout aims to minimize the movement of workers along the line. More importantly it decreases the amount of lifting each worker does.

Trial Run of Pre-packing Proposal

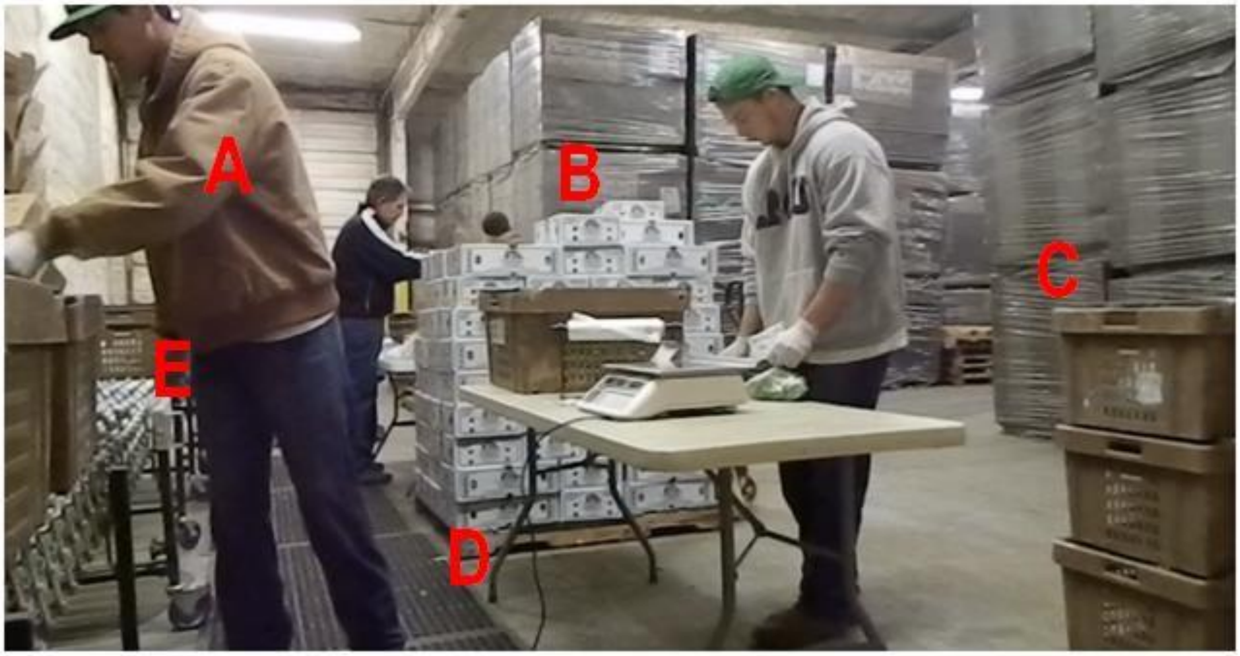

Figure 17: Trial 1 of Proposed Pre-packing

A. Ergonomic – Weighed bags of produce are placed in a tote at hip level. This height is more comfortable and avoids reaching or bending.

B. Shared Resources – Placing the boxes of produce in the center of four workers drastically decreases worker movement and therefore increases speed. This resource is easily accessible for each worker to grab produce.

C. Accountability – Each worker has a dedicated tote to place their weighed bags of produce in. This makes each worker accountable for the number of bags in their tote.

D. Rubber matting – Moving the pre-packing system in the same environment as packaging allows the worker to utilize existing equipment. The rubber matting makes it easier for workers to stand for long periods of time.

E. Conveyors – Utilizing the conveyor from packing introduces less lifting, as totes can travel by conveyor to the pallet.

Proposed Design of Packaging

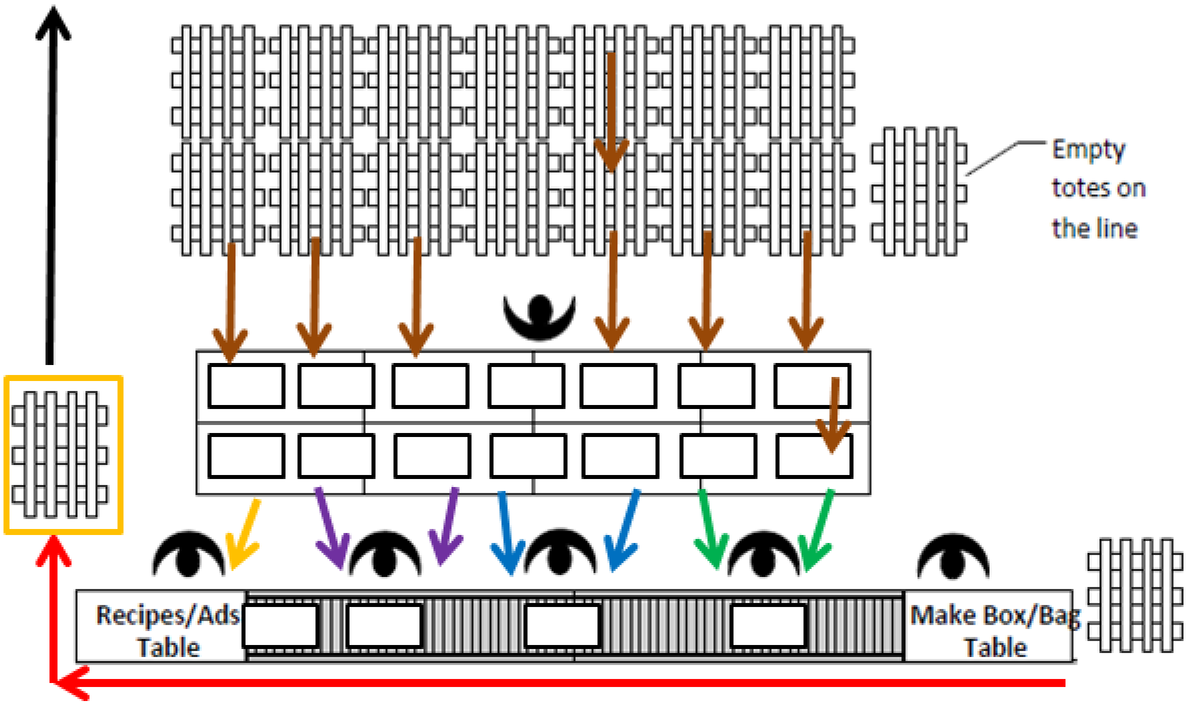

Figure 18: Proposed Packaging Design

The proposed packaging layout consists of two rows of tables directly behind the workers in front of the conveyor. The two tables will carry totes of produce that are to be picked from by each worker next to the conveyor. The first worker on the right will fold boxes one at a time and then place a bag into a box. If enough personnel are present the first worker will only box and bag. The empty box will then travel to the next worker, and the first type of produce will be placed into the box. After their designated produce has been placed into the box it will then be moved onto the next station. This will be repeated several times until it reaches the last worker. Figure 18 shows different color arrows next to each worker. Each color represents the produce each worker will place into a box. This assigned workstation must be strictly followed to implement standardization along the line. In addition, each worker should only be working one box at a time. The final worker will place the recipes and advertisements, close the box, and then place it in the pallet of finished boxes indicated by the orange

square. The red arrow indicates the flow of the box along the packing line. Once this pallet is filled, the entire pallet is moved to the cooler as indicated by the black arrow.

The brown arrows indicate the movement of totes. Having two layers of totes along the tables allow enough of a buffer for the worker to replenish empty totes on the table on time. This worker is solely responsible for replenishment of totes on the table along with cleaning and rearranging of empty totes and boxes. Finally, when a pallet is empty of totes, the pallets behind it will serve as the replenishment source for the line.

Trial Run of Packaging Proposal

Figure 19: Trial 1 of Proposed Packaging

A. Fold boxes as needed. Labor hours need not be wasted pre-folding boxes. This prevents punched out boxes from consuming valuable facility space. Folding boxes in advance do not contribute significantly to throughput.

B. Quality Control – All totes in the tables can be easily seen. All workers serve as quality control points, checking to see if produce is defective. Workers can easily see when a tote is about to run out of produce and needs to be replaced.

C. No queued boxes, reducing time boxes spend in the system.

Figure 20: Trial 1 of Proposed Packaging

D. Single Piece Flow – One worker works on one box at a time. This creates a steady pace and prevents confusion among workers.

E. Ergonomics – Workers to reach into the totes or boxes at hip level rather than bending or reaching several hundred times during a shift. Worker health and comfort are paramount in this design.

F. One workstation per person – Accountability of what each worker places inside the box to avoid confusion and mistakes.

The following concepts of 5S, Just In Time manufacturing, one piece flow, ergonomic design, and line balancing are the fundamentals of the proposed solutions suggested by the team. They serve as critical concepts to efficient processing, and are vital principles of industrial engineering.

5S Approach: Packaging and Pre-Packaging Line

The 5S approach to a system refers to Sort, Straighten, Shine, Standardize, and Sustain. These five concepts are integrated into your procedure to eliminate waste and increase productivity

- *Sort*
  - All supplies to be used for pre-packaging and packaging are stored in a designated area marked off by tape. Currently there exists a location for cleaning supplies in the facility, and totes are located in along the walls. The location has a dimension of 9.5ft. by 11.5ft.
  - The team proposes to have taped off areas for all equipment used for the packaging systems. Equipment include pallet jacks, stacks of empty pallets, totes, folded tables, mats, and cleaning supplies (brooms, brushes, bins).
- *Straighten*
  - The location of each produce pallet should be a designated a space on the production line. The designated space should be marked with colored tape to indicate the strict location of each pallet. The color tape markings on the floor should have corresponding tape markings on the floors of cooler storage space. This ensures that products from the storage space get delivered to the correct location on the production floor, and simplifies the morning set up processes.
- *Shine*
  - With all agricultural production processes, facility cleanliness and food safety must be carefully monitored. With the proposed procedure of having an employee restock totes on the tables, idle time was purposely allowed so that cleanliness could be maintained. Empty boxes are broken down by this employee, and the supply going to the main packaging line is kept organized and neat. Again, cleaning and addressing disorganization in the system contributed to increased throughput capacity and employee productivity.

- *Standardize*
    - SOP
        - Standard Operating Procedures should be followed for washing, prepacking, and packaging. Standardized, repeated processing steps not only will lead to more anticipated results but will also allow for steady continuous improvement. Aspects of the SOP can be reviewed and changed as necessary for changes in employee availability, demand, and equipment use.
- *Sustain*
    - Cultural Commitment
        - Gaining employee ownership as well as employee input must continue to be a priority for any implementation of the designs created in through this project. By having the employees as well as the company accept and sustain the Lean aspects of the proposed solutions, the Fresh Harvest program will continue to be able to improve and adapt to changes in consumer needs. Employee camaraderie, friendship, and appreciation are critical to the success of the program. Acts of respect such as giving leftover produce to employees should continue to be practiced.

Just In Time

- Frequently, Just-In-Time or JIT manufacturing theory was utilized in proposing solution design changes. For example, when defining the restocking procedure of the tables holding produce, boxes are stocked Just in Time so that packers do not run out of produce. This manufacturing technique enables the restocking employee in helping the line continue to function, and directs his work to the goal of the process, which is ncreased throughput capacity. Moving box folding to the packaging line is another critical JIT proposed design change. By boxing while every box is

packaged, inventory of folded boxes is kept to a minimum; space is saved in the facility and workers focus on adding value to the product Just in Time for shipment.

One Piece Flow

- The standard of one box moving at a time through the process also keeps the system lean and manageable. Work in progress inventory decreases significantly, and every employee's process is much more consistent. For example, in cases where two boxes were moved in the system at a time, worker's needed to adjust in order to push boxes forward. When processing times varied for the two boxes being moved, errors occurred since workers either tried to help others by working on their tasks or rushed in order to keep items moving. By encouraging one piece flow, less variable processing times are executed and more consistent throughput can be reached. This one piece flow must also be considered for the prepacking procedure. Bagging items and filling just one tote at a time for each employee simplifies and cleans the process steps for every employee.

Ergonomic Design

- Table Justification
    - Based off worker feedback (Mateo), using tables to replace the deep bins located in the first section of the line (usually contains lemons/avocados) removes the strain of having to repeatedly bend over 100-300 times in a day of packaging.
    - Having totes placed on top of the tables enable hip height picking from produce. This prevents workers from straining to reach up and pick produce from totes/boxes. This is especially beneficial to workers who are vertically challenged, as they experience more strain in reaching into these totes/boxes.

Line Balancing

- Utilizing time studies, working element task times were analyzed and estimated. Since the processing approach is a one piece push system, waiting times and work piece flow are very important. In order to evaluate and avoid excessive bottlenecks, the work elements of the system were balanced amongst the employees working. This approach showed great promise in the pilot study of the new Standard Operating Procedure; employees moved product efficiently and employee utilization was improved. Immediately, box folding and bagging as well as box closing and palletizing represented the longest work elements. These elements were then used as the "takt time goal" (the pace of production), and all other stations were designed to take the same length of time. Employees distributed the work elements evenly, which allowed for consistent and improved throughput. By doing this, the box never sees idle time, and the employee efficiency is maximized.

Layout Evaluation

Throughout the development of proposed solutions for the pre-packaging and packaging processes, different layout models for a new facility were designed to accommodate those areas. All of the proposed facility layouts will hold double the demand capacity of the current facility. All of the fresh harvest boxes must be ready to ship at the current designated delivery take-off times at 9:30am and 11:00am. If the demand doubles, two production lines will be utilized in the facility to increase the throughput and have the boxes packaged on time.

Series

The figures below show the first facility layout alternative for the fresh harvest program. Included in this layout are the pre-washing area, production area, cooler, loading dock, storage area, and personal belongings area. The total dimensions of this facility layout are 98'6" X 54'. The production

area has two different set-ups, which include both the pre-packaging and packaging design models. Figure 21 displays the pre-packing model in the production area in series. For this model the pre-packaging stations will be set-up side by side. The storage area is placed above the production area for easy access to the cabinets and shelving holding the supplies needed for pre-packaging. With both lines being in series, the forklift has easy access and well over 9 feet to maneuver around the production area.

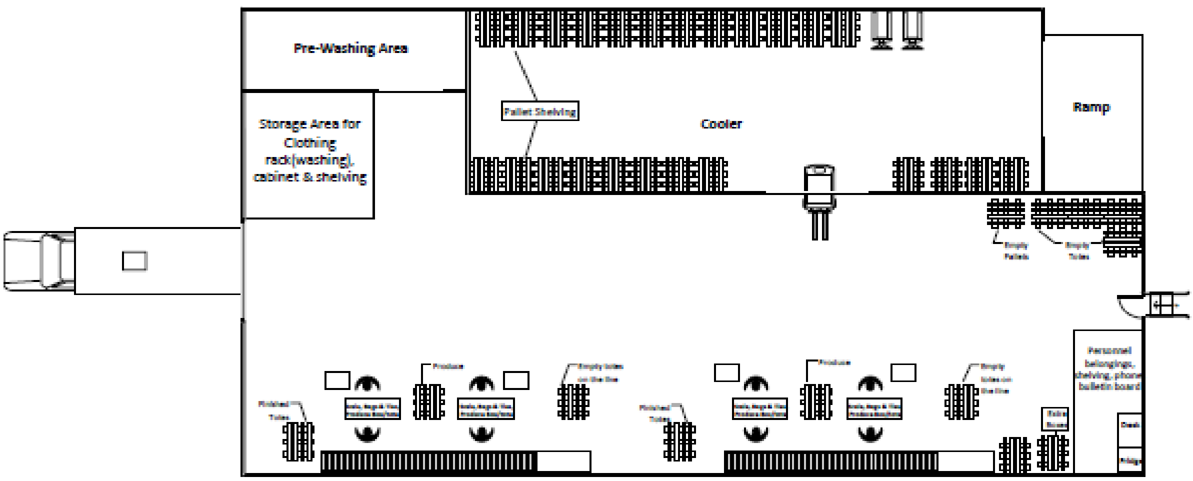

Figure 21: New Facility Series Layout Design Pre-Packaging

Figure 22 displays the same series layout with the packaging model in the production area. The model shows the double line in series utilizing the maximum capacity of the space.

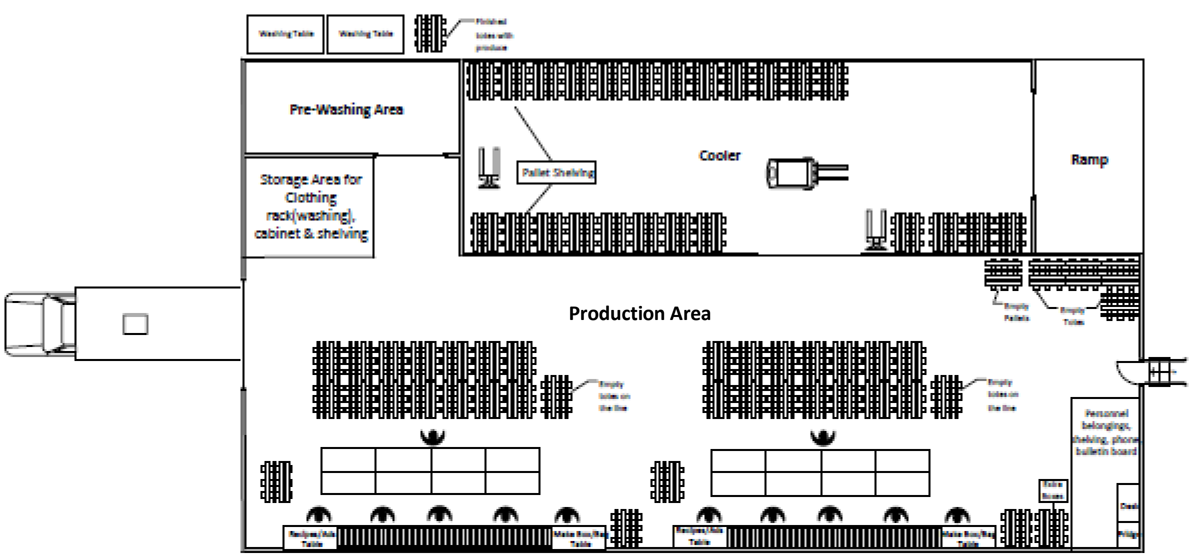

Figure 22: New Facility Series Layout Design Packaging

This layout is designed for one way flow through the facility. First, the forklift comes up the ramp into the cooler to drop of the produce or to lay out the produce in the production lines. The aisle width in the production area is 9 feet for forklift safety regulations. When the pallet of produce boxes is complete, a pallet jack is used to move from each of the lines to the loading dock for delivery. For the initial setup of the packaging lines, there are empty totes, pallets, and boxes nearby in the right corner of the production area. One of the only concerns with the placement of empty totes, pallets, and boxes is the distance the employee would need to go to reach the second packaging line, which adds tremendously to the total distance traveled.

The cooler utilizes the maximum capacity of the floor space, fitting 24 pallets on the ground with at least 10 feet for the forklift to maneuver the pallets. In order to fit all the produce needed for packaging every day, pallet shelving would be implemented to double the amount of pallets. On the other hand, one of the issues with the current cooler design is the ability for the forklift to pick-up pallets in the back corners, a pallet jack may be needed for the tighter spaces which may add wasted time for setup.

The pre-washing area is an outdoor overhang located at the top left of the facility. With the building being two feet above the ground, an employee can easily wash the produce above the pre-washing tables. The placement of the pre-washing area allows forklifts to safely drive on the outside of the facility, above the building where no through traffic will be allowed. The storage area is placed next to the pre-washing area for close proximity to the clothing rack and shelving with needed supplies. The personnel area is the taped off section located near the entrance to the facility for all employee belongings. Included in this area is a desk, phone, fridge, bulletin board for announcements and schedules, and shelving for personnel belongings. However, in this design, there is no restroom in the facility for the employees. This adds tremendously to the amount of wasted and idle time used for the employee to leave the line to use the restroom.

Parallel

The second layout alternative utilizes a more spacious facility with a larger cooler space. Included in this design is the production area, cooler, pre-washing, and a storage area for supplies. The total dimensions of this facility layout are 95' X 55'6". Figure 23 below displays the parallel production area layout with the pre-packing operation. With the two production lines in parallel to each other, there is a lot of excess space for the forklift to move around. One of the many benefits with this layout is that the pre-packing supplies are located next to both pre-packing lines which eliminates the total distance traveled.

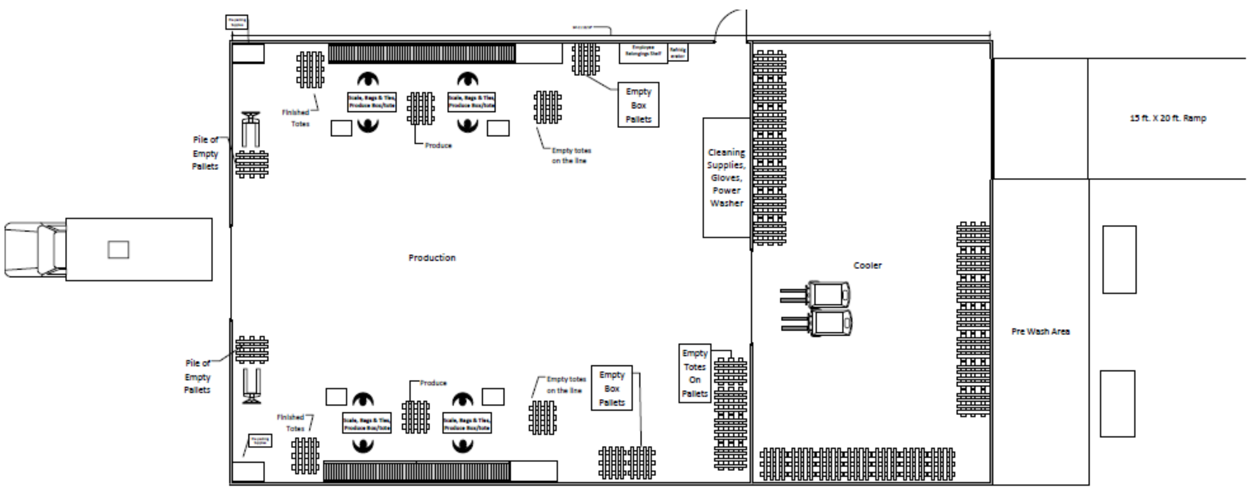

Figure 23: New Facility Parallel Layout Design Pre-packing

Figure 24 below displays the packaging operation in the production area for the second layout.

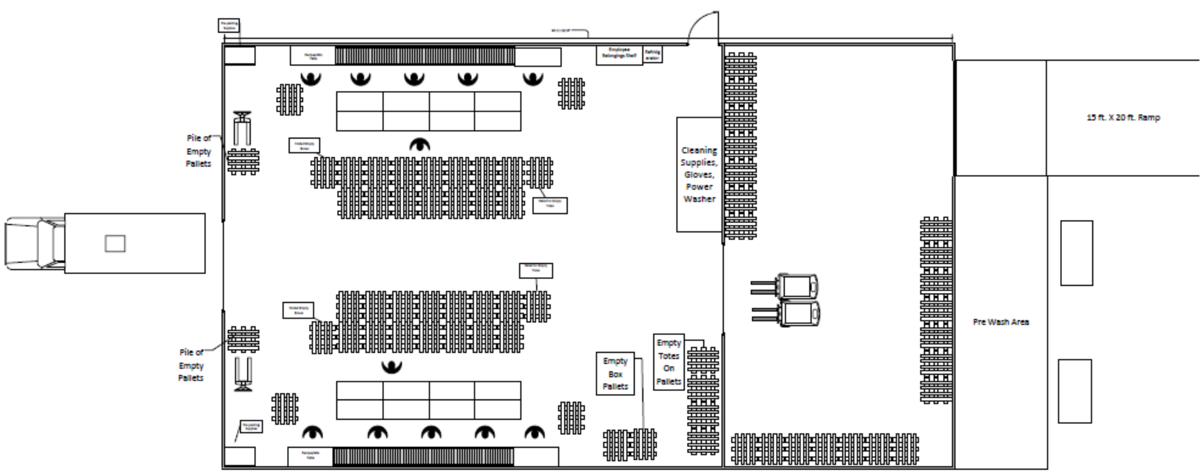

Figure 24: New Facility Parallel Layout Design Packaging

This layout is also designed as a one way flow through the facility from the cooler to production line and finishing at the loading dock. The packaging line utilizes full capacity of the facility floor with the supplies needed close by to each packaging line. One of the benefits of the packaging lines being in parallel is close proximity to the loading dock once the boxed pallets are completed. One of the biggest changes in this facility design is the capacity of the cooler space. Over 21 pallets can fit on the floor with plenty of room for the double wide forklift to move around. This cooler will also use shelving pallets to get the maximum capacity of storage for the pallets of produce. The benefit of using the double wide forklift for packaging set-up is time that will be reduced when bringing the produce pallets onto the production floor. However, there is a lot of wasted floor space in the cooler that can't be used if a forklift is going through it. Another main area for the facility is the overhang pre-washing area which is located near the ramp and cooler. The benefit of the location of the pre-washing area is the close proximity the forklift must travel to take the produce to the hydro-cooler once washing is completed. On the other hand, in this design, the employee must walk through the cooler to get the supplies needed for pre-washing.

Automation

After developing several layouts and developing a hybrid solution from the previous designs the team also considered incorporating automation into the last layout. This is an option to consider if Talley Farms decides to heavily invest in the Fresh Harvest program as its own business entity. The same building dimensions will be used as enough space exists to allocate the chosen automation options. The prepacking and packaging systems were analyzed to determine which sections would benefit from automation. The sections that were considered for automation are box folding, palletizing, picking, and transportation of boxes for the packaging systems. For the prepacking system the weighing and bagging sections were considered.

Tools Considered for Automation

- XP-E3000R ROBOX - a robotic case erector costing $10,000 will be utilized in the beginning of the packaging line to automate the box folding section. Its small footprint and modular design will easily integrate into the existing packaging line and will replace the menial and repetitive task of folding boxes.

Figure 25: Automated Box Folder

- A700 Robotic Palletizer Machine – a robotic palletizer costing $12,000 will be utilized at the end of the packaging line to automate palletizing section. This eliminates the repetitive motion and back injuries that come with manual palletizing.

Figure 26: Robotic Palletizer

- Gantry Robot – a gantry robot, an estimated $180,000, would be utilized to replace the worker who refills the depleted boxes from the fold up tables; this would be located off of the main

packaging line. This would eliminate some of the heavy lifting this position requires, and most likely be faster than human refilling.

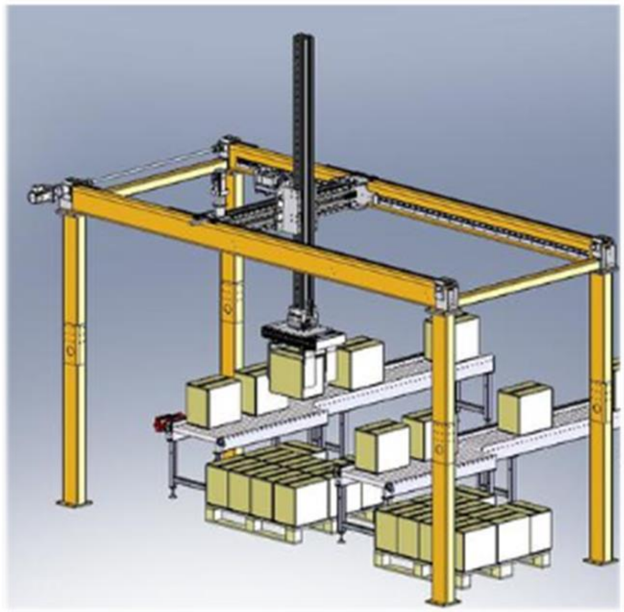

Figure 27: Gantry Robot

- Conveyors – Conveyors, costing an estimated total of $ 31,752, would be used to transport boxes down the packaging line and towards the source produce table. It would help pace the line appropriately, and minimize the amount of packaging employees leaving the line to move boxes.

Figure 28:Automated Conveyor

- Pre-packing Machine – the vertical filler, estimated at $38,000, would be used to replace the manual prepacking process to accelerate the process significantly. This would be located off of the main line, and utilized specifically for the produce that requires prepacking.

Figure 29: Automated Pre-packaging Machine

Proposed Automation Layout

After identifying automated components for the facility design, the team generated a facility layout on the same facility footprint as the previously described proposed layouts. It is shown in Figure # below.

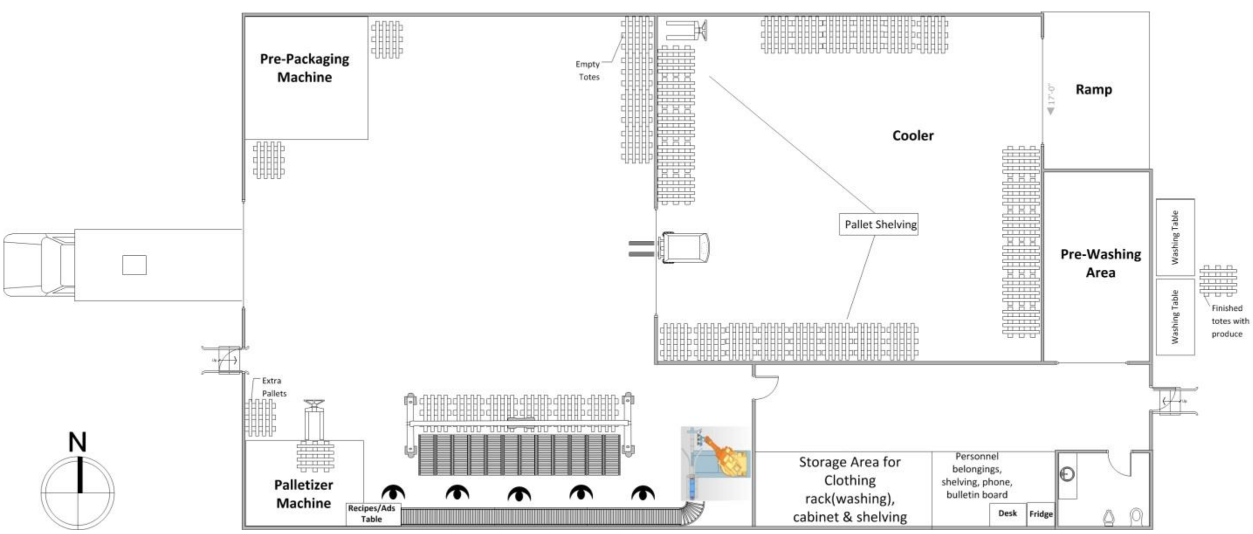

Figure 30: New Facility with Automation Layout

Overall, the facility contains much more open space, but the flow of the produce and final product moves in the same flow patterns as previously proposed layouts. Pre-packing would be completed off of the main line, and a qualified technical supervisor would be required as well.

Summary and Automation Feasibility Analysis

After creating this alternative facility layout design, we estimated the total investment cost on top of the facility cost to see if automation was feasible; the results are shown in figure #. Overall the total cost investment for automation equipment is estimated at 271,752. From this significant extra cost, the team concluded that the investment would not be justifiable. The benefits it would offer the Fresh Harvest program do not match with the current business priorities.

Equipment	**Total Net Profit per year**	**Company**
Conveyor	$31,752	Bastian Solutions
Vertical Filler	$38,000	Alibaba
Robotic Box Erector	$10,000	**XPAK**
Robotic Palletizer	$12,000	Columbia OKURA
Gantry Robot	$180,000	BPMatic
Total Cost	**$271,752**	

Table 1: Investment in Automation

Results

Proposed Solution

The fourth facility layout alternative was developed using properties of the first two facilities; automation was not cost effective for Talley Farm's business requirements. The total dimensions of this facility layout are 99' X 56'. In this layout, different areas of the facility are sectioned off into the production area, cooler, pre-washing area, and employee area. This design incorporates a parallel layout setup in the production area. The production area utilizes the space for both pre-packing and packaging operations as seen in the figures below. The pre-packing operation, shown in Figure 31, has two separating packing lines with 4 employees at each one. The storage area, with the supplies needed for pre-packing, is located in the taped off section of the employee area to the right of the facility. However, it is much closer to the bottom pre-packing line compared to the top pre-packing line which adds transportation time in the initial set-up phase. Empty totes are placed next to each packing line to eliminate transportation during the pre-packing operation.

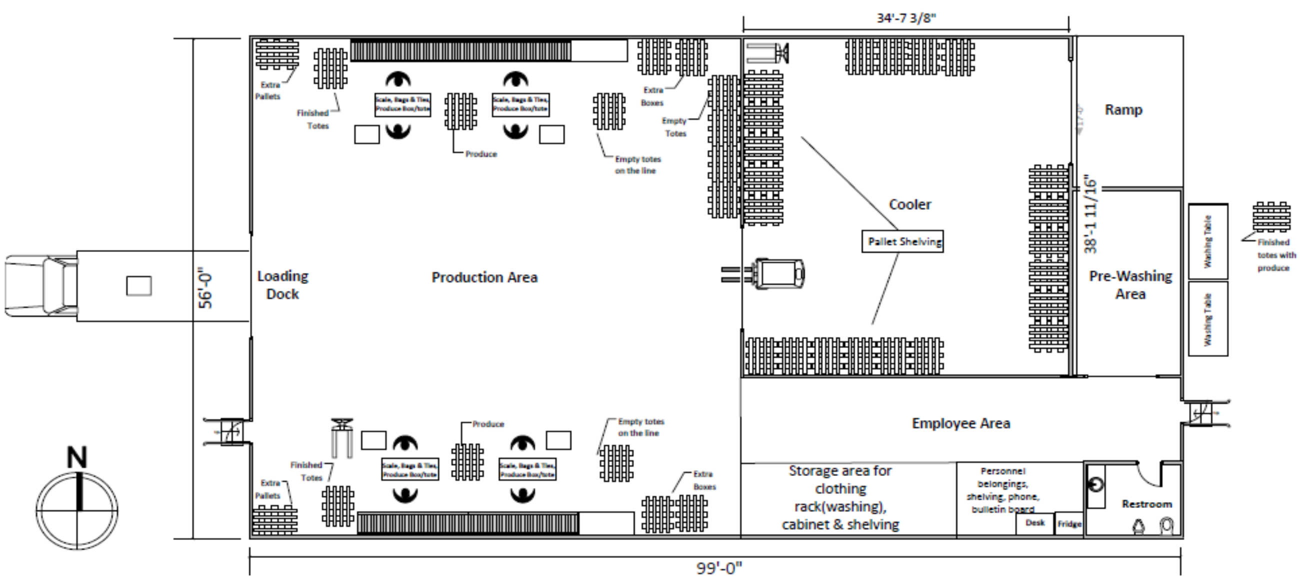

Figure 31: New Facility Proposed Layout Design Pre-packing

The packaging operation, as seen in Figure 32 below, has two separate packaging lines in

parallel utilizing the maximum floor space capacity.

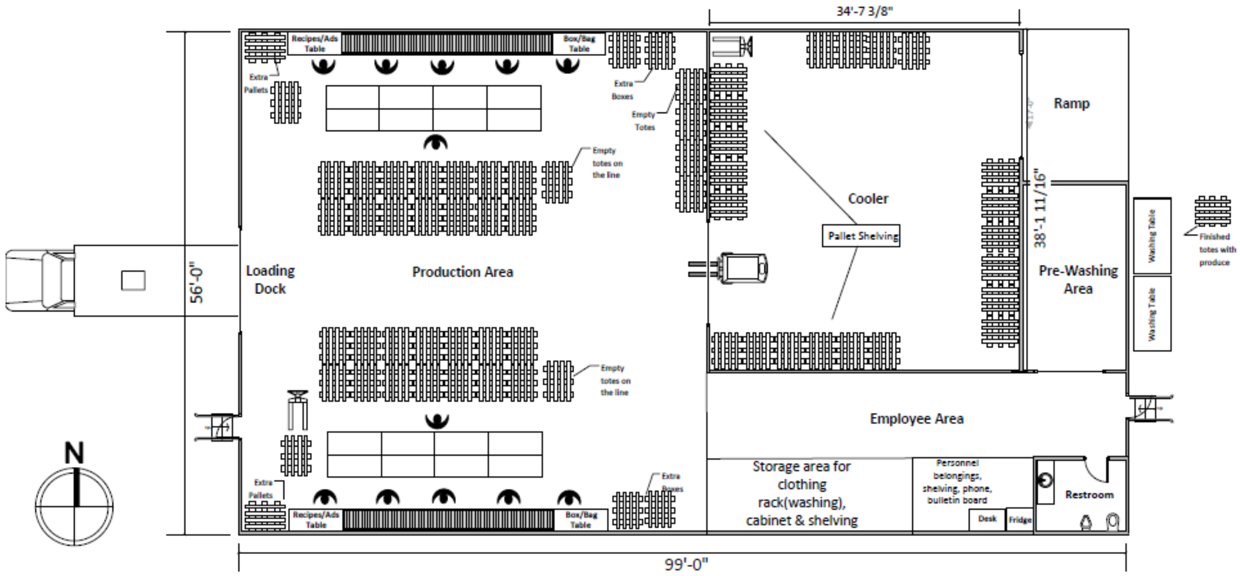

Figure 32: New Facility Proposed Layout Design Packaging

This layout is also designed as a one way flow through the system. The forklift enters the facility through the cooler and into the production area to drop off the produce. When the produce boxes are completed, pallet jacks are used to maneuver the pallets to the loading dock. This layout minimizes the distance traveled from the end of the packaging line to the loading dock for both lines. The production area has 9 feet aisles down the center of the two lines in order for the forklift to move the finished pallets into the truck. Empty box pallets and stacks of empty pallets are located near both packaging lines, which minimizes transportation time. Although the empty totes pallets are located closer to the upper packaging line, they are not needed during the packaging operation.

The cooler is approximately 1,330 square feet, allowing more space for the forklift or even double forklift to maneuver throughout. Over 21 pallets can be placed on the floor of the cooler allowing all of them to be moved by forklifts. Pallet shelving will be used in the cooler as well, in order to store all the produce pallets needed for the demand of 5000 boxes per week. This is the cleanest storage for the produce pallets, as well as the most space efficient. However, in order to move the pallets to and from the shelves will require a forklift. Figure 33 below displays an industrialized pallet shelving system.

Figure 33: Example Pallet Shelving System

The pre-washing area was placed in a similar location as shown in layout two but has access to the facility without going through the cooler. The benefit in this layout is the close proximity to the taped off storage area that stores the rack, and shelving with supplies needed for employees to wash the produce.

The main addition to this facility design is the taped off employee area. This area can either stay sectioned off just by the tape or have a wall built to make a completely separate room for the employees. This area has designated storage for all personal belongings along with a desk, phone, fridge, and bulletin board similar to the area in the first layout alternative. Another addition made in this employee area was a unisex restroom for the workers. This will save a tremendous amount of time wasted walking to another area of the farm to use the restroom.

Short Term

Currently, the Fresh Harvest program is reaching levels of up to 475 boxes in one day. With this capacity, it is a very safe assumption that the program can handle up to 2000 boxes per week, four 500

box days; that is roughly 500 more boxes than are currently being made weekly. This short term solution is recommended and should be suitable for a necessary capacity of up to 2000 boxes per week.

For the short term, the team proposes the layout in Figure 34 shown below. For this layout to function properly, as described in the Alternative Solutions section. This layout, as mentioned previously, is more ergonomic, standardized, consistent, utilizes less inventory, and has an increased throughput. However, in order to implement and utilize this procedure, investments must be made.

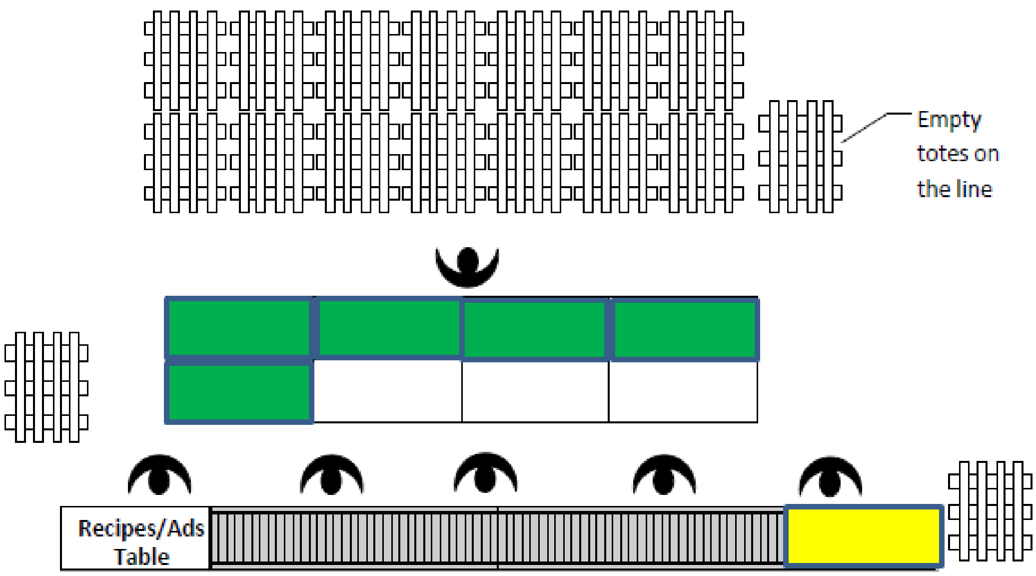

Figure 34: Economic Recommendations for Current Facility

Investments

- Six plastic foldable tables with a table size of 72” by 30” need to be purchased. 5 of these tables will be utilized for the staging area of the layout. These tables are highlighted in green. The other table will be utilized for the box folding area; this table is highlighted in yellow. These tables, cost about $85 each.

Figure 35: Plastic Folding Chair

- 2 Rolling Bins for waxed folded boxes and non-waxed folded boxes need to be purchased for efficient disposal of boxes emptied for both the pre-packing and the packaging processes. These bins on rollers will cut down transportation times, as well as keep both the pre-packing and the packaging workspaces clean. These roller bins, dimensioned at 35” X 24” X 28” , cost about $192.

Figure 36: Rolling Bin

Overall, these investments should allow for a more efficient and organized packaging procedure to be practiced. It will allow the proposed system design to be fully taken advantage of, and will help to increase the capacity of the Fresh Harvest program in the limited space it currently has. Along with these investments, the row of plastic wrapped boxes closest to the door to the pre-packing area constricts available pallet jack space. For this reason, it would be beneficial to also have these boxes moved.

Long Term

The proposed facility design includes significant initial investment; for this project loose estimates were used for all financial analyses and justifications. Currently, the facility space that the team recommends covers 5,540 square feet. This facility, including significant cooler space, two packaging lines, and necessary prewashing area, has the estimated capacity of 5000 boxes per week. However, justifying this investment requires the current system and its capacity. For this analysis, the team has

made multiple assumptions:

- According to a loose estimate by Ron Flechs, the facility manager at Talley Farms, this facility could be built for $200,000.
- In total, the facility investment would cost $210,000. This includes buying pallet shelving, which had a cost roughly estimated cost of $3,000.
- Cooling equipment, which can be very expensive, does not need to be invested in; the vacuum cooler has excess capacity to cool the new facility.
- The current system can pack 2000 boxes per week.
- Any box demand above 2000 boxes per week cannot be capitalized on without investment.
- Therefore, profit from boxes above 2000 per week is only made with the investment.
- Net profit per box is $10.
- The number of boxes ordered per week equals 55% of the total number of subscribers. This is the current proportion.
- The Payback Period refers to the time in years for the $210,000 to be paid back once the referenced boxes per week are reached.

Following the assumptions listed above, at the level of 5000 total subscribers or 3879 boxes per week, the investment of $210,000 would be paid back in .46 years. In a more optimistic approach, at 5430 boxes per week or 7000 subscribers, the investment would be paid back in .26 years. These results are showcased in Table 2 below.

Total Subscribers	Every Week Subscribers	Boxes Per week	Total Net Profit per year	Initial Investment Total	Pre-Tax Gains from Investment (Per year)	Best Case PBP (yrs)
2720	1500	2110	$1,097,221	$0	$0	0
3627	2000	2814	$1,463,096	$0	$0	0
3867	**2133**	**3000**	**$1,559,909**	**$0**	**$0**	**0**
4000	2206	3103	$1,613,560	$210,000	$150,464	1.40
5000	2758	3879	$2,016,950	$210,000	$457,041	0.46
7000	3861	5430	$2,823,730	$210,000	$806,780	0.26

Table 2: Economic Analysis Long Term

Although the table above shows values with very rough estimations, they are useful because they show the potential quick return this facility could offer. Also, these values show that the current facility is suitable for an estimated 900 more subscribers. This gives Talley Farms amble time to continue to analyze and reflect on the potential growth of the program.

This facility's benefits stretch farther then the Fresh Harvest program also:

- It would open up the space the program currently occupies, so that during certain times of the year, especially during bell pepper season, space for storage would not be a concern.
- The pre-washing area has the potential to be utilized to wash items for the pending Talley Farms produce market.
- The facility would be a permanent location for the Fresh Harvest program, which allows for more aggressive marketing of the program and therefore Talley Farms.
- In a worst case scenario, the facility could be utilized as a large cooler and storage facility for other programs within Talley Farms.

Overall, the team suggests investing in the facility, because the team believes the Fresh Harvest program can generate the necessary demand. It is clear from communicating about the project with friends and faculty that many potential customers in San Luis Obispo, especially on Cal Poly's campus, can be capitalized on. With effective marketing, and continued growth, the best option proposed by the team is building and investing in the proposed solution.

Conclusion

Future Topics and Next Steps for Fresh Harvest

After meticulous analysis and multiple iterative designs, the team concluded that two solutions needed to be generated for both short term and long term company gains. The short term requires a redesigned approach to the current packaging for short term benefits. Overall, it is projected that with these packaging improvements, an increase from about 2000 boxes to 3000 boxes in capacity can be possible. For the long term benefits, an evaluation of four facility alternatives was completed. And the final comprehensive layout design is proposed with features including a prewashing area, two processing lines, with space which can be utilized for both pre-packing and packaging, an employee area for a desk, refrigerator, bathroom, and employee personal belongings, an independent loading dock so pallets of finished boxes can be directly loaded for shipment, and a cooler designed for only Fresh Harvest produce storage. Along with this facility, Standard Operating Procedures for new proposed pre-packing and packaging set ups are included. These new process designs should not only boost productivity for the new facility, but should also help to increase the production capacity of the current area.

Through the systematic approach followed throughout this project duration, the team has offered viable suggested solutions for both the short term perspective and the long term perspective for meeting demand. However, the team suggests these topics for Talley Farms to pursue in the upcoming future.

The topics the team suggests for future project managers at Talley Farms include:

- Create more comprehensive cost analysis
- Evaluate pre-washing and identify possible alternatives.

- Create a more complete simulation of the proposed system.
- Conduct a 5S event of the storage area.
- LEED/Solar panels
- Road design for new facility location
- Exit door orientation
- Further Safety regulation Research
- *Cooler capacity evaluation*

Overall, these topics will continue the iterative process of developing a more justified and suitable solution after more data is collected and analyzed. This solution will address the problem statement more effectively, and will be developed when the demand growth for the program is better understood.

Immediate Suggestions

Although initial trials of the new system showed promising results, continued monitoring of the process as well as careful analysis of the throughput is very important throughout implementation. The team has many suggestions for continued improvement and effective analysis which include:

- The efficiency and effectiveness of the new procedure should be recorded. Extra attention should be paid to the rate boxes are made, as well as the set up time required.
- Working elements for this new system, especially the set-up, should be continually edited and improved upon. Trying to find consistent, standardized procedures day to day will help overall efficiency and should shorten set up times.
- Continue to monitor the state of Talley Farms potential produce market. If this market is implemented, changes in a new facility design may have to be considered.
- Prepare for procedural changes due to bell pepper season, and limited space.

- Continue to forecast expected needed capacity of program, and evaluate possible areas for potential customer demand.
- Maintain the social environment of the packaging line while changes are in place. The employees who work for the Fresh Harvest program are the center of its success. Remember to consider their input and recommendations for the system.

With careful monitoring, and an overall commitment to the new process from all stakeholders, the program could see significant improvements in capacity and efficiency.

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