Evaluating Lockheed Martin’s Packaging System: Implementing Lean Packaging Methods to Increase Efficiency and Meet Industry Demand
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ABSTRACT

With the increase in production of the F-35 Lightening II, Lockheed Martin is currently revising their manufacturing processes to ensure they are capable of meeting the new demand for the aircraft. Different aspects of manufacturing are being altered including innovative packaging for specific components necessary for assembly. Modern packaging of components can lead to shorter lead-times, an increase in reusable and recyclable materials, and an increase in product protection.

This senior project addresses these packaging issues and provides a solution for the needs required by Lockheed for the packaging of their components. The result involves using a Korrvu® packaging solution that provides adequate product protection, reduces the time to package parts, and is completely recyclable. Keeping this packaging solution sustainable follows Lockheed’s “Go Green” program by reducing the waste generated by individually packaging parts. The proposed solution has been developed and reviewed by Sealed Air engineers as well as Dr. Olsen, this student’s senior project adviser.
ACKNOWLEDGEMENTS

There have been numerous people who have contributed to this senior project that I would like to thank. First off I would like to thank Doctor Olsen who was my technical advisor and guided me through this project from day one. Dr. Olsen had previously worked with Lockheed and was a good person to bounce ideas off while working through drafts of my presentation. He gave me confidence in myself and taught me to be affirmative with my decisions and not be intimidated by Lockheed employees. I would also like to thank Dean Christy from the college of business for attending my out-briefing presentation at Lockheed Martin. Without his support, industry sponsored projects like this would not be able to take place.

There are specific people from the packaging industry who greatly helped with this project. I would like to thank Kent Robertson and Art Ybarra from Sealed Air for providing the Korrvu® samples which I proposed to Lockheed as a viable packaging solution. I was able to learn everything I needed from them in order to present Lockheed with a detailed description of this practical packaging solution. They also attended the out-briefing presentation and were able to assist me further with the applications of the Korrvu® packaging solution. I was very appreciative of both gentlemen’s flexibility and overall support of my senior project.

Last but not least, I would like to extend my thanks to every member at Lockheed Martin who assisted me with this project. Specifically I would like to thank Anne Wolff and Mike Kaplan for setting up a team at Lockheed to work with, and for responding to my frequent emails. I realize there were other projects taking place along with mine, and appreciate the dedication they showed to this project. I would also like to thank all others who took time out of their schedule to help with this project. This would not have been able to happen without the cooperation from all of the Lockheed associates who attended the meetings, and gave feedback throughout these past six months.
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SECTION I  
INTRODUCTION

Lockheed Martin is an American aerospace and defense company and the world’s largest defense contractor. The merger between former companies Lockheed and Martin Marietta in March of 1995 created the new combined Lockheed Martin. One of the aeronautic facilities located in Palmdale, California was built to manufacture the L-1011 wide-body commercial airliner in the late 1960’s. With production being terminated in 1984, the facility directed its focus to the advanced development program also known as Skunk Works. The Skunk Works Program has produced aircrafts at the leading edge of technology including the U-2, F-117, SR-71 and the F-22. Currently the facility also performs scheduled maintenance on F-22’s and is getting ready to support increased production of the F-35 in the near future.

**Problem Statement:**  Lockheed Martin’s current packaging techniques for the different components necessary for the F-35 Joint Strike Fighter are problematic. Currently each individual component is wrapped in Kraft paper and/or bubble-wrap which pose multiple problems throughout the production of the aircraft. The current process takes excess time to pack and repack parts and provides no clear organization or differentiation between them. A solution is needed to alter the current system in order to ensure protection of the parts and increase the efficiency of the packaging process.

The current method is sufficient for today’s production, but a faster, more organized method could offer a more practical and reusable packaging system. A clear organization system can allow parts to be accounted for in seconds, saving time that was previously wasted by counting individually packaged parts. By implementing an innovative packaging solution that reduces this time, employees will be able to quickly adapt to the increasing production demand anticipated in the near future. Reducing the total time it takes to package the product allows for
an overall more efficient system. With the current techniques, the packaging material is only used one time before being disposed of. If a sustainable system was created, there would be a significant decrease in wasted packaging material and a reduction in cost dedicated to buy new packaging.

During the packaging process, parts are transferred from one facility within Lockheed Martin to another. By refining the packaging process, Lockheed Martin can assure the quality of the final product before it is transported to another area. With this process, the packaging is focused on the protection of the product, rather than aesthetically pleasing attributes. However, some aesthetics are important for customers when visiting the facility and monitoring the process. These customers will have increased confidence in Lockheed’s end products when they see the components in confined and innovative packaging and will be confident that the parts will be protected while being transported to other facilities. The performance of the package is of primary concern and takes precedent over the aesthetics because even a small possibility of damage to any parts is unacceptable for Lockheed Martin.

**Needs:** There are specific needs that Lockheed Martin expects with the package solution. Some needs have greater importance than others which is seen in table I.

<table>
<thead>
<tr>
<th>NEEDS</th>
<th>RANKING</th>
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<td>Ability to organize products and account for all pieces</td>
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<td>FOD Prevention (Foreign Object Detection)</td>
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<tr>
<td>Identification of package and components inside</td>
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</tr>
<tr>
<td>Price for Implication</td>
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</table>

Table I Ranking of Needs
These specific needs are what Lockheed is looking for in the new package. While all needs might not be able to be met in one prototype, different ideas and methods can be implemented into parts of the design. Other future kits may adapt in order to fit the needs of the company depending on changing parts included in the kits.

**Background:** Professor Olsen and Professor Singh have done some preliminary work with Lockheed Martin in regards to this senior project. They both have an idea of what Lockheed Martin is looking for in the package design, and have suggested some interesting alternatives. Previous meetings were focused on creating a plausible senior project for a student rather than actually creating an applicable solution for Lockheed’s issue.

**Potential Solutions:** One possible solution would be to continue the current process that Lockheed uses at their facilities. This would not be the most useful choice since there are multiple needs within the company to alter the existing process. However, this process has been successful in the current level of production for the F-35. Creating a new method of transporting parts could prepare for the predicted increase in production of the aircraft in the upcoming years.

This project has multiple alternative solutions that could provide advanced packaging processes at Lockheed Martin. Some of these solutions would change the manufacturing style that they currently use and transition to a “Just in Time” (JIT) approach. This manufacturing technique decreases in-process inventory which is associated with extra costs. By using the JIT method, Lockheed Martin would be able to reduce space needed in the facility for extra inventory and lessen the chance of damaging parts. This method would streamline the production process and prevent extensive inventory of parts that are produced before they are needed. In order to do this, a Kanban system would be put into place in order to create a “pull” effect throughout the operation process. By passing down a Kanban card, the line associate knows that a part is needed and can then send the necessary part. This “Lean” implementation would clean up the extra inventory of parts and reduce the possibility of part damage. This potential solution might be applicable to some of the parts, but other less expensive parts would not need to follow this Just-In-Time approach.
Another potential solution would be to package the different components in affiliated kits. This kit package system would make it easy for associates to recognize when a kit had all the necessary components to transport to the next production area. The kits would provide protective material to prevent damage to the parts as they are transported through the facility. Since there is a wide range of sizes and weights for different parts, kits might need to be split up by size to make joint packaging of parts more feasible. If larger kits prove to be more efficient, it may be practical to have special compartments for specific parts all on a rolling platform. A clear plastic cover would prevent any Foreign Object Debris (FOD) from damaging the components and could provide a transparent cover making a quick visual check possible to account for all the parts. This wheeled kit could be moved across the shop floor without the possibility of dropping any parts. Reducing the chance of damaging parts by using kits is an effective way to further protect fragile components.

One final potential solution for the problem would be to create a “Point of Use” system for some of the specific parts. This could allow for some parts to be manufactured in bulk and then sit at the production line. A line associate would then pull the necessary parts from his work station instead of waiting for a part delivery. This system could be easily implemented for some of the smaller, less expensive components, but larger components would be too bulky to keep in mass quantities at the assembly point. This point of use system tends to work well for pieces such as washers or smaller hardware that cost less. A significant amount of these smaller parts would be kept at the point of assembly and easily accessible so that production would not be slowed down. However, larger more expensive parts will not spend excess time at a work station before being used because they are much more valuable and impose greater cost if damaged.

The best result will likely be a combination of the potential solutions explored above. Depending on the pros and cons of each solution along with the desires of Lockheed Martin, a joint implementation of solutions could prove to be the most effective alternative for increased productivity and to ensure the protection of parts.

**Contribution:** With the implementation of ideas expressed at Lockheed Martin, a more effective packaging and transportation system will allow for the efficient production of the F-35.
In order to meet projected future demands, it is essential that parts are delivered on time and in pristine condition. Along with safely transporting the components, prompt delivery of parts needs to be guaranteed in order for the packaging system to be useful. Eliminating waiting time for parts will allow for production to run smoothly. Engineers will also not have to dedicate precious time packaging parts when they could be working on other areas of production. Lockheed needs to ensure on time delivery of individual parts or kits of parts to make certain the packaging process is not delayed. By combining an on-time delivery with a new innovative package system, Lockheed will be able to meet the demand of production for future years.

**Scope of Project:** This project involves specific components intended for the F-35 production throughout the Palmdale, California facility. There are a select number of kits varying in weight and dimensions that will be the focus of this project. After creating innovative and protective packaging for these parts, initial testing will be conducted to assess if the parts fit in the packages appropriately. Analyzing these results will lead to possible design changes and or new ideas to provide more effective packaging.
SECTION II
LITERATURE SEARCH

Introduction: This project is based around creating a new packaging solution at Lockheed Martin for components of the F-35. Determining an efficient way to group the parts into kits and developing the logistics for a new packaging system will be the focus of this project. Lockheed Martin has specific goals that they would like to meet in order to accommodate for the projected production numbers of the F-35. All alternatives to the packaging of the parts of the F-35 for this project will be considered and analyzed carefully in order to provide the most economical result. This literature review is included as a foundation of knowledge of packaging in the industry and provides a starting ground for this project. Different ways of packaging and the logistics of other projects can be used for case study purposes and further develop ideas for changing the current system at Lockheed Martin. This review is composed of different sections including previous projects and improvements, kit implementation, packaging functions, and packaging solutions. The combination of these sections creates the foundation of the project and focuses in on areas that can be changed to increase efficiency at Lockheed.

Previous Projects: Lockheed Martin is one of a select few industry leaders in the aeronautical division and is dependent on high-tech manufacturing processes in order to stay ahead of the competition. Caron and Fiore explain how “customers are increasingly demanding, and manufacturing systems have to become more flexible and guarantee shorter production lead-times” (Caron, Fiore, 1995). In order to comply with customer demand, the communication within a company and the process of manufacturing needs to be as well-organized as possible. Current new methods like lean manufacturing cut out excess waste and have recently become an industry standard. According to Caron and Fiore, “an emphasis on product differentiation and ‘time to market’ requirements focuses management attention on the integration of manufacturing” (Caron, Fiore, 1995). In order to improve Lockheed Martin’s manufacturing
methods and their ability to meet these requirements, the transportation of parts from one facility to another needs to be improved. The current system involves timely wrapping and re-wrapping of parts, increasing overall packaging time, and adding more waiting time for the next manufacturing process. By creating a more efficient process for packaging, valuable time will be saved and the product will be able to be manufactured quicker.

There have not been other Cal Poly senior projects that have focused on packaging implementation at Lockheed Martin. However, Lockheed Martin has made its own improvements in past years at their facilities. One of the main changes that Lockheed implemented was in the system of transportation of the flat, large components. These parts are fragile and need to be continuously supported throughout the transportation process. Lockheed decided to use a body-board solution to strap these parts on sturdy boards retrofitted with straps and handles to attach the parts. While this implementation added significant weight, it increased the total protection of the components. These changes eliminated the risk of bending and flexing of parts because they are supported with a sturdy backboard. By making similar changes like this, the whole production process benefits from the time saved in this one process step.

Lockheed also added a rolling shelf system in their transporting van. The current vehicle is an old delivery van with wooden shelving units that were added for product protection and that provide easy access to the products. These rolling racks allow for products to be put in the van without having to climb inside the back. The shelves have been covered in industrial carpeting for additional cushion and protection for the parts as they are transported to the other building for assembly. Lockheed is in the process of purchasing a delivery truck which would allow more products to fit in the back and reduce the total number of trips the truck has to make throughout the day. This truck will be retrofitted to make the transporting of parts safe and efficient. By increasing the capacity of the vehicle, fewer trips are necessary each day of production and the system is more effective.

These two changes are beginning steps to make Lockheed Martin’s transportation and packaging process more efficient. There are other changes that need to be made to increase the effectiveness and reduce the time that parts spend not being used when going through this stage
One important method of creating a lean workplace is to have continuous improvement and always be looking for ways to make a more practical process. Zangwill confirms that “continuous improvement is an array of powerful techniques that has produced substantial improvements in numerous companies and organizations” (Zangwill, 1998). By implementing this philosophy at Lockheed Martin, they will be able to create a more efficient and improved work environment.

One improvement they can make in order to cut down the time and making for a more lean production method would be to use a kitting method when packaging and transporting components to the next stage in production. The parts are already grouped in specific kits but are not currently packaged together this way. By packaging them together, material packaging costs will decrease and fewer parts will be misplaced or lost. This kitting method would also reduce the work-in-process as well as the total operation cost.

**Kit Implementation:** Using a kit system for the production process can be beneficial if conducted in the correct fashion. Ronen explains that “the fundamental idea of using kits is that the work should not start until all the items required for the completion of the job are available” (Ronen, 1992). When implementing this type of system with Lockheed, all line associates will need to be trained on the operation strategy behind kitting components. Both components and information regarding contents of the kit should be included in order to make this process uninterrupted. These kits can be constructed to support multiple uses and do not need to be disposed of after one use. Brandt states that “one-piece flow and reusable packaging materials both have environmental benefits as well with the reduction of excess packaging materials being discarded” (Brandt, 2009). Although set up costs will increase initially, reducing the quantity of packaging materials will be cost-effective for increased production in the future.
However, there are a few negative aspects of the implementation of kits in the packaging system. Primarily, significant issues can arise if incomplete kits are processed through the operation. According to Ronen, these “evils” in an incomplete kit can lead to problems in the whole operation including:

- More work-in process (WIP)
- Longer lead time (LT)
- Poor quality and more rework
- Decline in productivity
- More operating expenses
- Decline in workers’ motivation

(Ronen, 1992)

According to Ronen, if the kit is conducted in an accurate manner, this process has proven to be a trusted manufacturing procedure with considerable potential for improving both production and service operations. Ronen states that “working with complete kits leads to the fastest productivity gain in most types of manufacturing, engineering, research and development, service and paperwork environments” (Ronen, 1992). Passing on kits without all the components creates excess work, higher operational costs, and leads to poor manufacturing practices. Discipline and training in the workplace is essential to the success of the kit system. According to the efficiency syndrome presented by Ronen, workers follow the fallacious notion that they should be busy all the time which causes managers to have their workers pass on incomplete kits just to prevent them from being idle. Managers need to be the ones who stick to the principle of not passing on an incomplete kit and stress this importance to the employees on the floor.

**Packaging Functions:** Different packaging designs can be developed for specific customer demands. Chan states that “there are some industry standards on the main functions a package is supposed to provide including containment, protection, apportionment, unitization, convenience, and communication” (Chan, 2006). Lockheed has narrowed their focus and determined which of those functions take priority over others in their packaging system. Based on their needs, the top priorities of this new package are organization, visibility of the parts, protection of the components from FOD, security, and the ability to identify the packages. Another important focus for Lockheed is the time it takes to pack and repack the products. These different needs
may not be met with one specific solution, but rather by implementing many different packaging alternatives.

Currently Lockheed uses Kraft paper to package each part individually which adds excess time and more labor to the total process. This also makes it much easier to lose track of all the parts in the kit group. With a packaging system that incorporates all of the different components, employees will not have to worry about misplaced parts. Each and every part will have a specific place in the package so employees can quickly account for each part. The cushion system within the package will also guarantee that the product does not experience shocks or vibrations that could damage the parts as they are transported throughout the process.

By altering the packaging method, process flow will become more streamlined and efficient. Implementing a packaging system that combines multiple products in one package and is easy to pack and repack will be cost-effective for Lockheed Martin. While a more economical solution needs to be implemented, the integrity of the parts needs to be top priority. Creating a final solution to improve the packaging system will allow Lockheed Martin to focus on other areas of their production and be prepared for the increased demand of the F-35.

**Value Added with Lean Implementation:** With a new packaging solution at Lockheed Martin, a more productive method will be put into place to accommodate the increasing demand of the F-35. The end result will greatly reduce the amount of waste that is produced with the current packaging technique. Moore states that “categories of waste include excess inventory, wait and delay times, [and] off-spec product[s]” (Moore, 2007). By cutting down, or possibly eliminating excess waste, Lockheed will have reduced costs, an increase in quality, and a decrease in process time. With these changes, the work environment at Lockheed will become leaner and employees will feel their work is more meaningful and strive to be more productive. Hunter comments on lean principles by saying “Proper lean production implementation requires that less than half of the inventory-on-hand be kept and that when a factory adapts lean production practices, it will manufacture products with fewer defects and, therefore, an increase in quality will result” (Black, Hunter, 2003). At the packaging stage at Lockheed, a leaner
approach will generate fewer defects, faster cycle time, and a more efficient flow to the next stage of production.

When implementing lean manufacturing processes to a current system, the company must take the time to carefully evaluate its current situation. Liker states that “one method of addressing this is by stating the problem, document the current situation, determine the root cause, suggest alternative solutions, and then suggest the recommended solution” (Liker, 2003). The time spent thoroughly evaluating current systems within the company is crucial to the development of new processes for the company to implement in the future. One way of analyzing the current system suggested by Moore is by “conducting a root cause analysis [which] can help identify the root causes so that actions can be taken to prevent them in the future” (Moore, 2007). Some of the benefits of using a root cause analysis approach are:

- It saves time by tackling the root cause first, not symptoms
- A logical approach helps people discuss data and facts, not just opinions that are subject to much bias and change
- It provides a means to collect and communicate facts and ideas
- Most importantly, it facilitates finding root causes, so that actions can be taken to avoid repeating the incidents that initiated the analysis

(Moore, 2007)

One common way of conducting a root cause analysis is by asking the 5 Why’s. This is a technique that helps to get to the bottom of a problem rather than attacking a minor portion of it. By continue to ask why, the entire workforce helps contribute to the identification of the cause of the problem. By involving all people who the problem pertains to, more ideas are brought to the table and further analyzed and discussed. This ensures that all aspects of the problem are considered by employees, and details are not overlooked.

Evaluating the performance of the transportation system is another way of making the packaging process at Lockheed more operative. In order to pinpoint where bottlenecks appear in the process it is important to evaluate the path that each part follows before and after packaging. Baudin states that “in-plant transportation differs from inbound and outbound in that the greatest improvements are achieved by eliminating trips rather than by reducing distances” (Baudin,
Distances that products travel inside Lockheed’s facility can differ depending on where they are received and where their next destination is. Baudin says that “the first step in analyzing in-plant transportation is of course to measure the volume of traffic between destinations” (Baudin, 2004). After analyzing traffic patterns within the facility, the path with the largest volume of products passing through it should be the first one to improve.

The current system of packaging and repackaging of individual components at Lockheed Martin wastes valuable time. Different processes can be broken down to value added work, and non-value added work. Since the actual packaging of the parts adds no value to the product itself, this process needs to be evaluated. While the safety of the product is necessary, the system can be altered so that there is less time spent during the total packaging process. By reducing the time it takes to package the individual products, the non-value added time is significantly decreased. This allows employees to focus on other areas that add value to the product.

One way to reduce the time it takes to package the products is to implement a variety of new packaging materials and methods. New methods require less time to package parts, and make packaging multiple parts at once a possibility. One alternative is a product called Instapak Quick®. This self-expanding foam expands in seconds to form custom-fit foam cushions (Introduction to Instapak Quick® RT Packaging). This process takes significantly less time than wrapping each individual product with Kraft paper and also provides more stable packaging to protect the products. Another more advanced solution is called Korrvu® packaging which involves placing the parts in between two pieces of film to suspend the product. This would eliminate time consuming tasks currently in place like wrapping the product and sealing the ends with tape.

Reusability is another major advantage of using a new packaging process. The current packaging material is discarded after transport and not reused. By implementing a Korrvu® package solution, waste will be reduced at both ends of the production cycle because the packaging is reusable (Korrvu® Retention Packaging). This is something that Lockheed is interested in doing in order to be a more environmentally friendly company. It is important to be
environmentally conscious when choosing a packaging process because some systems can involve tremendous amounts of waste if not designed correctly.

Large multi-use carts could also be used which would eliminate any wasted packaging. By creating slots or compartments in the foam, the end user would not need to discard any material and could simply return the cart for another use. Carts could also contain hinged shelving units where multiple levels of parts could be transported at one time. Baudin confirms this in stating that “a hinged cart is an effective device for transportation but not for line side presentation” (Baudin, 2004). The presentation of the cart is not as big of an issue at this stage in production since the next person to handle the cart is not the final customer, but rather another Lockheed employee. Depending of the durability of the cart, they could last for years to accommodate the long timeframe of the F-35 project.

This solution would also be cost-effective after several years of implementation because there would be no need for additional packaging materials. Some other advantages of reusable containers are the following:

- *Packaging Quality.* Plastic containers, particularly stackables with part-specific dunnage, are simply better protection against handling damage than disposable, corrugated cardboard boxes
- *Environmental Responsibility.* Disposable containers generate waste that returnable containers don’t. Some managements view the switch to returnable containers as a way of “greening” the company. The public relation benefits may be substantial but are difficult to quantify.

(Baudin, 2004)

After the parts are removed, the empty containers would be sent back to the packaging facility. This transportation would not need to be an extra process since the vehicle would be returning for the next load anyways. Once the empty containers returned to the packaging facility, the employees would then also know what parts were used and which parts need to packaged next. Depending on Lockheed’s evaluation of this system, using a returnable container could be the best alternative for a timely delivery process.
Conclusions: Lockheed Martin has prioritized the following needs for their packaging system: protection, organization, FOD prevention, security, and component verification. Items such as cost, appearance, and weight are not the most crucial factors when considering packaging alternatives. Finding a combination of ideas that touch on all of the needs would be the best fit for this project. Based on the specified requirements, a new importance ranking has been assigned to the needs as shown in table II.

<table>
<thead>
<tr>
<th>NEEDS</th>
<th>NEW RANKING</th>
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<tr>
<td>Ability to organize products and account for all pieces</td>
<td>4</td>
</tr>
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</tr>
<tr>
<td>Price for Implication</td>
<td>1</td>
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Table II New Ranking of Needs

The new rankings have many similarities to the original ones given by Lockheed Martin. A few of the sections such as “Identification of package and components”, “Aesthetics of package”, and “Security” are rated with a lower importance. This should not affect the project since the primary needs still align directly with Lockheed’s. If there were discrepancies between the needs, it would be more difficult to find a compromise on which needs need to be addressed and in what priority. Implementing a perfect package solution for Lockheed Martin is probably an unrealistic goal at this point due to the scope and accessibility of this project. However, based on the new information and research, finding a solution that surpasses their expectations at Lockheed Martin is completely viable.
SECTION III
SOLUTIONS

This project in collaboration with Lockheed Martin consists of proposing an alternative process to the current packaging system for the parts of the F-35. This step in the manufacturing process is located at the Palmdale, California facility and is intended to protect the parts going to and from different assembly points within the facility. Currently Kraft paper and bubble wrap are used to protect these expensive components. For smaller components, multiple plastic bags are used to separate and organize parts. The time is takes to pack and re-pack each individual item is extremely wasteful, and a new method is needed to decrease production time. Time is also wasted when having to count and recount the multiple parts in the bags when a much simpler method would create visibility of all parts for employees to quickly check to make sure kits are complete. Implementing a compartment system where each part goes in one slot and making sure all slots are filled before moving on could be one solution to this problem. A new type of package that can be packed and repacked in a quick fashion will help reduce the time of this step, and allow for employees to focus their attention into other aspects of the manufacturing process.

Reusability is also an important goal when choosing a new packaging system. Finding a package that can be used multiple times is extremely important and will decrease the amount of byproducts produced. An ideal package would be able to be reused infinitely, but having a multiple use lifecycle will be sufficient for Lockheed’s needs. Along with reusability, having a system that is recyclable is also an important factor to address. Lockheed will be able to cut costs and create an environmentally friendly packaging process if the materials used to package parts are recyclable. Being able to recycle materials from the facility allows for a cost-saving opportunity which Lockheed would like to take advantage of.
When the new packaging solution is implemented at Lockheed Martin, employees and managers should see improvements in process flow immediately. The solution will reduce packaging time, decrease the time taken to account for all parts, cut down on wasted packaging materials, and ensure superior protection for all parts being transported to different facilities.

**Solution I:** One alternative packaging system considered when evaluating the current issues at Lockheed Martin would be the use of Instapak Quick® foam packaging as seen in figure 1. This is a fast, easy, and versatile process to package products of any size and shape. These individual bags expand in seconds to create a polyurethane foam cushion that takes the shape of the product being packaged (www.sealedair.com/products/protective/instapak/quick). Different types of foam can be used for different products depending on the weight and size of the component being packaged. The Instapak Quick RT® version is specifically intended for industrial applications and can adapt to much larger and heavier components similar to those at the Lockheed facilities. There is also a minimal start up cost affiliated with this system since it is completely self-inclusive and does not involve the implementation of any additional packaging machinery. These small bags take up a very small space before being expanded which decreases the space needed to store the packaging supplies when they are not being used and opens up space in the facility to make for a cleaner more organized work place.

![Figure 1 Instapak Quick®](image)

The Instapak Quick RT® would have a regular corrugated box for each of the items being packaged. The employee would then place the component in the box with one of the foam bags. Once the chemical reaction takes place and the bag starts expanding, the package is sealed up
and the foam expands around the part to create a complete cushion that protects the product on all sides. The advantage of this system is that it is adaptable to any size product. Since the foam is not already pre-cut into certain shapes to fit specific packages, it can be used to protect any of the products. This makes it easier and less complicated for employees to package the vast array of products affiliated with this step in production.

While this alternative has obvious time saving benefits and offers better protection than the current system, there are some down-sides to using this method for packaging all of the parts. The foam-in-place creates excellent protection since it produces an exact flush fit with the product being packaged; however, sometimes this protection is not necessary for each and every component. Some of the parts do not need as much protection as others and therefore packaging them with this system would be over-packaging and not cost effective. Some of the smaller less fragile components do not need the protection and could be passed along in a box and not risk being damaged.

Another negative aspect of the Instapak Quick® alternative is the visibility of the product after being packaged. Once the foam expands around the product, the only way to see what is inside the box is to completely unpack the package. The foam also makes it so the employee cannot tell if the product is inside by just opening the box lid. If a system was created where after a product has been packaged, it moves to a certain area with other accounted for parts then this issue would be solved. However, once certain boxes get moved around it is impossible to tell if a part is in a certain box or not. The facility would have to implement strict organization of boxes for a system like this to succeed. Certain products would have to go in designated boxes in specific locations to make sure no parts are lost or unaccounted for. A color coding system of boxes or even a RFID system could also potentially help with this issue of accountability.

This method of packaging does have a limited lifespan for the different foam cushions once they have expanded around the product being packaged. The multiple uses for each of the cushions could prove to be a hassle when keeping each cushion with its corresponding part. With this system, components and parts would have to be tracked together, or else multiple new bags would have to be expanded each time a new product needed to be packaged, making the
cost significantly more than other alternatives. This increased cost would also occur when having to replace damaged or mistreated cushions. These are costs Lockheed would most likely not want to continue to pay repeatedly in future years of production.

Besides the few drawbacks with the Instapak Quick® alternative, this system could prove to be extremely beneficial to Lockheed Martin. The time saved and increased protection are both huge advantages to this alternative and could prove to be valuable to the current system. Even though this might not be a solution for all parts in this process, implementing this system to specific parts could be very helpful.

**Solution II:** Another potential solution to the packaging issues at Lockheed Martin would be to use a suspension and retention method called Korrvu®. This packaging solution uses strong, highly-resilient, low-slip film to surround the products and protect them from damage due to shock, vibration and impact (www.sealedair.com/products/protective/korrvu). The films come in a variety of sizes and shapes to fit any size of product which is an advantage similar to the Instapak Quick® option. This method also stores flat when not being used which reduces inventory space needed to store the packaging materials in the facility. The Korrvu® system is also environmentally friendly since it contains 30% recycled material and easily recycled at a standard corrugated hydra-pulping facility. This package can also be used for return shipments which minimizes waste at both ends of the production process.

The suspension method involves placing the product in a specially designed corrugated box that has one piece of film in the middle to support the product as seen in figure 2. Then a top piece is set on the product to completely support the unit in the middle of the box. When the lid is applied, the product is safely suspended in the middle of the package system and not in contact with any edges of the box but rather the sections of film. This suspension technique separated the product from the package system and significantly reduces the amount of force the product sees through vibration and other movement while being transported. The superior protection as well as elegant see-through design is an advantage of this system along with its availability to accommodate all sizes of products.
The retention method of Korrvu® uses a similar corrugated/film combination in order to protect the products. This method however is intended for more durable products that can see higher levels of forces without being damaged. The retention method involved placing the products between a layer of film and a corrugated board as seen in figure 3. Then when the lid is applied, the film is stretched across the products and holds them in position on the board. This method prevents products from shifting around inside the package and being damaged that way. With the products fixed in place, it is highly unlikely that scratching of the two products against each other or the edged of the box would occur. A quick visual inspection of the parts on the board with the clear film stretched over also gives the advantage of part accountability.
Altering this retention method to work with a pre-existing tray could also be a great way to package some of the unique sized parts this project deals with. Having a tray with multiple parts in their specific compartments and then stretching the film over the top would prevent parts from migrating in the tray through transport as well as provide a window for employees to account for all of the parts in the tray.

With this suspension method, there is no need to count out each individual part like they currently have to do at Lockheed. Using washers as an example, an employee can lay out 12 washers in a 3 x 4 pattern on the board or tray, apply the film and then package them. The end user can then open the package and see the 3 x 4 layout is still present and knows that all the washers are present. With traditional methods, a stack of 12 washers might be packaged in one box or bag and then the end user would have to go back and count out how many they received. This counting process is wasted time and adds no value to the product. By reducing wasted time, other additional value-adding tasks can be addressed to ensure an efficient process is being executed.

The lifespan on the Korrvu® packaging system will depend on the actual distribution cycle that takes place with these parts, and the individual weights and dimensions of the parts. In-house testing will quickly determine how many cycles each package can undergo with the products before needing to be replaced. There could potentially be a point where after extensive use, the packaging does not perform as desired. In this case, a new package system can be constructed and implemented in a quick manner.

The Korrvu® method could make the packaging process more efficient and might be the best solution for Lockheed Martin. Being able to quickly package a variety of parts as well as see what parts are present within the package is important. Implementing a system like this also allows for an easy transition for current employees to adapt to. There is minimal skill needed for a new employee to be able to operate this system, and former employees could adapt to it relatively quickly. Employees must be instructed on which parts go in which containers and know not to cut open the film to access the parts but rather remove the top sheet of film.
these advantages could make this alternative the best fit for the implementation phase of this project.

**Solution III:** One last possible solution to change the current packaging situation at Lockheed Martin would be to implement rolling bins or carts to hold the parts while being transferred to different facilities. These carts could be similar to a laundry cart with foam cut-out sleeves or compartments for the parts to fit in while being transported as seen in figure 4. The rolling carts would be easy to move to different parts of the facility at Lockheed and only need one person to manage. They could also be created to fit into the current vehicle that takes parts over to the other buildings. The truck could pull up to the loading dock and these carts would be able to roll straight on to the vehicle and lock into place once inside. This reduces the actual human handling of the parts and reduces the chance of dropping parts through the transportation process.

Carts would also only take a quick visual inspection to confirm the components inside. An employee could take a quick look into a cart and see if all of the parts were present or not. A clear plastic lid could also be applied to cover the parts to reduce the possibility of FOD. This would prevent unintended parts or debris from getting inside the cart and potentially ruining the components. This is tremendously important with Lockheed Martin since the final product is very intricate, and the cleanliness of the individual components is extremely essential.
With a cart implementation, the ability to group components into kits would be necessary. Grouping the different parts that go together in the same package improves efficiency and allows for each employee to know which parts go together. Different kits would have different cut out compartments to contain the variety of parts. They could also be color coded to make it easy for employees to know which parts are in which kit based on a simple color of cart. The size of the cart would also be large enough to identify the kit and the components from across the facility.

After a cart was unpacked and returned for repacking, the employees would know the demand for the next production step. The empty carts would act like a Kanban card in a way to let the production employees know which parts had just been used and which need to be repacked. These carts would also have a long lifespan as well which reduces waste and is more environmentally friendly. There would be a higher implementation cost for this alternative but it would be more cost-effective in the long run due to less continuous costs throughout the packaging process. Since the carts would be used to fit parts for a product which production is ramping up for, there is not a large risk of implementing this package solution and then having the whole project cancelled.

It is also possible to include a suspended spring bottom to the cart that raises and lowers depending on the load placed within as seen in figure 5. The spring-loaded bottom allows for added protection against vibration and shocks throughout handling. When an item is placed in the cart, the bottom slowly lowers to a point based on the size of the springs and weight of the item that isolates it from the actual bottom of the cart. This floating bottom also assists employees when loading and unloading the carts with multiple parts. There is no need to bend all the way over to the bottom of the cart to load or remove the first parts. The spring base allows for the parts to be at the top of the cart every time regardless of the size of the load.
There are still different factors affiliated with this implication such as type of materials used, as well as the assignment of the parts to a kit, but if this solution proves to be the most ideal, these factors would be able to be figured out relatively quickly. Depending on what Lockheed Martin’s needs are for the solution, different alternatives can be evaluated with this idea.

**Hypothesis:** Based on the complexity of parts involved in this project, a variety of different solutions will need to be implemented for each of the different components. Different sizes and weights will greatly affect how to package them safely, efficiently, and appropriately. While some of the larger and heavier parts will work better with the laundry basket approach, other smaller parts might work better with the Korrvu® solution.

There also could be a combination of solutions for a group of parts. Individual parts could be packaged together in the Korrvu®, and then placed in a laundry basket with other boxes before being transported. This combination will provide even more protection for the products, but also increase the convenience for employees who have to move the parts. Moving them individually would create a lot of excess transportation with multiple trips that could be decreased by implementing a rolling cart system. This would increase the process time and not hold up the production for high demand parts since a bulk load would be delivered each time.
SECTION IV
RESULTS

This project with Lockheed Martin refines their packaging for different components dedicated for the production of the F-35. Currently, superfluous packaging is used for these parts which slows down the process and requires time consuming labor. A new reusable packaging solution is necessary to improve the process flow and cut excess packaging time. By examining Lockheed’s specific needs and customer demands the multiple solutions that were proposed were narrowed down to three viable possibilities. The proceeding steps of the project included a presentation to Lockheed Martin covering the options discussed in this paper to allow for experimentation within their facility with their actual products.

Advantages/Disadvantages: Each of the three proposed solutions possessed their own individual advantages. Some have longer life-cycles, while others provided superior product protection. The goal of this project is to combine aspects of each proposed alternative and provide a comprehensive final solution for Lockheed Martin. By making slight modifications to the alternatives and adapting according to Lockheed’s prioritized needs, an ideal and complete system will be created. This final solution will be able to protect the parts from damage, reduce the time to package parts, and improve the process flow of the whole system. By making these changes for this process, the demand for increased production in the near future will be obtainable.

Two of the advantages that the Instapak Quick® alternative provides are a significant increase in product protection and a reduction in packaging time. These two advantages of this process are extremely important for Lockheed. It is essential that products get transferred without being damaged since damaged products cost tremendous amounts of time and money.

One disadvantage of the Instapak Quick® system is the fact that the foam is not recyclable. While it can be used a couple times before disposal, the foam has to be thrown away since it
cannot be reformed to fit a different part, or recycled for a monetary refund. Since multiple parts could be potentially packaged by this, the restriction of set foam is not ideal for this application. Another disadvantage of this packaging method is the lack of visibility of the parts once packaged. The employee would have to open the corrugate box and then remove the foam to view the contents. One alternative that allows for viewing parts would be the Korrvu® packaging.

Korrvu® has the advantage of increased part protection and reduced packaging time like Instapak Quick® while allowing employees to view the components through a layer of clear film. This benefit sets this packaging alternative apart from other options. The reusability of the product is another benefit this alternative provides. The same Korrvu® package system can be reused multiple times depending on the distribution cycle of the parts within Lockheed. This eliminates the costs affiliated with one-time-use products and cuts down on wasted packaging material needed to be disposed of. When the packaging does eventually need to be disposed of, it can be recycled at any existing recycling facility. These attributes set Korrvu® apart from the Instapak Quick® method by giving a greener alternative to the solution. Since Lockheed is an environmentally conscious company, implementing a multiple-use packaging system that use recyclable materials will directly align with the company’s existing values and goals in regards to sustainability.

Determining the life-cycle of the Korrvu® film is an important focus for Lockheed Martin. While the film’s life-cycle had been determined at three transport cycles, the number of actual cycles using the Lockheed distribution and packaging system has not been discovered since it is much different than the typical method the Korrvu® film is rated for. Sealed Air has confidence that the Korrvu® will over perform that statistic but internal testing will have to be conducted to support this claim.

Implementing a system that has an indefinite life-cycle would be the best alternative to reduce cost and wasted material. Laundry carts to transport the parts around the facility can be used to increase efficiency. These carts would only need to be purchased once, and come in a variety of shapes and sizes depending on the parts being packaged. The carts are ideal for larger and heavier individual parts, or a variety of smaller ones that are packaged together. The safety of the product can be improved by implementing a spring-loaded base with the cart to help reduce
vibration that the products would experience when rolled around the facility. Foam trays or inserts could also be used for specific parts that need additional protection. The carts also have information pouches that can hold identifying part numbers and other important documents that can help with part recognition. A visual confirmation of the contents of the cart would take much less time than having an employee dig through the contents in order to identify parts. Carts also reduce the human error factor of dropping parts when being carried throughout the warehouse. Rolling the components in carts ensures a less intense transportation method and allows for them to be close to the ground in case an accident did occur. If a part was accidentally dropped from someone carrying it, the likelihood of it breaking would be much greater than if it fell from the lower height of the cart.

One disadvantage of the cart system is that they are only appropriate for specific sized parts. Kits that contain smaller parts do not need a large cart for transportation. Over packaging parts is not cost-effective and will waste funds that could be used in other areas of the production process. When applying a cart system, determining which parts to be used with which cart is crucial in order to protect the appropriate parts and avoid creating more work than necessary for the more durable components. Larger, heavier parts would be ideal for this type of transportation and packaging method.

By evaluating the advantages and disadvantages of each of proposed alternative packaging systems, Lockheed Martin can choose which system or combination of systems is the best option for the company to put into operation. Lockheed Martin may combine advantages of each packaging solution to create a new combined solution that best fits their needs. For example, the protection and ease of packaging is an advantage of Korrvu®, but the handling process is not ideal. By combining the use of a cart and the Korrvu® solution, a new more efficient process could be put in place. This combination of ideas helps to find the most effective solution for Lockheed Martin. A comparison of solutions can be seen in table III.
<table>
<thead>
<tr>
<th>NEEDS</th>
<th>Instapak Quick®</th>
<th>Korrvu®</th>
<th>Laundry Basket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to organize products and account for all pieces</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Protect the components from any damage</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Reusability/Durability of package system</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Ability for package to adapt for shape changes in products</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Weight (light enough for anyone to lift)</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>FOD Prevention</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Security</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Appearance and aesthetics of package</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Identification of package and components inside</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Price for Implication</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Table III Needs Comparison

From the table, the Korrvu® system seems like the most appropriate solution for this application. However the laundry cart system is close on this scale of advantages. Completely eliminating all attributes that come from the laundry cart solution would not be ideal since it has some excellent advantages that could support the needs of Lockheed. A combination of the Korrvu® packages, and carts used for the transportation kits could be the best solution for this project.

The Korrvu® product is the most desirable solution based on its advantages compared to the other possible solutions. This is the product that underwent further testing at Lockheed’s facility with the actual parts. A Sealed Air representative was present to assist with proper packaging and to ensure that the prototypes are designed correctly for the parts. After testing, an open discussion took place to interpret the findings and consider ways to improve the implementation. There were employees present from all areas of production allowing for everyone’s ideas are heard and considered.
After the open forum, Sealed Air constructed a working prototype and sent it to Lockheed for more testing with the actual parts. After further testing at the Lockheed facility, Sealed Air can make alterations to meet any new requirements discovered. This process will happen multiple times in order to come up with the most appropriate prototype. From here, other prototypes can be constructed for different applications containing different components.
Two Sealed Air representatives brought Korrvu® prototypes to the Lockheed facility for internal testing. The actual parts were placed into the prototypes and examined for further revisions. Multiple engineers and managers from Lockheed examined the packaging system prototypes, and worked on improving the prototype and generating future designs. The majority of the engineers liked the prototype’s ability to completely protect the product while also displaying the components together in a clear way.

After initial testing, Lockheed associates agreed that they wanted to combine a new specific group of parts, and requested a new prototype that would package the following five parts as seen in table IV:

<table>
<thead>
<tr>
<th>Part Labels</th>
<th>Dimensions (in)</th>
<th>Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A</td>
<td>8x8x5.5</td>
<td>4</td>
</tr>
<tr>
<td>Part B</td>
<td>11x4.5x4</td>
<td>2</td>
</tr>
<tr>
<td>Part C</td>
<td>10x4x3.5</td>
<td>2</td>
</tr>
<tr>
<td>Part D</td>
<td>9x4x2</td>
<td>1</td>
</tr>
<tr>
<td>Part E</td>
<td>9x4x2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table IV Kit Dimensions

These five components will be the first kit that Lockheed will implement using the Korrvu® technology as seen in figure 6. Multiple prototypes will then be created to fit these exact parts in
a variety of configurations in order to adequately protect and present these products within the kit. Future kits can then be grouped and packaged in additional Korrvu® designs customized specifically for the components.

Sealed Air representatives describe the Korrvu® process as one that involves multiple prototypes and test runs before determining a final design. Since the customization factor of Korrvu® is essentially endless, the time needed to implement the system can be greater than other alternatives. While this time seems extensive, it is critical in creating a packaging system that is easy to use and effective. Assisting the establishment of a good relationship between Lockheed and Sealed Air is important because communication is essential in the prototyping process. Lockheed needs to inform Sealed Air of any changes or alterations to the products they are packaging, and must be available for constructive feedback to make continuous improvements after testing sessions. These improvements can change the way the parts are arranged, and the specific size and dimensions of the compartments.

The first working prototype Sealed Air provided was a corrugate pad that will be placed under the layer of film beneath the five individual parts. This prevents migration of the parts, provides adequate protection, and accomplishes the goal of having all five components in one kit contained by a single outer box. Sealed Air will send assembly instructions along with the prototype to ensure proper use. With a unique packaging system, it is important that products are
correctly laid out, and the retention flaps are properly tucked under the package system. Sending thorough instructions with pictures and diagrams will make it easy for Lockheed employees to understand the packaging technique, and quickly adapt to the new package change.

**Deliverables:** The final result of this project leaves Lockheed Martin with a working prototype of a packaging solution for a specific kit containing five unique components. This packaging system will make the process of packaging these components more efficient and provide increased protection for these expensive parts. By changing this process and making it more efficient, the quantity of kits that go through the facility will increase significantly. Since the demand for parts for the F-35 project will be increasing, this packaging solution is being delivered at the ideal time. The saved time by changing the packaging allows for Lockheed employees to focus their efforts in other areas of the production, or at other kits needed to be processed.

Lockheed Martin and Sealed Air made an important connection through this senior project through prototype testing and constant communication of changes needed according to Lockheed’s requirements. This relationship will be beneficial for both parties since Lockheed needs packaging materials and Sealed Air has the products that are desired. By introducing these two parties and having meetings together, a bond was created which could lead to future business transactions. Lockheed views the Korrvu® packaging system as a likely route they will pursue to renovate their internal packaging process. Sealed Air views Lockheed as a huge potential buyer of products, specifically Korrvu®. By introducing each company to each other and having them work together on this product, they each have a better understanding for how the other company functions. Because the sales representatives at Sealed Air and the engineers at Lockheed and work quite differently, initially there was not an immediate agreement on how to begin this project. However, after meeting in person the first time, there was a mutual agreement on the process of creating this project that met both companies’ needs.

**Learning Outcomes:** After working with Lockheed Martin for the past six months I have learned a lot about the company itself, industrial packaging technology, and what it is like to work with large companies as a university student. There were a number of road blocks faced
while working with Lockheed for this senior project. One of the most difficult was the process of receiving security clearance at the facility in order to see the actual components. Products were not shown until the last visit to the facility which made coming up with a packaging solution quite difficult. While holding a high level of security for a company dealing with complex and important parts is understandable, providing a student with the basic needs of a project should also be a priority. With each trip to Lockheed I gained a better understanding of the project and the needs of Lockheed Martin. When it comes to designing an adequate package solution, being able to see, touch, and test the product being packaged is essential to ensure that it is properly constructed. Working on this project without knowledge of the specific details of the kit components was a challenge that did arise when analyzing the alternatives.

Another issue faced while working with such a large corporation on a student project was the response time to questions. There were multiple times where numerous days would go by after an email was sent before a response would be provided. Understandably, a senior project does not take precedent to Lockheed employees, but it was difficult to communicate when answers were needed to meet deadlines for the report portion of the project. This presumably would be an issue with any large corporation and is not specific with the way that Lockheed deals with senior projects.

While these few barriers caused some difficulties throughout the project, multiple project management lessons were learned. Being proactive and asking as many questions as possible when visiting the facility was one important lesson learned through this project. The three visits to the Lockheed facility provided a wealth of information, but more planning could have taken place in order to predict future questions one might have. Spending more time preparing for the visits could have prevented questions that were not asked at that time and later needed to be answered.

Along with increased planning, making sure that the scope of the project is set and manageable for the given timeline before the start is crucial in order for success. This was challenging because Lockheed changed the parts they wanted to package several times. The first description of parts that was provided was completely different than the final description of the
chosen parts to package. Part of this issue could have been the original scope of the project was not practical for the timeline of the project. Originally there were three different kits with approximately thirty different parts ranging in sizes and weights. If from the beginning of the project, only the five products were chosen to be packaged, there would have been less time spent determining a potential solution for excess parts. If the scope was narrowed down from the beginning, everyone would be able to direct attention away from creating more potential solutions, but rather implementing the best solution for the five products. The original amount of parts presented by Lockheed caused excess time spent throughout the project trying to encompass all parts in one design. Coming up with a kit to hold only five components is much more feasible for a project with a limited timeline.

**Open Issues/ Future Potential Projects:** After concluding this project with Lockheed, there are still various issues that were not addressed in the short timeframe of the assignment. By the end of this project, a working prototype was created and sent to Lockheed for further testing. A final solution was not able to be created during these past six months, but the prototype will be tested and slight alterations will be made by Sealed Air for the next version. Determining what type of packaging would be most useful was the most significant result of this project. Since the Korrvu® system is customizable and designed for individual solutions, the implementation phase of the project would not fit entirely into the two quarter schedule. However, a future senior project could use this project and could continue testing and making appropriate changes to the prototype created by Sealed Air. Currently Lockheed will test the prototype and then give their feedback directly to Sealed Air to make the desired changes.

After introducing Lockheed Martin to the Korrvu® packaging system, there may be other future practical uses for this system in different areas of their facility. This system can be applied to specific kits and new designs can be constructed and implemented for other groups of parts in order to improve packaging. Before identifying other kits that could use the Korrvu® system, a cost analysis could be beneficial for Lockheed to make sure this packaging is cost effective for other kits of materials. Determining the life-cycle of the package will also be necessary in order to compare costs accurately. Lockheed should also consider the monetary incentives for recycling materials from their facility.
Working with such a large and respectable company for this senior project was a great experience. The lessons learned through this project reinforced the concepts taught in the Industrial technology department at Cal Poly. Being able to partake in an industry sponsored project, and actually having the company implement your project is extremely rewarding. This project has been a great way to put what I have learned in school into action and has allowed for personal insight on how large government contracted companies work. Being able to work with such a reputable company for this senior project is an opportunity most other Cal Poly students are not offered.

I feel extremely privileged to have been able to work with Lockheed Martin for my senior project while attending Cal Poly. The relationships I have made with both Lockheed and Sealed Air employees have been extremely beneficial as far as working through the prototype process in this industry. The results from the project are something Cal Poly, Lockheed Martin, Sealed Air and I are extremely proud of. Going into a company like Lockheed and refining some of their existing processes as a student reflects the quality of education received through the Industrial Technology department. I appreciate everything the department has taught me and all of the opportunities I have been exposed to through my education at Cal Poly. This senior project has been both challenging and enjoyable and has stretched my knowledge as a student and prepared me for the workplace after graduation.
SECTION VI
REFERENCES


APPENDIX B
PDCA A3

Title: Lockheed Martin Kit Design

Root Cause Analysis

Fishbone Cause/Effect Diagram:

Select the Best Alternative

Brainstorm List of Best Alternatives

- Just in Time Manufacturing (JIT)
- Kit Approach
- Current packaging system
- Point of Line (products stored at production line)

Build the Plan

Key Steps

- Complete QFD
- Complete FMEA
- Intermediate Key Performance Indicators
- On time completion of project milestones

Key Stakeholders

- Lockheed Martin
- Production employees
- Material handling employees
- Cal Poly Professors
- Purchasing employees
- IDO Government
- Security personnel

Do

Implement, Monitor & Adjust

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Action</th>
<th>Who</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockheed</td>
<td>Redo</td>
<td>Team</td>
<td>2/2003</td>
</tr>
<tr>
<td>Material</td>
<td>Rebuild</td>
<td>Team</td>
<td>9/2003</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Revise</td>
<td>Team</td>
<td>3/2003</td>
</tr>
<tr>
<td>Security</td>
<td>Inspect</td>
<td>Team</td>
<td>11/2003</td>
</tr>
</tbody>
</table>

Check

Measure & Analyze

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Target</th>
<th>Results</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to package</td>
<td>120%</td>
<td>120%</td>
<td>100% completion</td>
</tr>
<tr>
<td>Time to identify components</td>
<td>90%</td>
<td>90%</td>
<td>100% completed</td>
</tr>
<tr>
<td>Protected Products</td>
<td>45%</td>
<td>45%</td>
<td>100% protected</td>
</tr>
</tbody>
</table>

Act

This section will be filled out in the later stages of the project

PDM Report Template - Updated 09/14/2003 - Printed - 2003
APPENDIX C
ORIGIONAL COMPONENT LIST

Kit A I.
1. 13.5 x 1.5 x 8
2. 34 x 10 x 4 (stored on side)
3. 33 x 9.5 x 3 (stored on side)
4. 11.5 x 5.5 (flat plastic board)
5. 11.5 x 5.5 (flat plastic board)

Kit A II.
1. 26.5 x 13 x 3
2. 10.5 x 2 x 1.5
3. 22 x 5 x 4
4. 23 x 9 x 2
5. Label

Kit B I.
1. 70 x 17 x 5.5 (stored on side)
2. Same as part 1
3. 40 x 16 x 6 (stored on side)
4. 22.5 x 7 x 2.5

Kit B II.
1. 98 x 5 x 14.5
2. 98.5 x 17.5 x 5.5
3. Barcode
4. 18.5 x 2.5 x 1.5
5. 98 x 5.5 x 2.5

Kit C I.
1. Bag of bushings Qty (17)
2. Bag of inserts Qty (17)
3. Bag of washers Qty (17)
4. 143.5 x 6.5 x 4.5 (Spar)

Kit C II.
1. 150 x 10 x 5.5
2. 150 x 10 x 4.5
3. 11.5 x 5.5 (flat plastic board)
4. 11.5 x 5.5 (flat plastic board)
5. 22.5 x 7 x 2.5
6. 13.5 x 1.5 x 8
7. 13.5 x 1.5 x 8

Kit C IIa
1. 9.5 x 6 x 1.5
2. 147.5 x 10 x 5.5
3. 146 x 9 x 5.5
4. 143.5 x 6.5 x 4.5

Kit C III.
1. 6.5 x 2.5 x 1.5
2. 13 x 5 x 3
3. 15 x 6 x 5
4. 10 x 6 x 5
5. 7 x 4 x 4
6. Barcode
7. 147.5 x 11 x 5.5

Kit C IV.
1. 13 x 12.5 x 3 (white boxes, Qty. 34)
2. 19.5 x 18.5 x 3 (n=2)
3. 22 x 3 (heat sealed bag)
4. 27 x 3 (heat sealed bag)
5. 14 x 12 x 1 (envelope)
6. 13 x 5.5 x 4
7. Same as part 6
8. 13 x 2 (flat part, n=2)
9. 10.5 x 1 (hose parts, n=4)
10. Misc small components in Ziploc bags (n=7)
11. 147.5 x 11 x 5.5

*Note: All parts measured in inches
APPENDIX D
ASSEMBLY INSTRUCTIONS

1. PRE-FOLD TENSION FLAPS TO RELEASE FILM. PLACE PRODUCT UNDER FILM.

2. FOLD BOTH TENSION FLAPS WITH EQUAL FORCE DOWN AND UNDER BASE.

3. FOLD BOTH INNER PANELS UPRIGHT. MAKE SURE POP-DOWN TABS (IF PRESENT) ARE FOLDED DOWN.

4. FOLD RAIL PANELS DOWN AND HOLD TOGETHER WHILE INSERTING INTO CARTON.

Sealed Air
Korrvu®
Retention Frame with Rails

For assistance:
Contact your Korrvu® sales representative
http://instructions.korrvu.com

Ret-Rail Rev. A 10/28/04 (REF. US13454/000)
APPENDIX E
PROTOTYPE 1

SEALAD AIR CORPORATION
KORRVU PACKAGING

SAC #: UL08754P00
CUST: LOCKHEED
DIE#
DATE: 3/8/10
RAY LEE

NOTES INSIDE VIEW
P = 1/4 X 1/4 PERF
S = SCORE

USSRD

ETERNAL
FLAT

STRIP JIG: Y N
MAKE READY: Y N

CORRUGATION DIR
BOARD: 275B
LINER: KRAFT
NET: 15.75 X 20.0025
RULE INCH: 131
DIE CUT: SF (UP)
CUT - HEAVY SOLID BLACK

Lead Edge →

15.750

3.250

2.000

.500

.125

1.750

2.000

500

S

.500

2.875

3.000

8.250

8.813

20.063

13.813

4.063

2.500

2.000

41