BY PRODUCT SYNERGY ANALYSIS

THESIS

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Abstract

The United States Air Forces generates various waste during the repair and overhaul activities. These wastes often involve hazardous materials (engine oil, hydraulic, solvents, battery cells, tires, etc.). Depending on the material, technologies exist or could be readily developed to convert wastes into feed-stock for other processes – a step beyond recycling.

The old concept of managing material from cradle-to-grave now has evolved into cradle-to-cradle. This concept goes beyond the disposal of waste and can be even more cost effective than recycling. The objective is to generate “food” by identifying and developing other processes to use current wastes in their production processes. Shifting from waste disposal to an endless reusing model improves cost efficiency and reduces the overall environmental impact (not limited to landfill space, water consumption, and carbon footprint).

This research developed a methodology to employ state-of-the-art commercial practices to analyze depot waste production processes. The goal was to identify and classify waste generated by volume, hazard, and costs, then analyze the environmental flow by comparing government and commercial users of by-products in a synergy model. Optimal solutions for current product flow were identified, along with potential areas for investment in by-product technologies. Solutions are mutually beneficial for both parties, not only economically but also from social and environmental concerns.

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To God for bring me the opportunity to improve myself; and to my mother; my father; and my brother. Their love, support and understanding allows me to complete this assignment.

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Francisco Edgardo Leguiza

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I. Introduction

Background and motivation

In order to perform the mission assigned, the United States Air Forces (USAF) performs multiple activities; some of them require aircraft maintenance, repair, and overhaul activities. Typical activities include processes like parts cleaning; paint stripping; coating and painting; metal parts fabrication; etc. These industrial processes produce or generate residuals that frequently involve hazardous material such as fuel, engine oil, hydraulic, solvents, caustic cleaners, battery cells, tires, etc., usually considered as hazardous waste. Depending on the material, technologies exist or could be readily developed to convert wastes into feed-stock for other processes – a step beyond recycling.

The old concept of managing material from cradle-to-grave now has evolved into cradle-to-cradle. This concept goes beyond the disposal of waste in landfills and can be even more cost-effective than recycling. The objective is to generate “food” by identifying and developing other processes to use current wastes in their production processes. Shifting from waste disposal to an endless reusing model improves cost efficiency and reduces the overall environmental impact (not limited to landfill space, water consumption, and carbon footprint).

Environmental legislation intended to reduce the social and environmental impact of waste production has become stricter in order to protect current and future generation’s quality of life; it applies not only to the private and commercial field but also governmental organizations like the Department of Defense and the services. The Air Force Policy Directive (AFPD) 32-70 “Environmental Quality”, shows the Air Force’s commitment to the environmental field. The directive states that “*Achieving and maintaining environmental quality is an essential part of the Air Force mission. The Air Force is committed to: cleaning up environmental damage resulting from its past activities; meeting all environmental standards applicable to its present operations; planning its future activities to minimize environmental impacts; managing responsibly the irreplaceable natural and cultural resources it holds in public trust; and eliminating pollution from its activities wherever possible.*”

Aircraft maintenance activities at different levels from on-aircraft to depot level frequently imply the use of environmentally hazardous materials that produce or generate hazardous waste. This situation may not be avoided due to the particular nature of the activities, so hazardous waste management assumes a critical relevance in order to minimize potential risks related to hazardous waste that can cause high level environmental damages if they are not adequately managed. There are also social impacts that activities performed by governmental organizations like services have on the public opinion.

Waste management demands special procedures and a considerable amount of resources (money, personnel, equipment, facilities and time), so improving management activities will finally produce a positive impact on the economic, environmental, and social fields. Economic cost, environmental protection, and social cost reduction are strategic factors to be considered in modern organizations in order to improve performance.

Economic costs are relevant because activities like recycling and material disposal are costly, so any improved procedure that helps reduce or minimize these activities are critical to every organization. The conservation and optimized use of resources like raw material and energy are points that managers cannot avoid when defining strategies to reach organizational goals. These strategies must be directed to define the action plan to reach the objectives in the most effective and efficient way.

Environmental protection is relevant not only because of various laws and regulations, but also because of the organizational commitment to assure to future generations a healthy environment. It is thus important to minimize the environmental footprint of organizational activities under the Zero Footprint criteria when possible.

Social costs sometimes become more relevant than economic cost due to the impact of environmental friendly activities on public opinion; organizational activities can have a huge impact on public perception that can be critical for the future of the organization.

In addition, waste management activities, and particularly hazardous waste management, are critical due to the serious legal and environmental impacts associated with deficient or insufficient hazardous waste management (AFPAM 32-7043, 2009, p.4). This consideration can be perfectly considered not only for the Air Force but also in general for any waste generator.

In order to successfully reduce environmental impact, managers often rely on basic environmental activities like Reduce, Reuse, and Recycle (also known as the 3Rs of waste management) and using landfill disposal as the last option for the waste stream. More effective and efficient 3Rs activities could result in a higher social impact and could be also related to economic benefits.

The USAF as a government organization it is not exempt from laws and regulations to minimize environmental risks, reduce the waste stream, reuse and recycle as much as possible. All the activities must be directed to reduce the environmental footprint. New rules also imply and demand higher levels of social and environmental responsibility. "*Achieving and maintaining environmental quality is an essential part of the Air Force mission…planning its future activities to minimize environmental impacts; managing responsibly the irreplaceable natural and cultural resources it holds in public trust (AFPD 32-70).*"

It is important to not only develop activities to accomplish environmental protection legislation but also try to identify and explore new possibilities applying new theories or concepts like Cradle to Cradle design and By Product Synergy (BPS) to improve organization performance. The Cradle to Cradle design is a concept that could be considered as an evolution of Cradle to Grave concept and implies that every design or process in all organization must be directed to minimize the environmental impact and at the same time improve material utilization and waste production, which are relevant not only from the economic point of view but also from the social benefits produced with optimized procedures. It is very important to minimize the flow of waste to landfills.

By Product Synergy concept which is defined by the Ohio By Product Synergy Network as "the practice of matching under-valued waste or by product streams with potential users, helping to create new revenues or savings for the organizations involved while simultaneously reducing environmental burdens" will be used during the research.

BPS is a new approach designed not only to increase or create revenues or savings for the users but also improves environmental protection by facilitating the identification of potential users of under-valued waste (by product) that can be important to reduce cost in other organizations. The BPS model is based on cooperation among organizations that share information about consumed materials on production processes and waste produced or generated as a result of those processes that can be used as inputs in other organizations. Some benefits obtained by users of BPS models are reduction in waste disposal to landfill and recycling costs, reduction in energy consumption, enhanced corporate reputation, reduction of carbon footprint and gas emissions.

Problem statement

Based on the premise that achieving and maintaining environmental quality is an essential part of the Air Force Mission (AFPD 32-70, 1994, p. 1), and considering that an adequate management of waste produced or generated during daily or programmed aircraft maintenance activities must be aligned to that objective, the goal of the present work is analyze current AF waste management flow. This work will focus on hazardous waste generated at depot level units, compare that flow with an alternative commercial way than usual methods of recycling or landfill disposal such as BPS, under the criteria to turning waste into profit not necessarily from the economic but also environmental and social point of view.

Research Focus

The research initially will focus on analyzing commercial applications of the By Product Synergy method and the benefits not only from the financial side but also social and environmental point of view exploring the relevance of a synergistic use of assumed non valuable resources (waste) instead the usual procedure of recycling.

Current waste management processes used at Depot Level in the Air Force will be analyzed in order to be contrasted with private / commercial processes trying to identify potential areas that allow us to improve processes in use.

Information about waste generation and management of non classified waste material at Depot Level Maintenance from Robins Air Force Base will be used as a pilot sample during the research.

This research will develop a methodology to employ state-of-the-art commercial practices to analyze depot waste management processes.

Research Objectives

The goal is to demonstrate the applicability of BPS in the AF. Identify and classify waste generated at Depot Maintenance level by volume, hazardousness according to EPA code, analyze the environmental flow by comparing AF and private / commercial users of by-products in a synergistic model, and benefits related to apply BPS. Optimal solutions for current product flow will be identified, along with potential areas for investment in by-product technologies. Possible impediments to implementation of BPS will be identified.

Potential solutions should be mutually beneficial for both parties not only economically but also from social and environmental concerns.

Assumptions/Limitations

The research will be focused initially to analyze basic information available at Depot Level related to unclassified waste material, especially hazardous materials due to the relevance and impact that these kinds of materials represent to the environment. In the future, this could be adapted to another type of by product material.

Depending on the waste classification (quality, quantity, hazardousness, cost), some kind of waste could not be considered as by product; in the worst case scenario current procedures will remain the same.

Standardized procedures about waste management could be different from one facility to another depends on local or federal regulations.

Present regulations from other organizational levels than the Air Force like Environmental Protection Agencies, Defense Logistics Agency can be restrictive to the application of new management concepts but it is assumed that in the future regulations can be modified to allow this new concept.

Summary

This research proposes and encourages changes in procedures related to waste management helping to reduce waste disposal, treatment and storage costs, or diminish volume of waste directed to landfill.

Cost reduction, environmental protection, and social responsibility should also be part of the strategic goals and objectives of any organization.

The By Product Synergy model can be a good option to support improvements at different organizational levels by changing and adapting processes and procedures actually in use in other fields to take advantage of new concepts.

It is very important to understand and recognize that adequate waste management must be a strategic issue; so every new tool, concept, or theory that helps to increase energy saving, reduce costs and pollution, and enhance our social reputation as a government organization is relevant.

II. Literature Review

Introduction to environmental quality

During the last decades of the 20th century, words like environment protection, sustainable development, depleted ozone layer, global warming, natural resources extinction, takes relevance and urge at global level the necessity of changes in order to minimize damages that human activities produce in the environment to preserve it for future generations.

According to United Nations (UN) World Commission on Environment and Development, industries and industrial operations should be encouraged that are more efficient in terms of resource use, that generate less pollution and waste, that are based on the use of renewable rather than non-renewable resources, and that minimize irreversible impacts on human health and the environment (UN A/42/427, 1987).

With different priorities, countries around the world decide to implement different strategies in order to regulate human activities not only for commercial and industrial field but also including particular and government agencies activities, the objective basically imply the generation of environmental standards to be applicable on each level encouraging people and organizations to develop processes to reduce, minimize and even avoid waste generation.

Figure 1shows a simplified version of production process, raw material is used in a process to produce products and at the same time some waste is generated. The objective of a good management is to optimize the use of resources maximizing production and minimizing waste generation.

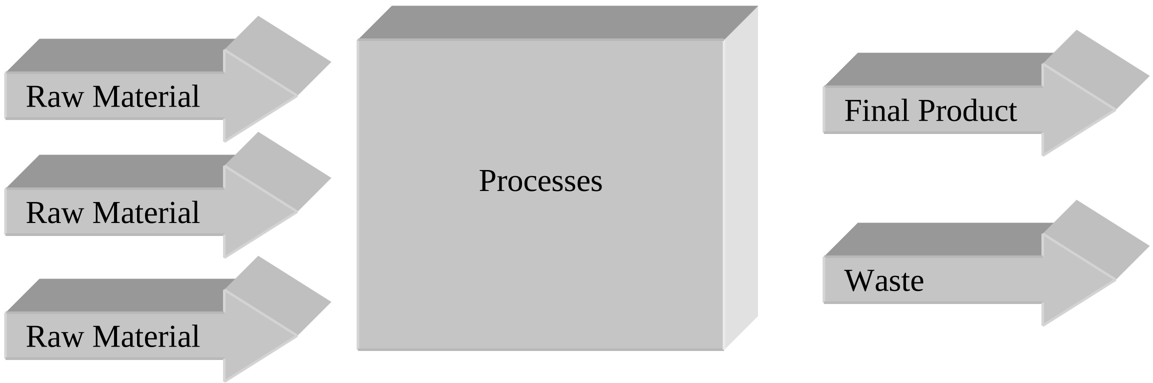

Figure 1. Simplified Production process

In the case of aircraft maintenance, we consider as a raw material all elements to be used to perform maintenance processes such as spare parts, grease, and lubricants, paint and solvents, etc., and as final product we have a serviceable aircraft and waste we need to manage properly according to regulations to minimize environmental damages.

Managers and decision makers from governmental and commercial organizations take different approaches in order to accomplish laws and regulation primarily directed to optimize the consumption of raw materials, minimize energy utilization and reducing waste generation.

Next paragraphs presents basic information about different regulations, focused on Air Force Directives and Instructions developed in order to design policies and strategies aligned with federal regulations.

Main streams from the commercial side are presented to reflect different concepts and activities developed to improve organizational performances taking advantage of economic, environmental and social benefits by designing and implementing new processes to minimize the organization’s environmental impact and pollution and obtaining more profit due to a rationalized and adequate use of materials.

From each side – governmental and commercial, the objective is directed to reflect the commitment and responsibility from managerial levels to accomplish laws and regulations and optimize performance.

Federal Regulations

The main Federal Law in the US referred to the disposal of solid waste and hazardous waste is the Resource Conservation and Recovery Act (RCRA), this law assigns under RCRA Subtitle C to the Environmental Protection Agency (EPA) the authority to regulate hazardous wastes. The principle objective of hazardous waste regulation is the protection of human health and the environment. RCRA regulation is also intended to encourage the conservation and recovery of valuable materials.

The definition of solid waste under RCRA, which serves as the starting point for the hazardous waste management system, reflects EPA's effort to obtain the proper balance between these two underlying objectives (EPA, 2001, p. 2). Solid waste is defined as any garbage, refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility, and other discarded material, including solid, liquid, semisolid, or contained gaseous material, resulting from industrial, commercial, mining, and agricultural operations and from community activities (EPA, 2001, p. 2).

The Code of Federal Regulations 40CFR Protection of the Environment established by the EPA provide important regulatory definition of elements related to environmental protection that should be considered as pillars to develop complementary directives, instructions at different organizational levels like DoD or military services in order to accomplish federal regulations.

On 40CFR under the solid waste definition, the concept of discarded material is presented and include material which is abandoned, recycled, considered inherently waste, or military munitions identified as solid waste in §266.202 (40CFR, 2010, §261.2).

Recycling, in this case a material is recycled if it is used, reused, or reclaimed. These three terms have specific regulatory definitions. A material is reclaimed if it is processed to recover a usable product or if it is regenerated. A material is used or reused if it is either employed as an ingredient in an industrial process to make a product or if it is employed as an effective substitute for a commercial product (EPA, 2001, p. 4).

By-product is defined as a material that is not one of the primary products of a production process and is not solely or separately produced by the production process (40CFR, 2010, §261.1).

Hazardous waste disposal, the role of DLA/DRMS

According to Defense Materiel Disposition Manual; DLA/DRMS is responsible for the disposal of Hazardous Waste (DoD 4160.21-M, 1997, p. 10-1). Nevertheless Commanding officers has delegated broad authority to decide how best to accomplish the mission (DoDD 4001.1, 1986, p.1).

DLA will assume responsibility for the disposition (treatment and disposal or recycling) of hazardous waste with the exception of certain categories that will be responsibility of the installation (such as radioactive waste, RCRA regulated solid waste, infectious medical waste, contractor generated waste, etc.) (AFI 32-7042, 2009, p. 10)

DLA provides by services Defense Reutilization and Marketing Service (DRMO) at different locations including AF aircraft maintenance depot level units; DRMOs manages the disposal of hazardous property for DoD activities. Hazardous property is handled according to the same priorities as other property: reutilization within DoD, transfer to other federal agencies, donations to qualified state and nonprofit organizations, and sale to the public including recyclers. This process maximizes the use of each item and minimizes the environmental risks and the costs associated with disposal. DRMOs provide safe, temporary storage of hazardous property during the disposal cycle (https://www.drms.dla.mil/drmo/warnerrobins.shtml).

USAF Policies and Strategies

As it was mentioned on previous paragraphs, laws and regulations become pillars to develop regulations for the military services. In the particular case of the Air Force, directives and instructions that define policies and strategies were prepared and executed in order to reach basically the objectives of maximize the use of resources and minimize waste generation.

USAF Environmental Quality

The Air Force Policy Directive 32-70 "Environmental Quality" presents the commitment of the AF in order to achieve and maintain environmental quality during daily operations aligned with national environmental policies. The directive states the necessity of develop environmental quality programs based on four pillars: cleanup; compliance; conservation; and pollution prevention as shown in Figure 2.

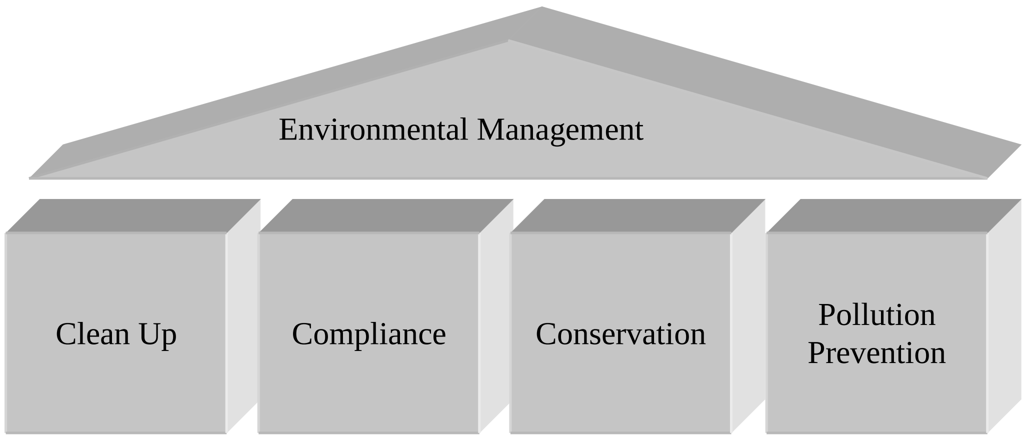

Figure 2. Pillars of Environmental Management (AFPD 32-70, 1994)

The last one, referred to pollution prevention requires avoid future pollution by reducing use of hazardous materials and releases of pollutants into the environment to as near zero as feasible (AFPD 32-70, 1994, p.2). The directive also present basic concepts about pollution prevention such as source reduction as often as possible, minimize the use of hazardous material, reuse or recycle waste and as last option when disposal is necessary implement disposal procedures on a safe manner.

Waste and Hazardous Material Management

In order to implement AFPD 32-70, Civil Engineering developed the Air Force Instruction (AFI) 32-7042 “Waste Management”; the objective of the instruction is to provide a framework for complying with standards applicable to solid waste and hazardous waste management. This instruction assign to the Air Force Institute of

Technology (AFIT) Civil Engineer and Services School the responsibility of provide educational programs in support of the waste management programs (AFI 32-7042, 2009, p. 7).

AFI 32-7042 on Chapter 2 describes the activities to develop a Hazardous Waste Management Program including: planning, implementation and operation, checking and corrective actions. From the management point of view these activities are considered as the Deming Cycle, Deming Wheel or PDCA Cycle – Plan, Do, Check and Act (Figure 3). These four phases represent an easy way to implement continuous improvement activities.

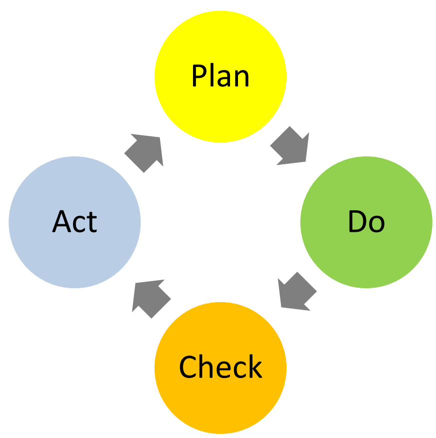

Figure 3. PDCA Cycle (Heizer and Render, 2006)

The cycle of continuous improvement requires that during the Plan phase management levels design strategies and policies to achieve the objectives or goals; Do phase is directed to the implementation of processes according to the policies and strategies; Check phase imply measure the level of success during the previous phase, and during the Act phase managers perform necessary activities in order to improve processes.

Based on a set of regulations, AF units like Depot Maintenance Level Units developed their own Environmental Management Systems to align their activities according to different regulation levels.

Commercial streams

Since environmental matters begin to have more and more relevance on the world agenda at different levels of responsibility that include not only governmental and non governmental agencies and organizations but also individuals, industrial organizations recognize the significance of the topic and that instead the old thought that everything related to environmental protection imply expend more resources on new procedures and processes some of them begins to applied changes on policies and strategies that initially looks as high risk investment with low probability of success but they start to perceive that changes were beneficial not only on the environmental field but also economical and social.

Since the second half of 20th century different streams were developed and implemented in order to combine environmental friendly activities with production processes not necessary to meet laws and regulations but also get economical and social benefits; some organizations developed environmental friendly processes that that allows them to improve performance by reducing raw material consumption and waste generation.

Eco Efficiency, 3 Rs, and Eco effectiveness

One of the steps that some industries start to apply in order to reduce or minimize the impact of their activities and accomplish regulations was directed to obtain the eco efficiency; defined by the World Business Council for Sustainable Development (WBCSD), eco efficiency is achieved by the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing environmental impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity (WBCSD, 2000, p. 4). Considering that efficiency is basically do the same things with less resources, we can extrapolate that concept to simplify eco efficiency concept to produce more with less resources consumed and less waste generation.

Another concept that some companies adopted as strategy is consider reduce, reuse and recycle activities as a corner stone to improve organizational performance.

Reduce, reuse and recycle known as 3Rs are activities directed to minimize pollution and can be applied at different levels from people to commercial or government organizations.

Reduce in order to optimize the use of resources, reuse whenever possible and recycle finding alternative use for residuals, basically 3Rs are directed to minimize waste and is widely applied; benefits from economic and environmental point of view can be perceived once this concept is applied.

But eco efficiency is not enough, is an outwardly admirable, even noble, concept but is not a strategy for success over the long term …, works to make the old, destructive system a bit less so. (McDonough and Braungart, 2002, pp. 61-62). This position is clear, every model, concept or process can be improved in order to increase performance.

Analyzing the definition of eco efficiency developed by WBCSD it is visible that the definition takes care of only of two of the basic pillars of sustainability economic and environment fields, which is natural because eco efficiency is basically a business concept developed by business persons; but there is another field that managers need to consider during the decision making process, the social field, and their decisions should be integrated and considered on their final decisions. Even when the objective of every business is to generate profits, it is important to consider that objectives should be reached under a social responsible manner.

Eco Effectiveness means working on the right things – on the right products and services and systems – instead making the wrong things less bad (McDonough and Braungart, 2002, p. 76).

This concept can be related to Japanese continuous improvement philosophy Kaizen, which is directed to constantly seek new ways to improve organization performance.

Do the right things is just the first step on organization improving, the best deal must include do the things right, and this objective imply that managers should work to modify processes or design new more effective processes to optimize resource usage and minimize waste generation.

Cradle to Grave

The cradle to grave concept it is used on the environmental field to present that everyone – people or organizations- must be responsible for the materials they use in production of goods or services; from design or acquisition to final disposal and that includes waste generated before the processes and particularly hazardous waste.

This means that the life cycle of waste produced in production of goods or services should be considered on responsible management decisions.

The process life cycle is a sequence of transformations in materials and energy that includes extraction and processing of materials used for process equipment and supplies, process operation and control, equipment cleaning and maintenance and, and waste disposal or recovery (Fiksel, 2009, p. 79). Figure 4 shows a product life cycle. The property of a product to be recyclable can change, there are some products with limited recyclability cycles which imply that after certain number of cycles the product should be finally discarded or eliminated.

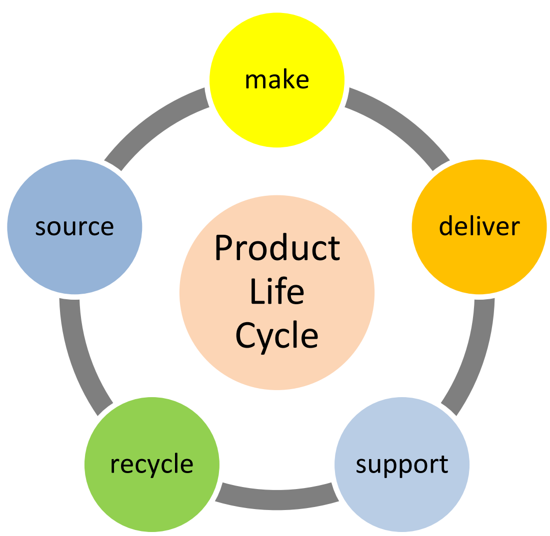

Figure 4. Product Life Cycle (Fiksel, 2009)

Cradle to Cradle

The Cradle to Cradle design developed by McDonough and Braungart include the concept of sustainability into the cradle to grave model, which means that residuals or waste from certain production processes can be used as by product into another processes, turn waste into food it is used as analogy to understand Cradle to Cradle concept.

Design for Environment

The Design for Environment (DFE) defined as the systematic consideration of design performance with respect to environmental, health, safety, and sustainability objectives over the full product and process life cycle (Fiksel, 2009, p. 6). DFE concept begin to be an obligation for managers not only due to the pressure of laws and regulations or customers about environmental protection but also because using optimized processes that minimize waste generation and consider that waste can be used as by product in other processes – Cradle to Cradle concept- also imply economical benefits to the organization.

ISO 14000 Series

The International Standard Organization (ISO) 14000 Series describe the way to develop an Environmental Management System (EMS), this series of standards are focused on processes rather than performance and are related to environmental management systems and life cycle assessment; Figure 5 shows ISO 14000 framework (Sturm and Upasena, 1998, p. 8).

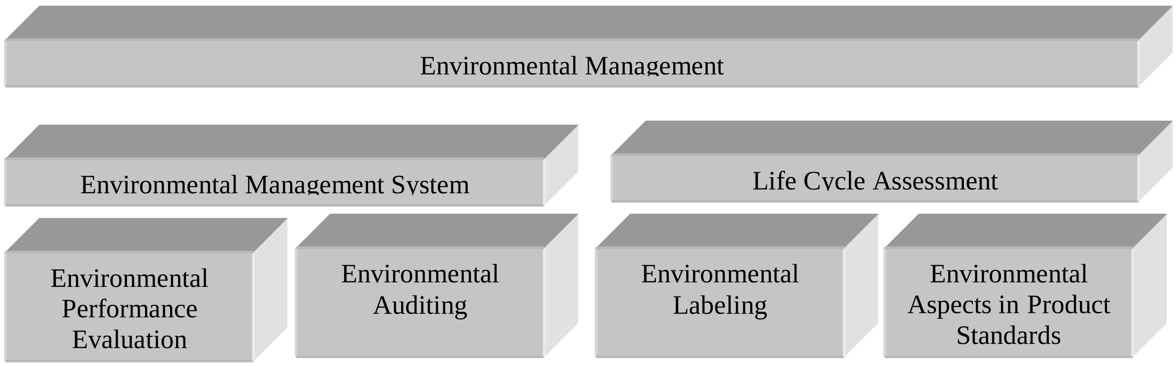

Figure 5. ISO 14000 Frame work (Sturm & Upasena, 1998)

ISO 14000 Series can be used as a tool to develop EMS in order to accomplish environmental objectives, do not replace laws and regulations, ISO 14000 are not mandatory but companies that developed EMS according to them perceive improvements in environmental management and shows high levels of environmental responsibility which is important to customers. ISO 14000 Series were considered to design many of EMS actually in use on AF Units.

Defining By Product Synergy

During the late 90’s the United States Business Council for Sustainable Development (USBCSD) developed the concept of By Product Synergy (BPS), the main idea was convert wastes into useful energy and materials, rather than operating as isolated entities (Fiksel, 2009, p. 162).

Applying this idea to the basic production processes presented previously on Figure 1, now some of the waste generated by primary production processes can be classified as under-valued waste or By Product, defined as a material that is not one of the primary products of a production process and is not solely or separately produced by the production process (EPA, 2001, p. 5).

Waste materials with by product properties can be used as inputs in other processes, so organizations can get not only economical benefits but also social and environmental benefits due to less waste for disposal activities. Figure 6 represents this concept; primary processes generate some final product, waste and by products that can be used on secondary processes within the organization or in primary processes on an external organization that also generate after new processes other final products, waste and sometime other by product materials.

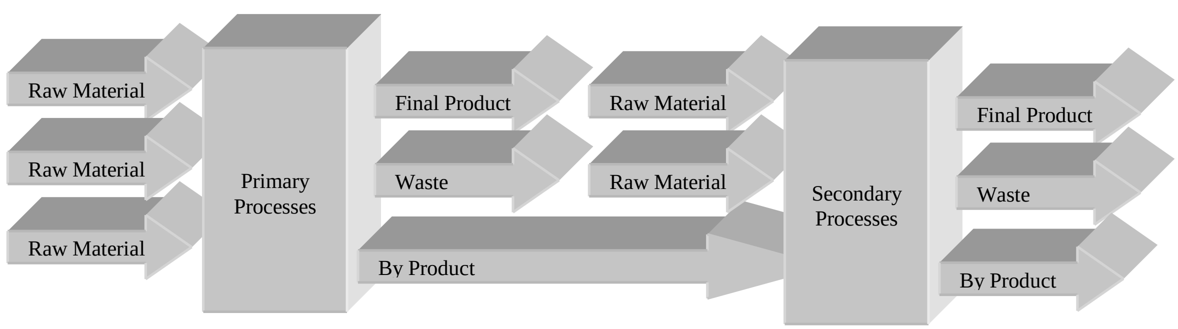

Figure 6. By Product Flow

By Product flow illustrate the essence of BPS, defined by the US Business Council for Sustainable Development as "*the practice of matching of under-valued waste or by-product streams from one facility with potential users at another facility to create new revenues or savings with potential social and environmental benefits*" (USBCSD, 2010a). Managers should be able to identify waste that can be considered as by product and potential uses of that material, not only within the organization but outside, sharing information about waste stream provide opportunities to identify potential users.

Since BPS concept was developed in the United States, other countries begin with programs based on the same concept, one of the most relevant is the National Industrial Symbiosis Program (NISP), this program developed in the United Kingdom is one of the successful examples of benefits that members can obtain from the program, NISP, instead BPS concept define and utilize Industrial Symbiosis concept which brings together traditionally separate industries and organizations from all business sectors with the aim of improving cross industry resource efficiency and sustainability; involving the physical exchange of materials, energy, water and/or by-products together with the shared use of assets, logistics and expertise (Lombardi and Laybourn, 2006, 15). The program is sustainability in action: environmental, economic and social benefits. What adds to the credibility of the program is that outputs are audited; underscoring the importance of metrics and measurement in industrial symbiosis programs (Lombardi and Laybourn, 2006, 14). On the same way than BPS, NISP promote the transition from a linear or traditional system towards a circular system; to achieve a low carbon, sustainable economy (Laybourn and Morrissey, 2009). Figure 7 shows Traditional versus Circular systems according to NISP criteria.

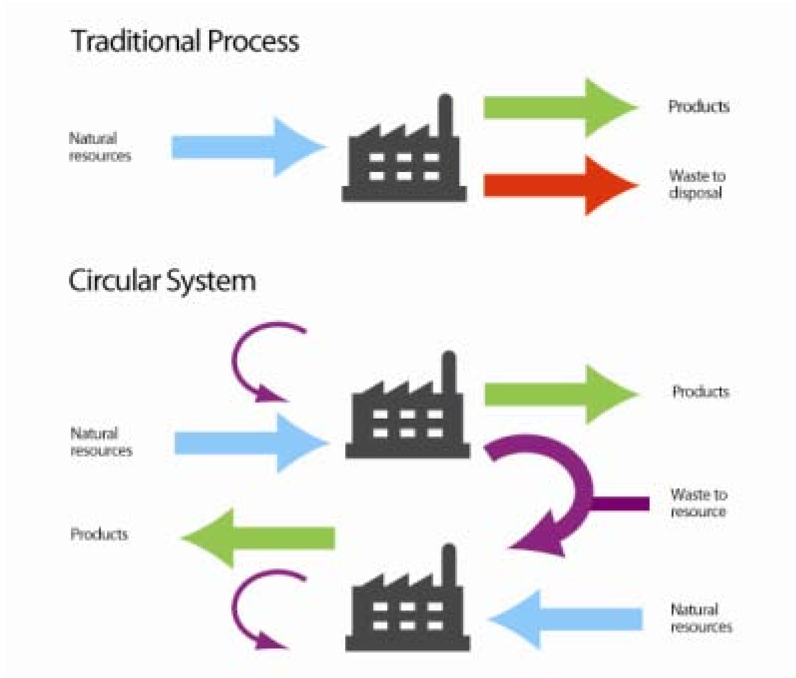

Figure 7. Traditional Vs Circular System (Laybourn and Morrissey, 2009)

BPS implementation require members to work in a collaborative system sharing basic information about by products they generate and can be used by other members of the system, the difference between just recycling and BPS is represented by the advantage of the synergistic effect of the system instead working individually. Working as part of a synergistic system allows participants to reach higher environmental, economic and social benefits.

The US BCSD BPS methodology involves establishing a forum where companies, regulators and municipalities explore reuse opportunities through collected information and facilitated interactions. Participants sign an agreement that spells out deliverables, confidentiality issues and intellectual property rights. Rather than simply declaring potential exchanges, the BPS process fosters relationships among companies and municipalities. The process is about information gathering and facilitation, but also about trust and bridge building (Mangan and Olivetti, 2010, p.2).

BPS need to be directed by facilitators, one of their roles is to find the way to improves communication channels between organizations to share information without affecting critical information that could be risky for participants. The role of facilitators is important and critical in order to identify potential synergies between participants and promote interaction between them.

A facilitator can serve a critical role in introducing companies to each other, helping to build the network either from the main players (by encouraging sub-networks), or across them (by encouraging cross-industry exchanges), or both. Any targeted facilitation approach (e.g. by industry sector, or by geography sector) has potential trade-offs with the diversity and density of the emerging network (Lombardi and Laybourn, 2006, p. 50)

Independently of the name used: BPS network, NISP program, etc. and considering the main concept about BPS developed by the United States Council for Sustainable Development; the program imply that members should work in a collaborative and cooperative environment.

The Ohio State University - Center for Resilience grouped some of the main benefits of implementing BPS and is listed next on Table 1:

Table 1. BPS Benefits (OSU – Center for Resilience, 2010)

By Product Synergy Benefits
Increased revenues from by-product sales
Reduction in waste disposal costs
Substitution of lower-cost, locally sourced recycled feed stocks
Reduction in solid waste and other environmental burdens
Reduction in energy use and greenhouse gas emissions
Reduced demand for virgin materials leading to resource conservation
Stimulation of regional entrepreneurship and economic development
Enhanced corporate reputation for sustainable practices
Interaction with other leading companies and technical experts

Since the concept of BPS was developed by US BCSD, it was applied at different organizational levels, some of them promoted by official organizations, but there is no restriction or limitations to apply the concept within a company in order to take advantages of potential synergies.

One of the programs is the Kansas City Regional BPS program; the program involves more than ten companies and organizations. Figure 8 presents the first diagram used to identify the flow of potential synergies (Mangan, 2010, p.5).

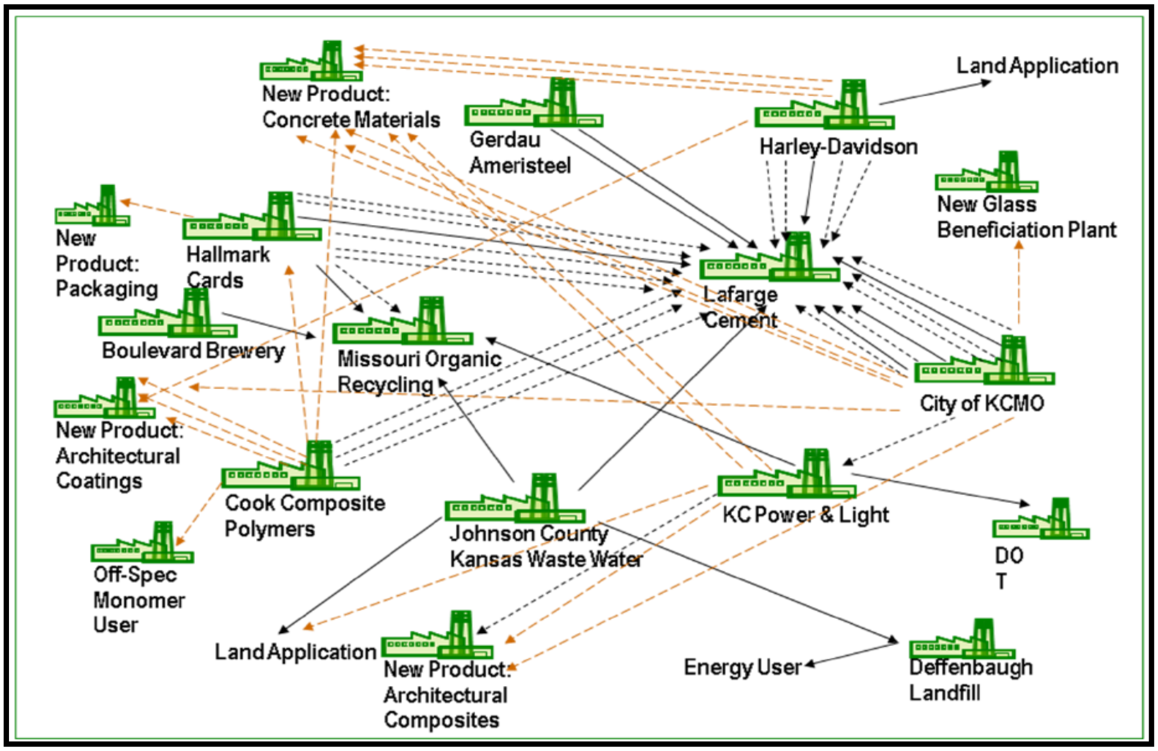

Figure 8. Early Diagram Kansas City Synergies (Mangan, 2010)

Implementing By Product Synergy programs requires some basic steps to be developed by managers in charge, following figure presents phases proposed by BCSD-GM that should be considered at the time of implementing the process:

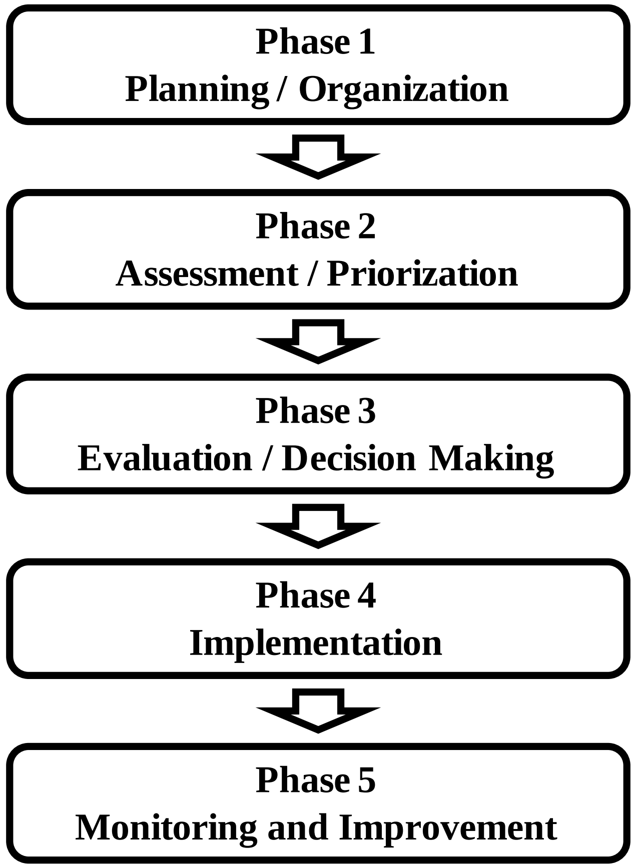

Figure 9. Phases of By Product Synergy Process (Mangan, 1997)

On Phase 2 activities like identify candidate waste, by product and resource streams, characterize candidate streams and identify and contact potential collaboration partners are performed as part of the process (Mangan, 1997, p. 20).

These activities are basically directed first at all to analyze waste streams and identify waste with potential by product properties that can be used as raw materials in other processes and also find potential members to be part of the by product synergy network.

One of the most remarkable benefits of the process is that it can be applied within an organization and also between different organizations, but the same basic process which is finding other uses than disposal for residuals or waste with by product properties remains the same.

Eco-Flow™: a tool for better decision making

The relevance of an adequate waste management confirmed by multiple successful individual efforts promote the development of tools directed to maximize those individual efforts. Designers from the Ohio State University's Center for Resilience have developed an especial tool known as Eco-Flow™.

Eco-Flow™ is a tool developed in order to facilitate understanding material flow, developing network integrating information about waste and by products from multiple sources (companies/organizations) determining potential users for that material, the software identify by integer programming techniques the better – most profitable route for each by product.

The model assumes that the output of any industrial process can become either resources or feedstock for another industrial processes or unrecoverable wastes sent to disposal sites, and it calculates the most profitable allocation based on revenues, transportation and operating costs as well as other characteristics, such as capacity and environmental constraints (Slattery Wall, 2007, p. 19).

The model requires members to share information about by products they produce or generates and that usually considered as residuals of main production processes, and could be used as resources in other processes. Figure 10 show a model of Eco-Flow™ software.

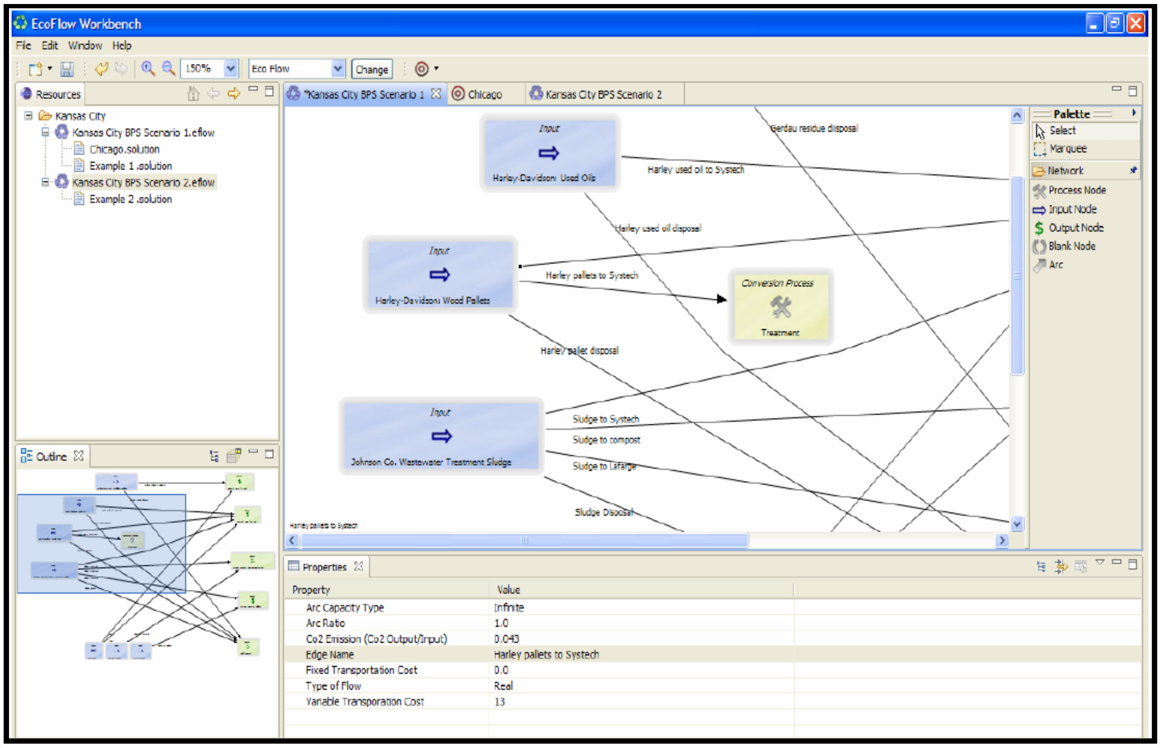

Figure 10. Eco-Flow™ workbench (OSU – Center for Resilience, 2010)

Relevance of waste management on sustainability

The necessity of an adequate waste management program for organizations at different levels, not only from the commercial side but also governmental are highly related to the sustainability concept.

According to UN World Commission on Environment and Development a Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs (UN A/42/427, 1987).

Considering that a sustainable product or process is one that constrains resource consumption and waste generation to an acceptable level, makes a positive contribution to the satisfaction of human needs, and provides enduring economic value to the business enterprise (Bakshi and Fiksel, 2003, p.1350).

The definition of sustainable process can be extrapolated and related to AF policies and strategies and then to maintenance activities from the triple bottom line or pillars of sustainability which are economy, society and environmental protection, these three elements are the pillars in which managers should base their decision to improve performance on their organizations. Figure 11 represent one of the most used models to represent sustainability, based on the three pillars or dimensions: environmental (conservation), economic (growth), and social (equity) dimensions (Keiner, 2005, p.2).

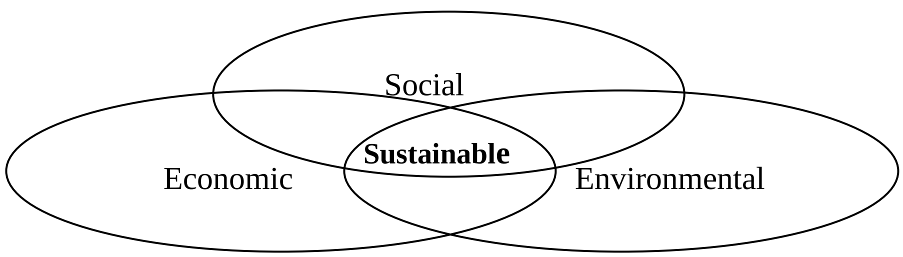

Figure 11. Three Pillars of Sustainability

At this point it is necessary to consider the relevance of these three pillars on the sustainable development definition which means ensuring dignified living conditions with regard to human rights by creating and maintaining the widest possible range of options for freely defining life plans. The principle of fairness among and between present and future generations should be taken into account in the use of environmental, economic and social resources (Altwegg, Roth and Scheller, 2004, p.14).

Considering the previous definition of sustainable development decision makers must consider the impact of their decisions at on the three pillars of sustainability.

Summary

Once reviewed several information sources related to waste management, including laws and regulations from the government side, and different concepts and models developed by managers from the commercial side, it is important to note that as usual commercial side is more flexible and dynamic to changes at the time to develop new objectives and policies and strategies to reach them, and also is more agile to develop and implement new procedures to improve organizations. From the other side even considering that laws and regulations are developed by governments, official organizations need more time to prepare, introduce, and implement changes, sometimes organizational cultural barriers demand more time until new processes mature and be effective.

In the particular case of waste management, new development related not only to new equipment or technologies but also processes about waste recycling change constantly; engineers and designers look for improve processes and designs to optimize performance and work under different kind of incentives not necessary economic.

It is also important to consider that sometimes due to the nature of the organizations some methodologies cannot be directly applied on all fields; they need to be adapted before to be implemented. Barriers can be present on regulations and also in organizational policies and strategies that need to be redefined in order to allow new methodologies to be applied.

Managers should be able to recognize the relevance of new streams, definitions, concepts and tools and benefits related to them and analyze the feasibility of apply on their organizations.

III. Cases of Study

Introduction

In this stage of the research current waste management stream will be presented from two different perspectives, in first place the hazardous waste management stream at Depot Level maintenance unit, provided by DRMO at Robins AFB as case of study from the AF side classifying hazardous waste level by volume, EPA management code and costs, and from the commercial side the application of BPS on commercial side such as Ohio BPS Network, Chaparral Steel Company and Florida Power and Light by product and pollution prevention programs as cases of study will be presented.

Cases of study represents different ways that organizations at different fields – commercial and military; define how to implement environmental management to accomplish not only organizational goals but also laws and regulations.

USAF – Robbins AFB case study

The Warner Robins Air Logistics Center at Robins AFB developed an environmental management system manual; the manual was prepared according to the ISO 14001 standard.

The program is focused on the four pillars presented previously on Chapter I Figure 2 – clean up, compliance, conservation and prevention pollution. These four objectives are the core of the environmental management program.

Prevention pollution practices are implemented in acquisitions, operations, and maintenance programs. The overall goal is to continually improve and work toward zero discharge of pollutants (from any media) into the environment through instilling prevention values and a hierarchy of methods (WR-ALC, 1999, p. 9).

According to their mission, DLA implement a DRMO at Robbins AFB, their objectives are: manages the disposal of hazardous property for DoD activities. Hazardous property is handled according to the same priorities as other property: reutilization within DoD, transfer to other federal agencies, donations to qualified state and nonprofit organizations, and sale to the public including recyclers. This process maximizes the use of each item and minimizes the environmental risks and the costs associated with disposal. DRMOs provide safe, temporary storage of hazardous property during the disposal cycle (DLA, https://www.drms.dla.mil/drmo/warnerrobins.shtml).

DRMO under the DRMS is the DoD preferred hazardous waste disposal agent (DoD 4160-21M, 1997, p. 10.1). Figure 12 present the stream from DLA point of view (Hirschman, 2008, p. 3).

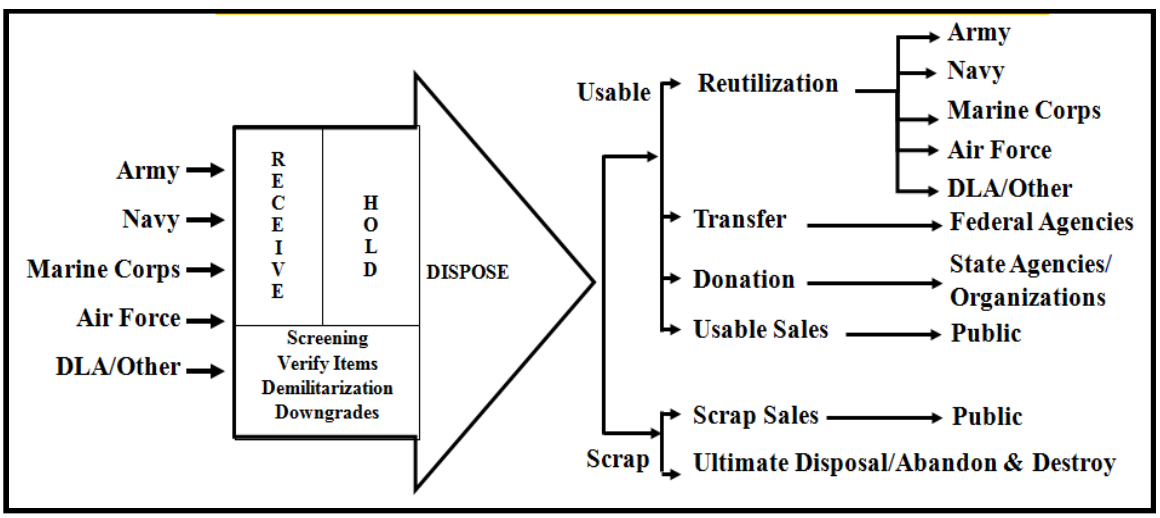

Figure 12. DLA Disposal scheme (Hirschman, 2008)

From the services point of view, specifically from the AF, the typical hazardous waste stream is presented on Figure 13.

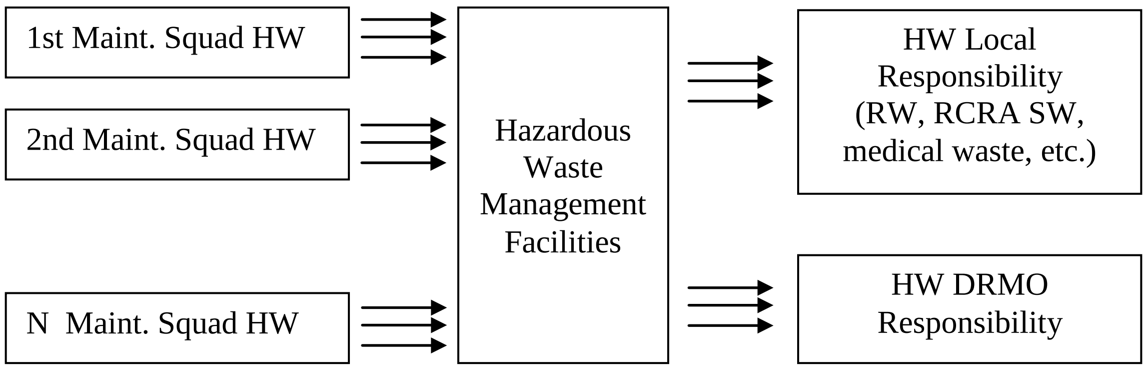

Figure 13. AF HW Disposal Stream scheme

Through different processes performed by maintenance squadrons hazardous waste is generated and directed to hazardous waste management facilities, then waste is classified and according to their responsibility levels it is assigned to local hazardous waste management or DRMO hazardous waste management agent. DLA/DRMS/DRMO is responsible for the disposal of Hazardous Waste (HW) … A decision not to use the DLA/DRMS for HW disposal may be made in accordance with DODD 4001.1, for best accomplishment of the installation mission, (DoD 4160.21-M, 1997, p. 10.1)

By yielding responsibility over certain hazardous waste to DRMO service units loses control about some material with potential by product properties and also from the benefits related to these by product materials.

Robbins AFB Hazardous waste levels / classification

Hazardous waste generated by different units, according to information provided by Robins AFB can be classified according to Environmental Protection Agency Code by volume involved due to DRMO activities for disposal of hazardous waste are presented on Tables 2 to 4 grouped by biennials reports 2005, 2007 and year 2009. References cost was developed in all cases by using 2010 CLIN (Contract Line Item Number) costs provided by Robins Air Force Base Hazardous Waste program manager for year 2009.

Table 2. Robins AFB HW Volume Biannual 2005

EPA Management Code	Volume
H010 Metal Recovery	35,830
H040 Incineration	1,054,062
H061 Fuel Blending	579,555
H111 Stab. Chemical Fixation	94,800
H112 Macro Encapsulation	6,602
H132 Landfill	669,515
Total Pounds	**2,440,364**
Total Tons	**1,220**

Table 3. Robins AFB HW Volume Biannual 2007

EPA Management Code	Volume
H010 Metal Recovery	821,272
H040 Incineration	221,737
H061 Fuel Blending	646,957
H111 Stab. Chemical Fixation	162,361
H112 Macro Encapsulation	8,860
H132 Landfill	1,433,666
Total Pounds	**3,294,853**
Total Tons	**1,647**

Table 4. Robins AFB HW Volume & Cost Year 2009

EPA Management Code	Volume	Cost	% Vol	% Cost
H010 Metal Recovery	172,158	$72,493	7.19	6.54
H040 Incineration	254,828	$151,897	10.65	13.70
H061 Fuel Blending	451,545	$113,033	18.87	10.19
H111 Stab. Chemical Fixation	105,843	$27,971	4.42	2.52
H112 Macro Encapsulation	3,071	$690	0.13	0.06
H129 Other Treatment	510,150	$86,726	21.32	7.82
H132 Landfill	895,666	$655,998	37.42	59.16
H134 Deepwell/ Ugnd Injection	7	$2	0.00	0.00
Total Pounds	**2,393,268**	**$1,108,810**	**100**	**100**
Total Tons	**1,197**			

Figures 14 to 16 present distribution of volume by percentages for 2005 and 2007.

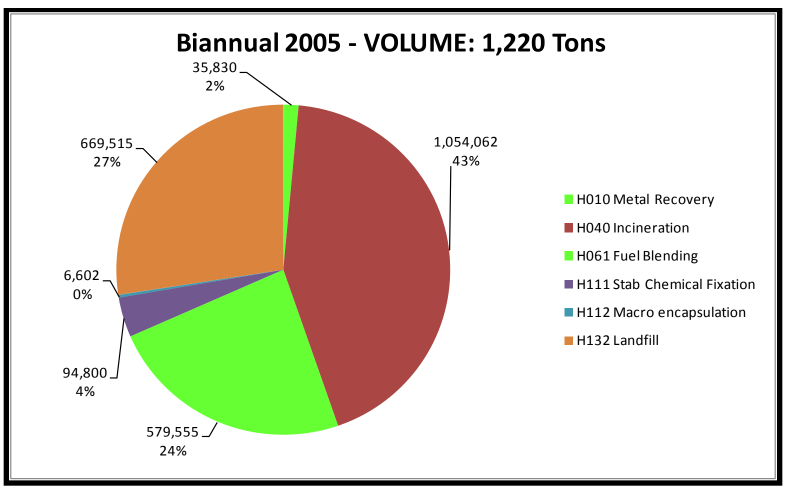

Figure 14. Robins AFB HW Biannual 2005 Volume Distribution

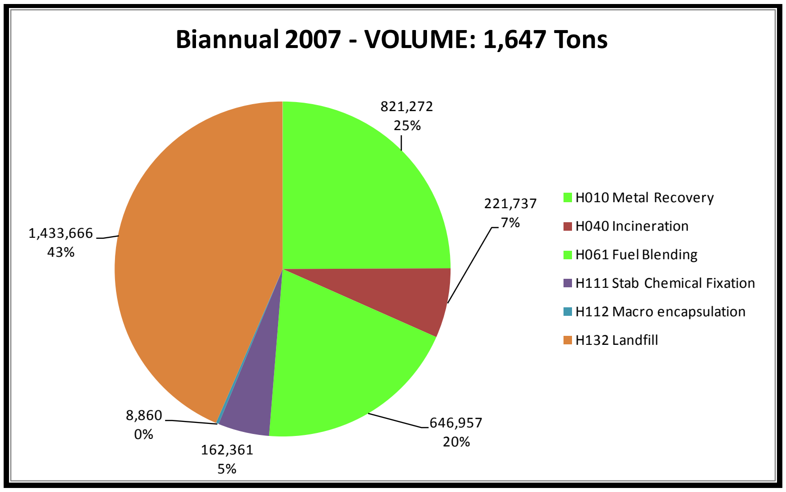

Figure 15. Robins AFB HW Biannual 2007 Volume Distribution

To be used as reference on next chapters, Figure 16 present distribution of volume and costs for year 2009.

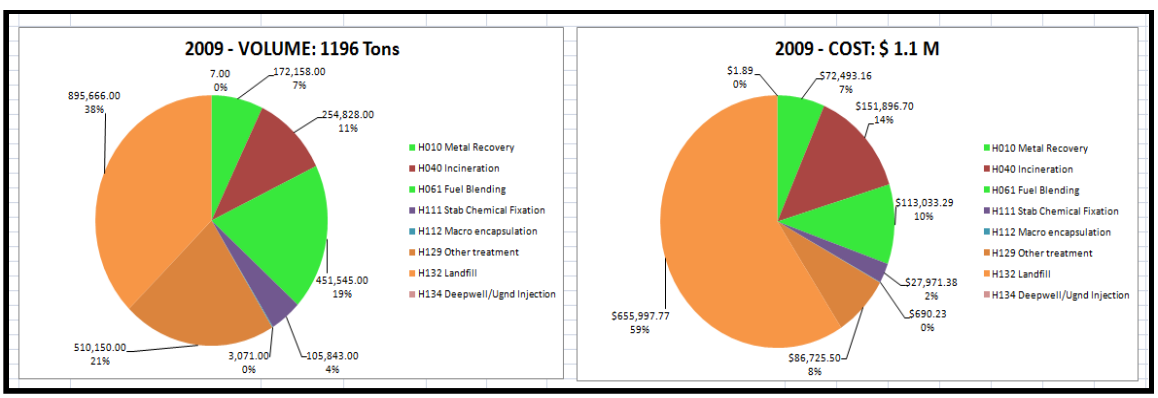

Figure 16. Robins AFB HW Year 2009 Volume and Cost Distribution

Different kind of waste was classified on each case by EPA management code; Table 5 presents an extract of the Management Method Code Group, and Appendix B presents a complete set of codes (EPA, 2009, pp. 68/69).

Table 5. EPA Management Method Code Group (EPA, 2009)

Reclamation and Recovery	
Code	Management Method Code Description
H010	Metals recovery including retorting, smelting, chemical, etc.
H061	Fuel blending prior to energy recovery at another site
Destruction or Treatment Prior to Disposal at Another Site	
H040	Incineration - thermal destruction other than use as a fuel
H111	Stabilization or chemical fixation prior to disposal at another site (as the major component of treatment; not H071-H075, H077, or H082)
H112	Macro-encapsulation prior to disposal at another site (as the major component of treatment; not reportable as H071-H075, H077, or H082)
H129	Other treatment (specify in comments; not reportable as H071-H124)
Disposal	
H132	Landfill or surface impoundment that will be closed as landfill (to include prior treatment and/or stabilization)
H134	Deep well or underground injection (with or without treatment; this waste was counted as HW)

From this list hazardous waste grouped at reclamation and recovery – codes H010 Metal Recovery and H061Fuel Blending, have immediate potential by product properties to be used as resources to be reclaimed or used in other processes within the organization by developing recycling technologies and outside.

By Product Synergy - commercial cases study

By Product Synergy programs are actually implemented at different levels, promoted and managed by governmental organizations or even applied at company levels.

Independent from the level at which BPS concept is applied, sharing information is necessary, in places where BPS programs are implemented and involve multiple organizations, members must follow clauses of confidentiality about information shared in order to preserve some critical information.

Some cases of study such as the Ohio BPS Network, Chaparral Steel Company and Florida Power and Light BPS and pollution prevention program coincide with the benefits of BPS concept and demand managers to identify by product properties of waste generated by production processes and also to locate potential users to take advantage of the synergies, and in some cases the program allows managers to identify hidden but profitable business opportunities by developing or acquiring new technologies, and example will be presented on next chapter.

Cases of study of BPS principles present as common factor benefits listed previously on Chapter 1, Table 1 “BPS benefits”, the key of success of BPS programs require managers to identify by products and potential users. There are cases where synergies cannot be identified by the nature of material involved and the option is dispose waste on the traditional way.

The Ohio BPS Network is one of the newest programs is with the sponsorship of US BSCD is managed by the Ohio State University. This program relate by products to potential users from a wide spectrum of organizations and companies in the area and as potential benefits initials opportunities can divert nearly 30,000 tons/year to landfill, reduce 230,000 tons/year of $CO2$, and an estimated of $3.5 million/year in cost savings. In addition to environmental and economic benefits social benefits like the creation of new jobs by utilizing local resources will be present as benefits from the program.

Chaparral Steel Company case study (IISD, 2010a); this company decide to apply BPS principles developing a system named STAR (Systems and Technology for Advanced Recycling), project was set up to process wastes, conserve natural resources and prevent pollution, through the recycling of waste materials generated by steel and cement manufacturing. The mission of the STAR project is to develop synergies between the two manufacturing processes and the automobile shredding facility. Next figure shows the recycle facility flow diagram.

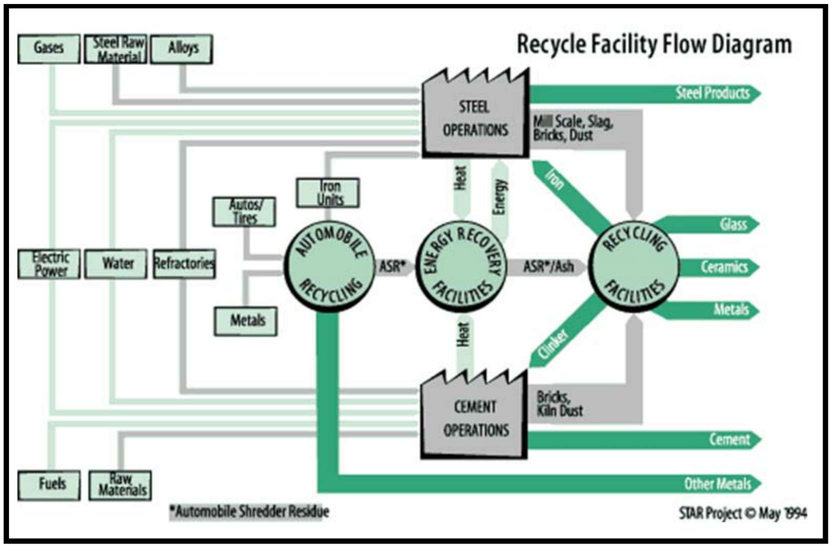

Figure 17. Chaparral Steel Company (Mangan, 1997)

According to the information available, benefits on some processes include reducing energy requirements by at least 10%; environmental benefits by reducing carbon dioxide emissions. They also installed additional technologies to reduce the amount of automobile shredder residue sent to landfill, some processes represent economic benefits up to $500.000 a year.

Florida Power and Light case study (IISD, 2010b); in this case the company developed by product synergy and pollution prevention programs, including waste minimization and recycling initiatives, have been in place for several years at various FPL sites. The company managed to reduce the cost of disposing of this scrap material from $1.2 million in 1991 to just $281,000 in 1995. Even more impressive is the revenue generated from these activities - $2.8 million in 1994. The company implemented several BPS and pollution prevention projects including sale of scrap PVC, polyethylene, and polycarbonate for reuse, consolidation and use of surplus paints, solvents and degreasers, donation of unwanted poles to local farmers for fencing, etc.

Summary

Reviewing the cases of study: Robins AFB waste stream, Kansas City Regional BPS program, Chaparral Steel Company and Florida Power and Light BPS and pollution prevention programs, it is possible to perceive that the traditional concept of Cradle to Grave applied at Robins AFB can be upgraded to new principles in order to take advantage from potential synergies or in some cases managers can decide to make investment on new technologies that can be applied for a more profitable use of by products originally considered as waste and that were disposed demanding high cost due to the nature of hazardous waste processing.

Next chapter will present some potential alternatives such as processes improvement on hazardous waste stream and benefits of applying available technologies to optimize hazardous waste management.

IV. Analysis and Highlights

Introduction

This chapter will be focused on the analysis of information collected and potential opportunities will be presented to improve processes related to hazardous waste management such as taking advantages of new principles like BPS and also acquiring new technologies that can be applied on hazardous waste processing in order to obtain other uses for potential by product residuals than just dispose it via DRMO.

Robins AFB

Analyzing current hazardous waste stream at Robins AFB and according to information received; hazardous waste is finally disposed via DRMO. Costs generated by disposal processes are charged to the unit, but there is no economic benefit received by potential by product properties of hazardous waste.

According to the classification of hazardous waste by EPA management code, there are some hazardous waste utilized for metal recovery (Code H010), or fuel blending (Code H061); this mean that this kind of hazardous waste present some by product properties prior to final disposal.

Activities like reclamation or recycling to obtain further use of this kind of waste can be implemented and also including this king of waste on a BPS program for potential users are both options to be considered at the time to decide improvement on processes.

On the next paragraph the research will be focused on a special kind of hazardous waste related particularly to painting activities during aircraft maintenance processes in order to support a change in hazardous waste stream.

Table 6 presents hazardous waste data year 2009 related to painting maintenance activities and percentage of volumes and costs are related to the total amount of waste during the period; and Figure 18 presents a graphic distribution by EPA management code.

Table 6. Robins AFB Hazardous Waste Painting activities related 2009

Epa Management Code	VOLUME (pounds)	COST ($)	%VOL	%COST
H010 Metal Recovery	125,800	$50,320	5.21	4.54
H040 Incineration	5,180	$1,113	0.21	0.10
H061 Fuel Blending	183,318	$46,886	7.60	4.23
H111 Stab Chemical Fixation	3,271	$604	0.14	0.05
Pounds	317,569	$98,923	13.16	8.92
Tons	159			

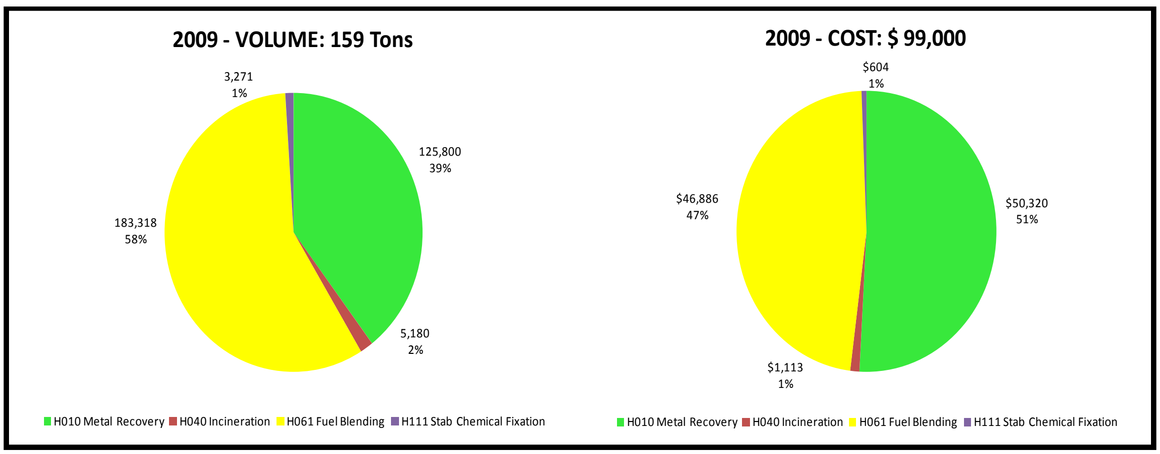

Figure 18. Robins AFB HW Painting activities related 2009 - Volume and Cost

Comparing values with total numbers by EPA Management code on each case, hazardous waste related to painting activities represents 13.16% of total volume and 8.92% of total costs involved on hazardous waste disposal management.

Potential Areas of Investment

Assuming that hazardous waste codes H-010 (Metal Recovery) and H-061 (fuel blending) are those that presents potential by product properties, and analyzing the impact on total values for year 2009 on Table 7 it is possible to appreciate that hazardous waste related to painting activities represents around 70% of volume and cost for Metal Recovery and around 40% of volume and cost for fuel blending.

Table 7. H010 & H061 HW General values 2009 vs. Painting Related Activities

Epa Management Code	VOLUME (pounds)	COST ($)	%VOL	%COST
H010 Metal Recovery 2009	172,158	$72,493.2	**73.07**	**69.41**
H010 Metal Recovery Painting Related	125,800	$50,320		
H061 Fuel Blending 2009	451,545	$113,033.29	**40.60**	**41.48**
H061 Fuel Blending Painting Related	183,318	$46,886		

Under the previous stated assumption – by product properties of H010 and H-061; these kinds of hazardous wastes can be directed to further processes (reclaiming or recycling), next paragraph will present two cases study to be considered as an option by acquiring new technologies to take advantages of some by product properties of hazardous waste. In cases presented different organizations generating same kind of waste decide to use recycler to recover solvents from post painting processes hazardous waste; savings related to less hazardous waste disposal volume and cost and savings on purchasing material are mentioned in both cases.

Acquiring new technologies

The first case to be presented is Charleston AFB Methyl Ethyl Ketone (MEK) recycling (DPPEAa, 2010). The annual disposal of paint waste generated by 437th Equipment Maintenance Squadron (EMS) prior to the acquisition of solvent recycler was 7,260 pounds. After the first year of operation MEK recycled: 5,335 pounds; Table 8 presents relevant information about the case.

Table 8. Charleston AFB Case Study - Solvent Recycler

Charleston AFB 437th EMS	
Reduction of HW Stream	Nearly 80%
Recycling Unit Cost	$3,180
Annual Disposal Cost	$9,175
First Full Year savings (in disposal and purchasing costs)	$5,300

The by product recovered by the recycling unit that doesn't present original MEK specification is reused on paint spray guns cleaning. Due to the volume of recycled product involved, the break even cost was less than a year.

The second case of study is related to a small volume waste generator on the commercial side; Vintage Class Motor Cars waste reduction case study (DPPEAb, 2010). Table 9 presents relevant information on this case.

Table 9. Vintage Class Motor Cars – Solvent Recycler

Vintage Class Motor Cars	
Reduction of HW Stream:	Nearly 80%
Recycling unit cost	$5,189
Annual disposal cost	$1,080
Year savings (in disposal and purchasing costs)	$2,960

In both cases and according to specification mentioned for the equipments they are able to recover up to 80% of solvents. Equipment available are designed to recover many different products such as acetone, MEK, toluene, paint thinners, etc. Considering actual purchasing cost of $10,000 for a 4 gallons recycler plus accessories; the return of investment (ROI) will depends on the use of the equipment. Figure 19 shows an estimated ROI considering only savings due to reduction of disposal cost of HW related to painting activities code H061 less 80% of solvent recovery (estimated). Monthly distribution of HW generated was assumed linear considering total generation of 183,318 pounds of painting activities related HW for year 2009 with a total disposal cost of $46,885.

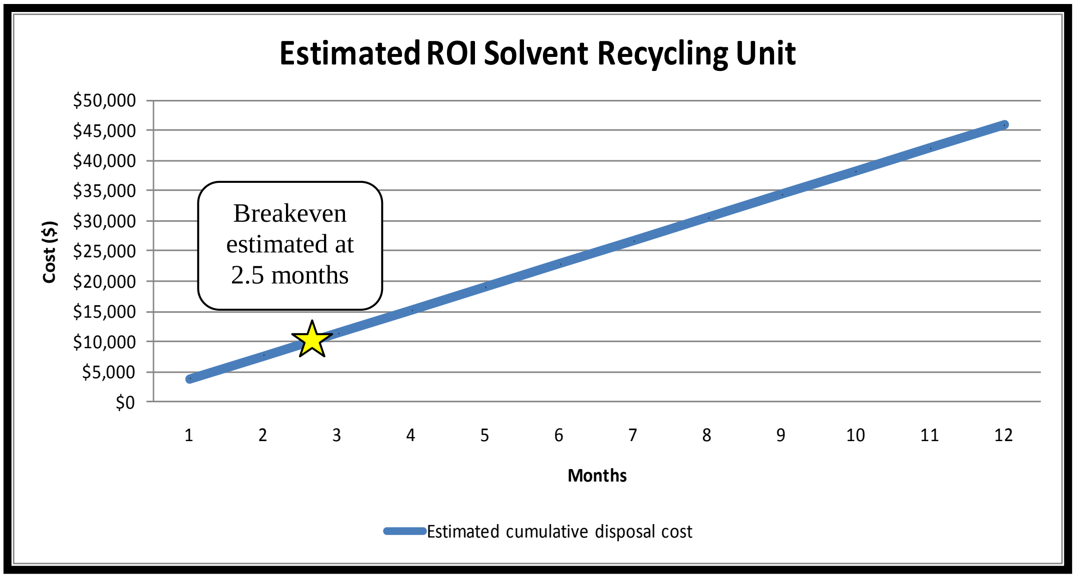

Figure 19. Estimated ROI Solvent Recycling Unit

Under the previously stated assumption the recycling system cost will be break even approximately in 2.5 months. Figure 20 presents how volume and costs evolve assuming theoretical effectiveness of the recycler around 80%.

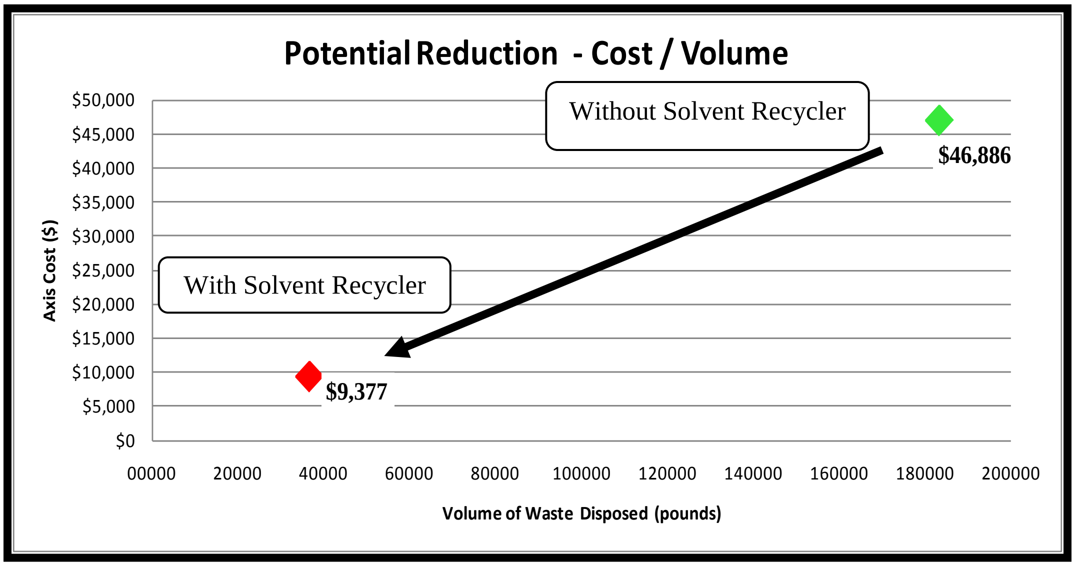

Figure 20. Evolution of Cost and Volume by using Solvent Recycler Unit

Considering potential reductions due to reuse of recycled solvents, savings will be increased depends on the use of recycled products (e.g. cleaning parts).

Developing a new process

Another improvement opportunity is related to new waste management principles, in particular By Product Synergy (BPS).

BPS programs as mentioned on previous chapters depends on the creation of a cooperative system or network where members share information trying to match potential by products generated and that can be useful in another organizations processes. Nevertheless these kinds of programs do not guarantee participants that their by products can be used or demanded by other members. Cultural and organizational barriers need to be solved.

A single way to solve cultural barriers is information. Managers should guarantee that members involved in processes know and understood clearly the objectives pursued by implementing new processes. Organizational barriers should be more complicated because of regulations that need to be considered and sometimes changed in order to be able to implement new processes.

Considering the constraints that both kinds of barriers present to change, in the case of places where BPS programs are not implemented and assuming that organizations are involved and understood principles like Cradle to Grave, change to the next step of Cradle to Cradle or BPS will be more simple; BPS programs should be promoted first at all in order to break some cultural barriers like confusing BPS and just recycling; and also natural concerns about the confidentiality of information shared in the program.

BPS is a trademark from the US Business Council for Sustainable Development, Recognizing the strengths of the BPS process.

The council has created a BPS license model to accelerate its adoption and implementation while protecting the council's intellectual property, the BPS process and the council's brand. The council has been working to pilot a national expansion program that would use service companies as providers of the BPS process. Under the plan, the service company would provide operational resources, manpower and tools to help companies, chambers of commerce, municipalities, governmental departments and agencies implement regional by-product synergy projects (USBCSD, 2010b).

Considering potential economic, environmental and social benefits obtained by implementing BPS, in the case of the AF, the first step should be directed to improve the current hazardous waste stream show on Figure 21. In this flow hazardous waste is directed to Defense Reutilization and Marketing Office in order to be disposed, instead of potential by product properties. Units lose control of this kind of material that only generates disposal costs.

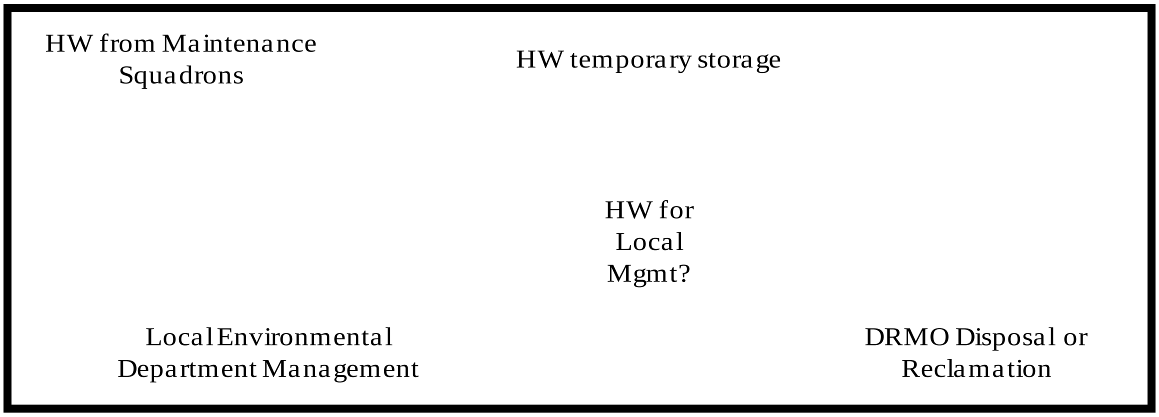

Figure 21. Current Hazardous Waste Stream

In order to take advantage of potential by product properties of hazardous waste generated during aircraft maintenance processes, a new model is proposed in which developing on site recycling facilities and the by product synergy approach on the current hazardous waste flow are included.

Figure 22 presents changes proposed to the current hazardous waste stream.

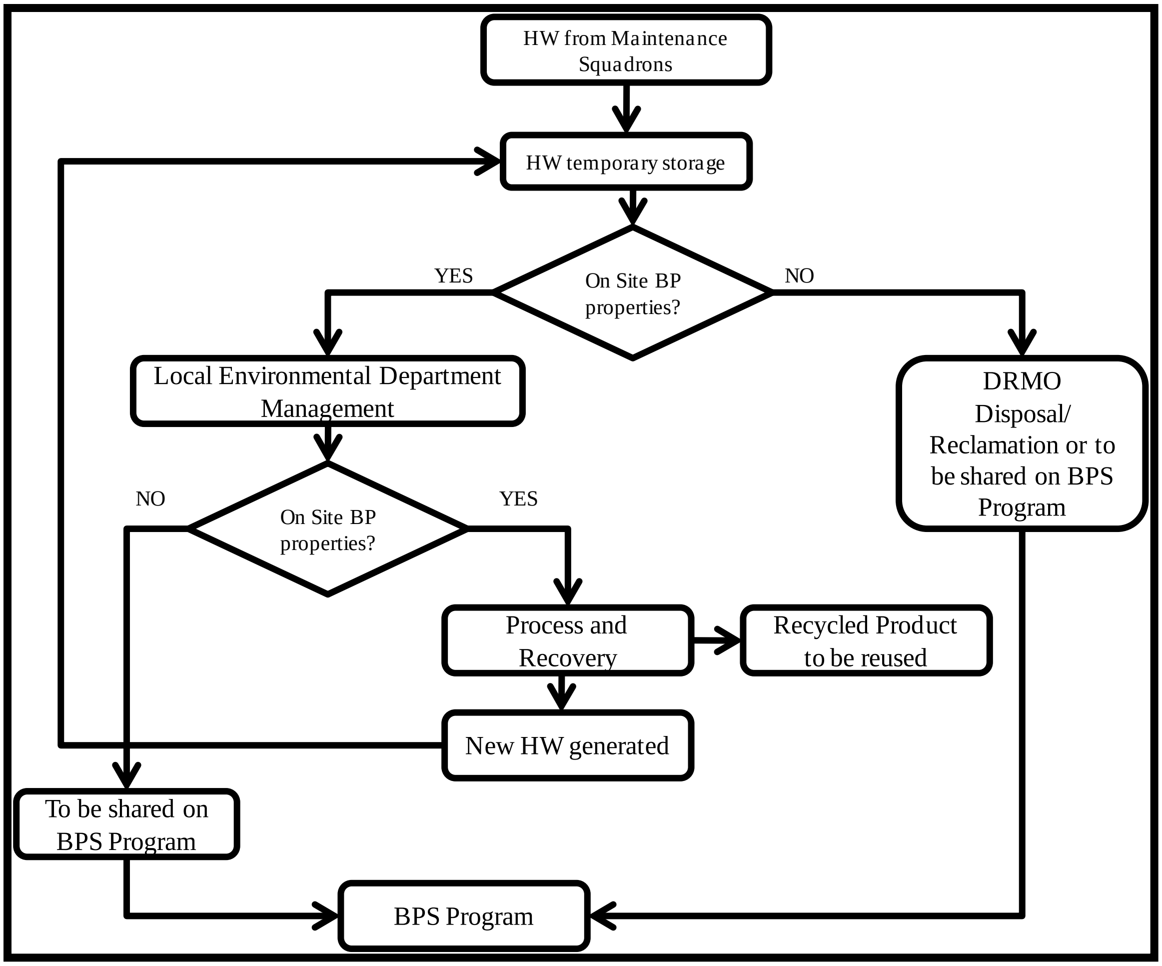

Figure 22. HW Stream considering potential By Product properties

The diagram includes the implementation of On Site Recycling Facilities adding benefits such those presented on previous pages, considers in the first stage the necessity of identifying potential by product properties of waste generated, and in which case the local environmental department should direct waste to On Site Recycling facilities or to be shared on BPS program.

In the case of existence of On Site Recycling facilities; (after processing), the recycled products can be reused in other processes and new hazardous waste generated are again directed to the beginning of the stream to start the selection process again.

The mission of DRMO doesn't changes. They still have the responsibility to process hazardous waste generated by the unit that neither have the possibility to be processed on site. However changes in volume of waste with potential by products properties should be perceived as an opportunity. DRMO should be part of the BPS program, and continue to decide about the final disposition of hazardous waste.

The main decision on the flow chart proposed is to determine by product properties that can be used to generate further benefits at unit level.

The success of implementing BPS programs is based primarily on the ability of facilitators to identify potential by products and the potential synergies that can be developed.

Because of the skills required of facilitators, and also the capacities or potential demand of by products from participants, it is hard to estimate the success of BPS programs; nevertheless Figure 23 presents typical benefits from economic, environmental and social areas perceived on different programs actually on course.

ECONOMIC	ENVIRONMENTAL
Additional sales of by product material	CO_2 savings
Reduced disposal costs	Waste diverted from landfill
Raw material purchasing savings	Water pollution savings
SOCIAL	
Improved company profile	
Jobs created	

Figure 23. BPS Programs – Economic, Environmental and Social Benefits

Analysis tools can facilitate understanding of potential benefits of a BPS network, linking participants and their by products and estimating economic and environmental benefits. The next section will present a modeling of current hazardous waste stream and a proposed hazardous waste stream considering potential by product properties to simulate the processes as presented previously.

Eco-Flow™ workbench application

Under the authorization of The Ohio State University's Center for Resilience to utilize the Eco-Flow™ application, two models were implemented in order to simulate the processes of the current hazardous waste stream and the proposed by product stream that were presented on Figures 21 and 22.

Assumptions in data utilized to develop models include:

- Four Maintenance Squadrons generate equal amount of hazardous waste.
- Hazardous waste generated equals contractor demand.
- Four contractors exist, one for each kind of hazardous waste classified by EPA Management Method Code Group (H010, H040, H061, H111)

- Transportation cost from DRMO to contractors by truck: $2 per ton (as used on Eco-Flow™ workbench model).
- Environmental impact; green house emissions of CO_2, defined by Eco-Flow™ application.
- Contractors can process 100% of hazardous waste generated – 2009values.
- Solvent recovery process performed by one machine that can recycle 80% of hazardous waste into reusable product.
- Hazardous waste after solvent recovery process does not have by product properties, and is directed to incineration.
- There is no environmental impact during the process of storage and classification of waste at unit hazardous waste facilities and DRMO facilities.
- HW disposal cost per ton via DRMO: Metal Recovery $798.73, Incineration $428.07, Fuel Blending $511.85, Stabilization prior to landfill $377.5.
- Solvent recovered cost: $11,428 per ton based on 7lbs per gallon at $40 per 5 gallon can.

Three models were tested; Figures 24 and 25 present's processes developed using Eco-Flow™ application, the first case considering current flow, and Case A considering that solvent recycling facility can process 50% of hazardous waste with fuel blending property, and Case B considering that solvent recycling facility can process 100% of hazardous waste with fuel blending property.

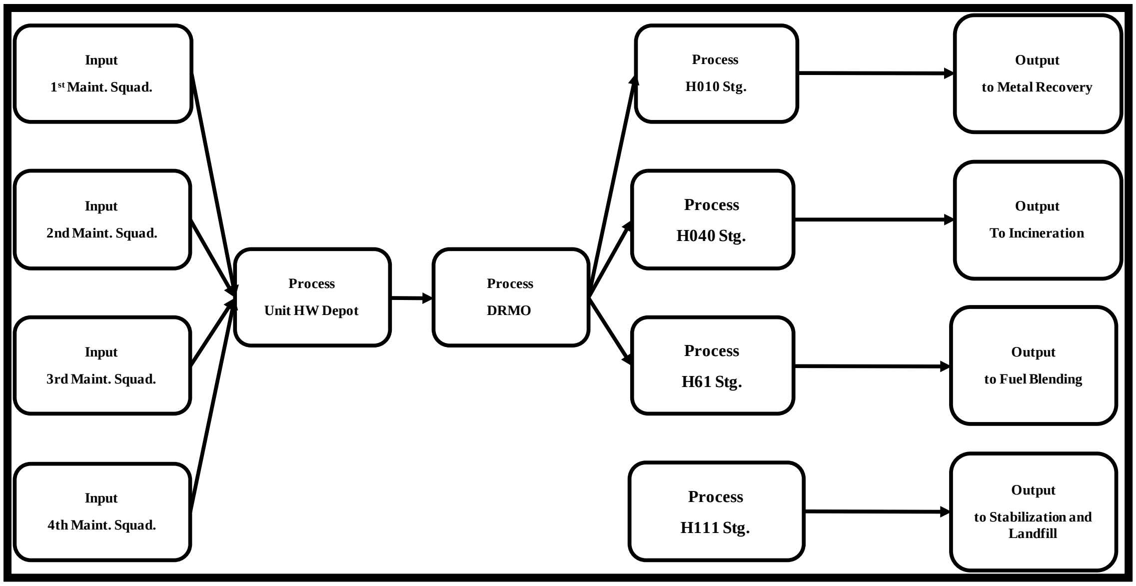

Figure 24. Current HW stream using Eco-Flow™ workbench application

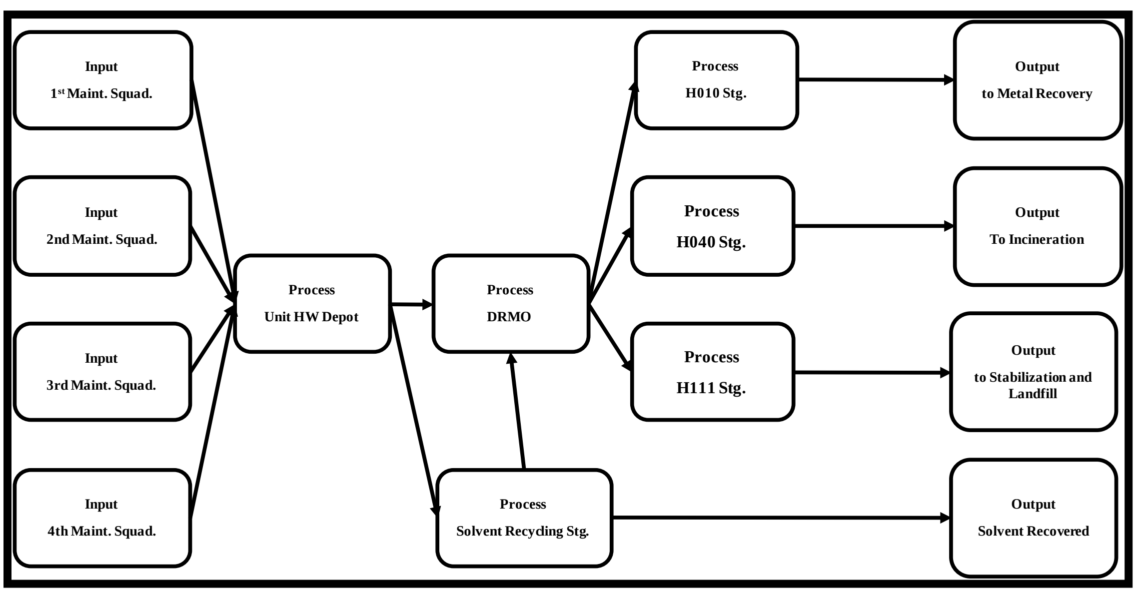

Figure 25. Proposed HW stream Eco-Flow™ workbench application

Running Eco-Flow™ the results generated are presented on the next table:

Table 10. Comparing Eco-Flow™ workbench application models

		Current Case	**Case A**	**Case B**
Input (Tons)	Maintenance Squadrons	159	159	159
Processed (Tons)	by HW Unit Facility	159	159	159
	by DRMO	159	122	86
Output (Tons)	to Metal Recovery	63	63	63
	to Incineration	2	12	21
	to Fuel Blending	92	45	0
	to Stab and Landfill	2	2	2
	Solvent Recovered	0	37	73
DRMO Cost:		**$98,589**	**$79,139**	**$59,708**

The final cost to processing hazardous waste via contractors is reduced by approximately 20% on Case A and approximately 40% on Case B as a result of different solvent recovery performance.

The cost reduction comes from sending less hazardous waste to contractors. 73.09 tons and 36.63 tons of solvent can potentially be recovered according to Cases A and B, and the same amount of hazardous waste is not released to contractors.

Next table presents the variation of CO_2 generated on the models analyzed, the variation is related to the total weight processed by contractors

Table 11. Eco-Flow™ workbench application models – Eco Impact

	Pilot Case	Case A	Case B
Eco Impact (Kg. CO2)	445.85	240.17	342.94

The cost reduction comes from sending less hazardous waste to contractors. In the model a total of 77.86 tons of solvent recovered are hazardous waste not released to contractors.

In order to estimate cost avoidance by reusing solvent recovered, at a cost of $11428 per ton based on the retail price for a 5 gallon can of thinner of $40 Table 12 presents the estimated cost avoidance on each case and potential benefits.

A mid size solvent recycled performances were considered with $10,000 acquisition cost and 10.5gallon capacity working on a 4 hours cycle; 10 lbs/gallon was considered for hazardous waste, that ratio requires 857 cycles to process 45 tons of waste and 1,752 cycles to process 92 tons of waste. Labor cost considered was $21.75 per hour for a WS-8 step4 according to US Office of Personnel Management 2011 rates.

Table 12. Estimated Cost Avoidance and Benefits

	Current Case	Case A	Case B
Solvent Recovered (Tons)	0	37	73
Estimated Cost Avoidance	**$0**	**$422,857**	**$834,286**
One Time Equipment Investment	**$0**	**-$10,000**	**-$10,000**
Labor Cost	**$0**	**-$74,570**	**-$152,457**
DRMO Cost*	**-$98,589**	**-$79,139**	**-$59,708**
First Year Benefits:	**-$98,589**	**$259,148**	**$612,121**

(*) from table 10

Considering the fact that solvent recovered does not have 100% of the characteristics of virgin material, recovered products should be used in alternative processes other than aircraft painting such as for cleaning painting equipment. Empirical information from the Argentine Air Force depot level painting processes shows that at least 30% of the solvent used in painting activities is used on cleaning equipment.

Other potential uses for recovered material are sharing surplus with other maintenance units, or release to DRMO to be offered as recycled material with higher value than hazardous waste.

As presented on chapter 2, the return of investment of one solvent recycler just considering diverting this kind of hazardous waste from contractors will be reached in less than three months. Additional benefits from selling or sharing surplus; less hazardous waste to contractors or landfill should be considered.

The Eco-Flow™ application permits developing models of production processes and allows managers to quickly identify costs or volumes involved on each stage in order to make accurate decision making.

As an example, on the model comparison developed, there is a reduction of approximately 45% on the environmental impact referred to Carbon Dioxide emitted by transporting hazardous waste to contractors.

Summary

In this chapter after analyzing waste stream and hazardous waste generated; two potential improvement opportunities were presented.

First, by developing on site recycling facilities to take advantage of by product properties from waste generated in common maintenance processes, recycled materials can be used in other production processes.

Second, modification of the current hazardous waste stream by considering not only potential properties of hazardous waste but also including the BPS concept and maintaining the normal procedure of managing hazardous waste via DRMO only as a last option when hazardous wastes have no any potential by product property.

The next chapter will present conclusions about the present research and some managerial implications.

V. Conclusions

This chapter presents a research summary, managerial implications, limitations and areas of interest for future researches.

On previous chapters, the relevance of taking advantage from new technologies and management concepts were presented. Without the necessity of complex solutions it is possible to improve organizations performance. Since environmental protection takes more relevance at every organizational level, it is important to be flexible enough to promote changes that allow organizations be more effective.

Research summary

During this research hazardous waste streams were analyzed and classified by type and volumes and costs. Residuals with potential by product properties were found and several examples of simple recyclers like solvent recyclers and associated benefits were presented.

Benefits from programs like BPS increase economic, environmental and social concerns are becoming more important due to the impact of the synergy when organizations joint efforts to a common goal.

Considering information from literature review and data analysis, Chapter 4 includes two proposals that can help managers to improve performance by taking advantage of hazardous waste generated rather than simply disposal via DRMO.

Encouraging and implementing BPS programs

Benefits from implementing BPS programs are clearly presented however, this kind of program demands commitment and cooperation between members. Unfortunately they cannot guarantee that all members will find users for their by products, but in an environment where technological advances occur quickly, new ways of processing by products may appear. Once developed; the network may provide enough flexibility to members not only to take advantage from by products they produce but also may promote development of new technologies based on products other members need.

Obtaining benefits like energy and cost savings, minimizing hazardous waste directed to landfill or reducing greenhouse gas emissions by implementing a BPS network will require several steps. Based on information from BPS Northwest Project (BPS NW, 2010); the program should include at least the steps listed on next figure:

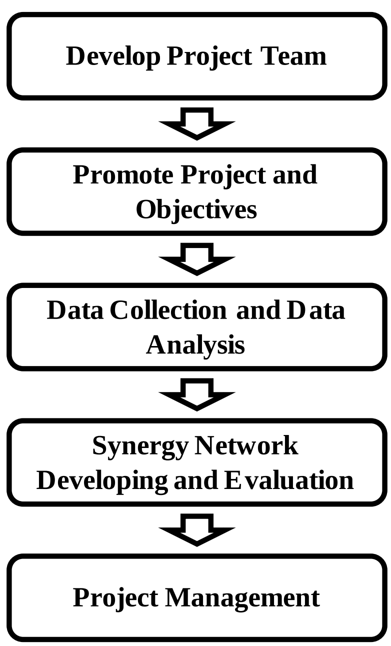

Figure 26. Basic Steps to develop a BPS network (BPS NW, 2010)

Managerial implications

As it was mentioned in previous chapters it has become standard practice to take advantage from recycling solid waste like paper, aluminum cans, etc., but in some cases it is possible to take advantage from recycling hazardous waste or considering that kind of waste in programs like BPS. If hazardous waste is just directed and disposed via DRMO, it generates only cost and zero revenue.

This research presents options to be considered in order to take advantage from hazardous waste generated during aircraft maintenance processes.

Due to the nature of the material involved, changes in current waste flow should be implemented. Currently, the AF is losing potential benefits of by products. Simple solutions like acquiring new affordable technologies or forming alliance with those who can affordably develop necessary technologies that can involve short time for ROI should be considered.

During the data analysis phase of this research, one of the relevant points to be considered was that even when regulations promote certain activities, like recycling or reclaiming, these kinds of activities are usually performed only on solid. There is no evidence of similar standardization levels to take advantages from hazardous waste recycling or reclaiming like Charleston AFB solvent recycling case. Standardizing the use of recycling processes on all units with similar maintenance processes should have a remarkable impact on economic and environmental concerns.

It could be possible that BPS projects were no present at AF Depot Maintenance units locations and that’s a good opportunity to take advantage of the situation and turn into a corner stone to develop that kind of project in the area or region, bigger the network higher the opportunity to found potential users for residuals with by product properties and more benefits from synergistic effects on economical, environmental and also social point of view.

This research provides managers with an idea that can allow them to generate savings from certain hazardous waste that usually is disposed through contractors via DRMO.

Evolving from the current hazardous waste flow to a fully integrated by product network is showed on next figure.

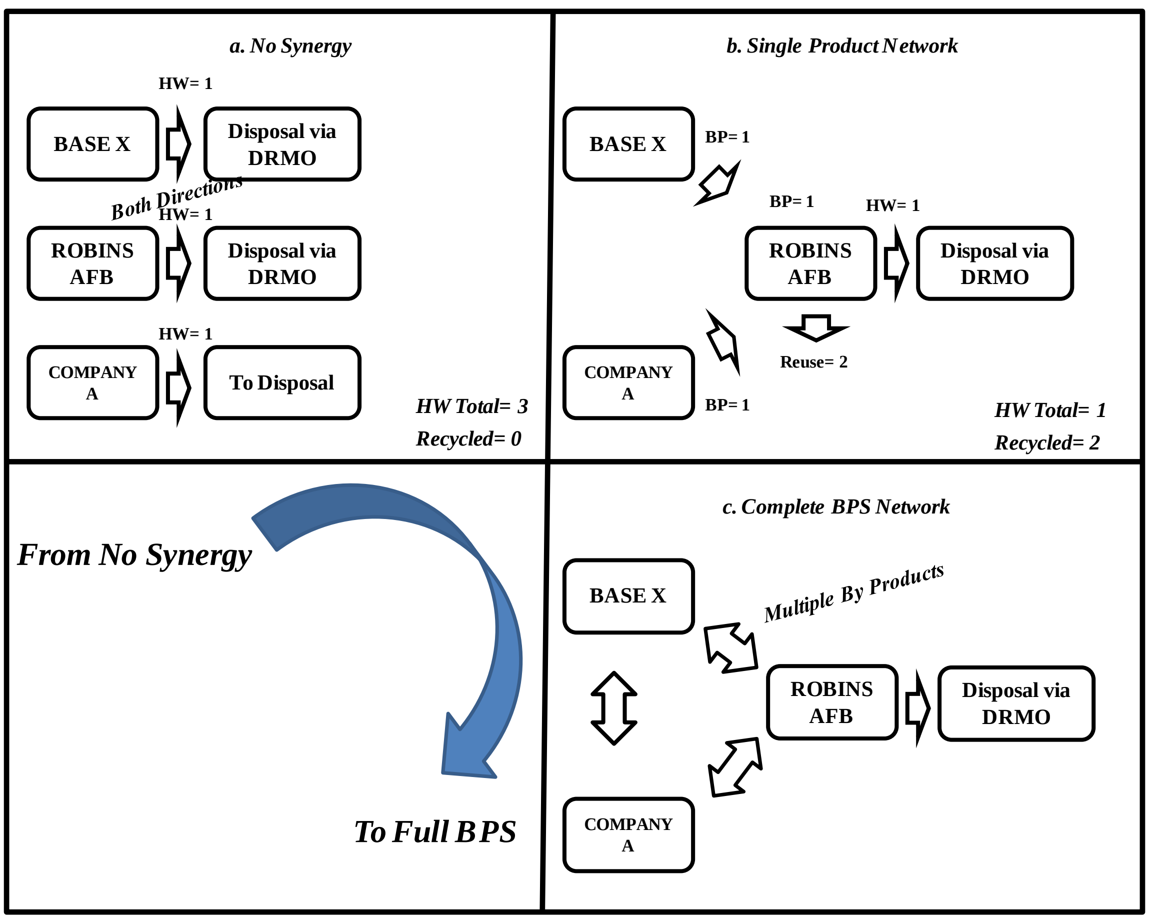

Figure 27. Evolution to a Complete BPS network

Figure 27a. presents current hazardous waste flow – zero reuse or recycling, hazardous waste no synergies are considered, hazardous waste is just disposed.

Figure 27b. single recycling processes are used and some waste need to be disposed

Figure 27c. represents a complete synergy network where members share by products, advantages are increased by the synergies and waste minimized utilizing DRMO services as a last option.

Recommendations

In order to support future decision making some recommendations can be extracted from this research:

1. Upgrading current environmental policies including new waste management approaches like by product synergy utilizing advantages of the use of material with potential BP properties.
2. Standardization of recycling processes at maintenance bases should be promoted to increase synergistic effects.
3. Develop on site recycling facilities should be considered as a way to reduce environmental impact, cost saving and generate profit.
4. Promote the use of tools like Eco-Flow™ to support decision making by modeling processes and evaluating cost optimization, profit optimization, and eco impact.

5. Promote BPS network in the area of influence to take advantage from potential synergies related to waste management.

Limitations

The main limitation to implement changes to the current hazardous waste stream will be presented when BPS programs were no present in the area. In which case main benefits will come from just implementing on site recycling and still the same process to dispose hazardous waste via DRMO. But the possibility that Air Forces units begin as promoters of this kind of programs in their area of influence can be even more important.

In this research the example of solvent recyclers was presented but there are other hazardous waste that can be recycled or reclaimed by similar processes like engine oil, even in the case that recycled products cannot be used again in aircraft maintenance it is possible reuse it on other processes like fuel blending.

Areas for future research

Recycling technologies evolve quickly; periodical analysis of hazardous waste properties needs to be performed in order to identify new by products and separate them from simple hazardous waste without any further use than disposal.

BPS networks or programs allows throughout sharing information to identify potential and profitable uses of by products.

Conclusion

Changing from traditional concepts like Cradle to Grave to new ones like Cradle to Cradle or By Product Synergy that are a step ahead from just disposal or just recycling is a challenge to every organization. Cultural and organizational barriers need to be solved but just need time and political decisions. As managers we should be able to identify potential and real opportunities of improvement, and consider that sometimes economical benefits are not enough, and that other like environmental or social benefits can be even more important and should be part of the decision making process.

Even in areas where a BPS program doesn't exist, AF units can be the corner stone or promoters of this kind of programs; this will be a good way to show the organizational commitment not only with the environmental protection but society.

Eco-Flow™ is a very useful tool to simulate production processes and estimate their effects not only from cost associated but also from the environmental impact perspective.

Current AF policies based on Cradle to Grave concept should evolve to new concepts like Cradle to Cradle. By Product Synergy programs or networks and tools like Eco-Flow™ will facilitate managers to identify improvement opportunities with economical, environmental and also social benefits.

Appendix A: List of Acronyms

AFPD: Air Force Policy Directive
BCSD-GM: The Business Council for Sustainable Development – Gulf of Mexico
BPS: By Product Synergy
CLIN: Contract Line Item Number
DFE: Design for Environment
DoD: Department of Defense
DLA: Defense Logistics Agency
DPPEA: Division of Pollution Prevention and Environmental Assistance - North Carolina Department of Environment and Natural Resources
DRMO: Defense Reutilization and Marketing Office
DRMS: Defense Reutilization and Marketing Service
EPA: Environmental Protection Agency
EMS: Environmental Management System
HW: Hazardous Waste
IISD: International Institute for Sustainable Development
ISO: International Standard Organization
RCRA: Resource Conservation and Recovery Act
SW: Solid Waste
UN: United Nations
US: United States
USAF: United States Air Force
US BCSD: United States Council for Sustainable Development
WBCSD: World Business Council for Sustainable Development
WR-ALC: Warner Robins Air Logistics Center
3Rs: Reduce, Reuse and Recycle

Appendix B: EPA Management Method Code Group

Management method codes describe the type of hazardous waste management system used to treat, recover, or dispose a hazardous waste.

Reclamation and Recovery	
Code	Management Method Code Description
H010	Metals recovery including retorting, smelting, chemical, etc.
H020	Solvents recovery (distillation, extraction, etc)
H039	Other recovery or reclamation for reuse including acid regeneration, organics recovery, etc. (specify in comments)
H050	Energy recovery at this site - used as fuel (includes on-site fuel blending before energy recovery; report only this code)
H061	Fuel blending prior to energy recovery at another site (waste generated either on-site or received from off-site)

Destruction or Treatment Prior to Disposal at Another Site	
Code	Management Method Code Description
H040	Incineration - thermal destruction other than use as a fuel (includes any preparation prior to burning)
H071	Chemical reduction with or without precipitation (includes any preparation or final processes for consolidation of residuals)
H073	Cyanide destruction with or without precipitation (includes any preparation or final processes for consolidation of residuals)
H075	Chemical oxidation (includes any preparation or final processes for consolidation of residuals)
H076	Wet air oxidation (includes any preparation or final processes for consolidation of residuals)
H077	Other chemical precipitation with or without pre-treatment (includes processes for consolidation of residuals)
H081	Biological treatment with or without precipitation (includes any preparation or final processes for consolidation of residuals)
H082	Adsorption (as the major component of treatment)
H083	Air or steam stripping (as the major component of treatment)
H101	Sludge treatment and/or dewatering (as the major component of treatment; not H071-H075, H077, or H082)
H103	Absorption (as the major component of treatment)
H111	Stabilization or chemical fixation prior to disposal at another site (as the major component of treatment; not H071-H075, H077, or H082)
H112	Macro-encapsulation prior to disposal at another site (as the major component of treatment; not reportable as H071-H075, H077, or H082)
H121	Neutralization only (no other treatment)
H122	Evaporation (as the major component of treatment; not reportable as H071-H083)

H123	Settling or clarification (as the major component of treatment; not reportable as H071-H083)
H124	Phase separation (as the major component of treatment; not reportable as H071-H083)
H129	Other treatment (specify in comments; not reportable as H071-H124)

Disposal	
Code	Management Method Code Description
H131	Land treatment or application (to include any prior treatment and/or stabilization)
H132	Landfill or surface impoundment that will be closed as landfill (to include prior treatment and/or stabilization)
H134	Deep well or underground injection (with or without treatment; this waste was counted as hazardous waste)
H135	Discharge to sewer/POTW or NPDES (with prior storage - with or without treatment)

Transfer Off-site	
Code	Management Method Code Description
H141	The site receiving this waste stored/bulked and transferred the waste with no treatment or recovery (H010-H129), fuel blending (H061), or disposal (H131-H135) at that receiving site.

2009 Hazardous Waste Report Instructions and Form EPA Form 8700-13 A/B, pages 68/69, available at http://www.epa.gov/wastes/inforesources/data/br09/br2009rpt.pdf

Appendix C: Blue Dart

First Name: _Francisco ________________ Last Name: _Leguiza_________________

Rank (Military, AD, etc.): _Lt. Col.___Designator #_AFIT/LSCM/ENS/11-08_

Student Involved in Research for Blue Dart:_Lt. Col. Francisco E. Leguiza___________

____

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School/Organization: _AFIT____

Status: [X] Student [ ] Faculty [ ] Staff [ ] Other

Optimal Media Outlet (optional): ____

Optimal Time of Publication (optional): ______________________________________

General Category / Classification: [ ] core values [ ] command [ ] strategy

[ ] war on terror [ ] culture & language [ ] leadership & ethics

[ ] warfighting [ ] international security [ ] doctrine

[X] other (specify): _By Product Synergy Analysis________________

Suggested Headline: Assessing hazardous waste management considering other methods than recycling like By Product Synergy

Keywords: _ By Product Synergy, Cradle to Cradle, Hazardous Waste Management.

Blue Dart: "By Product Synergy Analysis"

Almost every human activity and particularly those related to equipment or maintenance generate some kind of waste or residuals.

In the particular case of military services like the Air Force maintenance personnel at unit or depot level should perform a myriad of repair and overhaul activities in order to reach the desired level of combat ready capability on aircraft and other special equipment.

Due to the nature of material involved on those activities which in some cases require the use of hazardous material, generation of hazardous waste is inevitable, instead of the efforts to improve maintenance procedures hazardous waste generation remains.

During the last decades, pressures from different sides – government, society, and even organizational levels – pushed managers to develop and improve production over the environment.

Regulations related to environmental protection were developed; the Environmental Protection Agency is in charge environmental standards and regulations.

The Air Force is not except from regulations and through different directives and instructions shows an increased commitment to maximize the use of resources and minimize waste, and particularly hazardous waste generation through the aircraft and special equipment maintenance processes. The goal is to develop environmental quality programs based on cleanup, compliance, conservation and pollution prevention activities under the concept of cradle to grave.

Environmental protection activities are very dynamic not only due to new technologies that allows to recycle waste in a more efficient way but also new managerial concepts to improve waste management; actually the old concept of managing material from cradle-to-grave, now has evolved into cradle-to-cradle. This concept goes beyond the disposal of waste and can be even more cost-effective than recycling.

The main idea is to understand that there are some waste with potential by product properties which mean that can be used as food or raw material in another processes generating not only economical benefits to the producer but also environmental and social improvements.

By Product Synergy is a concept that tries to take advantage from that kind of waste or by product by finding potential users of residuals through developing a network in which members basically share information about by products they produce or demand.

Some of the benefits include cost efficiency improving and reduces the overall environmental impact (not limited to landfill space, water consumption and carbon footprint)

This research analyze, identify and classify waste generated by volume, hazard, and costs at depot level based on pilot information from Robins AFB, finding hazardous waste with potential by product properties.

On the current hazardous waste flow, hazardous waste is directed to DRMO to be released to contractors for post processing and final disposal, after the classification it was determined that some of the waste present potential by product properties such as fuel blending or metal recovery.

According to the information collected, there are not on site recycling facilities that allow depots to recover some material like solvents from hazardous waste from painting activities, or other more complexes like metal recovery.

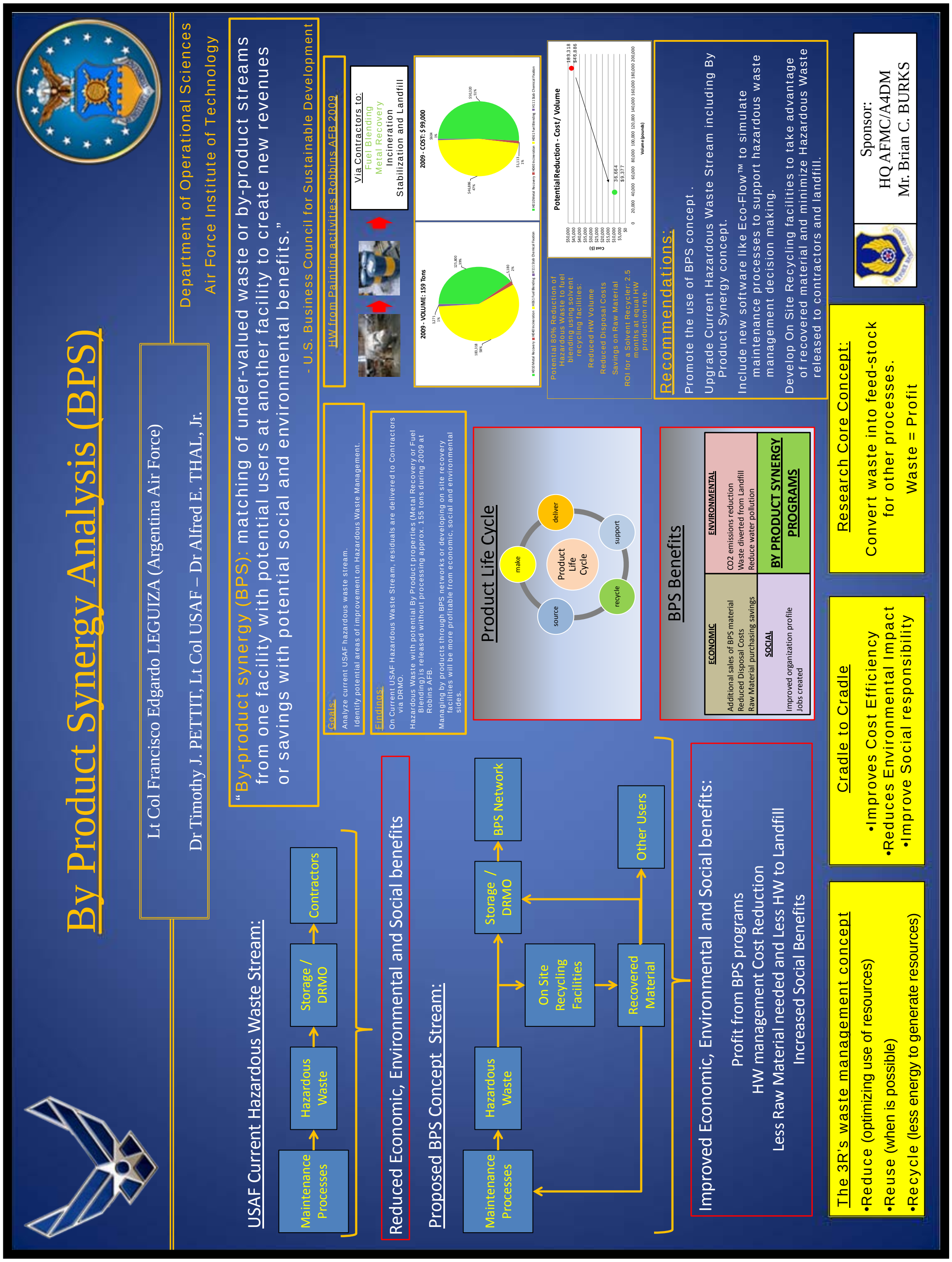
The research it is not directed to a specific recycling facility development, it is directed to present that opportunities of improvement exists that can be beneficial to depot units by developing some recycling on site capabilities, and considering the benefits of implementing by product synergy concept.

The current hazardous waste flow should be upgraded to include not only on site recycling facilities but also looking for include the organization as part of a by product synergy network.

Developing on site recycling capabilities is just part of the possible solution, the main benefits from economic, environmental and social point of view will be reached taking advantage from the synergies that by product synergy provide.

It could be even more important that the Air Force Materiel Command units when is possible be the corner stone to promote in the by product synergy concept not only as a way to promote the organizational commitment with the environment and society but also taking advantage from the potential economic benefits of hazardous waste management cost reduction and raw material acquisition.

Appendix D: Quad Chart



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Vita

Lt. Col. Francisco Leguiza graduated from Teniente Benjamin Matienzo Technical High School in Presidencia Roque Saenz Peña, Chaco, República Argentina. He entered the Escuela de Aviacion Militar, the Argentine Air Force Academy in 1987, where he graduated as an Air Force Officer. He earned a degree as Aeronautical Military Engineer and Electronic Engineer in 1993.

His first assignment was the 6th Air Brigade “Tandil” (1993-1997) where he performed different functions as Marcel Dassault MIRAGE Aircraft Maintenance Officer. Then he was assigned to 7Th Air Brigade “Mariano Moreno” (1997-2002) as Maintenance and Quality Control Officer and as Maintenance and Inspection Squadron Commander of Bell B-212, UH-1H Huey, MDHC Hughes and Boeing Vertol CH-47 Chinook. During 2002 and 2004 was assigned to the Area Material Quilmes, one of the Argentine Air Force Logistic Centers where he performed activities as Engineering Department Chief.

He entered Escuela Superior de Guerra Aérea, the Argentine Air War and Staff College in 2005 where he received the Staff Officer Qualification and was assigned to Argentine Air Force Materiel Command HQ as Staff Officer where he work until be assigned to the United States Air Force Institute of Technology

He also performed several overseas deployments as Aircraft Maintenance Officer of Argentinean helicopters squadrons working for United Nations in Cyprus and Haiti.

Upon AFIT graduation, he will be assigned to the Argentine Air Force Materiel Command HQ.

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13. SUPPLEMENTARY NOTES			

14. ABSTRACT

The United States Air Forces generates various waste during the repair and overhaul activities. These wastes can involve hazardous material. Depending on the material, technologies exist or could be readily developed to convert wastes into feed-stock for other processes The old concept of managing material from cradle-to-grave now has evolved into cradle-to-cradle. This concept goes beyond the disposal of waste and can be even more cost-effective than recycling. The objective is to generate "food" by identifying and developing other processes to use current wastes in its own production processes. By shifting from waste disposal to an endless reusing model improves cost efficiency and reduces the overall environmental impact (not limited to landfill space, water consumption and carbon footprint). This research will develop a methodology to employ state-of-the-art commercial practices to analyze depot waste production processes. The goal is to identify and classify waste generated by volume, hazard, and costs, then analyze the environmental flow by comparing government and commercial users of by-products in a synergy model. Optimal solutions for current product flow will be identified, along with potential areas for investment in by-product technologies. Solutions are mutually beneficial for both parties not only economically but also from social and environmental concerns.

15. SUBJECT TERMS

By Product Synergy, Hazardous Waste Management

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