BOX REDESIGN: ELIMINATING WASTE AND IMPROVING SPACE UTILIZATION BY REDUCING BOX PALLET FOOTPRINT

A Thesis

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To the Graduate Council:

I am submitting a thesis written by Kimberly M. Harris entitled “Box Redesign: Eliminating Waste and Improving Space Utilization by Reducing Box Pallet Footprint”. I have examined the final copy of this thesis and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science with a major in Industrial Engineering.

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DEDICATION

To my incredibly supportive parents that have sacrificed for me, whom I will always love and appreciate, thanks for giving me the drive and ambition that allowed me to pursue my own interests, as well as, planting the foundations in my mind to further enhance my education. To my encouraging friends and family who have cheered me through, thanks for being with me through the struggles. To my undergraduate professors, thanks for pushing me throughout my final years there and never giving up on me. To my high school instructors that know me well, thanks for seeing the achiever in me and displaying extra interest to further groom me for success. To those that were blessed with the gift of envy, thanks for paying attention. And, to those who I have met along the way that have had encouraging words and wisdom, thank you.

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ABSTRACT

The XYZ Corporation is headquartered in Dalton, GA. It is a full service flooring company with approximately 30,000 employees. The company sells woven and tufted broadloom carpet and other flooring products in Canada, Mexico and the U.S., and exports worldwide. One of their projects is to develop an improved packaging design, which will help in streamlining the internal packaging and distribution process. The aim of this research is to eliminate waste and improve the use of shipping pallets to reduce the amount of footprint used by applying techniques of lean manufacturing systems.

To understand the existing packaging method, a flow diagram was created. Non-value added functions were identified by applying aspects of lean principles. The existing model is identified with four kinds of waste: Overprocessing, Transportation, Waiting, and Inventory. With the improvement of the packaging model, it aided in eliminating those kinds of wastes.

The research further addresses the related effects from overprocessing and transportation in our environment. Based on the study, the necessary recommendations are provided to restructure packaging, which will lead to improved distribution.

Table of Contents

List of Figures

Definitions

Action Plan: Detailed list of what, who, and by when each recommendation will be carried out.

Activity: A specific task or set of tasks that are required by the project, use up resources, and take time to complete.

Assembly Line: A manufacturing process in which parts are added to a product in a sequential manner using optimally planned logistics to create a finished product much faster than with handcrafting-type methods.

Carpet: A textile floor covering that is distinguished from the more general term "rug" by being fixed to the floor surface and extending wall to wall.

Event: The result of completing one or more activities.

Footprint: Defined as the area taken up by some object.

Gantt Chart: A graphical representation of the duration of the tasks against the progression of time.

Kaizen: Japanese for continuous improvement; a Japanese philosophy that focuses on continuous improvement throughout all aspects of life.

Lean: A production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful.

Learning Rate: A decreasing fixed percentage of the previous value.

Less-Than-Truckload (LTL): A type of truck carriers that are used when shipments are not large enough to justify dedicating an entire trailer to the shipment.

Muda: Traditional general Japanese term for activity that is wasteful and does not add value or is unproductive.

Network: The arrangement of all activities and/or events in a project arrayed in their logical sequence which defines the project and the activity precedence relationships.

Pallet: A wooden frame on which certain goods are stacked in warehouses and during transport.

Product Development Process: The sequence of steps or activities which an enterprise employs to conceive, design, and commercialize a product.

Project Charter: A written agreement between the PM, senior management, and the functional managers who are committing resources and/or people to the project.

Quality System: The process, organizational structure, procedures, and resources used to control variables to produce a product of consistent quality that meets defined specifications.

Raw Material: A material or substance used in the primary production or manufacturing of a good

Return on Assets (ROA): An indicator of how profitable a company is relative to its total assets.

Rug: A piece of thick heavy fabric that usually has a nap or pile and is used as a floor covering

Six Sigma: A virtually no defects philosophy of continuous improvement.

Value Chain: Refers to the points along the production chain where value is added.

Value Stream: The specific activities required to design, order, and provide a specific product, from concept to launch, order to delivery, raw materials into the hands of the customer.

Waste: Anything beyond the minimum amount of materials, manpower, and machinery needed to add value to the product or service.

Section I: Introduction

Difficult marketing conditions have called for companies to downsize. For the past few years, citizens of the United States have feared a slumping economy. As we enter 2009, the United States economy is in a downward spiral. The downturn began at the end of 2007 as businesses started slashing jobs which they have done every month since (Reynolds, 2008). Many thought that it was headed towards a recession. Though experts and government officials argued that it was not so and encouraged citizens not to worry, many factors proved otherwise. Crude oil prices began to raise, layoffs increased, and companies began to shut-down many of their branches. Though several were observing the changes taking place in the worsening economy, major notice of the U.S. recession increased in the summer of 2008 when gas prices continued to hit record highs (Gas prices hit another record high, 2008). In addition to the rising gas prices and layoffs, many homes went into foreclosure. Citizens began to struggle to pay their bills. Car notes went into collections and the stock market hit an all-time low. And, with the layoffs, many families lost their health insurance. The number of government aid and welfare recipients increased.

In addition to the worsening economy, the effects of global warming have really taken affect on the businesses as well. Global warming has been a problem for years. Part of its cause is through using and wasting energy in our homes and at work (Mullen, 2006). Yet, it's mostly triggered by the increase in greenhouse gases in the atmosphere (Mullen, 2006). Evidence shows that landfill waste is a major contributor to greenhouse gases. Landfills contribute 10% of the gases that are warming the globe (Ladd, 2002). Industries

and commercial operations have used landfills as integral parts of their operations (Tammemagi, 1999). As a result, many companies have taken the initiative to take part in "going green." Going green is about reducing waste, whether it's energy, refuse or resources (Mullen, 2006). Many have found new ways to recycle and reuse their products and the elements involved in creating those items. "Going green" has had an effect on buyers as well. Many buyers look to use companies who are increasing their efforts to reduce, reuse, and recycle to help preserve the environment. Being environmentally aware doesn't just work at a cost level, but at a reputation level, too. Consumers are starting to value businesses, from supermarkets to hotels, that are environmentally sound (Mullen, 2006). And, as consumers become more informed, products that offer green benefits and have less impact on the environment increase appeal (Chmielecki, 2007). Since this has become a major factor, companies are now looking for new ways to reduce their costs while improving the services to its customers.

With all that's happening in the economy, the nation's manufacturing sector managed to slip into a recession with almost nobody seeming to notice (Leonhardt, 2007). With the global credit crunch and budget cutbacks, funding is being preserved for what works. Manufacturing companies have made good use of this. Many carpet manufacturers are figuring out ways to better streamline their processes and create sustainable designs for their products. One area in which companies are trying to implement is the distribution area. Freight is one of the top five expenses for most companies (Polakoff, 2008). Various measures have been taken to reduce the freight costs.

Smart Packaging is an area that is newly being considered. Smart Packaging is to bring the market new and improved product concepts where the packing does more than simply contain and protect the contents (Packaging Materials & Technologies, 2008). Packaging must do more. It must add to the value-proposition of the purchase by offering new levels of functionality that result in consumer benefits.

In manufacturing facilities, many products are packaged in cardboard boxes, stacked onto pallets, and then loaded onto the less-than-truckload (LTL) trucks to be taken to the distribution centers. One challenge that manufacturers face is how to get more product to the customer without increasing their cost. In an effort to help decrease manufacturing costs, freight costs, and landfill waste, companies should focus on improving space utilization.

A. Overview

The focus of this research is to suggest ways to eliminate waste and improve the use of shipping pallets by redesigning the shipment boxes to reduce the amount of footprint used at XYZ Manufacturing facility. The implementation process includes:

1. Studying the problem.
2. Defining the project development process by use of flow diagrams and a Gantt chart.
3. Analyzing the process using lean methodology to identify waste which are: overprocessing, transportation, inventory, and waiting.
4. Using concepts, tools and techniques from Product Development, Technical Project Management, and Strategic Management & Technology.
5. Applying concepts of lean manufacturing.
6. Understanding and awareness of the current economy and environmental conditions.

B. Manufacturing History

The manufacturing process involves taking raw materials through a variety of steps to produce a finished product. Efficiency in the manufacturing process correlates directly to the cost of the product to the consumer. As efficiency of production increases, the price of the product decreases. History shows that customers value quality and variety, manufacturers desire efficiencies, and workers desire satisfaction from their jobs.

Craft

During the 19th century, the United States (U.S.) industrialized rapidly and quickly. American inventor, Eli Whitney, devised the concept to use uniform interchangeable parts by which a broken machine could be easily replaced with an identical part. Preceding this

concept, manufactured items were individually tailored by hand (what's up in factories, 2009).

Mass Production

In the early 1900s, Henry Ford developed a system of mass production for assembling automobiles. Ford built on methods already being used by some factories to produce items quickly and in large quantities. In applying those methods, Ford was able implement the use of interchangeable, standardized parts that could be assembled quickly and break down complex operations into simple tasks that would allow hire of unskilled workers to do them. Ford later put an assembly line into operation. Prior to this system, automobiles were put together by skilled craftsmen and fitters who carefully hand-tooled each part (what's up in factories, 2009).

Mass Customization

Mass customization leverages the capabilities of advanced industrial production to better serve niche markets or individual customers in cases where an individualized product adds value and helps turn a profit. It proactively manages product variety in the environment of rapidly evolving markets and products (what's up in factories, 2009).

C. U.S. Carpet and Floor Covering Industry Background

This U.S. industry comprises establishments primarily engaged in manufacturing woven, tufted, and other carpets and rugs, such as art squares, floor mattings, needlepunch carpeting, and door mats and mattings, from textile materials or from twisted paper, grasses, reeds, sisal, jute, or rags and/or finishing carpets and rugs (US Census Bureau, 1997). The United States supplies approximately 45 percent of the world's carpet (Carpet and Rug Institute, 2009). The industry posted gains each year since 1991 and has been

dominated by sales of tufted rugs and carpets, which accounted for 92 percent of the industry's revenues. Woven carpet and rugs totaled just 4 percent. All other varieties (primarily needle punch) totaled 6 percent (Carpets and Rugs, 2009). During the early 2000s the industry's growth slowed due to weak economic conditions (Carpets and Rugs, 2009). Carpet mills specialize in producing carpet backing, as well as carpets and rugs. Intense competition in the 1980s led forward-looking companies to acquire both manufacturing and retailing operations in an effort to cut costs (Carpets and Rugs, 2009).

Tradition, profits, and consumer preferences, more than a specific management approach, have historically dictated the organization of the carpet industry. Conventionally, the product flows to residential and contract clients primarily via the following two methods: directly from mill to client or from mill to dealer or wholesale distributor, then to a retailer who sells to a client (US Census Bureau, 1997). However, in a more cost savings move, some in the industry have decided to eliminate the distributors and deal directly with the retailers.

Research and technology for the carpet industry has focused on producing high quality and environmentally-friendly products, and responding to contemporary customer needs. To these ends, several innovations were in progress in the early 1990s (US Census Bureau, 1997).

Included in those innovations were waste reduction and reclamation. Some in the industry campaigned to reduce carpet trim waste, which not only costs U.S. carpet companies an estimated $25 million per year, but also generates tons of useless material destined for landfills (US Census Bureau, 1997). Other ideas being studied for waste reduction included reducing widths of backings and developing pure synthetic backings to

match face fibers, which would allow burning or recycling of the whole carpet (US Census Bureau, 1997). Many adopted the goal of "zero manufacturing waste." Recycling programs focused on recycling or converting packaging materials (US Census Bureau, 1997).

Carpet manufacturers are striving to minimize the quantities of natural and energy resources used in day-to-day operations. They are reducing waste, reusing and recycling raw materials, packaging materials, waste, and by-products. Individual companies are pursuing environmental efforts at different points in the manufacturing process.

D. XYZ Manufacturing Background

XYZ Manufacturing is a manufacturing plant that produces woven and custom tufted rugs. XYZ consists of a wide range of machine made area rugs. This facility is a division of the XYZ Corporation, headquarter in Dalton, GA, USA. The company sells woven and tufted broadloom carpet and other flooring products in Canada, Mexico and the U.S., and exports worldwide. It sells its residential products to distributors and retailers and offers commercial products directly to customers through its contract flooring divisions. The company began producing rugs in the 1990's and has become a top brand in the area rug industry. XYZ Corporation is a full service flooring company with approximately 30,000 employees.

E. Waste and the Environmental Footprint of the Carpet Industry

Carpet makers are on a mission to minimize their environmental footprint (Chmielecki, 2007). This has become the new benchmark of forward-thinking corporate leadership in virtually every area of the flooring business (Chmielecki, 2007). The carpet industry is among the most progressive in the country in addressing the potential human health, environmental, and sustainability factors of its products (Carpet and Rug Institute,

2008). As stated by the VP of technology and sustainable development for Mohawk Industries, there are three reasons why going green makes good business sense. It involves environmental responsibility, economic viability, and social equity (Chmielecki, 2007). Strides have been made in reducing the environmental footprint of carpet, including landfill use, carbon dioxide emissions, energy consumption, waste generation, water usage and hazardous air pollutants (Carpet and Rug Institute, 2008). For more than a decade, reduce, reuse, recycle has been a mantra in the carpet industry (Carpet and Rug Institute, 2008).

Waste has become an issue of increasing concern. To further assist manufacturers, many facility managers have implemented Kaizen and Lean techniques into their daily functions. Kaizen aims to eliminate waste. In Kaizen, cost management is not cost cutting (Moore, 2007). Costs are reduced by reducing waste through activities that continuously improve productivity, quality, and reduce waste (Moore, 2007).

F. Raw Material Cost Improvement

Raw material costs are driven by supply and manufacturing costs. In an effort to reduce raw material costs, many manufactures are trying different approaches such as: reducing the number of suppliers in exchange for higher volume and lower pricing, searching worldwide for suppliers that appear to have good value, not just low price, and improving manufacturing performance to increase yields and reduce waste and scrap (Moore, 2007). Raw material and feedstock purchases often represent some 50 percent or more of total manufacturing costs, which in many larger manufacturing plants only represent 5 percent to 20 percent of total costs (Moore, 2007). If companies could achieve a 10 percent reduction in raw material costs, this would amount to the equivalent of 25 percent to 100 percent reduction in direct labor costs (Moore, 2007).

G. Packaging Redesign

Package redesigning is a trend that is being passed along many of the manufacturing markets. In the food processing and packaging industry, many beverage companies are adopting a slimmer box design that was marketed in 2001. The "Fridge Pack" is a reinvention to the traditional suitcase package used for sodas and other beverages. Its longer, narrower design allows consumers to store an entire case in their refrigerators. Prior to this design, research showed that consumers would store some of the cans into the refrigerator and the remaining into cabinets and pantries. This innovative design increased the chances of consumers choosing a beverage from the 12-pack to another drink.

In the cereal division of the food processing and packaging industry, Kellogg is testing a new package format that will contain the same amount of food in a smaller box. The new boxes are designed to more easily fit into consumer pantries. At the same time, they allow retailers to make more efficient use of shelf space, and could enable them to stock a wider variety of products (Heller, 2009). In addition, the new design will use 8 percent less packaging material than the current box (Heller, 2009).

H. The Trucking Industry "Green" Efforts

The trucking industry is making efforts to participate in "going green." In May 2008, The American Trucking Associations outlined a series of proposals, ranging from reducing truck speeds to increasing vehicle size and weight limits. The group said those measures would reduce fuel use by more than 86 billion gallons and cut 900 million tons of carbon dioxide emissions over the next 10 years (Natter, 2008).

Trailer space is one of the primary determinants in the amount of product that can be shipped to the customers. Many LTL carriers say that about 85 percent of their shipments are now palletized (Bohman, 2002).

Smaller shipments are more expensive shipments. LTL rates are more expensive on a per hundred pounds basis for lighter shipments (Polakoff, 2008). As with an observation that was made with Boston Scientifics airline's pallets, a space analysis showed that the existing cartons were too wide to optimize the pallets' carrying capacity (Levans, 2002).

I. Problem Statement

This thesis involves developing a box design that will reduce pallet footprint and eliminate waste for rug products that are shipped to the XYZ customers. Many manufacturers are not maximizing the space on the pallets used in shipping. If companies are able to redesign the packaging for the products to a more efficient smaller size, pallet footprint can be reduced. And if the pallet footprint is reduced, it is possible to add more products to the pallet.

Trial for this study was conducted on two XYZ customers. The present layout for Customer A consists of a standard pallet with measurements 40''x 47'' and 32 cardboard boxes (Figure 1). Each box consists of 2 rugs, which totals 64 rugs per pallet. The current positioning of the boxes is 10 stacks high, 3 across, with 2 boxes stacked on the end (Figure 1). The present layout for Customer B consists of a standard pallet with measurements 40''x 47'' and 60 cardboard boxes (Figure 2). Each box consists of 2 rugs, which totals 120 rugs per pallet. The current positioning of the boxes is 10 stacks high and 2 rows of 3 across (Figure 2). Once pallets are stacked completely and wrapped for shipping, it is then

taken to the dock and loaded onto a LTL trailer. From there, the pallets are taken to the XYZ distribution centers and then to the customer.

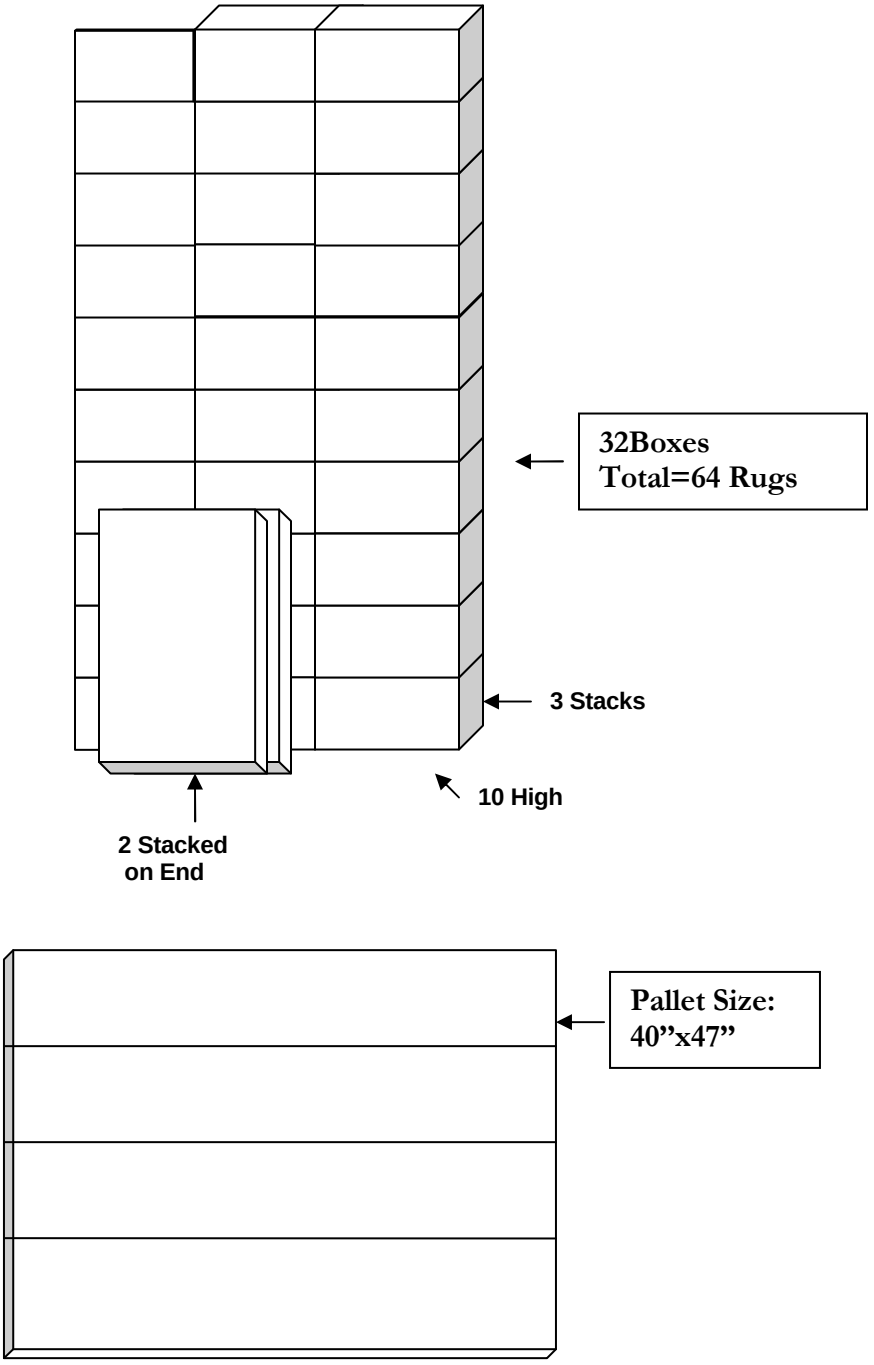
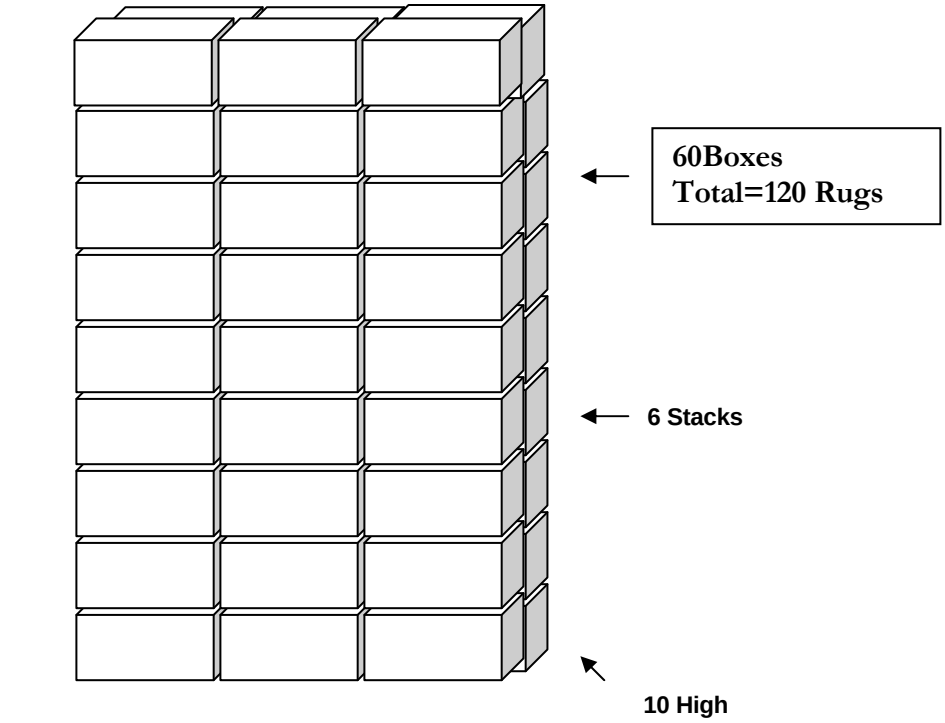


Figure 1: Customer A Current Layout



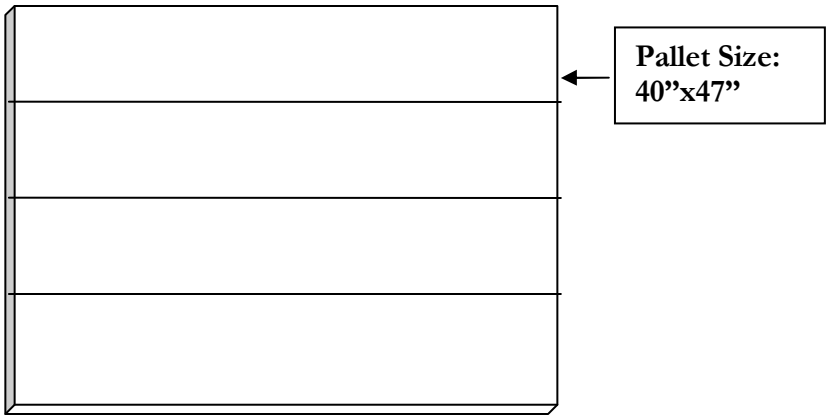


Figure 2: Customer B Current Layout

Presently, XYZ has a standard rate on its LTL shipments. The LTL trailers can hold approximately 26 pallets.

These layouts have the following problems that affect the output:

1. Box sizes are too large, reducing the magnitude of space to be used on the pallet.
2. Costs associated with the amount shipped are considerably greater than the budgets set forth by the company due to cutbacks.

Effects of the problem:

1. Fewer products are shipped to the customers in the current trailer travel time.
2. Trailer costs are not being optimized.
3. More money is being spent than necessary in the facility, causing less money to be spent on other projects and departments.
4. Time consumed by LTL trailer travel to and from plants, distribution centers, and customers to move shipments increases mileage, wear and tear, and costs associated with the trucks.
5. Increased raw materials.
6. The larger box sizes are more likely to increase the amount of waste that is sent to the landfills after the product is removed and placed in the customers' stores.
7. Possible increased air pollution.

J. Research Significance

The goal of this thesis is to study and eliminate waste in the existing structure for shipping pallets and develop a new model for the shipment boxes to reduce the amount of footprint used, reduce manufacturing and freight expenses, increase customer supply, and improve certain environmental conditions. This will streamline both the internal and

external distribution process. To identify waste, the research applies concepts from lean manufacturing. Recommendations are provided based on the results obtained.

K. Thesis Organization

This thesis has five sections. Section One provides an introduction and background to the problems of the manufacturing industry and environment, the history of manufacturing, background information about the company, information on common and recently used practices, the problem statement, and research objectives. Section Two contains information obtained from the literature in the following areas:

1. Lean Manufacturing
2. Product Development
3. Project Management
4. Strategic Management

Section Three presents the research statement and methodology. Section Four discusses data analysis and results. And, Section Five delivers the conclusion and recommendations.

Section II: Literature Review

A. Introduction

Lean is a methodology that is used to accelerate the velocity and reduce the cost of any process by removing waste (George, 2009). It identifies the steps that add value and eliminates the rest. Lean methodology has helped companies throughout the world achieve huge economic benefits while improving quality, costs and cycle time (Magnet, 2009).

B. Lean Manufacturing System

Lean Manufacturing is a manufacturing system and philosophy that was originally developed by Toyota and is now used by many manufacturers throughout the world (Epply, 2003). Lean originally focused on reducing waste in manufacturing processes. However, now huge gains are being achieved by applying Lean to transactional and service environments. The basics of Lean include the following key concepts:

- Specify Value: Value addition is judged by the customer through specific products with specific capabilities at specific prices through dialogue with specific customers.
- Identify the Value Stream: The value stream is all of the activities that are necessary to bring a specific product through three critical business tasks:
    - Problem solving
    - Information management
    - Physical transformation
- Pull: Real customer demand pulls products and information through the system. Inventory is waste and producing/working on items that are not used is waste. Remove excess capacity or increase the rate of customer pull.

- Flow: The distance that product/information must travel and the time it takes. Reduce non-value add time by reducing time and/or distance between resources.
- Perfection: Opportunities for improvement are identified and implemented. These include the reduction of effort, time, space, cost, and mistakes as well as increasing customer satisfaction.

Lean production also embodies the theory of kaizen. It is an ongoing process involving a variety of activities to reduce waste and inefficiency. The concept of implementing lean manufacturing systems starts with identifying and defining value from the point of the customer (Prahladaraj, 2004). It focuses on the elimination of waste in all forms. This results in designing and developing products and services that will fulfill customer's requirements (Prahladaraj, 2004).

B.1. Toyota Production System (TPS)

With the incorporation of assembly lines to produce needed items in a timely manner, the Toyota Production System (TPS) ensured that quality was built into each component at each process in the sequence. The attitudes and tools of the TPS heighten awareness and give whole new perspectives on identifying waste and the unexploited opportunities. One of the key steps in Lean and TPS is the identification of which steps add value and which do not.

B.2. Lean Thinking

Lean thinking provides a way to do more and more, with less and less while coming closer and closer to customers with exactly what they want (Womack, 1996). Implementing "Lean" can create superior financial and operational results. Many

companies are turning to Lean Manufacturing in an effort to become more profitable (Rampersad, 2007).

B.3. Waste (Muda)

"Waste" can be defined in many ways. From a lean standpoint, it is anything that does not add value to the customer. Furthermore, waste is broken up into two categories: Type I Waste and Type II Waste. Type I Waste is found in activities that add no value to the customer, but are necessary, in the current development framework, to deliver the product. Type II Waste is found in activities that do not create value and can be eliminated immediately. "Waste reduction" is an effective way to increase profitability. Waste occurs when more resources are consumed than necessary to produce the goods. Proportionally, elimination and reducing wasteful activities, becomes a tremendous increase in value to the customer (Rampersad, 2007). Lean identifies the seven types of wastes:

1. Defects: Any aspect of the service that does not conform to the customer needs.
2. Inventory: Any work-in-process that's in excess of what is required to produce for the customer.
3. Transportation: Unnecessary movement of material or information.
4. Waiting: Any delay between when one process step/activity ends and the next step/activity begins.
5. Overprocessing: Using a more expensive or otherwise valuable resource than is needed for the task.
6. Motion: Needless movement of people.
7. Overproduction: Production of service that does not conform to the customer needs.

B.4. Waste (Landfill)

In an environmental sense, landfill waste can also be seen as non-value added.

Waste Types:

As stated in *The Waste Crisis*, waste generators will be grouped as follows (Tammemagi, 1999):

- Municipal Waste: Produced by the everyday activities in a community. Sources include:
  - Residential-houses and apartments
  - Commercial-stores, restaurants, office buildings, service stations, etc.
  - Institutional-schools, courthouses, hospitals, etc.
  - Construction and demolition-construction sites, road repair, building demolition, etc.
  - Municipal Services-street-cleaning, garden and park landscaping, wastewater treatment, etc.
- Industrial Waste: Garbage produced by consumer goods from the industry suppliers. Sources include:
  - Byproducts of the manufacturing or chemical processes used by different industries.
- Hazardous Waste: Generally waste that is toxic or hazardous to humans or to the environment.
- Radioactive Waste: A specific type of industrial waste mainly generated by electricity-producing nuclear reactors, research, and medical procedures.

Environmental problems, such as, the greenhouse effect, ozone depletion, groundwater depletion and pollution, deforestation, desertification, and species extinction are effects of landfill waste that have threatened the globe and remove value from our planet. The space occupied by thousands of landfills displaces millions of acres of land from other uses, such as agriculture and urban development (Tammemagi, 1999). Landfill waste impairs the environment, uses up valuable resources, and places limitations on future resources.

B.5. Kaizen

Kaizen uses common sense tools, checklists, and techniques that do not cost money. It further eliminates the gap between the customer and the supplier. To stay competitive, businesses use kaizen to change the way they do business.

B.5.1. Kaizen Events

Kaizen events are highly effective team events that focus on achieving rapid results. In Kaizen, teams use various Lean techniques, such as Value Stream Mapping, 5S, and Total Productive Maintenance. Kaizen events are:

- Widely Applicable: Can be used in both manufacturing and non-manufacturing environments.
- Team Based and Cross Functional: Team members can be from various functions of the business.
- Planned and Tied to Business Goals: Events are planned in advance and tied to business goals and/or value streams.
- Focused in Scope: Events are very focused.
- Short term, Fast, and Iterative: Events last approximately 2 to 5 days.

- Highly Effective and Results Oriented: Kaizen events will generate quick results, measurable results, establish the baseline, and measure change.
- Use Many Lean Tools
- A Learning Experience: Every member of a Kaizen team will walk away from the event learning something new.

B.5.2. Value Stream Mapping (VSM)

Based on customer's specification on value, the producer maps a value stream by which a product is manufactured (Prahladaraj, 2004). VSM is a Lean technique used to analyze the flow of materials and information currently required to bring a product or service to a consumer. The value stream includes every activity required to deliver a product or a service. It helps you visualize more than just the single-process level in production (Rother, 2003). VSM is managed in two steps: Current State and Future State.

- **Current State of the Process**
  - Detail Process Flow Steps:
    - Maps out the "as is" process.
    - Observations of the current state are made.
    - Recommendations, issues and actions, are posted.
    - Identify waste issues
  - Identify "who" does which steps in the current process details
  - Timeline of how long each process step takes
- **Future State of the Process**
  - Maps the reformed process.
  - Lists the improvements.

- Forms an Action Plan.

VSM helps see the sources of waste in the value stream. VSM is commonly used in Lean environments to identify opportunities for improvement in lead time.

After developing value stream mapping, management should focus on the elimination of waste from the manufacturing system (Prahladaraj, 2004).

"Parking Lot" Issues

Typically, during the VSM process, many issues are discussed and noted. However, some of the issues may not directly be in the scope of the overall streamlining process. The "parking lot" is a phrase used for an area placed on a separate sheet from the VSM that is used to contain issues discussed but were out of scope, but should be considered for future action. The "parking lot" generally contains ideas that may require capital expenditures.

B.6. Quality Function Deployment (QFD)

Quality Function Deployment (QFD) is a comprehensive quality system that systematically connects the needs of the end user with various business functions and organizational processes such as, marketing, design, quality, production, manufacturing, sales, etc., aligning the entire company toward achieving a common goal (QFD Institute, 2009). It is designed to help planners focus on characteristics of a new or existing product from the viewpoints of market segments, company, or technology development needs. QFD provides a system of comprehensive development process for:

- Understanding customer needs
- What 'value' means to the customer

- Understanding how customers or end users become interested, choose, and are satisfied
- Analyzing how do we know the needs of the customer
- Deciding what features to include
- Determining what level of performance to deliver
- Intelligently linking the needs of the customer with design, development, engineering, manufacturing, and service functions
- Intelligently linking Design for Six Sigma (DFSS) with the front end Voice of Customer analysis and the entire design system

QFD helps transform customer needs into engineering characteristics for a product or service.

C. Value

The word "value" is an abstract word and has several classifications based on the context in which it is used. As noted in *Lean Thinking*, the critical place to begin any improvement effort is clear specification of the value of a product as perceived by the end customer (Rother, 2003). Value is created by the producer (Womack, 1996). From an engineering point of view, the economic value of a product or process is the main concern (Kaufman, 1990). From the customer's standpoint, this is why producers exist (Womack, 1996). In Lean, value is separated into two categories: value-added and non-value-added. Value added activities are those that change the form, fit, or function of the material and is something that the customer is willing to pay for. Non-value-added activities are an activity that utilizes time or resources, but does not meet the customer requirements.

D. Generic Competitive Strategy

Strategic thinking involves a comprehensive analysis of a business (or division) in relation to its industry and its competitors (Cox, 2008). Three competitive actions we may choose are:

1. Cost leadership: By achieving the lowest production cost, we can either reduce prices or keep improved profits to reinvest.
2. Differentiation: Better design, service, delivery, etc.
3. Focus: Knowing the product and the customer very well.

Strategic positions can be based on customers' needs, customers' accessibility, or the variety of a company's products or services (Cox, 2008).

E. Project Planning

The primary purpose of planning is to establish a set of directions in enough detail to tell the project team exactly what must be done (Meredith, 2006). It is crucial that the project's objectives be clearly tied to the overall mission, goals, and strategy of the organization (Meredith, 2006). Project plans are usually constructed by listing the sequence of activities required to carry the project from start to completion, and developing an action plan to complete the activities.

E.1. Project Charter

The project charter typically details the expected project deliverables, often including the project's schedule and budget (Meredith, 2006). It attests to the fact that senior management, functional managers, and the Project Manager (PM) are in agreement with what is to be done, when, and at what cost (Meredith, 2006). In Lean environments, the PM is often interchangeable with the Six Sigma Manager. Charter steps include:

1. Signature Block: The list of management involved with the project, their signatures and dates signed.
2. Process/Product: Description of the process/product in which opportunity exists.
3. Project Objective: Description of the project's purpose.
4. Project Significance: Presents the primary and secondary key measures, the improvement that is targeted, and the impact on the entitlement.
5. Business Results: Presents the current year dollar amount of the anticipated improvement in business performance.
6. Entitlement Category: Presents when the anticipated annual savings occurs.
7. Team Composition: Lists the full-time members and any expert consultants on the team.
8. Benefit to External Customers: Explains who they are, what benefits they will see, and what their most critical requirements are.
9. Project Timeline: Lists the key milestones/dates, projected start dates, projected completion dates, and actual completion dates.

The three main uses of the project charter are:

1. To authorize the project.
2. To serve as the primary sales document for the project.
3. To use as a focus point throughout the project.

E.2. Scheduling

A schedule serves as the basis for monitoring and controlling project activity (Meredith, 2006). The basic approach of all scheduling techniques is to form a network of

activity and event relationships that graphically portrays the sequential relations between the tasks in a project (Meredith, 2006). Tasks that must precede or follow other tasks are then clearly identified, in time as well as function (Meredith, 2006).

Gantt Chart

One of the oldest but still one of the most useful methods of presenting project schedule information is the Gantt chart (Meredith, 2006). A Gantt chart is a type of bar graph that illustrates a project schedule. It shows planned and actual progress for a number of tasks displayed as bars against a horizontal time scale (Meredith, 2006). The Gantt chart can be helpful in expediting, sequencing, and reallocating resources among tasks, as well as in keep track of how things are going (Meredith, 2006).

F. Learning Curves

A way to measure improvement is to use learning curves methodology. Learning curves are useful both to cost estimators and analysts (Federal Aviation Administration, 2009). The learning curve was adapted from the historical observation that individuals who perform repetitive tasks exhibit an improvement in performance as the task is repeated a number of times (Federal Aviation Administration, 2009). The extent of task time decreases over time. The reduction in time will follow a predictable pattern. Time needed to produce a unit decreases with each additional unit. The learning curve should be taken into account where labor is significant. Performance improves by a fixed percent each time production doubles.

Types of Learning

- Individual Learning: Improvement when individuals gain a skill or efficiency by repetition of a job.

- Organizational Learning: Improvement from the groups of individuals from repetition and changes in administration, equipment, and product design.

Learning Curve Use:

Internal

- Determine labor standards.
- Establish labor costs and budgets.
- Scheduling.

External

- Purchasing.
- Subcontracting.

Strategic

- Determine volume cost changes.
- Evaluation of company and industry performance.

G. Advanced Product Development Phases

	Phase	Definition
1.	Product Definition	Product specifications and resource prioritization.
2.	Architecture	Simplified concept and optimized architecture including modularity and customization strategies.
3.	Design	Product/Process design as thorough that the need for prototype testing and pilot production is minimized or eliminated.
4.	Ramp-up	Smooth introduction into production with rapid volume ramp-up.

5.	Follow-up	Postmortem to capture lessons learned that can be applied to future projects

Section III: Research Statement and Methodology

This section provides an overview of the research objectives and hypothesis. It consists of the following sections:

1. Research Concept
2. Data Collection
3. Contribution to the Discipline

A. Research Concept

The manufacturing and distribution systems consist of a set of activities that are designed to comply with the requirements of both internal and external customers. Lean manufacturing is used in the manufacturing and distribution systems to improve the operations and methods used, to maximize value, and to eliminate waste. This research uses the concepts of lean manufacturing to identify and improve waste in product packaging and distribution. The objective of this research is to develop a leaner packaging design by analyzing the products using Lean methodology to eliminate the non-value aspects as described with the seven types of waste.

B. Data Collection

Analyzing the packaging process involved in boxed rug shipments resulted in identification of 4 kinds of waste: Overprocessing, Transportation, Waiting, and Inventory. The data collected started with collecting rug samples that are used with the existing shipping boxes. The rug samples were collected according to the customer, rug size, the amount of required rugs per package, and box style used. Once these samples were obtained, alternative folding methods were created. Thus, three types of folds were formed.

The next step was to contact the packaging supplier's sales representative. It was important that the company disclose the reasoning and application of best practice to the supplier in order to improve costs. Meetings were scheduled for the sales representative to measure the new folds and quote new box sizes and prices. Afterwards, the sales representative would email cost and size quotes and later return with samples for the new box models. Measurements of the current pallet fit vs. the alternatives were taken. A flow chart, a Value Stream Map (VSM), and a cost/savings model were created. After analysis of the information obtained, the results showed that there was probable cause to further proceed and continue to pursue the project.

C. Contribution to the Discipline

This research will aid in increasing the application of lean manufacturing to separate entities in both manufacturing and distribution sectors.

Section IV: Analysis

A. Introduction

Section IV discusses the types of wastes that were identified during the improvement phase of the project, quality considerations in the process, and potential obtainable savings from the project. This section also includes the problem definition, organization structure, project scheduling, and the development process flow diagrams.

B. Problem Definition

This thesis involves developing a box design that will reduce pallet footprint and eliminate waste for rug products that are shipped to the XYZ customers. If companies are able to redesign the packaging for the products to a more efficient smaller size, pallet footprint can be reduced. And if the pallet footprint is reduced, it is possible to add more products to the pallet.

Trial for this project was conducted on two XYZ customers. The present layout for Customer A consists of a standard pallet with measurements 40’’x 47’’ and 32 cardboard boxes (Figure 3). Each box consists of 2 rugs, which, totals 64 rugs per pallet. The current positioning of the boxes is 10 stacks high, 3 across, with 2 boxes stacked on the end (Figure 3). The present layout for Customer B consists of a standard pallet with measurements 40’’x 47’’ and 60 cardboard boxes (Figure 4). Each box consists of 2 rugs, which, totals 120 rugs per pallet. The current positioning of the boxes is 10 stacks high and 2 rows of 3 across (Figure 4). Once pallets are stacked completely and wrapped for shipping, it is then taken to the dock and loaded onto a LTL trailer. From there, the pallets are taken to the XYZ distribution centers and then to the customer. Presently, XYZ has a standard rate on its LTL shipments. The LTL trailers can hold approximately 26 pallets.

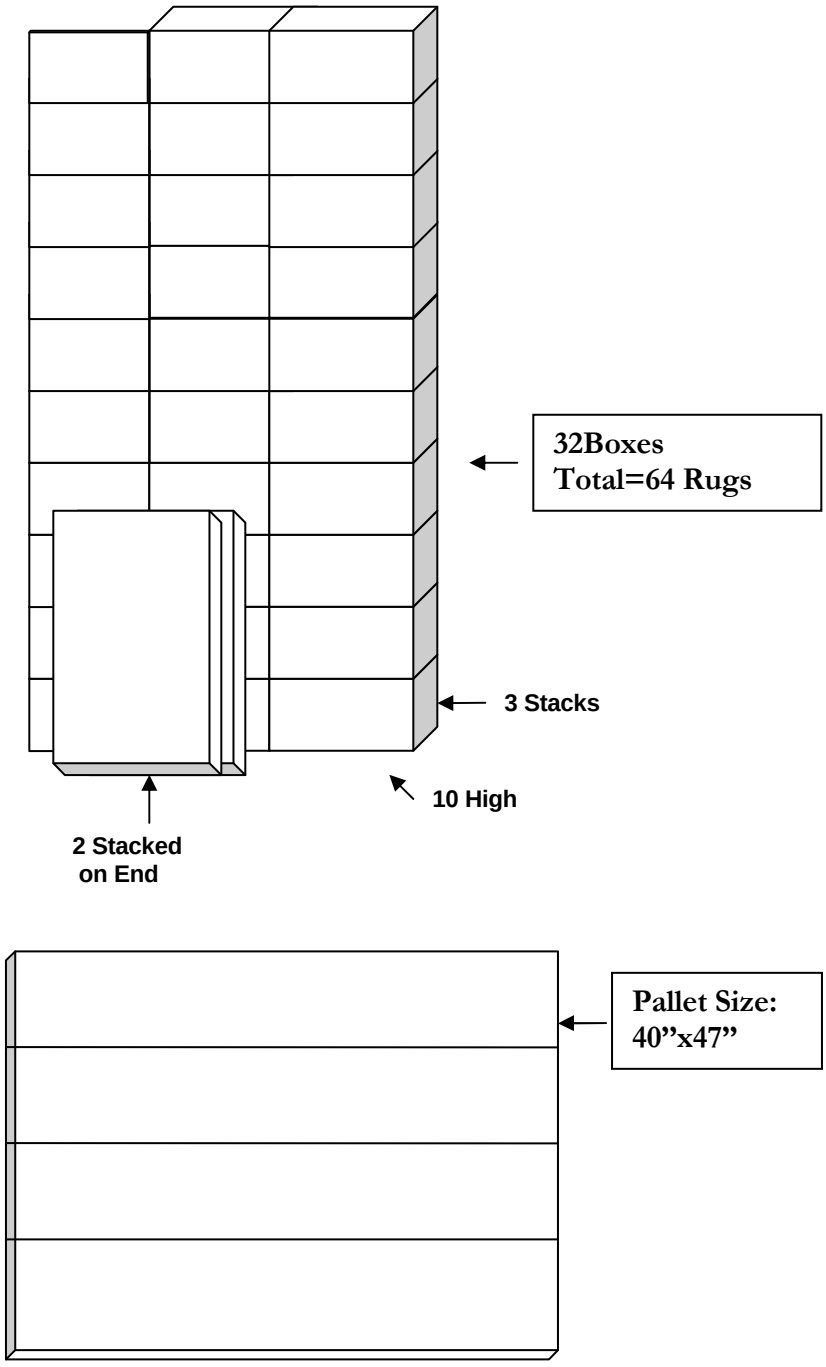
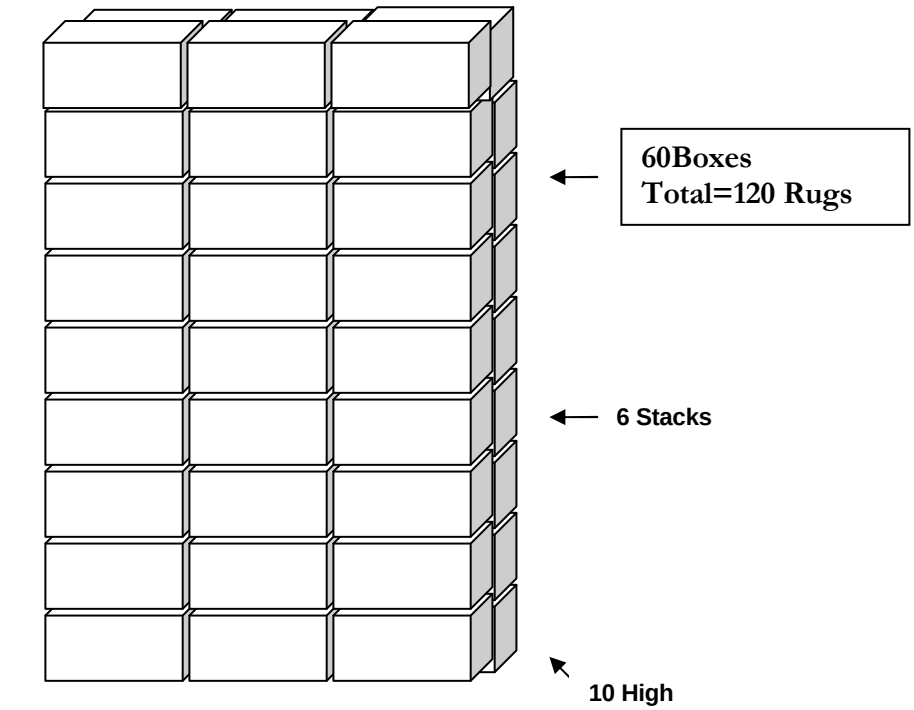


Figure 3: Customer A Current Layout



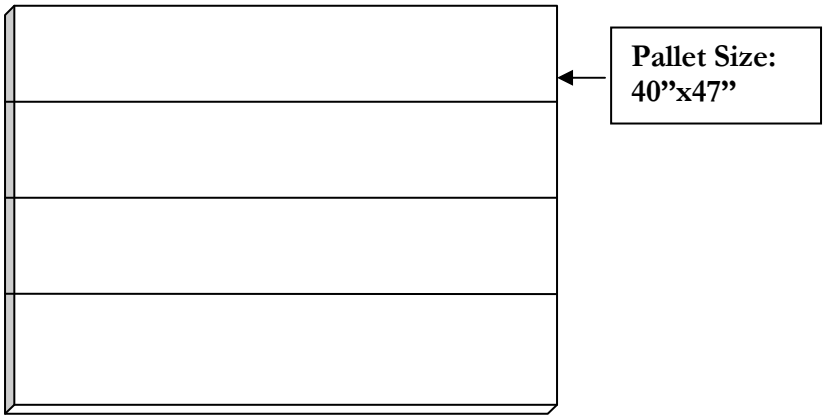


Figure 4: Customer B Current Layout

The current layouts have the following problems that affect the output of product to the customers:

1. Box sizes are too large, reducing the magnitude of space to be used on the pallet.
2. As a result, costs associated with the amount shipped to the customers are considerably greater than the budgets set forth by the company due to cutbacks.

Effects of the problem:

1. Fewer products are shipped to the customers in the current trailer travel time.
2. Trailer costs are not being optimized.
3. More money is being spent than is required in the facility.
4. Fewer funds disbursed on other projects and departments.
5. Time consumed by LTL trailer travel to and from plants, distribution centers, and customers to move shipments increases mileage, wear and tear, and costs associated with the trucks.
6. An increase in plant raw materials.
7. The larger box sizes are more likely to increase the amount of waste that is sent to the landfills after the product is removed and placed in the customers' stores.
8. Possible increased air pollution.

The aim of this project is to use lean manufacturing techniques to eliminate the non-value added activities from the packaging process and develop a box packaging model, which will streamline the distribution process.

C. Organization Structure

The company is in the durable goods manufacturing industry. The facility purchases its products from a number of internal and external suppliers. In turn, those suppliers deliver their products to the facility. Production can be divided into 3 entities: engineering, assembly and manufacturing, and quality. These departments work collectively as an integrated system. Production moves to the distribution division. And distribution moves to the customer. The facility's structure comprises of a mixed organizational system starting from the plant manager. Kaizen and Lean events enable all levels to work together.

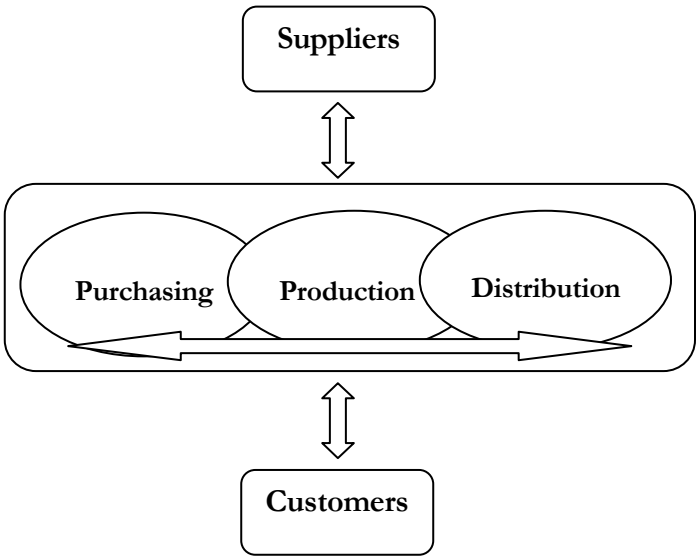


Figure 5: Supply Chain

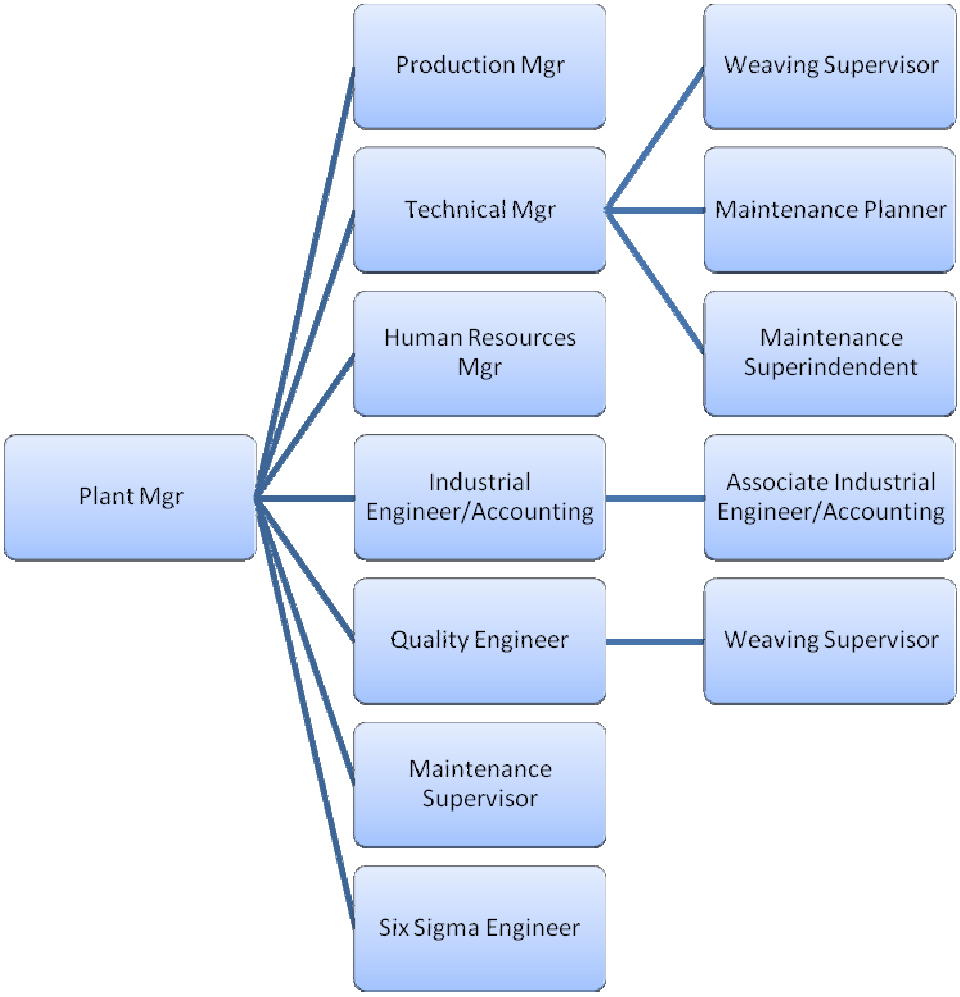


Figure 6: Facility Management Structure

D. Improvement Phase

This project is done with the customer in mind. In effort to decrease the amount of waste in the packaging process, improvement of the placement for boxes on shipping pallets had to be developed. One of the specifications for packaging of customers A and B products is ease of unloading and layout. When the product is shipped to the customers' stores, employees should be able to remove the product in pairs and place it on the shelf for consumers to purchase. To maintain providing this service, management and team

members had to investigate diverse concepts to facilitate that need. Figure 7 illustrates the steps that were implemented to improve the custom.

Development Process

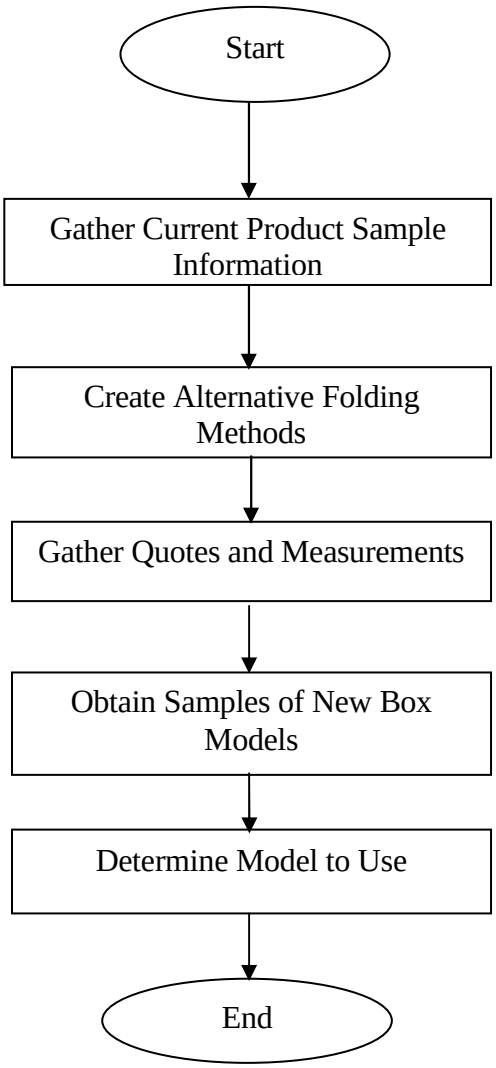


Figure 7: Development Process

D.1. Detail Activities in the Development Process

This section further explains some of the detailed activity involved in the development process flow diagram that demonstrated the steps used to improve the packaging process. Figure 8 gives details to the specific information required in gathering the current product sample information in the development process.

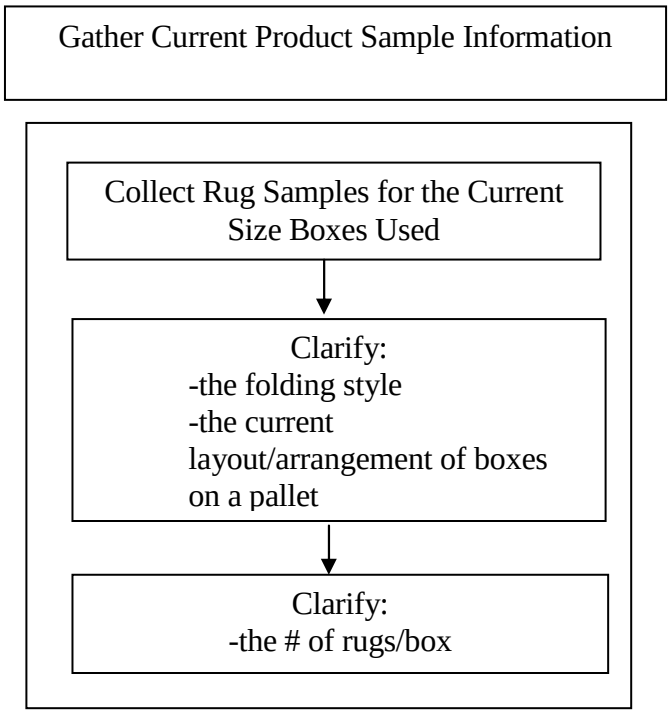


Figure 8: Gathering Current Product Sample Information Process

Figure 9 explains matters that must be considered in the alternative fold creation step of the development process.

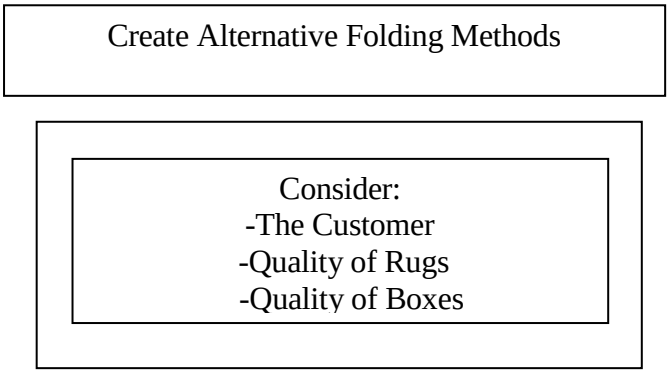


Figure 9: Alternative Folding Methods Process

Figure 10 further breaks down the steps involved in gathering quotes and measurements in the development process.

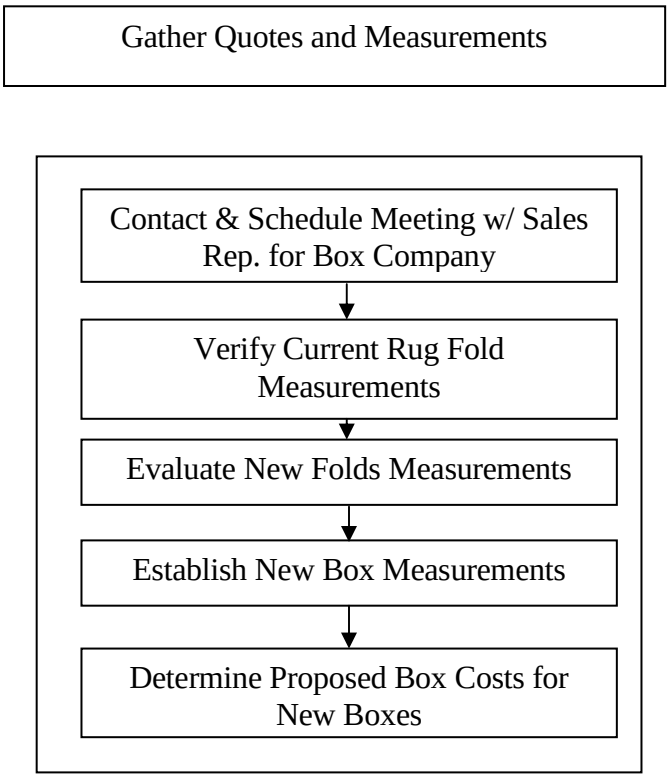


Figure 10: Quotes and Measurements Process

D.2. Waste Elimination in the Packaging Process

Four of the seven types of Type II waste were identified during the improvement process. The first of the seven is overprocessing. Using a slimmer design for the packing boxes was established to be less expensive than the present design being used. Therefore, use of the sleeker model would reduce the amount of facility capital used and the raw material usage from the supplier. In respect to the environment, lessening the amount of cardboard manufactured by using a smaller carton will decrease the amount of cardboard scrap that is sent to the landfills and lessens the effects of municipal waste.

The second of the wastes identified is transportation. The improved design maximizes the area of space that is obtainable on the shipping pallets. For Customer A, the amount of product per pallet is increased by at least 25 percent, which, in turn, adds approximately 31 percent more product to the trailer shipments that are sent to the distribution centers. For Customer B, the amount of product per pallet is increased by at least 33 percent, further increasing the amount of product per trailer shipment by approximately 33 percent also. Furthermore, the maximum optimization of pallet use better utilizes LTL use. As a result, LTL transport to the distribution centers and customers could lessen. To support in these modifications, LTL scheduling would need to be revised to better accommodate the need of the customer. From an environmental perspective, decreasing LTL transfer will further support the overall goal from national trucking carriers and related environmental associations of shrinking the amount of greenhouse gases and other air emissions in the atmosphere.

The third of the wastes identified is inventory. Inventory is a major capital investment affecting cash flow and profitability with the manufacturers and distributors.

Excess inventories subject the manufacturer to additional liabilities for things such as, damages, loss, rework, etc. From making the shipping and transportation operation more efficient with the amended design, optimal inventory levels will descend. Thus, creating more open space throughout the storage areas in the facility. Inventory reduction will also improve the facility's Return on Assets (ROA).

The fourth of the wastes identified is waiting. With the more efficient LTL transfer created, customer waiting will be decreased. Optimizing the pallet space footprint will allow the trailers to carry more products to the customers in less time than the present.

E. Project Scheduling

A Gantt Chart was created to plan how long the project should take. The project is set to last approximately 3 to 4 months, as shown in Figure 11.

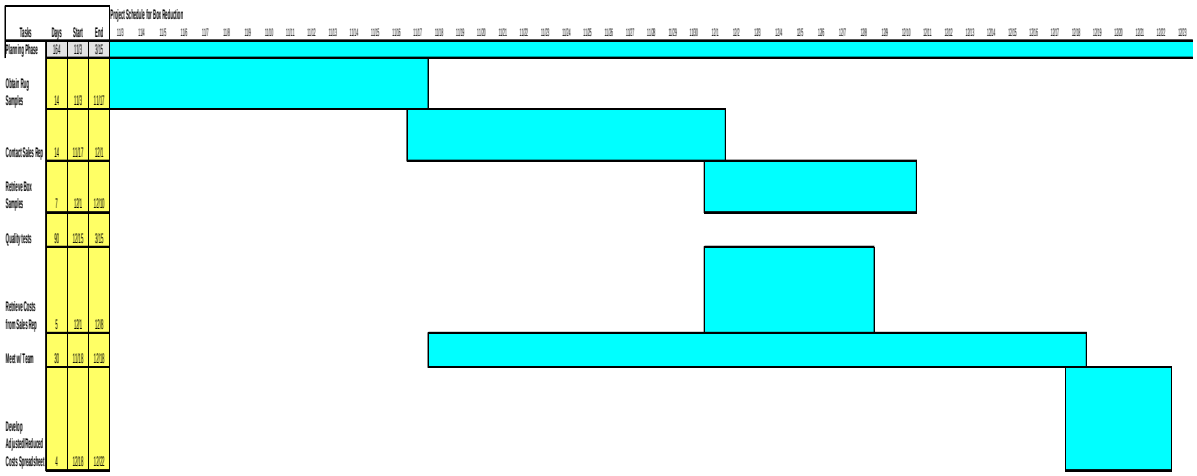


Figure 11: Gantt Chart

F. Box Size

The present shipping boxes' widths diminish the area available that can be designated to more materials being positioned on the pallet. The company wants to use a

smaller shipping carton that would still protect the product inside. In essence, mutually the company and the packaging supplier established that it would be in best interest to both the company and its customer to use the same quality structure as the current. The facility is making an effort to design their new packaging to continue to reliably but cost-effectively protect their products manufactured while decreasing the impact on the environment in waste and greenhouse gas emissions. With the purpose of reducing pallet footprint, the determined concept was to shorten the width and increase the height of the cases. This would require that the configuration of the units per case be changed.

G. Folding Methods

The current method comprises folding individual rugs starting from one end to the middle section and then the other end to the middle section. Subsequently, the rugs are stacked into a pile and added to the boxes in pairs. With the aim of restructuring the current shipping boxes, alternative folding methods were created to lessen the amount of footprint used per pallet. In creating other folds, it was important to maintain the quality standards that the facility holds from its customers. For that reason, quality department managers were also involved in the process to make certain that the new folding techniques would not leave creases and/or wrinkles to the rugs. Trials on the new folding methods in the new box designs are in progress to get an accurate analysis of any potential quality issues.

H. Savings

A savings model was created to compare the prospective revenue obtainable from the alternative layouts created. The facility would be able to obtain a potential 25 percent-37 percent savings in packaging costs per trailer for LTLs that transport product to the

distribution centers for Customer A. For Customer B, the facility would be able to obtain a potential 20 percent savings in packaging cost per trailer. Savings on the distribution end of the process would be obtained overtime from less maintenance that would have to be performed on the trailers due to: increased mileage, wear and tear, and other associated costs. Freight dollars spent per unit should also decrease. If the customers use their own trailers to transport product from their warehouses, they should also notice a decrease in their overall freight charges.

I. Results

Since the closing stages of the development process, 2500 units of the sample boxes have been ordered for a test run. Alternative layout designs have been created. Studies have been conducted on multiple shifts to examine the pace and adaptation to the new folds and box sizes. With repetition, plant workers speed increased. With continued repetition, based on an 84 percent learning rate, the average completion time per package for the units required per pallet would increase to at least 0.0625 minutes.

I.1. Further Savings

The company will save a total of 13 percent savings on all material costs for the customers studied.

Section V: Conclusions & Recommendations

A. Conclusion

With the new design and the increased products added to the pallet, in time, fewer pallets will be used. This results in reduced plant inventory. It will also lower costs in related areas and decrease the amount of cardboard waste that is taken to the landfills. With this change, companies should be able to increase the number of product that is shipped on the truckloads to the customer and better streamline the transportation network by reducing transit times to customers (minimizing the total miles traveled). Current savings on material costs will expand once the model is spread out to the manufacturer company's additional customers. Customers will be able to get the same amount of product in a shorter period of time. Therefore, their required inventory amount will remain the same. The manufacturer can continue to produce products at the rate of the customers' demand, but, the travel cost involved should lessen.

Many companies are practicing using a standard freight charge for the trailers used by the manufacturer, regardless of the weight. Therefore, the customer would be able to receive more products at the same cost. The customer benefits because they would receive more products on one load. With the improved designs, the customer should also be able to better store the products in their warehouses and stores. This should decrease the amount of trailers that are sent to the customer's distribution center and decrease the amount of trailers used. These deductions should further decrease the amount of fuel that's used by the manufacturer's trailers because fewer trailers will be used. The manufacturer would benefit because their customer would be more satisfied in receiving more product in less time. The manufacturer would also benefit, because they'd be getting the same

amount of product in smaller boxes that have the same quality as the current ones used, therefore they'd be shipping more and paying less in material cost.

B. Recommendations

To further expand the latest model concepts and techniques to the other XYZ customers, speak with the research and development representative to present the benefits obtained from this project and gain approval to impart the idea with its customers. Once all is in agreement, move forward with further implementation. If necessary, design a new transportation schedule to implement the changes made. In addition, there should be further exploration of alternative layouts for palletizing the shipping packages.

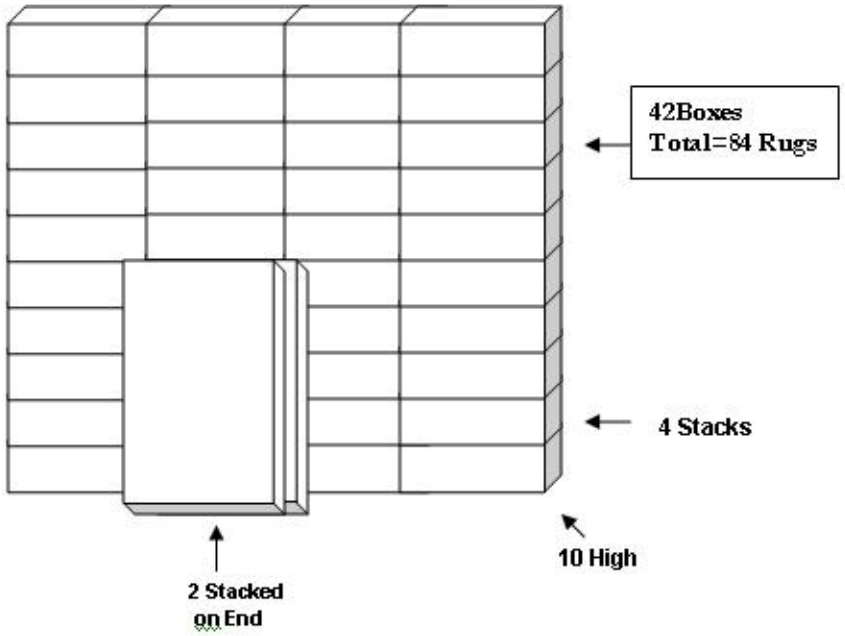
C. Future Research

Further expansion of research includes:

1. Determine whether the new folds add more labor time.
2. Costs associated with new folds and stacking methods.
3. Tests to determine whether the new fold styles will affect rug quality.
4. Current vs. New Method studies: Will or can another technique for packaging be created.
5. Examine developing a pull system for the inventory.
6. Ergonomics: Work-station layout.

Appendix

Figure 12 illustrates one of the alternative proposed layouts conceived for Customer A.

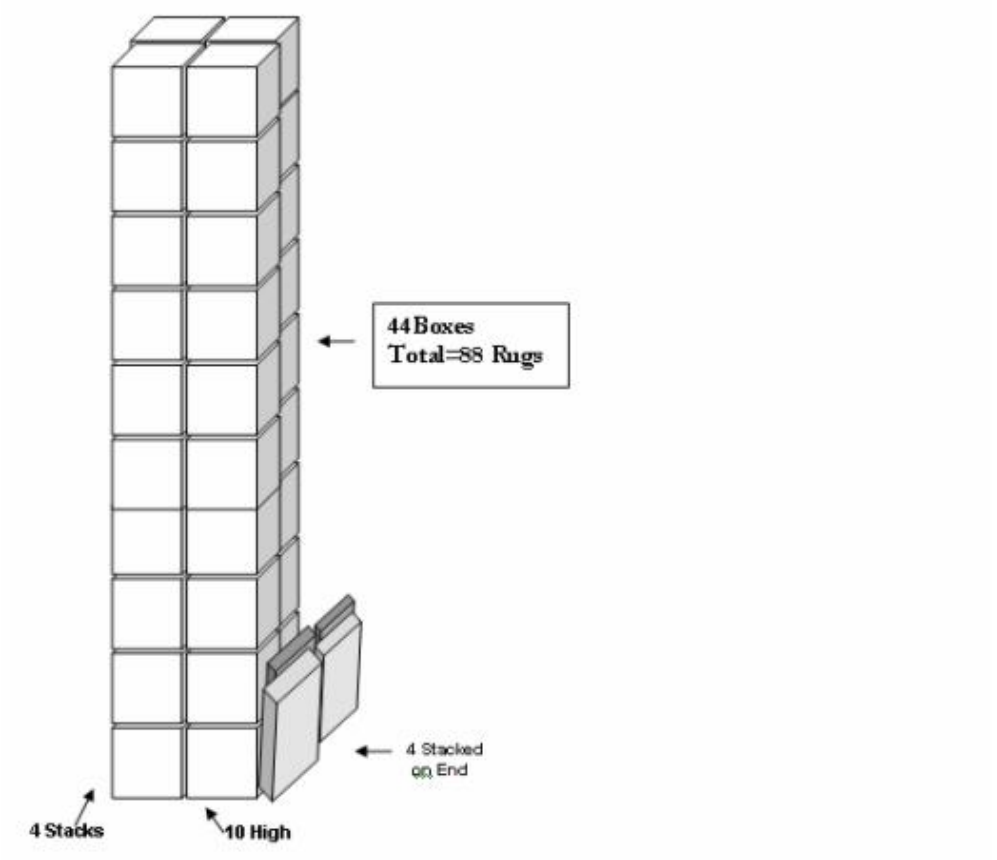


Design 1

- This design is just an estimate. An actual trial would need to be conducted.
- This is also not including box pallet end hang-off.
- This is based on current stacking height of 10 high; if it was stacked 9 high it would still allow more boxes on the pallet than the current.
- The 10 stack design may work since this design is 10/16ths taller than the current.

Figure 12: Customer A Proposed Layout 1

Figure 13 illustrates an additional alternative proposed layout created for Customer A.

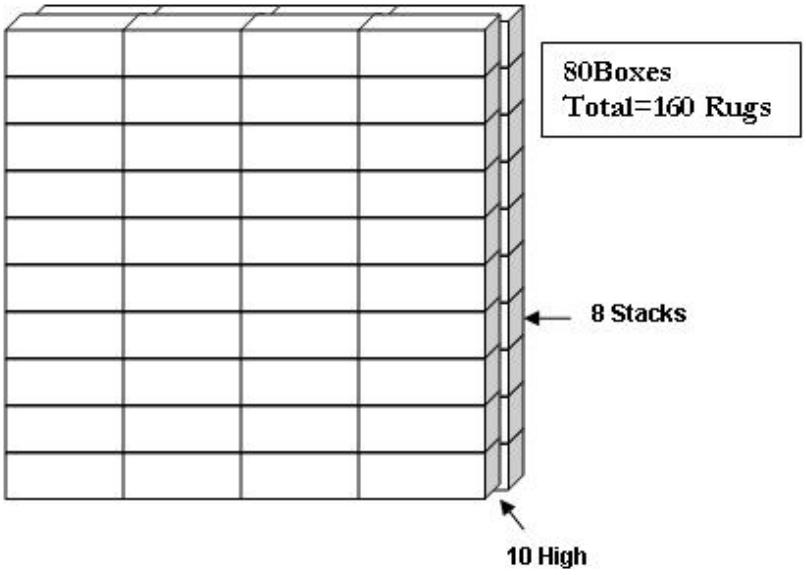


Design 2

- This design is just an estimate. An actual trial would need to be conducted.
- This is also not including box pallet end hang-off.
- This is based on current stacking height of 10 high; if it was stacked 8-9 high it would still allow more boxes on the pallet than the current.
- The 10 stack design **may not** work since this design is 1& 5/16ths taller than the current.

Figure 13: Customer A Proposed Layout 2

Figure 14 illustrates one of the alternative proposed layouts conceived for Customer B.

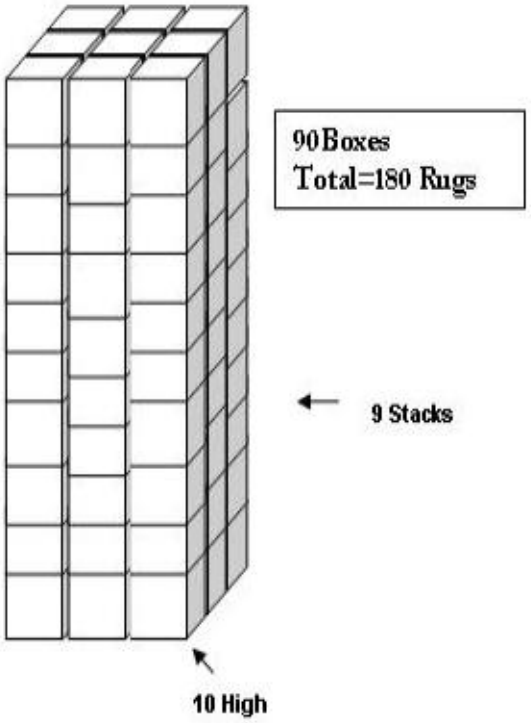


Design 1

- This design is just an estimate. An actual trial would need to be conducted.
- This is also not including box pallet end hang-off.
- This is based on current stacking height of 10 high; if it was stacked 8-9 high it would still allow more boxes on the pallet than the current.
- There is 5"-6" space left on the end of the pallet, so more boxes possibly could be stacked there vertically.
- The 10 stack design **may not** work since this design is 2 inches taller than the current.

Figure 14: Customer B Proposed Layout 1

Figure 15 illustrates an additional alternative proposed layout created for Customer B.



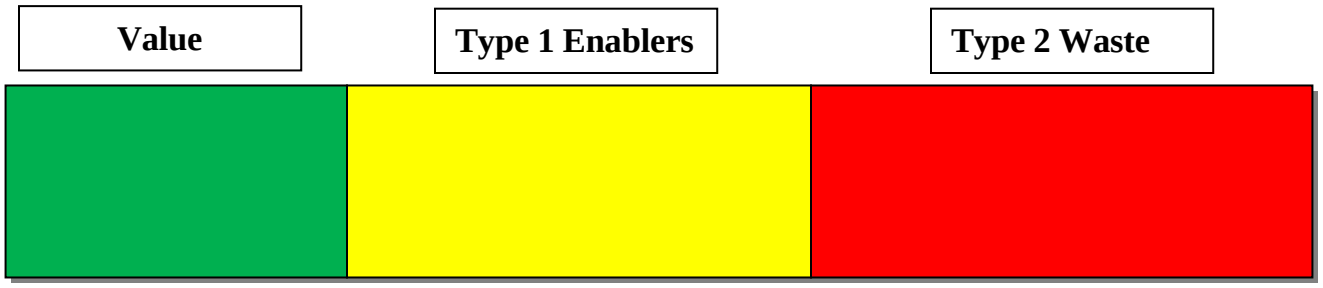
Design 2

- This design is just an estimate. An actual trial would need to be conducted.
- This is also not including box pallet end hang-off.
- This is based on current stacking height of 10 high; if it was stacked 8-9 high it would still allow more boxes on the pallet than the current.
- There is 5''-6'' space left on the end of the pallet, so more boxes possibly could be stacked there vertically.
- The 10 stack design **may not** work since this design is 2 inches taller than the current.

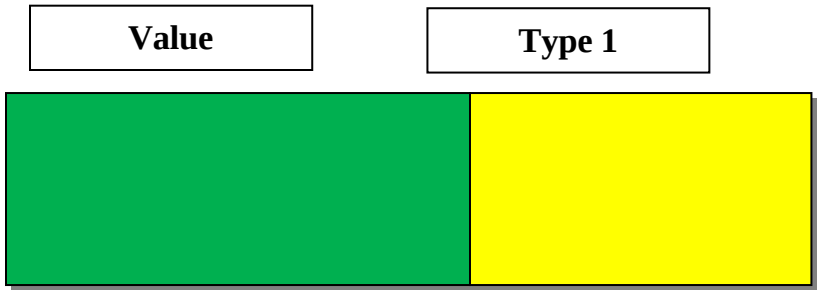
Figure 15: Customer B Proposed Layout 2

Figure 16 illustrates waste elimination through lean methods. It shows a comparison of the "current state" of a process to the "future state" by eliminating Type 2 non-valued added waste from a process.

Current State



A Lean "Future State"



Our goal is to eliminate Type 2 waste whenever possible, and minimize the waste in Type 1 through Lean methods.

Figure 16: Type 2 Waste

Figure 17 illustrates the phases necessary in developing a product.

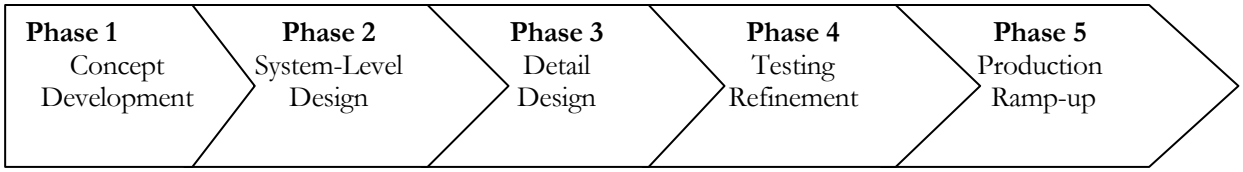


Figure 17: Generic Model of Product Development Process

Figure 18 illustrates the use of a quality system in a continuous improvement structure.

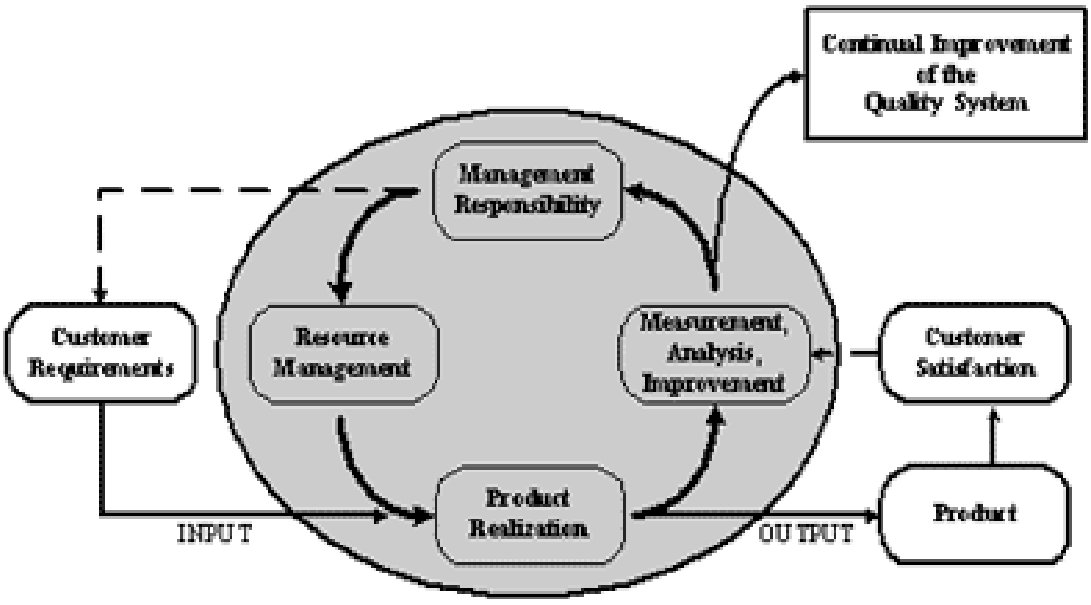


Figure 18: Quality Systems/Organizational Structure

Figure 19 illustrates an overview of the Design for Manufacturing (DFM) Process. The DFM method begins with the estimation of the manufacturing cost of the proposed design. This helps the team to determine at a general level which aspects of the design are most costly and directs the team's attention to the appropriate areas in the subsequent steps.

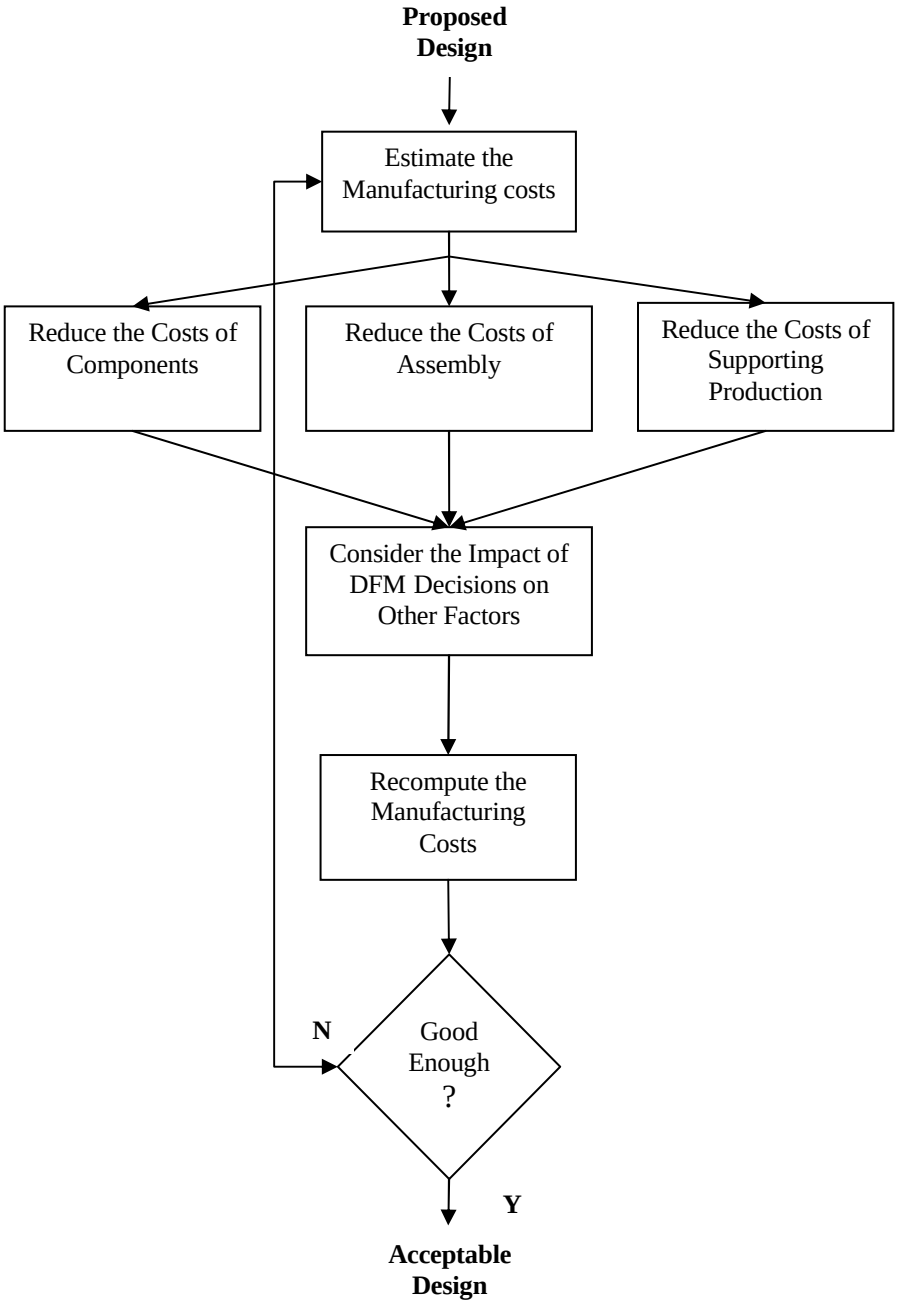


Figure 19: Generic Design for Manufacturing (DFM) Method

40% Paper: newspaper, office paper, packing materials, cardboard

12% Yard Waste: leaves, grass clippings

12% Plastics: beverage containers, high tech waste, packaging materials

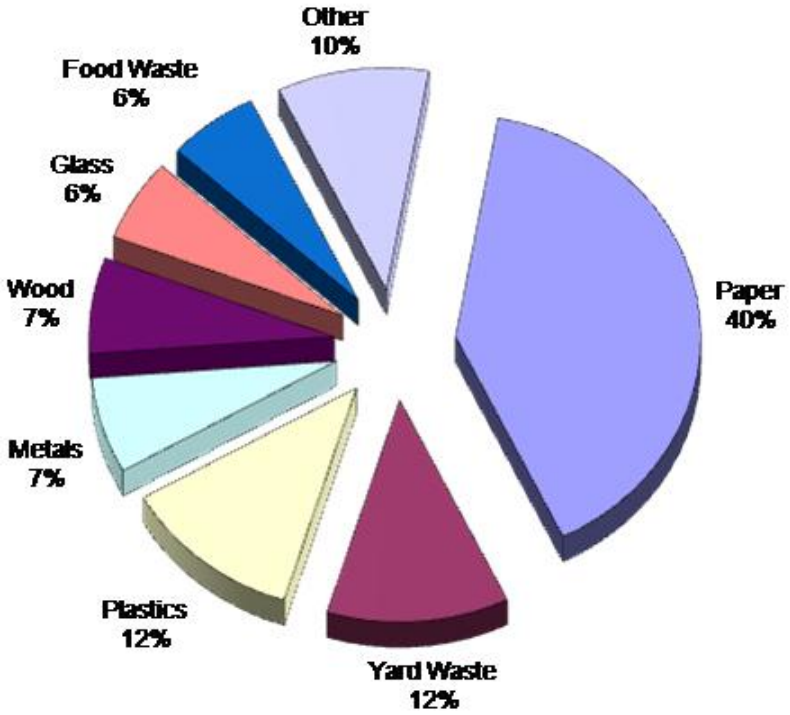
7% Metals: cans, high tech waste, scrap metals, appliances, building materials

7% Wood: furniture, building materials, pallets

6% Glass: windows, bottles

6% Food Waste: spoiled foods, peelings and scraps

10 % Other: miscellaneous items



Biodegradable waste is of specific concern because it breaks down in landfills to form methane, a potent greenhouse gas. If this gas is not prevented from entering the atmosphere, by implication, it contributes to climate change. Paper is almost 10% cellulose, a carbohydrate which is highly combustible.

Figure 20: Composition of United States Municipal Waste

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