Spring 2015

Environmental Security through Packaging Sustainability

Mark Betancourt
Loyola Marymount University

LMU|LA

College of Science and Engineering

SELP 695: Systems Engineering Integrative Project

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Mark Betancourt

Date

December 12, 16

Professor

Dr. Bohdan W. Oppenheim

Table of Contents

Table of Figures

Introduction

One year ago I threw myself into the world of logistics and its unbelievably complex packaging world. Prior to this, the only packaging with which I had experience was as a consumer of marketing goods. However, within a very short time I became acclimated to the requirements of the Package Engineering discipline, and due witness to what was evident packaging waste. The prototype shop I manage discards enormous quantities of foam, plastic and corrugated board. As I collaborated with shipping and transportation groups, I could see material wasted in sizable volumes: single-use wood crates that vary in size, padded by foam, plastic, and cardboard to support and protect the parts. These protective materials are ultimately discarded. So, as I began to research the subject of packaging, I found that Northrop itself is bound by its Corporate Responsibilities to reduce the waste and Green House Gases (GHG), which have been created through the company's landfill emissions, water usage, and transportation emissions. This is how I became passionate about changing the Package Engineering group culture. Typically, packaging is designed for here and now. My vision at Northrop Grumman as the Package Engineering Manager is to become a change agent in the world of packaging by instituting design for life cycles into packaging processes and design requirements

History of Logistics

The best way to broach a subject as vast and complex as packaging is to understand where its requirements came from and how the industry evolved. Since humans began following migration patterns as nomadic hunters and gatherers, packaging has been an essential aspect to the logistics of survival. Traveling forced our ancestors to construct devices for carrying and containing food, tools, and other valuables, in order that they be transportable, thus increasing the odds of resource and human survival. The art of packaging food in plant leaves or containers forged from wood or ceramic was commonplace. Eventually, these requirements would evolve into the need to build structures, navigate vast lands for exploration, and transport people, artifacts, food and animals. An example of early packaging can be found in Ancient Egypt. Material handling technology used in pyramid construction is still largely inexplicable, but the builders obviously applied a more scientific approach to building as they transported blocks of stone weighing several tons and assembled them at construction sites. In more recent history, between 1200 and 1800, advances in transportation — from shipbuilding to the steam train — allowed trade to take place internationally at speeds previous generations would have never

imagined [1]. With logistical advances came packaging challenges that required a more scientific understanding of logistical requirements to overcome the earthly elements of travel and preservation.

From this point forward packaging would become a necessary commodity to meet logistical requirements. This became clear during the First and Second World Wars, as increasing mechanization and technological sophistication of modern armed forces led to a very complex system of continuous supply from a strategic base. As a result, theater logistics became a more integral factor for success in war. This is where the art of sustaining came into play, driving the need for robust and sophisticated packaging requirements to support the harsh theater of war — both maritime and land — taking place on a global scale. Consequently,, in the early 1940s, military packaging specifications were put into effect to ensure support requirements for troops, and to standardize and update armaments on an ongoing basis [2]. In 1952, the first school of Package Engineering was opened, instituting the science of packaging to support the speed at which logistics were advancing and consumer needs growing among the most affluent and white collar workers alike [2]. Migration into cities reduced the need for large, bulky consumer packaging and increased the need for individual and smaller packaging. Manufacturers and producers needed the large storage containers and bins more than ever, but consumers needed other packaging options, consequently opening a new chapter in the packaging industry. Consumers were enticed into the era of shopping centers, where marketing was the driver and the consumption of goods was the reward.

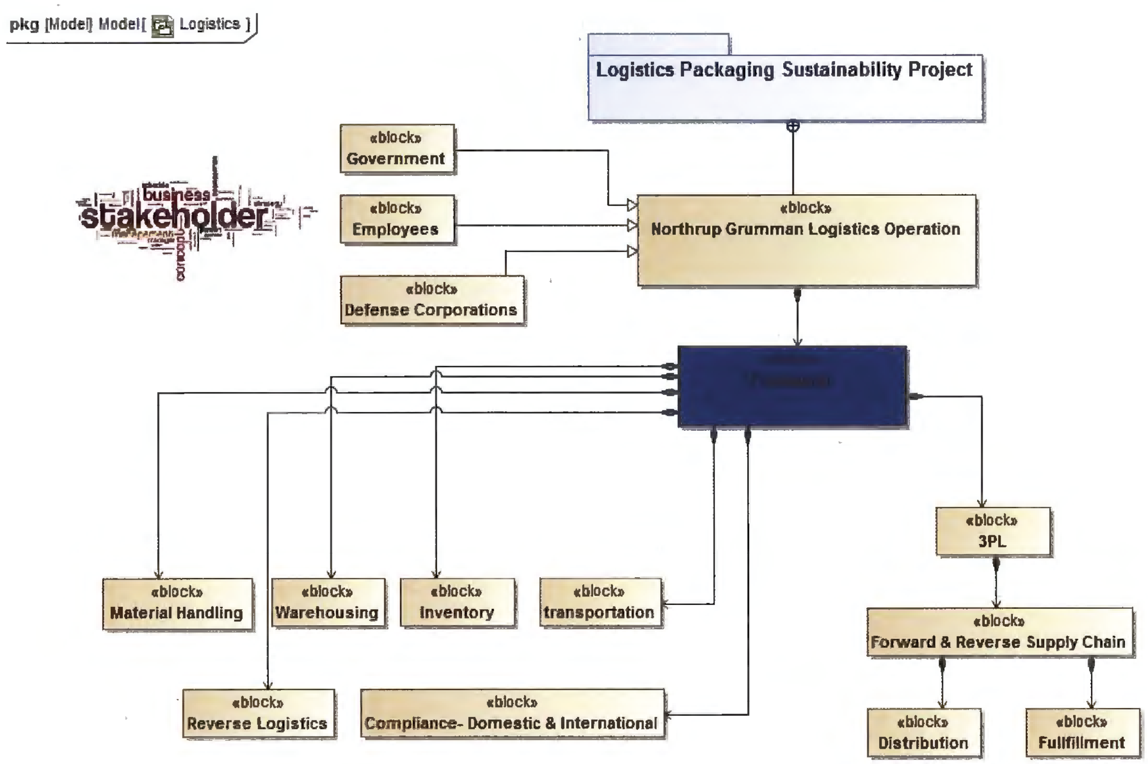

Figure 1 Logistics Operational Overview, Behavior Block Diagram

Problem Statement

It was the transition to a preference for single-use consumables over bulk that required packaging to become innovative, revolutionizing plastics or polyethylene, corrugated board, and paper in packaging. A consequence of this shift was greater stress placed on our environment. Issues with plastics sustainability would begin to surface, deforestation would drive people to consider paper recycling, and mountain-high landfills would become a global concern. Understanding the importance of sustainability in packaging is vital if we are to control and prevent environmentally destructive practices that are currently taking place on a global scale. So what is understood about sustainability in packaging and how can we substantiate its importance? To begin with, an understanding of sustainability is necessary to combat the culture of consumption and convenience that has driven to current disastrous levels the damage being done to the global environment. A good example that will be covered in detail is the saturation of micro-pollutants in our oceans and waterways. Sustainability in packaging can have distinct variables that essentially revolve around the creation of a closed loop, flowing in a system that is economically robust and provides benefit throughout its life cycle [3].

Valuing packaging sustainability entails fostering standards that bear in mind global impact. For example, a manufacturer might consider the safety of individuals and communities affected by its product, as well as the potential health benefits a certain type of packaging might provide throughout its life cycle. From a source perspective, is the manufacturing, transportation, and recycling of materials optimizing the use of renewable or recycled materials? Or, how do we manufacture using clean production technologies? What are the best practices for using materials that remain healthy throughout their life cycle while optimizing materials and energy? These questions are imperative to ask as we continue to constitute global logistical packaging requirements at a rate that is exceeding our environmental sustainment levels. For example, The EPA estimates that 75% of the American waste stream is recyclable, but we only recycle about 30% of it [4].

Interrogatories Statement

Who?

Northrop Grumman has adopted the greenNG environmental sustainability initiative as a component of the company's corporate responsibility actions. As a model for actions to be taken, we look to the Logistics leadership within the Global Supply Chain operations for support and accountability of actions. The Package Engineering group will be conducting analysis and executing the requirements of the project.

What?

The aim of this Packaging Sustainability project is to reduce or eliminate use of petroleum-based and un-recycled products in the design and build of packaging requirements. Furthermore, it is imperative that we develop new transportability protocols for crates and containers that extend the life of the program's shipping cycles. These protocols can be instituted by life cycle design requirements, and managing products to processes to reduce volumes of materials and toxic waste. This requires the development of unconventional materials other than wood and plastic to support global shipping initiatives for both Northrop Grumman and its suppliers.

Where?

The initiative will begin at the sector level, the Northrop Grumman Aerospace Sector. As proof of life cycle concepts become imbedded into sector processes and procedures, it is the intent of this project to one day be a corporate-wide program. This initiative came about as I

recently moved into the position of Package Engineering Manager, witnessing enormous volume of foam and plastic, wood and corrugated board, utilized in design and build phases that support the shipping and production requirements of the sector. To execute this initiative at the corporate scale partnership with the Northrop Grumman Corporate Responsibility group will be established to reduce Northrop's carbon foot print and environmental impact.

When?

With a keen understanding of the effects of these materials on the environment, I am committed to developing and instituting life cycle sustainability requirements in package engineering processes over the next five years.

Why?

It is imperative that sustainability in packaging operations support and encourage waste diversion begin to evolve from the most basis stage of requirements receipt. Further, the awareness of the environmental impacts upon energy consumption when packaging materials are disposed of is essential. For example, transportation of waste to landfills, incineration plants, and very popular trash shorting and recycling operations all require significant amounts of energy to operate.

How?

The implementation of these processes would focus on materials that have the greatest impact on carbon footprints and landfill management in the shortest time. To attack this large requirement it is best to follow lean philosophies, which state that one ought to start with the most common and effective problem to be solved. The process of supporting and securing resources with foam and plastic inserts as they are transported would be the first step, as it would reduce the use of wood or certified wood. The next stage would be developing resources to utilize recycled pulp to produce paper and corrugated board. Finally, the institution of a Zero Waste Program by benchmarking other companies such as General Motors who current have a robust program in place.

Requirements Analysis

If we intend to combat the issue of unsustainable packaging, there needs to be a clear understanding of what is required to reverse the cycle (see Figure 2). Research on the subject points to plastics as the number one factor that can have the greatest environmental impact, so

one would want to look at what it would take to transition from foam, plastic containers, liners, and flexible packing, to 100% biodegradable and compostable materials. To support the reduction of deforestation, certified forests have been fostered throughout the globe. These forests provide certified wood for paper products from "responsibly managed forests as defined by a particular standard [5]." This standard is known as third-party forest certification, an independent organizational standard developed to nurture good forest management. According to the EPA, the sustainability rate achieved by paper product recycling is currently at 50% of total waste diversion, which is the highest of all waste products. That's 68 million tons of paper products discarded annually with 44 million tons of that being recycled [6]. Another requirement that can be put in place is the use of aluminum for crate construction to ship resources long distances or in environmentally challenging conditions. Aluminum is relatively as expensive as wood when usage cycles are considered, and as it is highly recyclable and recovered at higher rates than wood, (8% v. 2%, respectively) [6]. Therefore, standard operating procedures shall be developed to integrate sustainability and Zero Waste standards into Northrop Grumman packaging practices, reducing solid waste by 70%. Suppliers who do not elect to adopt these standard and operating procedures will be charged equivalent reclamation fees to support recycling costs and reduce landfill use. The goals of these requirements will be to reduce the carbon foot print 30% from 2010 levels as per the sustainment goals set by Executive Order 13693 [7].

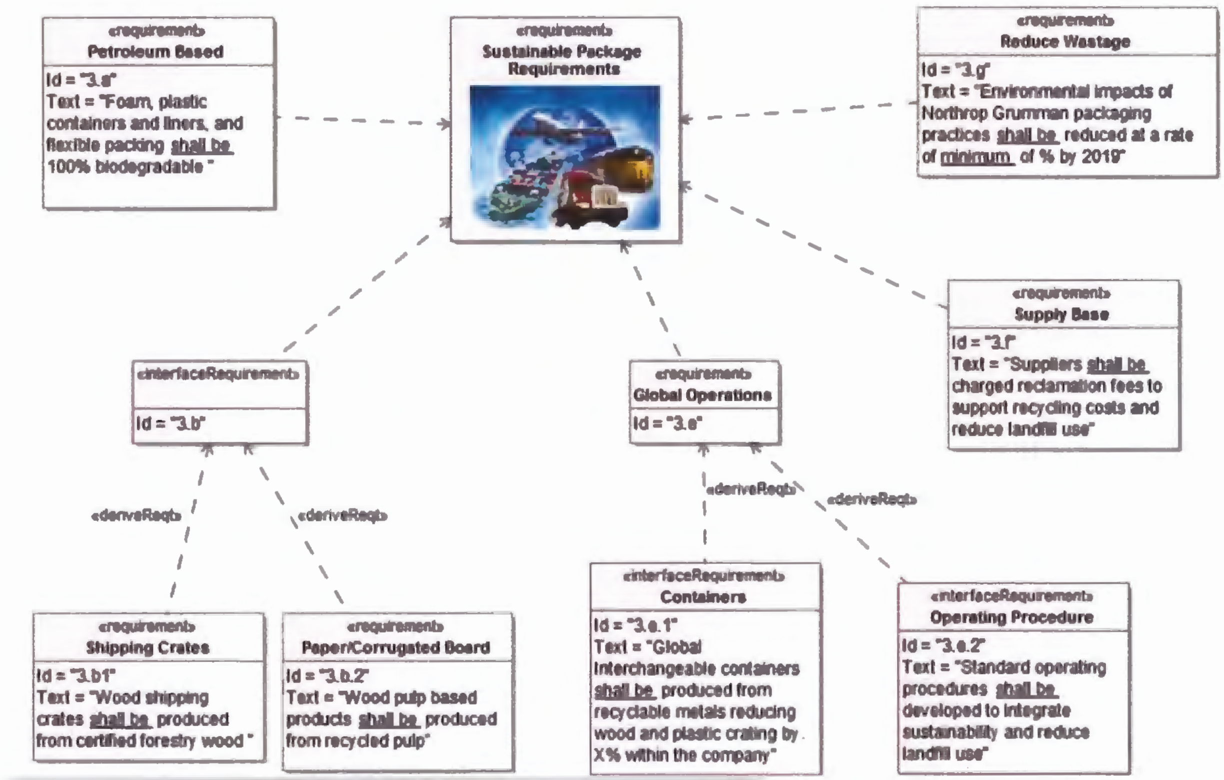

Figure 2 Sustaining Packaging Requirements Diagram

Architecting the System

In order to comprehend the solution to these complex requirements one will need to apply system architecture techniques to provide an operational perspective. To accomplish this, we will utilize the OV-1 operational view, Figure 3, along with the OV2 node connectivity diagram state, current, future, and ideal views. As we look at the operational view of logistics, one can gain a simple but high-level perspective of the responsibilities that accompany supporting global operations.

Figure 3 Logistics Packaging Con Ops, OV1

Logistics Packaging Operational Overview

To manage a logistics operation in the 21st century and beyond, consistent process improvement and operational evaluations are necessary. Each component has many variables that govern them. However, from Figure 3 it is clear that packaging supports six of the eight of support functions in a logistics operation. Though smaller companies may not support a logistics function, these are necessary aspects of logistics that are required by practically all businesses to functions successfully.

Packaging Sustainability, Current State

Another consideration is the projected growth of the package industry. It is useful to take a closer look at the different states of packaging operations, and how the functions and processes within each affect sustainability. In the current state, which emulates current industry processes and design practices, recycling of paper and cardboard products are the only truly sustainable attribute. Packaging waste is rampant and unchecked, for example 117 tons of package waste are generated annually in the US, with 68 million tons discarded to landfills disposed of by other

methods that do not support the recovery process. Currently, paper and corrugated board has the highest waste generation at 67 million tons and also has the highest recovery generation at 44 million tons [6]. It is evident that the current lack of life cycle accountability, based on the figures discussed, is the direct cause of the environmental devastation packaging is having on the earth. Consider the impact of 68 million tons of waste, in addition to an unknown amount illegally dumped [6]. When waste decomposes it emits methane and carbon dioxide, and the resin used in plastics and coatings produce chemical leakage that seeps into waterways, eventually ending up in the ocean. This has a direct impact on humans: when testing the presence of Bisphenol A, BPA, 93% of people were found to have the chemical in their urine [9]. Another alarming development is how discarded trash in the ocean coalesces in garbage patches, which then join the currents of ocean gyres. Three of the five largest gyres have enough garbage circulating in them to be equivalent in size to the state of Texas. The largest of the three is off the coast of California and reaches at times to the outer waters of Japan [8]. The effect of the garbage on these gyres has been to slow down their rotation, which is a cooling mechanism for the oceans and also is an important factor in moisture generation. Micro-plastic, a byproduct of plastic products that fragment from the collision of trash in the ocean, are the unseen element drawn together by the motion of the gyre, creating a dense layer that inhibits the reflectivity of the sun's rays, again adding a heat factor to the ocean [8].

The second major effect of packaging's current state is the relentless requirement of paper products and wood and the overwhelming effect on forests around the world. Over the last decade deforestation has been at the forefront of environmental disasters with over 18 million acres removed every year [11]. The results of deforestation are apparent in some cases but hidden in others. For example, depletion of forests provides less absorption of carbon dioxide, which allows it to move into the upper atmosphere, and cause greenhouse gas damage to the ozone. The deforestation of trees not only lessens the amount of carbon stored, it also releases carbon dioxide into the air because when trees die they release the stored carbon. Also, a devastating effect of deforestation is the extinction of species that reside in forests. This extinction rate is that of the most extreme in our earth's history. Extinction is taking place at a rate of approximately 10,000 species a year and is primarily caused by humans, whereas extinction in previous decades could be linked to natural causation [11].

Looking at the current state node connectivity diagram of packaging practices, one can see that it follows the basic pattern of environmental devastation.

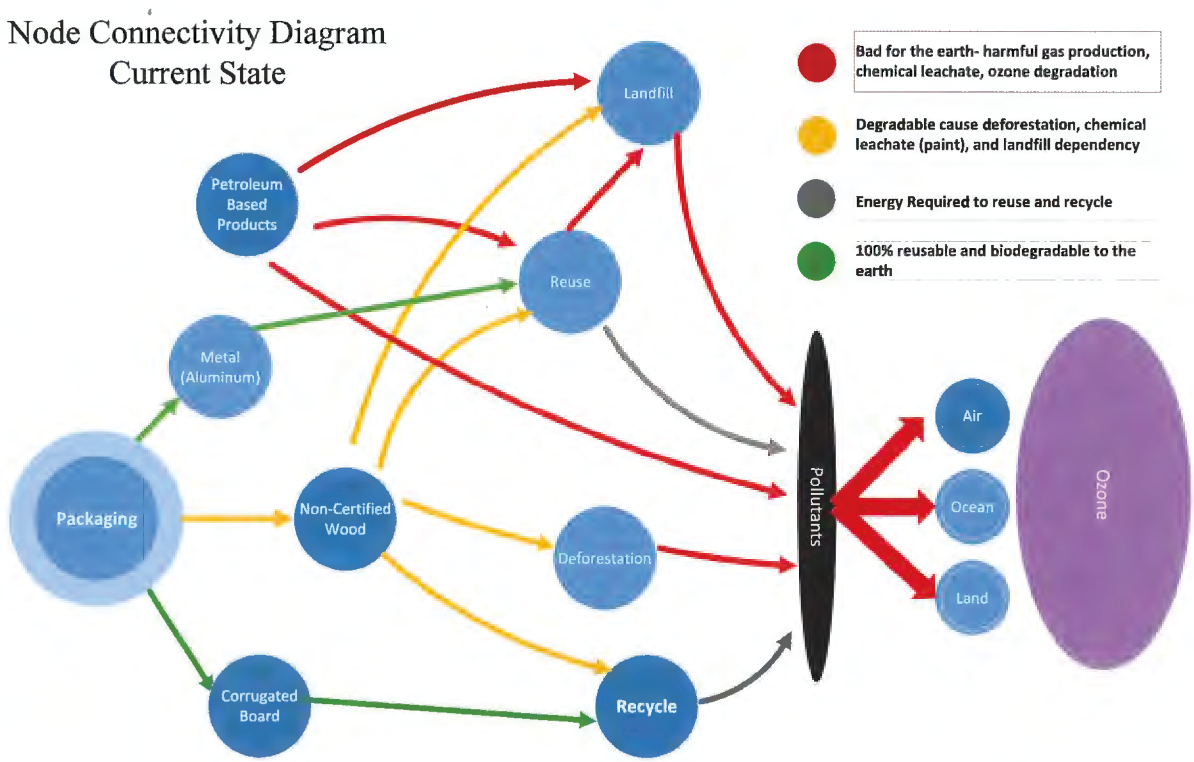

Figure 4 Current State, OV2 Node Connectivity Diagram

Packaging Sustainability, Future State

Understanding the current environmental impacts of packaging, it is vital that we develop a keen understanding of the future state and the effect one would desire to have on sustainability at a global scale. The dilemma is that as world population increases and world-wide distribution chains become more sophisticated, the corresponding increase in the use of packaging has the potential of becoming as much a problem as a solution. To conduct this process effectively a systems engineering approach would need to be adopted and established with the support of business process leadership. It is well known throughout every process improvement edict that a very low percentage of projects are successfully implemented without total leadership buy-in. If leadership, and for that matter the shareholders, cannot find value in an initiative, support from the parties necessary to implement the directives will not hold merit. In most cases where future requirements and process improvements are generated, value stream mapping is a constituted

tool to provide a clear pectoral of paths, responsibilities, and values to be executed on. In this sense, one can see that the greatest effect with the least resistance would be that of petroleum-based product wastage. With this path it is evident that many alternatives exist, and providing varying choices makes outcomes more predictable. For example, in the use of polyurethane foam there are multiple choices of packing with recycled polyurethane foam, plant based foams, and synthetic resin based foam.

To understand utilization of sustainable packaging alternatives, a future node connectivity diagram can be created to provide a view of the effects alternative implementations can have on the current state model.

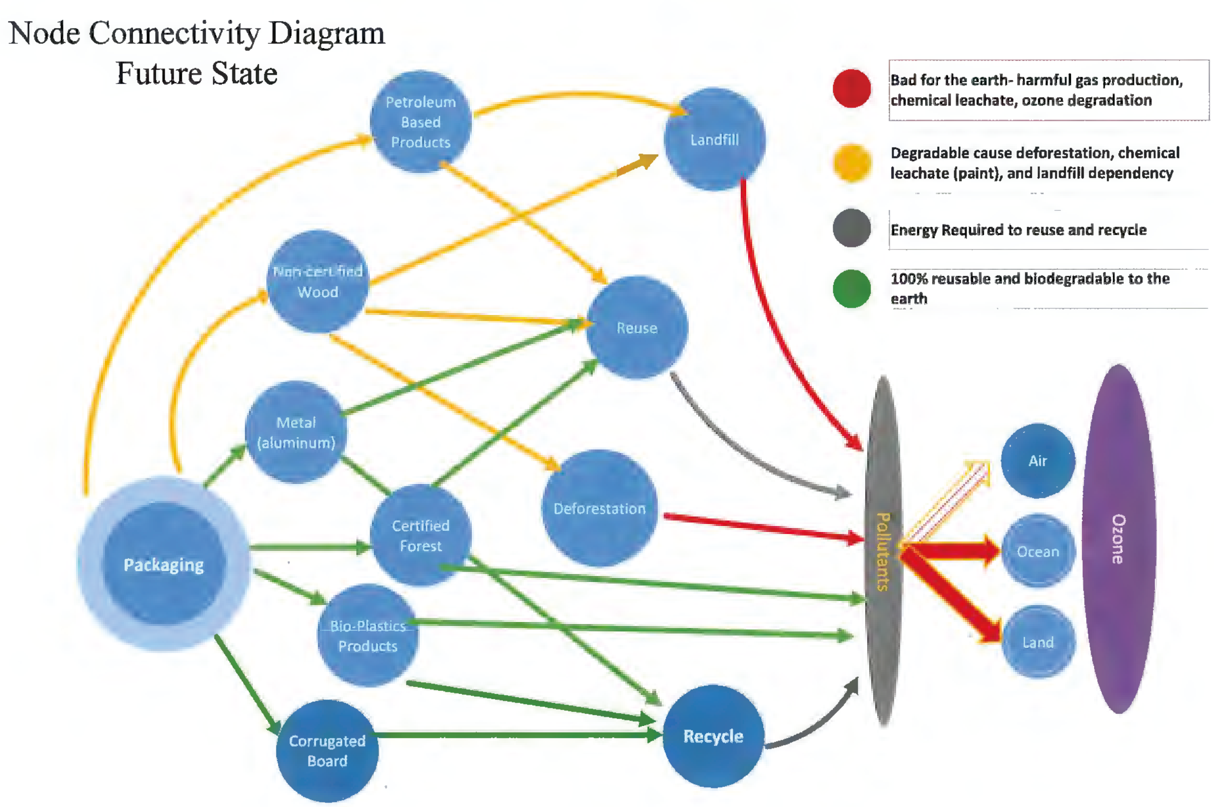

Figure 5 Future State, OV2 Node Connectivity Diagram

As can be seen in Figure 5, an approximate 25% increase in operational activity of the alternative implementation actions, would support a sustainable operation, and clarify the ideal path to 100% sustainability. In this future state, impacts would be measurable at a sustaining

level all the way up to understanding the impacts of each node on carbon footprint levels. For example, the development of life cycle package engineering protocols that focus around "reduce, reuse, recycle", and recover provides substantiation of materials that interlinked stages of a product system, from raw material acquisition, or generation from natural resources, to final disposal [12]." Adoption of this sustaining philosophy would require updating processes and procedures, along with buy-in from raw material suppliers to collaborate on supporting the future state sustainable raw materials. In doing so, what is becoming more apparent is culture or paradigm shift stratagem that will need to be invoked throughout the supply chain, logistics organization, Aerospace Sector, and eventually at the corporate level. Many of the sustainability changes will require an understanding of cost to carbon variance. What is meant by this is that at the procurement level, design costs will appear to increase, requiring budget reconciliation, with the realization that at the corporate and shareholder levels, bottom line profits can be substantially increased.

Therefore, a future state sustainable model factors the least impact on the bottom line by utilizing principles of how packaging can support sustainability and apply them in a practical sense. For instance, annualizing packaging design during product or resource design will make the packing more compatible with external and internal environments. Utilizing materials that are sourced in a responsible way, such as naturally based plastics, or highly recyclable aluminum and wood pulp, allow for multiple reuse cycles. At the same time products and packaging must meet operational needs and be sourced at competitive costs while being both recoverable and renewable.

Packaging Sustainability, Ideal State

As packaging sustainable processes and methods are continually refined through continuous improvement, lean principles, advancements in raw materials, and innovative life cycle designs, one will see the viability of an ideal state where zero waste is possible. To attain Zero Waste, a goal thinking philosophy would need to be instituted at the corporate level. Zero Waste is a "whole system" approach to resource management that maximizes recycling, minimizes waste, reduces consumption and ensures that products are made to be reused, repaired or recycled back into nature or the marketplace [13]. For example, by using recycled aluminum instead of virgin metals, an energy savings of up to 96% can be recovered by not having to mine, process and produce the product or resource [13]. From a packaging process, substanial goals can

be accomplished in a zero waste system, due to the fact that practically all the raw materials used in the design and production of packaging can be produced to be environmentally friendly or recycled. So let's take a look the Ideal State Connectivity Diagram and see just how this would look.

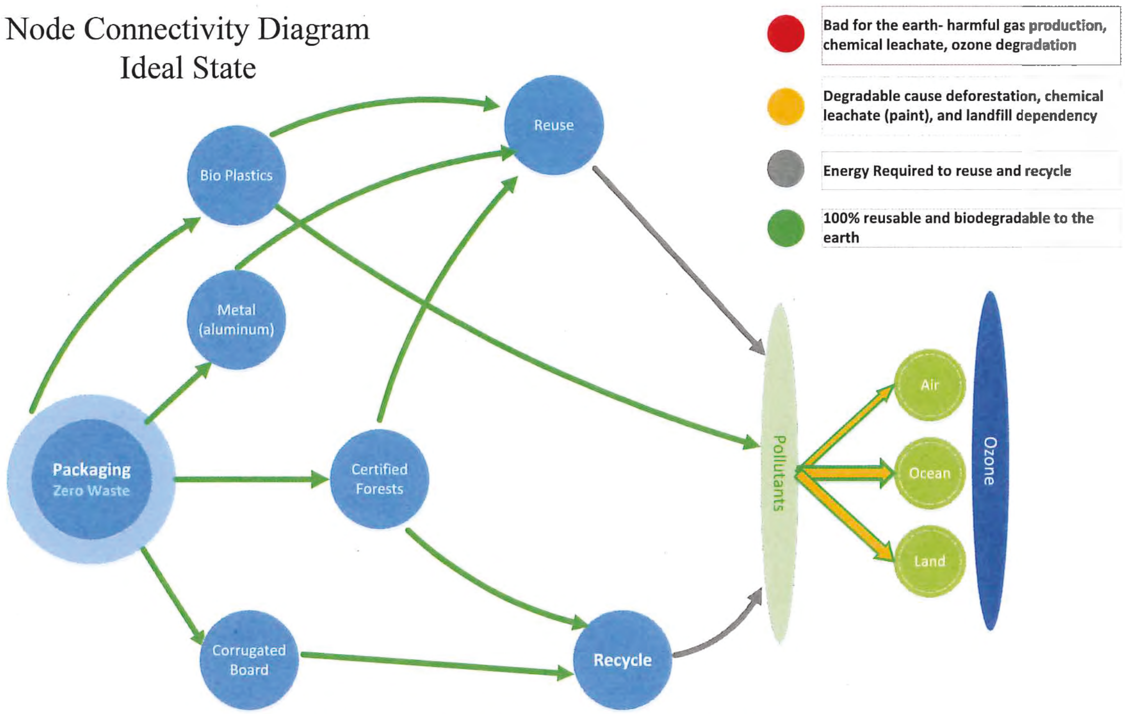

Figure 6 Ideal State Node, OV2 Connectivity Diagram

Stakeholder to Subsystem Synopsis

Now is the time to understand what the organizational sustainability would look like five, 15 or 25 years from now. What changes need to be made from the organizational level to the corporate leadership level? This is another area in which systems thinking can provide clarity and structure through the analysis of the subsystems and stakeholders. Let's use the Conceptual Structure model of Systems Thinking, Figure 7, where subsystems are broken down to understand who the stakeholders are. This will allow clarity in assigning responsibility and accountability to the proper leadership roles, thus creating a more focused approach for the implementation and execution of sustainable tasks and requirements.

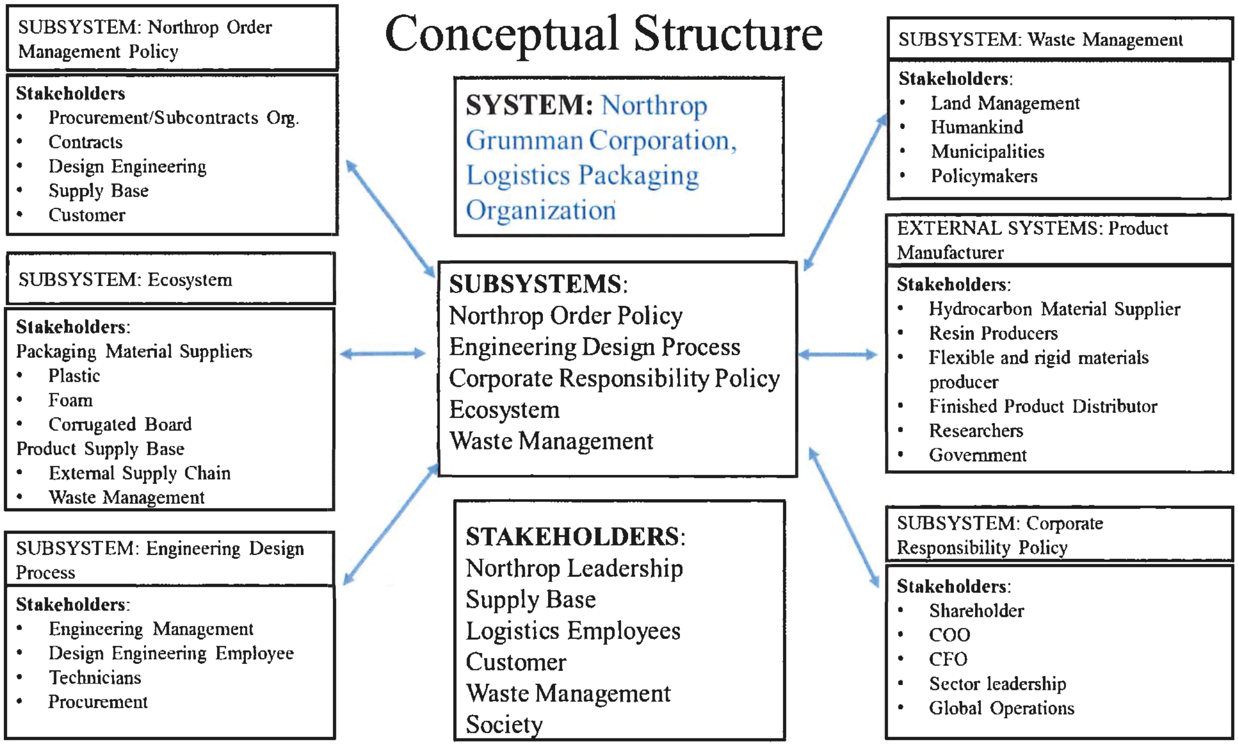

Figure 7 Systems Thinking Conceptual Structure Model

Alternative Solutions

It is well known and has been previously stated that for packaging sustainability to be successfully implemented, top to bottom leadership has to be committed to changing policies and procedures. A good example of this is the commitment Northrop corporate leadership has made to sustainability as evidenced by the Silver-level Zero Waste Certification award received in 2015 by the U.S Federal governing body for sustainability. Even as an employee, one can see aggressive actions being taken by the company to support sustainability with its greenNG program, consistent educational advertisements, as well as the volunteer programs.

It is clear that a project of this size and complexity can present challenges in many forms that will have to be measured and reviewed to understand the best alternative solution. The path of least resistance would be to make minimal changes to current practices and stick to business as usual. However, this would also be the most illogical trajectory, since we know that current processes and design constraints will only lead to continued environmental degradation as

materials are designed and procured that harm and poison our earth. These actions will continue to negatively affect our food and drinking water, oceans and forests, increasing CO2 output far beyond what can be absorbed by forests because they are being depleted, a 36%, increase in the earth's temperature, 1.4 degrees Fahrenheit since 1880 [10]. If we continue with the current packaging practices, the number of landfills increase, producing ever-more pollutants such as methane, carbon dioxide, and leachate, which have seriously adverse health effects. This will drive up the cost of medical care while causing and prolonging illness and suffering. Many of the carcinogens produced by these chemicals are found to cause abnormal cell development in humans. For example, between 2010 and 2013 the FDA began warning the public about the harmful effects of BPA a byproduct of crude oil and natural gas. In 2013 the FDA banned the use of BPA in baby bottles [14] and from that ruling the FDA has published several iterations of these warnings on the harmful effect BPA has, especially when used in food contact and packaging [15].

Consequently, to act in a more responsible manner and foster the mandates of Corporate Responsibility to which Northrop Grumman has committed itself, one must adapt alternatives that institute sustainable best practices. Currently, Northrop Grumman operates its environmental programs under the directive of reduce, reuse, and recycle, which will need to be the initial process adopted by the packaging engineering and shipping departments. For example, the company can keep the use of packaging materials to a minimum and develop designs so those materials are easy to reuse and recycle. Northrop Grumman has committed to a 70% reduction in waste diversion by 2025 with a significant reduction of new raw materials such as PET (polyethylene terephthalate) resin based packaging foam, and aluminum and wood for crates and containers, which would have a direct effect on landfill growth [7]. Designing for recycle is beneficial because resources developed from recycled goods require much less energy to produce; for example, recycling aluminum requires only five percent of the energy needed to produce new aluminum. This action reduces the coal production that supports power stations, and cuts one of the most harmful emissions to the atmosphere.

Packaging Design Life Cycle

To support the Sustainable Packaging Best Practices, the packaging processes and procedures would need to be amended for the life cycle design requirements. The key to conducting life cycle assessments of packaging material is understanding the requirements of sustainability and

the goals of the programs this packaging supports. Therefore, it is necessary to choose appropriate strategies that satisfy cost, performance, and cultural criteria, while also optimizing environmental objectives that do not counteract production or shipping requirements. Life cycle designing seeks to integrate product and process design to effectively reduce the cumulative environmental impacts associated with packaging requirements. It is also important that the life cycle stages themselves are understood in order to develop clear design criteria. The basic flow of packaging life cycles is:

1. Raw material acquisition
2. Engineered and specialty materials production
3. Manufacturing and assembly supporting logistics activity
4. Use and service
5. Retirement
6. Disposal Raw materials

To illustrate this, a model of the life cycle design process provides the framework necessary to understand the stages packaging sustainability should go through to properly evolve into a truly environmentally responsive operation, see Figure 8. The importance of this life cycle design process development must be in place and robust before the next alternative, institution of a Zero Waste Packaging Program, can even be considered.

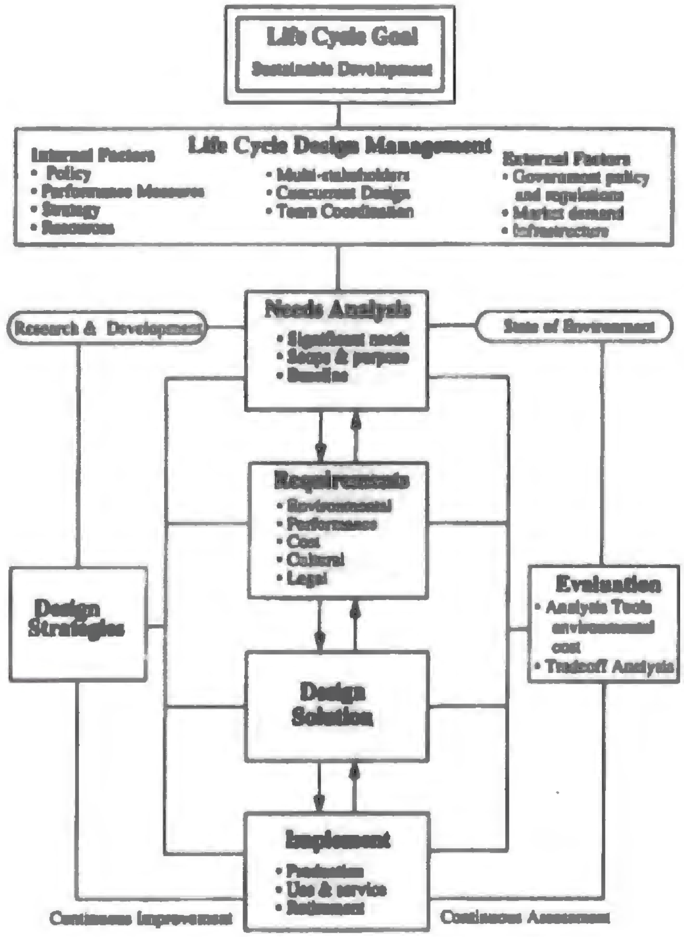

Figure 8 Life Cycle Design Process [15]

In order to understand the enormous task at hand, this alternative, Zero Waste, would need to be defined and implemented at the design level. The initial definition of Zero Waste is 90% overall non-hazardous wastes are diverted from landfills and incineration [16]. Therefore, packaging resource design is initiated with anti-landfill or incineration considerations such as biodegradable raw materials that decompose through composting or materials that are recycled and reused. Figure 8 shows the very successful steps General Motors has taken to successfully implement Zero Waste program.

Sustainable Decision Making

With the sense of responsibility actors apply to basic relationships of requirements to materials, one can begin to break down activities that focus on executing the analysis of sustainability

implementation. The development of a systems activity diagram, Figure 9, which depicts the two paths of sustainable decision making, provides detailed consequences for paths taken during the order management process. Furthermore, one can also begin to see rolls being played by the packaging requirements received and executed by Package Engineering. One also develops a perception of what these decisions can result in. The Life Cycle Design path, for example, relies on recycling, biodegradable plastics, and certified wood. These materials correlate directly into sustainably supported decisions, which take part in developing reductions in carbon emissions, zero landfills, and recycling programs that promote resource reuse and composting. On the other hand, non-sustainable decisions, ones that expose the lack of life cycle design planning, are clearly destructive and non-value adding when it comes to supporting a sustainable operation, or world. Currently, we individually generate 4.3 pounds of waste per day, 1.6 pounds more than in 1960, which does not even put into perspective the tonnage of packaging entering landfills because of business of varying sizes which invoke non-sustaining operations [10].

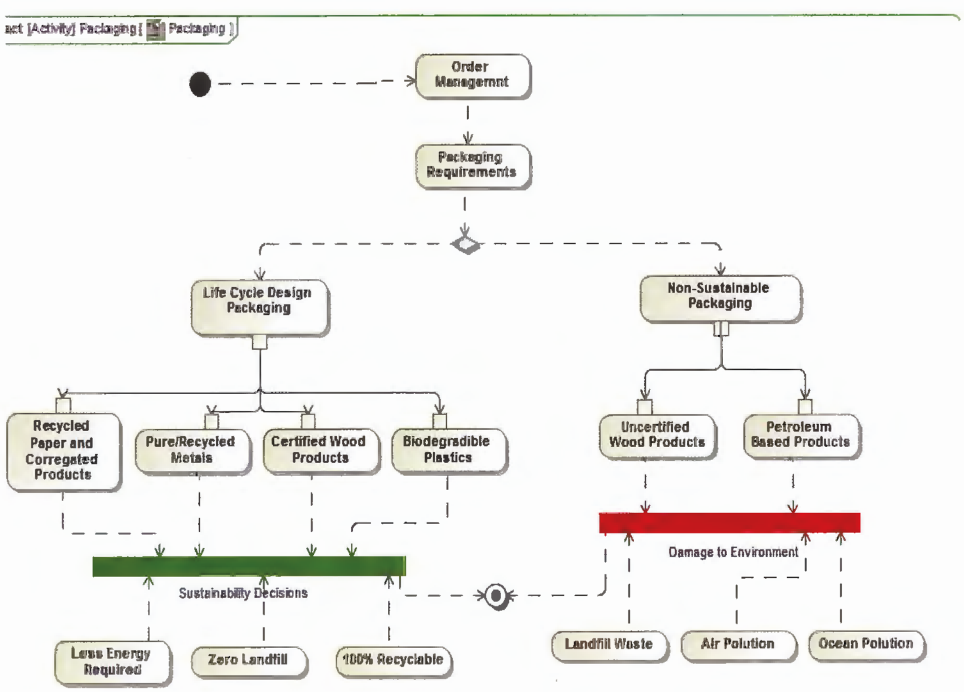

Figure 9 Order Management Sustainable Decision Making, Activity Diagram

Measures of Effectiveness

Using the Measures of Effectiveness (MOE) method provides pertinent analysis of the three alternatives, identifying a starting point for the sustainability initiative. As seen in Figure 10, instituting sustainable packaging best practices is an effective starting point with a 50/50 relationship to measurable factors being considered. Whereas, zero waste effectiveness relates more to the ideal state, one would use those measures to build off the successes of Best Practices alternatives. By refining the requirements of the Best Practices alternative and defining the principles that support waste reduction activities, a more defined business model can be constructed from the basics of sustainability reuse, reduction, and recycling.

Measure of Effectiveness	Minimal Change to Packaging Practices	Institute Sustainable Packaging Best Practices	Zero Waste Program
Cost	Low (3)	Medium (2)	High (1)
Implementation Time	Low (3)	Medium (2)	Medium (2)
Biodegradation Vs Degradation	Medium (2)	High (1)	High (1)
Raw Material Target Group	Medium (2)	Medium (2)	Medium (2)
Education	Low (3)	High (1)	High (1)
Leadership Buy In	High (1)	High (1)	High (1)
Packaging Performance	Medium (2)	Medium (2)	High (1)

Figure 10 Measures of Effectiveness Diagram

Risk Management

It is vitally important to a program implementation of this magnitude that all factors be considered and evaluated. This is where risk management, the process of identification, analysis and acceptance or mitigation of uncertainty in investment decisions, comes into play. It is imperative that risks be identified as best as possible in order to mitigate financial, operational,

supplier, and customer hardships. The risks to packaging sustainability effort would be focused on the current Best Practices alternative discussed earlier. It is only natural that a business the size of Northrop Grumman, which produces tons of waste each year, would face substantial risk up front.

	Risk	Probability	Consequence
1	If the shareholder does not buy into the sustainability movement the stock will lose value	C	4
2	If harmful polymers such as PET, polyethylene terephthalate, continue to saturate the environmental negative impacts will decimate the earth	E	5
3	If corporate principles and values are not clearly understood or adhered to adverse perceptions of the company could harm their reputation	E	4
4	If the operational effectiveness of sustainability is not understood packaging processes will be negatively effected	D	4
5	If financial impacts of sustainability are not adhered to, cost overruns will hinder the success of the projects	C	3
6	If waste management companies do not properly operate landfill ecosystem viable harm will come to the earth	D	5

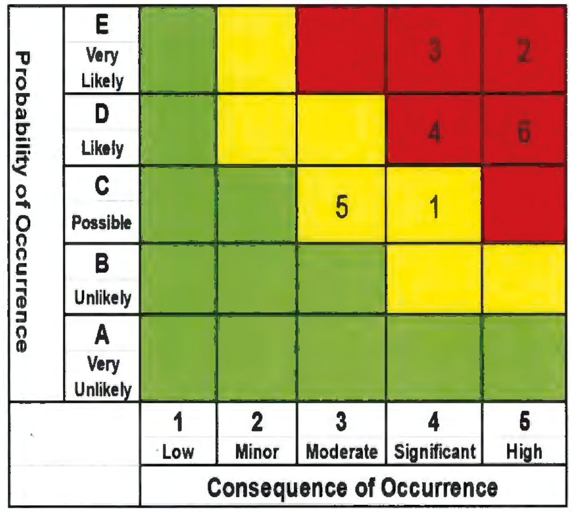

Figure 11 Measures of Effectiveness Diagram

However, with modern corporate philosophy supporting triple bottom line framework, financial risk would not hold as high a rating as the principles and processes that support the materials required to support the Ideal State model of Zero Waste. For example, looking into risk #2 in Figure 11, "If harmful polymers such as PET, polyethylene terephthalate, continue to saturate the environment, its negative impacts will decimate the earth." Thus this which carries the highest risk with the highest rating can provide the greatest value to the triple bottom line. If PET is allowed to continue its course in polluting unchecked, PET resins will have negative consequences that present serious health risks to humans, animals, and our planet. Financial impacts of PET are not purely visible in this risk review due to the fact that PET pollution is distorted by the mass (people, life, and earth) it effects, whereas purely financial impacts have direct risks that are always quantitatively measurable.

Along that same line of thinking, risk #3 in Figure 11 states, "If corporate principles and values are not clearly understood or adhered to, adverse perceptions of the company could harm their reputation," meaning there can be unmeasurable effects to the triple bottom line. The

devastating effects of the Deep Water Horizon oil spill and the Union Carbide pesticide plant accident were caused by individual choices based on objectionable financial assumptions, which took risks while failing to comprehend potential environmental disasters and the loss of life such a disaster would create. Hence, for a program of this magnitude to be successful from a Northrop Grumman perspective, strong leadership support and oversight of these values and principles is essential for success. From another perspective, outside vulnerabilities to risk are fundamentally plausible when a major component of the processes are managed by an external company. As noted in risk #6, "If waste management companies do not properly operate landfill ecosystem, viable harm will come to the earth." Though waste management is a highly regulated industry and has not necessarily experienced disasters, they manage many challenging risks daily with the type of materials and operations conducted, which makes any sustainability initiatives attractive. That is why partnering with waste management is essential to ensure sustainable goals are attainable through collaboration and innovation.

Risk Summary

It is one thing to identify risks facing a program, but necessary to develop mitigation plans so all stakeholders understand that everyone in an organization has a role in risk management. A good risk summary can also lead to opportunities to safeguard initiatives throughout the planning and design process. For example, shareholders need to be educated on the financial competitive edge sustainability has in the markets today with companies like General Motors and PepsiCo have communicate visions for sustainable business with the alignment of long-term value creation for their firms. The summary in Figure 12 shows such alignment with the Northrop Grumman sustainability goals and the results of a secure risk plan.

1. Educate shareholders on the value of the triple bottom line benefit
2. Put checks and balance in place to support biodegradable lifecycles
3. Fully understand corporate requirements and ensure buy in from stakeholders
4. Institute life cycle design best practices into the packaging processes to ensure operational effectiveness to corporate environmental goals
5. Work closely with suppliers to ensure they are engaged in the process and budget requirements
6. Work with the waste management team to ensure sustainable goals are attainable in the current state

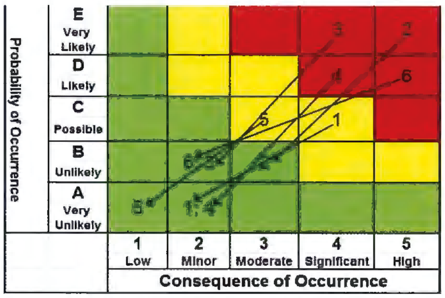

Figure 12 Risk Management Summary

Requirements Verification and Validation

Requirements	Current State	Future State	Ideal State
1. Foam, plastic containers, liners, and flexible packing shall be 100% biodegradable and compostable	Petroleum based materials take 450+ years to decompose	Bioplastics and lifecycle design consideration- 24 + months decomposition	Zero Waste 0 weeks to 24 months to decomposition recycle big factor
3. Global Interchangeable containers shall be constructed from recyclable metals, reducing wood and plastic crating by 40%	65% of crate production is expended on wood	Reductions in wood crating will help substantiate carbon footprint goals	Crate design factors for Zero Waste ! Rethink ! Reduce ! Reuse ! Recycle/Compost ! Recover
4. Sustainability in packaging shall reduce the carbon footprint 30% from 2010 levels	Greenhouse gases are generated in fabrication process of packaging system requirements	Reduction of petroleum raw materials (renewable vs nonrenewable) will substantially reduce the carbon footprint	Raw materials used in the packaging system shall follow the Zero Waste guidelines
6. Environmental impacts of Northrop Grumman packaging practices shall be reduce solid waste 70% by 2025	31 million tons of all municipal solid waste is plastics	Cuts cost more than 50% with composting and life cycle design requirements	Zero Waste Factor is predicated on 100% composting, product redesign and recycling (Palmdale facility earned Silver-level Zero Waste Certification)

Figure 13 Requirements Verification and Validation Summary

Validation

Now that we have the basis of packaging sustainability put into perspective, we will need to validate and verify the requirements, shown in Figure 13, to the project. Validation of these requirements requires that companies accurately state what is needed to attain sustainability in packaging and overall logistics operational goals. Therefore, we can use an industry standard to check them, such as "reuse, reduce, and recycle." One can see that both the future and ideal states meet reduce and recycle criteria for all four requirements, and can be improved from one state to the next. Additionally, these requirements support life cycle design, which is a critical factor ensuring traceability of materials and resources from cradle to grave. Understanding that Northrop's Corporate Responsibility goals were predicated on government sustainability standards, it is necessary to know the constraints.

As one can see, current state constraints implicitly validate the feasibility of the future and ideal states. For example, requirement 3 Figure 13, "Global interchangeable containers shall be constructed from recyclable metals, reducing wood and plastic crating by 40%," where currently approximately 60% of logistics crating is constructed using wood. It is well-documented that deforestation is one of the primary causes of ozone depletion due to the fact that trees use and store carbon dioxide. Therefore, the goals in both the future and current states directly correlate to reduction to the carbon footprint. Acceptance of the triple bottom line and sustainability initiatives will be difficult and conflict with carbon footprint requirements if inadequate communication on outcomes of the future and ideal states not clearly publicized to leadership or shareholders of Northrop.

Verification- Sequencing the Design Process

As we have seen, decisions flow requirements to the packaging operations, and are disseminated through the order management execution. Therefore, it is in our best interest to sequence how requirements are initiated and develop through the verification processes, see Figure 14.

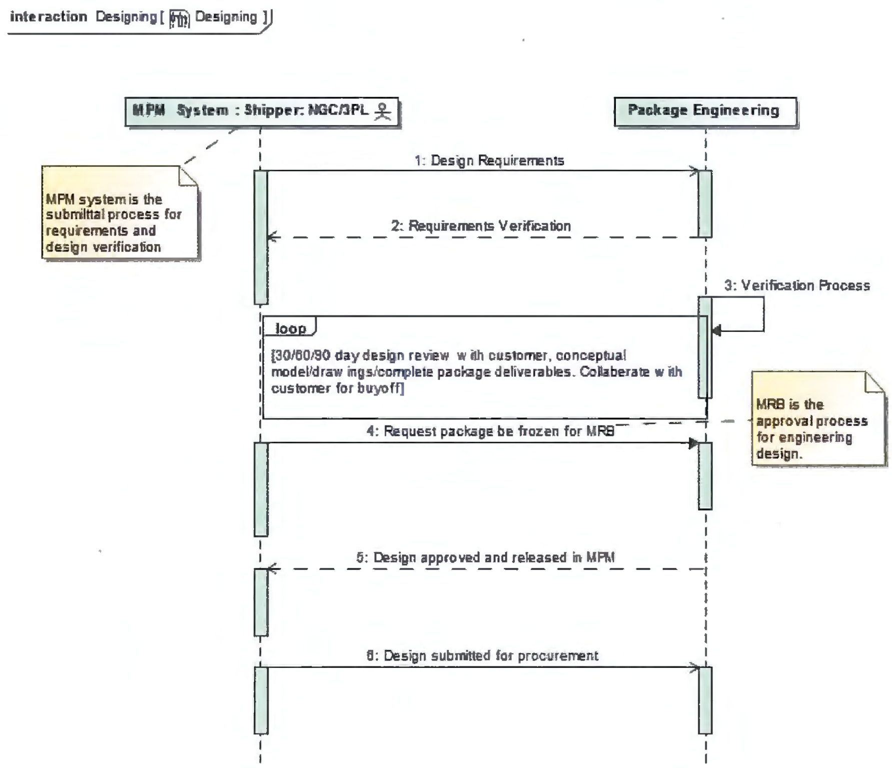

Figure 14 Sequencing Requirements Verification, Sequence Diagram

Initiated through the MPM, Materials Process Management system, requirements are directed to the packaging engineer, beginning the design, modeling, and review process with the customer through procurement processing. Therefore, adaptation of sequences within operations tend to develop sustainable process, and implementation of life cycle design or "cradle to grave" methodology.

Ethical Issues Reviewed

One can view ethics in packaging from many different perspectives, however I would prefer to utilize three of the four Ethical Lenses of Systems Engineering. The three lenses on which I wish to focus are Virtue (behavior showing high moral standards), Utility (sometimes used to refer to the balance of good over bad consequences), Justice (concern over people's rights, and righting wrongs when those rights are violated). With that said, one can look to apply these lenses to packaging sustainability so as to bring to light some of the diversities that Northrop Grumman would need to factor into their implementation decision. When it comes to virtue in packaging, one would need to understand first and foremost that materials used in packaging

knowingly devastate our earth, which is humankind's sole support system. It is evident in the current packaging world that many humans, both in business and social settings, have little concern for the throw-away world they live in. A recent example of this is the ban on single-use plastic bags and the inconvenience people complain about. However, if those same individuals were to take an ocean voyage to the large garbage patch off the coast of California, their sense of virtue would become quite humbled with the understanding that choices need to be made and cultures changed through moral decision making.

One thing needing to be understood about packaging, it is an aspect of our society that negatively impacts human lives, due to chemical seepage, deforestation for paper and wood products, and over 3,500 massive landfills in the United States that are poisoning our lands and waterways. That said, it is obvious that many humans walk around with narrow lenses, failing to see the destruction caused on a global scale. Then again, a gainful expression of utility was witnessed with the protestors that, for the moment, have halted the construction of the Dakota Access Pipeline project. Using the lens of justice, this case bears witness to corporate irresponsibility. Hence, it is fair to say that the basis of reasonable adjudication, and the actions of corporate responsibility are factors that drive the salvation of our planet. A most recent example of this is the rift in Larsen C, Figure 15, an ice shelf floating off the Antarctic Peninsula discovered, in late 2015 that has expanded to 70 miles (112 km) long and more than 300 feet (91 meters) wide. The dark depths of the crack plunge down about a third of a mile (0.5 km), all the way through the ice to the ocean below [22].

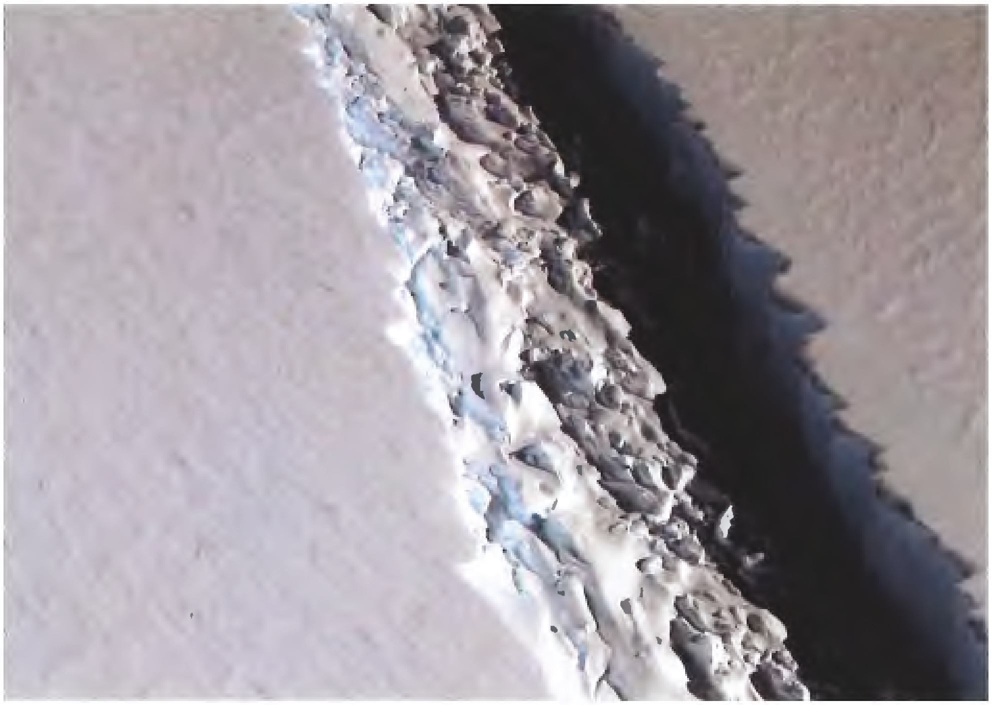

Figure 15 Larsen C Ice Shelf Rift, Antarctica

There are prominent factors that test the ideology of corporate responsibility, challenging ethical fabrics of humanity and health of our earth. On one hand, polymers are understood to be a chemical compound where molecules are bonded together in long repeating chains. Polymers, have unique properties and can be tailored depending on their intended purpose. The term is often used to imply "plastic" or "resin" [9]. This is one of the most harmful raw materials in packaging, and well known for decomposing into leachate from landfill, and saturating our waterways as micro-plastics which are fragments of plastic debris. Please revert to Figure 16 for a breakdown of polymers used in production and its degradation process from cradle to grave.

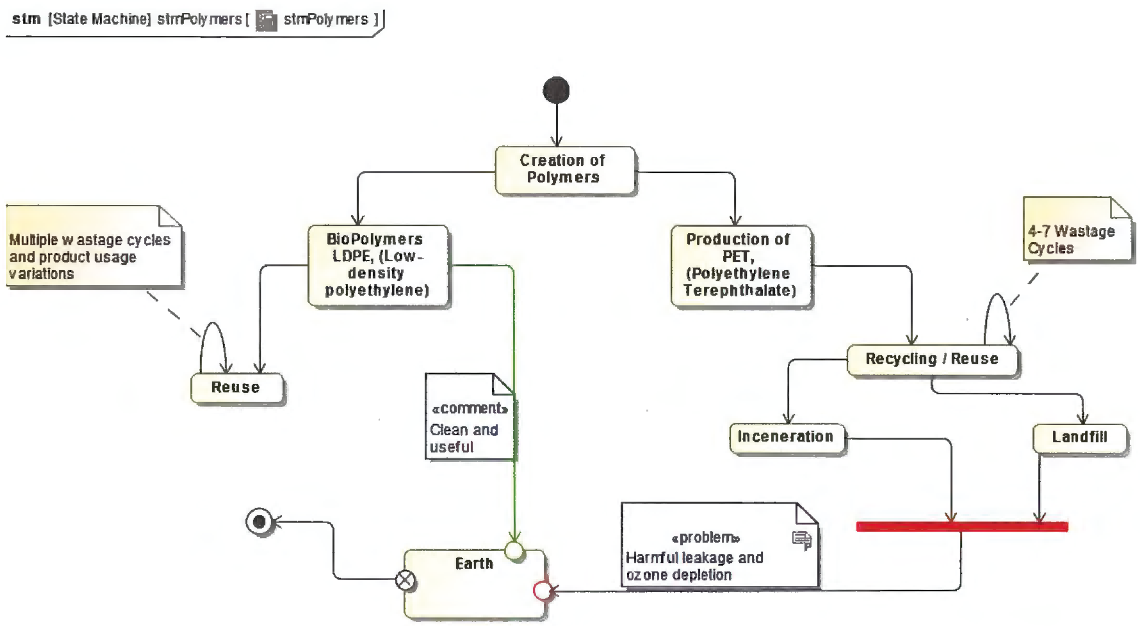

Figure 16 Polymer Processing, State Machine Diagram

There is an important polymer processes involving reuse and recycle, effecting how waste management organizations manage polymers. As shown in Figure 14, reuse can have two different behaviors that dictate the actions and culpability of polymers being used. In PET processing of polymers there are reuse and recycling capabilities, however as they are reprocessed, the molecules of the polymer lose strength exponentially, rendering the material useless. It is then sent to the landfill, where it decomposes into leachate or incinerated which negatively effect Green House Gases, GHG. Both of these outcomes have devastating ramifications for the ecosystem of the earth. On the other hand, when biopolymers are developed, there are many benefits to resources, energy, and the reclamation of our earth. For example, biopolymers can be composted and used in agriculture and recycled many times over as varying products. They also take less energy to produce and dispose of, which from a carbon footprint perspective, carries many benefits to the ecosystem.

Lessons Learned

My past professional experiences up to a year ago were focused on materials management, where constant attention was paid to waste processes. Before moving into the packaging world, my focus when it came to plastic was on the controversies of single-use bags in

stores and in the recycling of plastic. The thought of its primary component being harmful to me directly was never a thought, it was more of an environmental eye-sore issue. Over the past year as the Packaging Engineering Manager, I have witnessed and researched some very life-changing facts about the devastation humanity is imposing on the earth, along with direct health effects on all life. The ethical ignorance humanity has with regards to pollution, misuse of resource, and irresponsible behaviors are having scary hidden effects. Consequently, a problem this size can only be solved in pieces, but also with a sense of urgency. The advancement of technology must be enlisted to produce new sustainable materials, and relying on demand of all sorts will help speed up sustainable processes.

One of the more astounding takeaways of the Systems Engineering Masters' course for me was the understanding and integration of that knowledge into my daily habits. One that I am obsessed with, is to work all forms of lean from a perspective of perfection, which in packaging translates into Zero Waste. The more I read and research about Zero Waste, it becomes a bit more feasible to ponder the salvation of Earth, which makes me tend to believe that education on the consequences of poor decision making will grow the numbers of sustainable activists, making it possible to save the earth. This is evidenced by the fact that for now the Dakota Access Pipeline has been blocked from potentially harming the Native American land it sits on, and the country rallies behind the activists who led the way. This could lead one to believe that outside of corporate responsibly, social activism could be a new path to Zero Waste culture. To solidify the facts that we are harming ourselves, as discussed earlier in regards to BPA, 93% of all humans have BPA in their system, a testament to the fact that the saturation of our earth is translated into the saturation of our bodies.

Conclusion

This project has caused many conflicts within myself and how I go about my daily life while knowing the environment is in very poor condition due to packaging waste of all categories. It is astounding how we go through our day seeing, touching, watching humanity destroy itself to the point we are oblivious of it. We drive by landfills and think they are wonderful things because "that's is where our trash goes," or we purchase cases of water in bottles that take hundreds of years to decompose only to end up in our bodies causing disastrous things to us. For example, there are chemicals termed endocrine disruptors that are used in

practically every product used in packaging the food and drink we handle daily, plastic bottles, metal food cans, detergents, flame retardants, food, toys, cosmetics, and pesticides. It is obvious that the actions and cultures humanity lives by must change, which is why it must start with corporate cultural in order to have a chance to save our earth. Consumers look to the corporate world as examples on how to act and what is important to act on.

There is hope, however, and it does not have to be invented or conjured up, because it already exists in cities, businesses, and homes as Zero Waste. Zero Waste is a disposal concept that operates with the philosophy that everything is designed, life cycle and close loop design best practices, and manufactured to be reused, composted, or recycled. This will be the path that will work hand in hand with Northrop Grumman sustainability initiatives for carbon footprint and waste diversion. Landfills are becoming artifacts of the future, with less land available. Alternatives must be considered in order to rid ourselves of landfill production and incineration or humanity will continue to be decimated by health and environmental issues.

Finally, we must not forget that plastics that are petroleum based have decimated our oceans to the point of full-saturation of the food chain, including human kind. As we all know, plastics play an essential role to our society in both convenience and mandated requirements. However, the current solution of disposable plastics are more preventable and offensively driven than sustainable. For example, in 2014 global production of plastics reached 311 million metric tons with an average increase of 4% per year [20]. Additionally, more resin based plastics are cycled into landfills than recycled for reuse. The statistics of how much ends up in oceans and stun throughout our lands is staggering, having devastating effects on animal and human wellbeing at a level some say may be irreversible. Currently, it is evident that disposable plastics such as bottles, bags and packaging materials have the largest measured environmental impact. The problem lies in monetary profits, shareholder demand, human convenience and the power of oil. However, this is power that has diminished over the last couple years with the price of oil at its lowest point in many years. As seen in Figure 17, oil and natural gas supplies are diminishing and their dependencies will soon be at the door step of sustainability.

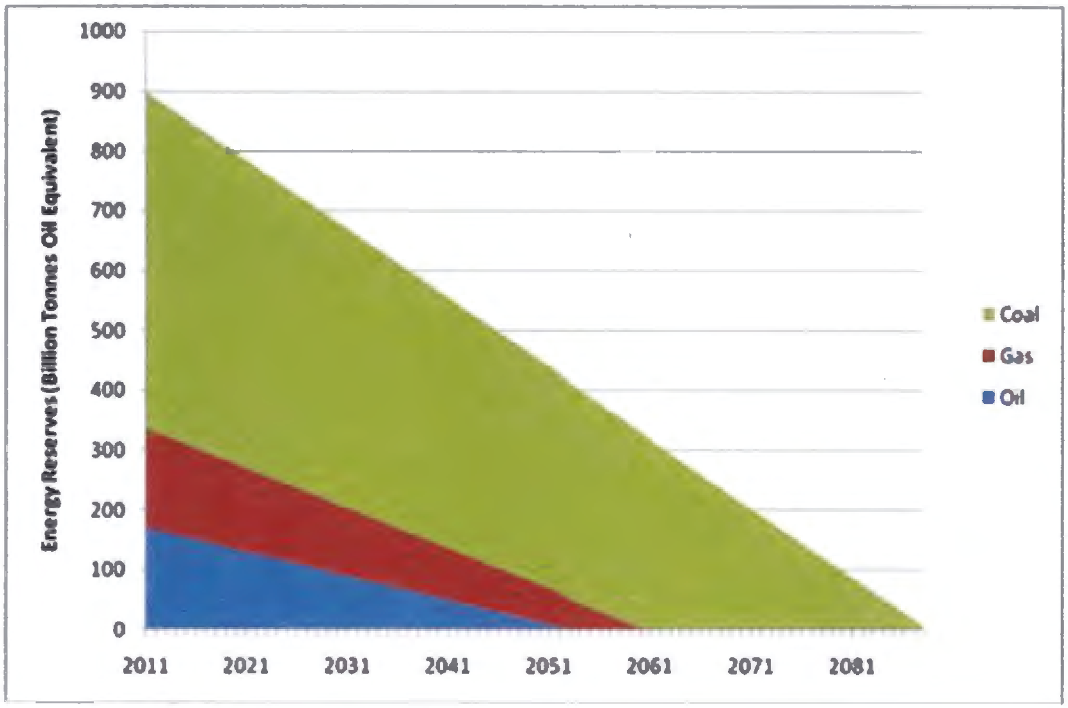

Figure 17 World Oil Reserve

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