Environmental Security Through Packaging Sustainability

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Course: SELP 695, Integrative Project

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Agenda

- Logistics/Packaging Overview
- Problem Statement
- Requirements
- Architecting the Systems
- Alternative Solutions
- Measures of Effectiveness
- Risk Management
- Verification and Validation
- Ethical Issues
- Lessons Learned
- Conclusion
- References
History of Logistics

- Logistics has played a significant role in global development for over 5,000 years
  - For example: the steam engine revolutionized railroads, ships and automobiles, globally evolving new opportunities for logistics
History of Logistics

- Rapid and complex deployment requirements gave birth to the logistics at a global scale
  - Technological transportation advancement, Information Systems, software, and automation are just some of the driving factors
Evolution of Packaging

- Advances in transportation of the steam engine, (trains, ships, and vehicles) required packaging of resources to be more robust, tackling environmental challenges
  - For example, corrugated boxes, metal cans, and cellophane were key innovations for transportation

- Consumer demands for convenience push manufactures to develop everyday packaging that appealed to the supermarket and window shoppers
Evolution of Packaging

- Economic growth from the 1960’s to 1990’s drove the need for:
  - Improvements in manufacturing and materials
  - Storage and preservation
  - Containers, crates, boxes

- As transportation complexities and preservation grew, Engineering in packaging became evident
Problem Statement
The current state of Logistical Operations produces a very large carbon footprint
  - Packaging supports over 60% of the operational effectiveness for logistics
  - Over 50% of material supporting packaging is not sustainable

Northrop Grumman committed to achieving a 70% solid waste diversion rate (percentage of total solid waste that is diverted from landfill) by 2025 [7]
  - Executive Order 13693- Planning for Federal Sustainability [7]
  - Triple Bottom Line
Problem Statement
Who?
- Northrop Grumman Corporation
  - Logistics
    - Package Engineering

What?
- Logistics packaging operations
  - Reduction of petroleum based packaging supplies (foam and plastic) and unrecycled paper
  - Improve packaging transportability- corrugated boxes along with wood and metal crates
Where?
• United States

Why?
• To attain sustainability in the packaging operations
  - Reduce the environmental impact of packaging
  - Reduce energy consumption required to create and dispose of packaging materials

How?
• Implementing sustainable policies:
  - Packaging materials
  - Carbon footprint reduction
  - Zero landfill mandates
Logistics

Packaging Requirements
1. Foam, plastic containers, liners, and flexible packing shall be 100% biodegradable and compostable
   1.1 Biodegradable products shall abide by current design constraints

2. Wood crates shall be constructed from certified forestry wood
   2.2 Wood pulp based products shall be manufactured from recycled pulp

3. Global interchangeable containers shall be constructed from recyclable metals, reducing wood and plastic crating by 30% by 2020
4. Sustainability in packaging shall reduce the carbon footprint by 30% from 2010 levels.

5. Suppliers shall be charged reclamation fees to support recycling costs and reduce landfill use.

6. Northrop Grumman shall reduce solid waste by 70% by 2025.

7. Standard operating procedures shall be developed to integrate sustainability and Zero Waste standards.
Architecting the Systems
OV1 Logistics Con Ops

OV1 LOGISTICS PACKAGING CON OPS

Reverse Logistics

Logistics

Inventory

Transportation

Material Handling

Packaging

Warehousing

Information Systems
• Packaging Waste [11]
  - EPA data on Municipal Solid Waste shows year over year Growth in landfill growth by 8 million tons of generated waste since 2012.
  - Packaging waste has increased by 9% with paper and corrugated board as the highest contributor, but the highest recycle rate
Current State- Devastation of the Global Environment

- Lack of life cycle accountability
  - Bisphenol A, BPA, levels found in 93% of human test cases [9]
  - Bisphenol A can leach into food from the protective internal epoxy resin coatings of canned foods and other consumer products
- Ocean Garbage Patches (Marine Debris)
  - Great Pacific Garbage Patch is bounded by the North Pacific Subtropical Gyre [8]
  - Made up of tiny bits of plastic, called micro-plastics
  - Petroleum based plastic is not recyclable but reusable
  - 4-7 usage cycles with a 450+ year degradability [3]
Current State - Devastation of The Global Environment

- Lack of life cycle accountability
  - Paper and corrugated board have the highest usage in packaging
  - 21 million tons of waste generated with 60% recovered during

  Between 1990 and 2015, the world lost

  129 million ha of forest

  An area the size of South Africa

- Wood is used for crating and storage
- 5 million tons of waste generated with only 1 million tons recovered
- Deforestation - trees illegally removed from forests
  - 58 ha (Hectare) of forest are lost each year \[^{[11]}\]
Future State - Invoke Alternatives

• Take a System Engineering Approach
  – No complex system can be optimum to all parties concerned
    • Sustainability in any process has to be supported by the leadership or it will not hold optimum value
  – Map the Value Stream
    • Identify highest value component of the current state for change
      – Petroleum based products have the most applicable alternatives
  – Understand all the complexities in your concepts
    • Modeling can flush out unknowns and identify key stakeholders
Node Connectivity Diagram
Future State

- Petroleum Based Products
- Landfill
- Non-certified Wood
- Metal (aluminum)
- Certified Forest
- Deforestation
- Bio-Plastics Products
- Corrugated Board
- Recycle

Legend:
- Red: Bad for the earth - harmful gas production, chemical leachate, ozone degradation
- Orange: Degradable cause deforestation, chemical leachate (paint), and landfill dependency
- Gray: Energy Required to reuse and recycle
- Green: 100% reusable and biodegradable to the earth

Pollutants:
- Air
- Ocean
- Land
- Ozone
Goal Thinking - Vision Development

- What is the future and ideal way packaging materials are deployed throughout the corporation? **Zero Waste!**
- The ideal state of packaging sustainability

- What would the organization look like fully sustainable 5, 10 or 25 years from now?
  - What would the materials, transportation, shipping, energy and waste management systems look and operate like?

- What impression would the corporation want to make in the various communities?
Ideal State - OV2 Zero Waste

Node Connectivity Diagram
Ideal State

- **Bio Plastics**
- **Metal (aluminum)**
- **Packaging Zero Waste**
- **Certified Forests**
- **Corrugated Board**
- **Recycle**
- **Reuse**

- **Air**
- **Ocean**
- **Land**

Pollutants

- **Red**: Bad for the earth- harmful gas production, chemical leachate, ozone degradation
- **Orange**: Degradable cause deforestation, chemical leachate (paint), and landfill dependency
- **Gray**: Energy Required to reuse and recycle
- **Green**: 100% reusable and biodegradable to the earth
Conceptual Structure

**SYSTEM:** Northrop Grumman Corporation, Logistics Packaging Organization

**SUBSYSTEMS:**
- Northrop Order Policy
- Engineering Design Process
- Corporate Responsibility Policy
- Ecosystem
- Waste Management

**STAKEHOLDERS:**
- Northrop Leadership
- Supply Base
- Logistics Employees
- Customer
- Waste Management
- Society

**SUBSYSTEM:** Waste Management

**Stakeholders:**
- Land Management
- Humankind
- Municipalities
- Policymakers

**EXTERNAL SYSTEMS:** Product Manufacturer

**Stakeholders:**
- Hydrocarbon Material Supplier
- Resin Producers
- Flexible and rigid materials producer
- Finished Product Distributor
- Researchers
- Government

**SUBSYSTEM:** Corporate Responsibility Policy

**Stakeholders:**
- Shareholder
- COO
- CFO
- Sector leadership
- Global Operations
A Look At Alternatives
1. **Minimal Change to Packaging Practices**

   - Continued environmental degradation
     - Ocean pollution: micro-plastics and leakage from landfills continue to poison food supplies and drinking water
     - Health effects drive care costs up and perpetuate suffering from illness
     - Deforestation continues to increase CO2 levels:
       - The earth’s temperature has increased 36% since 1880
   - Continuation of a Waste Management systems disaster
     - Greenhouse gases: methane, carbon dioxide, and leachate
2. Institute Sustainable Packaging Best Practices

- Reduce, Reuse, Recycle Program
- Life Cycle engineering packaging design process
  - Reduction in PET (polyethylene terephthalate) resin-based packaging foam
  - PET plastics/foam can be reused at a max cycle of 4-7 wastage cycles
  - Recycling converts waste into reusable objects with the goal of reducing landfill waste
    - Zero landfill program
3. Zero Waste Program
   - Resources are designed with anti-landfill or incineration life cycle considerations
     - Biodegradation - products that decompose or recycled back into natural elements
     - Packaging materials are designed with Zero Waste life cycles
       - Clean energy design principles
       - Reduction in greenhouse gases
       - Corporate responsibility (greenNG)
Analysis of Alternatives: Measures of Effectiveness
## Measures of Effectiveness - MOE's

<table>
<thead>
<tr>
<th>Measure of Effectiveness</th>
<th>Minimal Change to Packaging Practices</th>
<th>Institute Sustainable Packaging Best Practices</th>
<th>Zero Waste Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Low (3)</td>
<td>Medium (2)</td>
<td>High (1)</td>
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<tr>
<td>Implementation Time</td>
<td>Low (3)</td>
<td>Medium (2)</td>
<td>Medium (2)</td>
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<tr>
<td>Biodegradation vs Degradation</td>
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<td>High (1)</td>
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<tr>
<td>Raw Material Target Group</td>
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<tr>
<td>Education</td>
<td>Low (3)</td>
<td>High (1)</td>
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<tr>
<td>Leadership Buy-In</td>
<td>High (1)</td>
<td>High (1)</td>
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<tr>
<td>Packaging Performance</td>
<td>Medium (2)</td>
<td>Medium (2)</td>
<td>High (1)</td>
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</table>
Institute Sustainable Packaging Best Practices

- Reduce, Reuse, Recycle Program
  - Reduction or recycling of PET packaging foam
    - PET can be recycled at a max cycle of 4-7 wastages
  - Reusing aluminum allows for clean recycling
  - Recycling converts waste into reusable objects with the goal of reducing landfill waste
- The Palmdale Aircraft Integration and Center of Excellence earned Silver-level Zero Waste Certification
Risk Management
<table>
<thead>
<tr>
<th>Risk</th>
<th>Probability</th>
<th>Consequence</th>
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</thead>
<tbody>
<tr>
<td>If the shareholder does not buy into the sustainability movement the stock will lose value</td>
<td>C</td>
<td>4</td>
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<tr>
<td>If harmful polymers such as PET, polyethylene terephthalate, continue to saturate the environmental negative impacts will decimate the earth</td>
<td>E</td>
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<tr>
<td>If corporate principles and values are not clearly understood or adhered to adverse perceptions of the company could harm their reputation</td>
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<tr>
<td>If the operational effectiveness of sustainability is not understood packaging processes will be negatively effected</td>
<td>D</td>
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<tr>
<td>If financial impacts of sustainability are not adhered to, cost overruns will hinder the success of the projects</td>
<td>C</td>
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<tr>
<td>If waste management companies do not properly operate landfill ecosystem viable harm will come to the earth</td>
<td>D</td>
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</table>

Consequence of Occurrence:
- **E** (Very Likely): 3, 2
- **D** (Likely): 4, 6
- **C** (Possible): 5, 1
- **B** (Unlikely)
- **A** (Very Unlikely)

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<thead>
<tr>
<th>Probability of Occurrence</th>
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</table>
1. If the shareholder does not buy into the sustainability movement, the stock will lose value
   - **Risk**: Shareholders do not see value in sustainability
   - **Result**: Lack of confidence and loss of funding
   - **Mitigation**: Educate shareholders on the value of the triple bottom line benefit
2. If harmful polymers such as PET (polyethylene terephthalate) continue to saturate the environment, negative impacts will decimate the earth

- **Risk**: Unchecked or removed PET resins will have negative consequence

- **Result**: The leakage and degradation of PET resins present serious health risks to humans and the planet

- **Mitigation**: Put checks and balance in place to support biodegradable lifecycles
3. If corporate principles and values are not clearly understood or adhered to adverse perceptions of the company could harm their reputation

- **Risk**- Violation of corporate principles and values
- **Result**- Lack of buy in from leadership to support project requirements
- **Mitigation**- Fully understand corporate requirements and ensure buy in from stakeholders
4. If the operational effectiveness of sustainability is not understood packaging processes will be negative effective

- **Risk** - Poor execution of social and environmental impacts
- **Result** - Full impact of efforts to reduce petroleum not attained
- **Mitigation** - Institute life cycle design best practices into the packaging processes to ensure operational effectiveness to corporate environmental goals
5. If financial impacts of sustainability are not adhered to cost overruns will hinder the success of the projects

- **Risk**: The implementation of biodegradable products has negative impacts to the bottom line

- **Result**: Budget overruns, financial goals missed, shareholder confidence lost

- **Mitigation**: Work closely with suppliers to ensure they are engaged in the process and budget requirements
6. If waste management companies do not manage landfill ecosystem viable harm will come to the earth
   - **Risk**: Sustainable implementation will not support a zero landfill mandate
   - **Result**: Adverse impacts to the environment will effect the corporate image and sustainability goals
   - **Mitigation**: Work with the waste management team to ensure sustainable goals are attainable in the current state

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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
<table>
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<th>Requirements</th>
<th>Current State</th>
<th>Future State</th>
<th>Ideal State</th>
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<tbody>
<tr>
<td>1. Foam, plastic containers, shippers, and flexible packing shall be 100% biodegradable and compostable</td>
<td>Petroleum based materials take 450+ years to decompose</td>
<td>Bioplastics and lifecycle design consideration - 24 + months to decompose</td>
<td>Zero Waste</td>
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<td>0 weeks to 24 months to decompose</td>
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<td>3. Global Interchangeable containers shall be constructed from recyclable metals, reducing wood and plastic crating by 40%</td>
<td>65% of crate production is expended on wood</td>
<td>Reductions in wood crating will help substantiate carbon footprint goals</td>
<td>Crate design factors for Zero Waste</td>
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<td>! Recycle/Compost</td>
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<td>! Recover</td>
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<tr>
<td>4. Sustainability in packaging shall reduce the carbon footprint 30% from 2010 levels</td>
<td>Greenhouse gases are generated in fabrication process of packaging system requirements</td>
<td>Reduction of petroleum raw materials (renewable vs nonrenewable) will substantially reduce the carbon footprint</td>
<td>Raw materials used in the packaging system shall follow the Zero Waste guidelines</td>
</tr>
<tr>
<td>5. Environmental impacts of Northrop Grumman packaging practices shall be reduce solid waste 70% by 2025</td>
<td>31 million tons of all municipal solid waste is plastics</td>
<td>Cuts cost more than 50% with composting and life cycle design requirements</td>
<td>Zero Waste Factor is predicated on 100% composting, product redesign and recycling (Palmdale facility earned Silver-level Zero Waste Certification)</td>
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Packaging Through the Ethical Lenses

- **Virtue**- Materials used in packaging knowingly devastates our earth, which is human kind sole support system
  - Choices need to be made and cultures changed through moral decision making

- **Utility**- Packaging is an aspect of our society that largely impacts human lives, however with narrow lenses we fail to see the destruction caused on a global scale

- **Justice**- The principle of justice could be described as the moral obligation to act on the basis of fair adjudication, hence the actions of corporate responsibility are a factor that drive the salvation of our planet
Before moving into the packaging world, controversies of plastic were focused on store single use bags.

- Pollution, misuse of resource, and irresponsible behaviors are having scary hidden effects on our earth and ourselves.

- A problem this size can only be solved in pieces but with a sense of urgency, the advancement of packaging technology will help speed up the process.

- Work it from a lean perspective- perfection, Zero Waste.

- Education on the consequences of poor decision making.
  - 93% of all humans have BPA in their system.
The environment is in very poor condition due to packaging waste.

Corporate culture must change in order to have a chance to save our earth.

Perception of landfill vs zero waste.

Zero waste is a very viable solution and just needs manufactures to practice life cycle and close loop design best practices.

Landfills are becoming artifacts of the future, with less land and more people alternatives must be considered.

Plastics that are petroleum based have decimated our oceans to the point of saturation of the food chain, including human kind.
Questions?
References

1. DHL Logbook - in cooperation with Technical University Darmstadt, 2014
3. Sustainable Packaging As We Know it Tomorrow, Packaging.Org, 2014
4. Sustainability- Know Your Facts, Boston College, 2016
5. Forest Certification, PEFC, 2015
7. Environmental Sustainability greeNG, Northrop Grumman Corporation 2016
8. The Great Pacific Garbage Patch, National Geographic Society, Andrew Trugeon, 2014
10. Deforestation, National Geographic, 2015
12. Packaging – An Important Tool for A Sustainable Society, Position Paper; WPO
14. Regulations No Longer Authorize the Use of BPA in Infant Formula Packaging Based on Abandonment; Decision Not Based on Safety, FDA, 2013
15. Endocrine Receptors; National Institute of Environmental Health Science, 2015
18. Zero Waste vs Traditional Packaging; Be Green Packaging LLC, 2016
21. The End of Fossil Fuels; Ecotricity, 2015
22. 70 Mile Long Crack Opens up in Antarctica, Stephanie Pappas, Live Science Contributor