Barriers to and Enablers for Effective Pollution Prevention Practices in the Air Force

by

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B.S., Biology
Massachusetts Institute of Technology, 1993

Submitted to the Technology and Policy Program and the
Department of Urban Studies and Planning
in Partial Fulfillment of the Requirements for the Degrees of

MASTER OF SCIENCE IN TECHNOLOGY AND POLICY

and

MASTER IN CITY PLANNING

at the

Massachusetts Institute of Technology
February 1997

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Abstract

The Air Force defines pollution prevention (P2) as "those activities relating to the reduction or elimination of pollutants from all phases of the life cycle of weapons systems along with their subsystem and support systems. It is an integral part of the systems engineering approach which evaluates options, considering cost, performance, schedule, and environmental impact" (AFMC 2/24/95). Cost, performance, and schedule are the traditional metrics by which the Air Force measures its success. Environmental impact is a new variable in the Air Force success equation - and it is yet to be seen what form this new variable will take, and what weight it will be given.

Currently, despite the evidence showing that P2 initiatives can offer many win-win solutions[i], numerous promising P2 initiatives are not being successfully implemented. The reason for the lack of implementation is that, currently, there are many internal and external barriers that are hindering the Air Force from fully incorporating environmental impact into its decision-making equation.

The goal of this thesis and project, the Green Aircraft Research Project (GARP), is to bring the Air Force closer to fully incorporating practices to reduce and avoid environmental impact by:
- illuminating the sources of the internal and external barriers
- giving examples of practices that are being used to overcome these barriers
- recommending further enabling practices to help overcome these barriers.

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[i] By win-win, I mean a win environmentally due to a decrease in total emissions, and a win financially due to real monetary savings, a reduction in time spent on environmental issues, and a reduction in environmental risk.

Acknowledgments

I would like to thank my fellow research partner Vinayak Shanbhag. We traveled together all over the country doing site visits, interviews, and collecting information for the GARP project. Your insights, humor, and good spirits were greatly appreciated. I could not have asked for a better research partner.

I would also like to thank a previous researcher on the GARP project, Pamela Campos. Pam's hard work during the summer of 1995 laid the foundation for the GARP project and pointed us towards the important areas to focus on during our site visits.

Professor John Ehrenfeld's encouragement, support, and guidance in keeping me focused on the "bigger picture" was an important factor in completing this thesis. Thank you for the time you spent in giving feedback to my many rough drafts.

I would also like to thank Professor Vicki Norberg-Bohm for taking the time to read my rough drafts and offer feedback.

During all the site visits and interviews that we conducted, we encountered many friendly, accommodating and very helpful people. Without their cooperation and candid responses to our questions, this thesis would not have been possible. I would like to take this opportunity to thank them below.

Wright-Patterson Air Force Base

I would like to thank all the Air Force personnel who we met with who were associated with the C-17, C-130, F-22, and F-16 weapon systems, the ASC Environmental Management directorate, and the Joint Depot Environmental Panel.

Robins Air Force Base

I would like to thank all the Air Force personnel who we met with who were members of the Warner Robins Air Logistics Center (ALC). Special thanks goes out to Ms. Ellen Griffith, Chief of P2 and Hazardous Waste at the ALC, for hosting our trip, taking a lot of time to talk with us, and setting up many relevant interviews.

Hill Air Force Base

I would like to thank all the Air Force personnel who we met with who were members of the Ogden ALC. Mr. Craig Pessetto's efforts in hosting our stay, talking with us, and lining up a series of relevant interviews was greatly appreciated. Craig Pessetto is a member of the P2 division of the Environmental Management directorate at Ogden ALC.

Hanscom Air Force Base

I would like to thank all the members of the Acquisition Pollution Prevention Working Group (APPWG). We met with them three times over the course of three months, and had lengthy and insightful brainstorming sessions which helped to crystallize some of the points in this thesis. Captain Gerald Gendron deserves a big thank you for initiating contact between our groups (GARP and the APPWG), and facilitating very useful meetings. Without his energy during the initial stages of our contact, our meetings may never have happened. I would also like to thank Mr. Richard LaMontagne as he was instrumental in facilitating the meetings and maintaining contact between our groups. Finally, I would like to thank Major Robert Lang, Program Manager of the APPWG, for keeping such an open-mind and allowing our groups to meet.

Lockheed Martin

I would like to thank all the members of the Marietta, Georgia facility who took the time to meet with us and answer our questions. A special thanks goes out to Ms. Rochelle Routman, Environmental Coordinator, Safety and Environmental division. Thank you for hosting our visit, talking extensively with us, and scheduling many relevant interviews.

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List of Acronyms

ABC	Activity Based Costing
ACC	Air Combat Command
AEPC	Acquisition Environmental Protection Committee
AETC	Air Education and Training Command
AF	Air Force
AFB	Air Force Base
AFIT	Air Force Institute of Technology
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AFSPC	Air Force Space Command
Al	Aluminum
ALC	Air Logistic Center or Depot
AMC	Air Mobility Command
AMRC	Aerospace Maintenance and Regeneration Center
APP	Acquisition Pollution Prevention
APPWG	Acquisition Pollution Prevention Working Group
ASC	Aeronautical Systems Center
AQ	Acquisition
BOSS	Bicarbonate of Soda Stripper
BRAC	Base Realignment and Closure
Cd	Cadmium
CE	Civil Engineering
CEO	Chief Executive Officer
Dem/Val	Demonstration/Validation
DESCIM	Defense Environmental Security Corporation Information Management
DID	Data Item Description
DM-HMMS	Depot Maintenance - Hazardous Material Management System
DOD	Department of Defense
DPG	Defense Planning Guide
DRMO	Defense Reutilization and Marketing Office
EIPT	Environmental Integrated Product Team
EM	Environmental Management
EM&D	Engineering, Manufacturing, and Development
EMC	Environmental Management - Compliance
EME	Environmental Management - Compliance
EMP	Environmental Management - Pollution Prevention
EMV	Environmental Management - Pollution Prevention
EPA	Environmental Protection Agency
ESC	Electronic Systems Center
ESOH	Environment Safety and Occupational Health

EWG	Environmental Working Group
FYDP	Future Year Defense Plan
GARP	Green Aircraft Research Project
Hazmat	Hazardous Material
HMMP	Hazardous Material Management Plan
HMRB	Hazardous Material Review Board
HSC	Human Systems Center
HSMS	Hazardous Substance Management System
IMVP	International Motor Vehicles Program
IPT	Integrated Product Team
JDEP	Joint Depot Environmental Panel
JGAPP	Joint Group on Acquisition Pollution Prevention
J-LSC	Joint Logistics System Command
LA	Aircraft
LAI	Lean Aircraft Initiative
LCC	Life Cycle Cost
LCCE	Life Cycle Cost Estimator
LEM	Lean Enterprise Model
LI	Landing Gear
LM	Lockheed Martin
LSA	Logistics Support Analysis
MAJCOM	Major Command
MDA	McDonnell Douglas
MHAR	Material Hazard Analysis Record
Milspec	Military Specification
Milstd	Military Standard
MIT	Massachusetts Institute of Technology
NDCEE	National Defense Center for Environmental Excellence
NPV	Net Present Value
O&S	Operations and Support
ODC	Ozone Depleting Chemical
OS&H	Occupational Safety and Health
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
P2	Pollution Prevention
PAA	Primary Aircraft Authorized
PACAF	Pacific Air Forces
PEA	Programmatic Environmental Assessment
POC	Point of Contact
POM	Program Objective Memorandum
PPBS	Planning, Programming, and Budgeting System
PSO	Product Support Office
R&D	Research and Development
RD&A	Research, Development and Acquisition

RIF	Reduction in Force
RFP	Request for Proposal
SAF	Secretary of the Air Force
SAE	Society of Automotive Engineers
SAMP	Single Acquisition Master Plan
SECDEF	Secretary of Defense
SM	Single Manager
SMSC	Space and Missile Systems Center
SOO	Statement of Objectives
SOW	Statement of Work
SPO	System Program Office
TAI	Total Active Inventory
TBE	Technology, Business, and Environment
TI	Technology and Industry
TIS-X	Technology Information System Expanded
TO	Technical Order
TOA	Total Obligational Authority
TPIPT	Technical Planning IPT
USAF	United States Air Force
USAFE	United States Air Forces in Europe
WPAFB	Wright-Patterson Air Force Base
WSHMAR	Weapon System Hazardous Material Analysis Record
WWW	World Wide Web

Foreword

In this thesis I have attempted to display the research in a manner such that two different sets of readers, Air Force personnel and the lay reader, can enjoy, and easily glean the relevant ideas presented.

The first chapter gives an overall understanding of the context of this study. The second chapter is the heart of the thesis as it presents all the results and recommendations, as well as a section pulling out the critical barriers to pollution prevention in the Air Force. The third and final chapter draws out the key enabling practices that can be undertaken to overcome some of the barriers, as well as offering some thoughts for relevant further research.

Both sets of readers should go through the first chapter. I recommend that the lay reader, before going on to the second chapter, read "Appendix A: Organizations involved in the Operations & Support Stage" in order to gain an understanding of the functions of the different Air Force organizations that will be frequently mentioned in Chapter 2.

Chapter I: Background

The Air Force, Army, Navy, and Marine Corps currently spend about $5 billion a year on a variety of environmental programs. The range of programs fall under four categories: compliance, remediation and restoration (or clean-up), conservation, and pollution prevention (P2). Of the Department of Defense's yearly multi-billion dollar environmental budget, the lion's share (approximately $4 billion) is claimed by compliance and clean-up. However, in the last two years there has been a growing momentum to increase pollution prevention spending and programs.

Why is the pollution prevention agenda getting greater exposure? This can be seen by looking at the current situation that the Department of Defense (DOD) is facing with respect to environmental spending. A recent DOD estimate places the tab at more than $30 billion to eliminate the decades of fouling ground, air, and water resources. The estimates from the private sector for DOD's clean-up expenditures are much higher - they believe that the true costs lie in the hundreds of billions of dollars (Williams(a) 1995). The reason for P2's growing appeal is because it is seen as the primary means to ultimately trim the military's bill to the nation. Pollution prevention simply defined is an attempt to prevent pollution before it occurs or reduce pollution at its source. This is in contrast to the standard "end-of-pipe" approach which attempts to clean-up the problem after it has occurred. Under a successful P2 program there is less waste generated and therefore the cost of cleaning-up this waste and complying with the appropriate regulations is significantly reduced. In addition, this sort of preventive approach espoused by the pollution prevention paradigm has the following advantages compared to the traditional reactive approach that is adopted by most organizations (Karmali, 1990):

- Reducing organization's compliance costs including nonproductive pollution control equipment.
- Reducing the regulated organization's liabilities associated with transportation, storage, and disposal of hazardous wastes.
- Reducing accidental exposure to toxics from spills and accidents.

- Reducing consumer exposure to products containing toxics
- Improving health benefits to workers through reduced exposure to toxic chemicals.
- Improving industry's public relations and public image.
- Providing moral benefits by preventing the re-distribution of environmental risks between communities, nations, and/or generations.
- Promoting technological innovation.
- Enhancing industrial efficiency and therefore national and international competitiveness.
- Reducing government's regulatory costs of addressing problems arising from already generated pollution.

The proponents of P2 in the DOD believe that "pollution prevention holds out the promise of revolutionizing the Pentagon's far-flung and complex acquisition process and of directly contributing to healthier work places for military personnel and a cleaner environment for neighboring civilian communities in the U.S. and around the world" (Williams(a) 1995).

The Air Force defines pollution prevention as "those activities relating to the reduction or elimination of pollutants from all phases of the life cycle of weapons systems along with their subsystem and support systems. It is an integral part of the systems engineering approach which evaluates options, considering cost, performance, schedule, and environmental impact" (AFMC 2/24/95). Cost, performance, and schedule are the traditional metrics by which the Air Force measures its success. Environmental impact is a new variable in the Air Force success equation - and it is yet to be seen what form this new variable will take, and what weight it will be given.

The Air Force has embraced the concept of pollution prevention. At the fourth annual Air Force Worldwide P2 Conference, leading Air Force officers were in agreement that the P2 strategy will help achieve three goals concurrently (Williams(a) 1995):

- avoid contamination of people, ground, air, and water resources
- save shrinking budget dollars
- increase military readiness.

However, despite the agreement that P2 initiatives can offer many win-win solutions[i], numerous promising P2 initiatives are not being successfully implemented.

The reason for the lack of implementation is that, currently, there are many internal and external barriers that are hindering the Air Force from fully incorporating environmental impact into its decision-making equation. The goal of this thesis and project, the Green Aircraft Research Project (GARP), is to bring the Air Force closer to fully incorporating practices to reduce and avoid environmental impact by:

- illuminating the sources of the internal and external barriers
- giving examples of practices that are being used to overcome these barriers
- recommending further enabling practices to help overcome these barriers.

1.1 Origins of the Green Aircraft Research Project

The Air Force, in conjunction with the U.S. Environmental Protection Agency has funded this project at MIT's Technology, Business, and Environment Program (TBE). GARP is linked to the Lean Aircraft Initiative (LAI) which was born out of the International Motor Vehicles Program (IMVP). Hence, In order to explain how GARP began, a brief description of the LAI and IMVP must be given. The IMVP, from 1986-1990, conducted an extensive benchmarking study of the worldwide automobile industry. Their results, published in 1990 in the book "The Machine that Changed the World," spread the message of the lean enterprise across the manufacturing field. The lean concept, is largely based on the Toyota Production System. The Toyota Production System's goal is to increase production efficiency by eliminating or reducing *muda* or waste.

This book created great interest within the U.S. Air Force. The thought was: if the automobile industry can carry out lean production, why can't the aircraft industry? The lean concept was seen as a potential means for the Air Force to achieve greater efficiency with respect to its three

[i] By win-win, I mean a win environmentally due to a decrease in total emissions, and a win financially due to real monetary savings, a reduction in time spent on environmental issues, and a reduction in environmental risk.

most important metrics - cost, performance, and schedule. Especially in a time of decreasing defense budgets, the Air Force felt it was imperative that they become a "lean enterprise." Hence, in 1992, the Aeronautical Systems Center (ASC) at Wright-Patterson Air Force Base (WPAFB) approached MIT about beginning a study of the defense aircraft industry similar to the IMVP's study of the automobile industry. Thus, the Lean Aircraft Initiative was born.

The LAI's two meta-principles from which all of its research flows are: responsiveness to change, and waste minimization. However, their definition of waste minimization does not include environmental waste. Hence, pollution prevention issues and their tie to cost, performance, and schedule efficiencies, were not covered by the scope of the LAI's research. Essentially, environmental impact was being left out of the equation. The exclusion of environmental and eco-efficiency type issues from the LAI study led to a conversation between Dr. John Ehrenfeld, Director of the TBE program at MIT, and a senior Air Force official at the Human Systems Center (HSC) at Brooks AFB. HSC took interest in funding a separate project, that would supplement the LAI by examining pollution prevention issues over the life-cycle of military aircraft, and tie the results into the Lean Enterprise Model (LEM)[ii] developed by the LAI. Thus, GARP was born.

1.2 Purpose of GARP and Thesis

The research focus of this thesis is on organizational, not technical issues. This emphasis arose after preliminary observations indicated that although there were many apparently technically appropriate pollution prevention opportunities for the Air Force, relatively few examples of successfully implemented pollution prevention initiatives were observed. This thesis is designed to delve into the gap between what appears to be significant opportunities for P2 to take place versus what is actually being done.

[ii] The LEM is LAI's framework for organizing and presenting its results and recommendations.

One set of issues defining this problem is technical in nature - what new technologies, materials, processes, etc. can be used to minimize or eliminate pollution in the current product, military aircraft? The technical issues are being tackled by several Air Force and DOD projects, as well as the private sector, and so the GARP team did not feel that we would add much value to the understanding of these issues.

Another set of issues that define this problem is organizational in nature - what are the organizational linkages, information flow, culture, etc. that exist in the Air Force and how do they hinder the effective implementation of P2 initiatives. These organizational barriers to P2 have not been fully examined by others. There are also a number of financial barriers to P2 implementation that exist. It will be seen later that most of the causes of these financial barriers are organizational in nature [iii]. Hence, this thesis focuses on the organizational barriers to P2 faced by the Air Force. Furthermore, the focus has been narrowed to the Operations and Support (O&S) phase of a weapon system's[iv] life cycle, and the link between the O&S phase and the design phase. The reason for this focus is explained below.

A weapon system's life cycle consists of six distinct phases as shown in Figure 1.1 below.

Figure 1.1: Life Cycle of an Air Force Weapon System

Phase	Time Span
Concept Exploration (design phase)	0 - 2 years
Demonstration/Validation (Dem/Val)	2 - 3 years
Engineering, Manufacturing & Development (EM&D)	3 - 4 years
Production	3 - 6 years
Operations and Support (O&S)	18 - 40 years
Disposal	

Each stage of the weapon system's life cycle generates some amount of hazardous waste. However, by far the majority of the hazardous waste is produced during the Operations and

[iii] Of course more financial resources will always help to overcome financial barriers. However, in this case, the barriers are not as linked to quantity of financial resources as they are to the manner in which the existing finances have to be managed due to organizational rules (Air Force, DOD, and Congress).

[iv] The Air Force uses the terms, aircraft and weapon system, interchangeably.

Support phase - approximately 80 - 90% of the hazardous waste of the entire aircraft's life cycle (AFMC 2/24/95). This is primarily due to the large number of chemicals used during maintenance of the aircraft for procedures ranging from degreasing individual parts to de-painting the entire plane. Over the 18 to 40 years that an aircraft is in operation it must go in for a full maintenance every 2000 to 4000 flight hours. This means that each aircraft takes approximately 5 to 10 heavy-duty baths over its life time in order to keep it running at optimal condition. The chemicals used in these baths add up to produce a large amount of hazardous waste that cost a lot to be treated and disposed of carefully.

Regulations have spurred the Air Force to reduce some of their pollutants. In particular, the Air Force has been fairly successful in eliminating and finding substitutes for almost all of its uses of ozone depleting chemicals (ODCs). However, the reduction of other hazardous chemicals that are not mandated by law, has occurred only to a limited extent despite the opportunity in some cases for cost savings. Hence, there are significant opportunities for P2 initiatives within the world of Operations and Support to make a large impact in reducing the overall reliance on hazardous materials.

There are also a number of impacts during the O&S phase that can not be addressed unless changes are made to the aircraft by the contractors during the design phase. This is because the types of materials that are designed into the aircraft are a significant driver in determining what range of maintenance processes, chemicals, or technologies can be used by the Air Force maintainers. Therefore, in order to fully consider P2 opportunities in the O&S phase - there must be a consideration of the O&S phase separately, as well as its connection to the design phase. However, I would like to emphasize that the large majority of current and future environmental impacts are going to be caused by planes that are on duty and not by newly designed planes. This is because the current total active inventory of planes is in the order of magnitude of 10,000, and the number of new planes that are planned to be made for the Air Force over the next two decades is in the order of a few hundred. Hence, the impact of environmentally conscious design of a few hundred new planes pales in comparison to the possible impact of pollution prevention initiatives that diminish the environmental impact of the thousands of active planes. The point is

not to ignore or discredit environmentally conscious design of new planes as sometime in the future when these are the only planes flying it will make a significant difference. The point, however, is to be aware that in the foreseeable future the large majority of environmental impact is going to continue coming from active planes - this is why the focus of this thesis, P2 implementation during O&S of active planes, can make a significant contribution to environmental protection.

1.3 Methodology

To answer the questions posed, the GARP research team conducted over forty interviews of Air Force personnel during a series of site visits of Air Force Bases (see Appendix B for more details). We focused our information gathering efforts around four different military aircraft: F-16, F-22, C-17, and C-130. In this manner, we were able to develop concrete examples and stories of the pollution prevention efforts for each aircraft, and compare and contrast the efforts. Two fighter aircraft, one new and one mature, and two transport aircraft, one new and one mature, were selected for this research. Please see figure 1.2 on the following page for details of each aircraft and why it was chosen.

We interviewed P2 managers, ASC/EM staff, AFMC staff, shop workers, top managers, and other people in various directorates at the ALC's - aircraft production, commodities production, and technology and industrial support. We compared and contrasted the "stories" of each actor associated with the O&S stage who dealt with P2 issues in their work in some way. This comparison has shown mis-matches in the needs, wants, beliefs, and expectations across each type of actor as well as across the different Air Force bases that were visited. The analysis of these field interviews and associated archival information, has lent a great insight into:

- the organizational barriers to P2 in the Air Force
- what is being done, and what can be done to overcome these barriers.

Figure 1.2: Military Aircraft Studied

Aircraft	F-16	F-22	C-130	C-17
Name	Fighting Falcon		Hercules	Globemaster III
Versions	F-16A, F-16B, F-16C, F-16D, F-16ADF	F-22A, F-22B	C-130A (retired), C-130B, C-130C, C-130D, C-130E, LC-130H, C-130J (new - beginning FY 1996)	C-17A
TAI [v]	777	0	218	16
PAA [vi]	663	0	168	14
Average Age	4.6 years	0 years	22.9 years	1.2 years
Virgin Year	January 1979	1997 - first flight of development aircraft 2004 - Enters operational service	April 1955	January 1995
Contractor	Lockheed-Martin	Lockheed-Martin, with team members, Boeing and Pratt & Whitney	Lockheed Martin	McDonnell Douglas
System Program Office (SPO)	Wright-Patterson AFB Dayton, Ohio 513-255-6151	Wright-Patterson AFB[vii] Dayton, Ohio 513-255-4167	Wright-Patterson AFB Dayton, Ohio 513-255-6371	Wright-Patterson AFB Dayton, Ohio 513-255-1545
Air Logistic Center (ALC)	Ogden ALC Hill AFB, Ogden, UT 801-777-7221	*Currently slated for*: Sacramento ALC Mclellan AFB, CA 916-643-2111	Warner Robins ALC Macon, GA 912-926-1110	San Antonio ALC Kelly AFB, TX 210-925-1110
Engine	One augmented turbofan. Either General Electric F110-GE-100 or the Pratt & Whitney F100-PW-220.	Two Pratt & Whitney F-119-PW-100 turbofans.	Four Allison T56-A-15 turboprops.	Four Pratt & Whitney F117-PW-100 turbofans.
Reasons this Aircraft was Chosen for Case Study	Mature aircraft. Most prevalent aircraft in the Air Force. Some aspects of aircraft are being re-designed. So it will be interesting to see if environmental lessons learned get incorporated into the re-designed plane.	Newest fighter. In late stages of EM&D. As it is a new system growing up in an era of more stringent environmental regulations , its management system will serve as an interesting comparison to the F-16.	One of the oldest planes around, and they are planning to continue its life with a new version. Transport planes generally have much longer lives than fighters, hence, their impacts will be different.	The newest state of the art transport plane. This will serve as a good comparison to the old and mature C-130.

[v] TAI - Total Active Inventory: Aircraft assigned to operating forces for mission, training, test, or maintenance. Includes primary, backup, attrition, and reconstitution reserve aircraft.

[vi] PAA - Primary Aircraft Authorized: aircraft provided for the performance of the operational mission. The operating command determines the PAA required to meet the assigned missions.

[vii] The F-22 is unique in that one SPO is responsible for both the airframe and the powerplant.

Chapter II: Results and Recommendations

In this chapter the findings of our research are presented in table format. I have organized the findings into a framework that places each barrier to pollution prevention that we encountered into one of the following categories [i]:

1) Resource Barriers
   - Financial
   - Human
   - Technological
2) Knowledge Flow Barriers:
   - Information Flow
   - Authority Flow
3) Culture/Consciousness Barriers

Before presenting the barriers in table format, I will discuss the most important barriers in the following section. This will give the reader an overall context of the problems and an idea of which barriers should be given more attention.

2.1 Critical Barriers

Financial resources are always needed in order to carry out projects. The system can be perfectly organized to carry a project to completion, with highly trained and effective personnel managing the projects, but if the financial resources to fund the projects are not available, then none of the above matter. As mentioned in the opening paragraph of this thesis, financial resources garnered for pollution prevention projects are on an upswing. However, from our site visits and interviews, inadequate financial resources was mentioned often as a critical barrier to

[i] A discussion of the choice of the categories of barriers can be found in "Appendix C: Categories of Barriers".

implementing P2 projects. We found that the main source of this barrier is not the magnitude of funding available, rather it is due to two organizational issues:
i) the strict Congressional and DOD rules that govern the use of the funding. These inflexible rules create a context and feeling of "inadequate financial resources" when in actuality there should be enough resources to complete many more projects than are currently being completed.
ii) the current culture of the Air Force which emphasizes compliance with the law. This emphasis is a noble one, however, it makes it very difficult to justify funding for P2 projects unless not doing them would make the base non-compliant. Put more strongly, unless the "General is going to jail" if the project is not completed, it is hard to get high-level Air Force managers to approve funding for the project.

The Congressional and DOD rules part of this critical financial barrier can be labeled as a "Color of Money" problem. What is meant by this is that when funding is allocated for projects it shows up in pots of different shapes, sizes, and colors. Each pot has specific rules governing the purpose for which the funding can be used, the length of time that it is available for, and who is allowed to dip their hands into the pot (see "Appendix D: Funding Categories" for more details).

The "Color of Money" problem can be illustrated by the following situation at the Warner Robins Air Logistics Center (WR-ALC). The P2 manager at WR-ALC wanted to buy a new de-painting technology called the BOSS (Bicarbonate of Soda Stripper). The BOSS technology made use of a high powered sprayer, which sprays a mixture of baking soda and water at 15,000 psi. The BOSS cut down the use of the de-painting chemical Methylene Chloride (an EPA-17 chemical and suspected carcinogen) by approximately 95% and was able to de-paint the plane in the same amount of time. The P2 office had garnered funds to prototype this technology on base and found it to be highly successful in de-painting C-130's. The P2 office had a fairly healthy budget in 1995, of $10-$11 million and wanted to buy several BOSS machines for the C-130 de-painting facilities. However, the color of the funding that the P2 office had was not appropriate for this use. The P2 office could use its funds to research, develop, test, evaluate, and prototype a technology, but it can not use it to make the final purchase. The final purchase of equipment that will be used by production staff must come from the production units budget. This now entails

that the P2 Manager has to convince the production staff that not only is it worth it to change technologies but that they have to spend money from their budget to buy the new equipment. For Production the main mission is getting planes fixed and operational ASAP. If they had a choice between buying spare parts and environmental equipment, 9 of 10 times environmental equipment would lose out. So the problem here is not the lack of funds, as WR-ALC had a healthy P2 budget of $10-11 million. The problem is, despite the willingness of the P2 office to pay for the production equipment, the budgetary rules does not allow for it. In this case, after some lengthy debates as to the merits of the new technology, the production staff were convinced that it was an investment that would not only benefit the environment but significantly cut hazardous materials (hazmats) disposal costs and improve worker safety conditions. Hence, the BOSS is now being used at WR-ALC. However, many other projects have failed because even if P2 has proven its worth, the group that has to spend the money to buy it has other priorities, and is not able to spare the funds at that time.

The other part of this financial barrier, the culture of compliance, is one that the Air Force is actively working to change. Following the release of the *Air Force Pollution Prevention Strategy* (July 1995) by Secretary of the Air Force Sheila E. Widnall, the ASC began to organize 2-day educational forums to teach Air Force staff about the benefits of following a pollution prevention paradigm rather then one of strict compliance. These educational forums are part of the Air Force's efforts to institutionalize P2 in all phases of the weapon system's life cycle. Currently, most managers still view any environmental issues as a negative force and additional burden - something that is only going to add cost, time, labor, and paperwork to their programs. Hence, they are very reactive, and do only what is necessary when it is mandated by a law. The goal of the educational programs is to show that by being more proactive on environmental issues, one can see substantial benefits like avoiding wastewater treatment costs, hazardous waste costs, environmental fines, improving worker safety and as a result morale as well. Another manner in which the Air Force is trying to permeate all mission areas with the P2 ethic is through the use of P2 collocates. A P2 collocate is someone who has been hired by a P2 office or EM directorate, but is farmed out to a SPO or other directorate and does his/her work from there. In this manner, the P2 officer can bring P2 ideas to the SPO or directorate. This program is good in

philosophy, however, there is a lack of P2 staff for it to be truly effective. From our interviews, we gathered that the P2 managers at the SPO's are so busy with their own work every day that they have very little time to share their ideas with other staff. They need more P2 staff at each SPO.

The lack of human resources available to the P2 managers at SPO's[ii] is the reason that they often can not get a P2 project implemented even if they have the money. If the P2 money is not on contract within one-year of receipt then it is taken away. As there is only one P2 manager with no staff at each of the big weapon systems, money is not always obligated on time. If the P2 manager could use part of the P2 funds to hire a part-time staff person to help them, they probably would be able to initiate and complete many more projects. However, the rules do not allow for funds to be used to hire personnel from the P2 pot of money. It is only to be used directly to do P2 projects. For some reason this can not be translated to mean hiring a person to help to do that P2 project.

Another realm of critical barriers lie in the bad or sometimes non-existent channels of communication between the various organizations and personnel that are involved with a weapon system over its life-cycle. The results of this lack of communication is that:
i) Ideas that should be shared across organizations are not shared.
ii) Lessons learned by one group are lost to other groups and the next generation.
iii) Duplication of effort exists as one weapon system will not be aware that another weapon system has just completed the same project they are about to start.
iv) A consistent system to accomplish a P2 goal is not present.

Why is their poor information flow in the Air Force? Four reasons for this seem apparent from our site visits and interviews:
i) Lack of appropriate data - For example, P2 data that is needed by the SPO is not collected by the ALC. The ALC collects its data in aggregate across many different weapon systems that it maintains - they do not collect it by type of weapon system. Each SPO needs the pollution

[ii] The ALC's do not have this same problem as the P2 manager at the ALC has a number of staff members to rely on.

numbers on its weapon system and the processes that generate waste while maintaining its weapon system.

ii) Poor systems to collect and disseminate information - there is no one common repository of information where a P2 manager can log in the projects they are working on and the projects they have completed. If such a site existed, where a P2 manager could log in their offices projects and find out what other P2 offices are doing around the United States, then projects would not be so often duplicated, and time, effort, and money would be saved.

iii) Competitiveness between bases and the different armed forces leads to the tendency of hiding information rather than sharing it. Every base and every Force wants to be seen as the best or the first. This need to be the best has been enhanced by the Base Re-Alignment and Closure (BRAC) process and the Reduction-in-Force (RIF) process. For example, one ALC was unable to get detailed information from another ALC about a P2 technology that they had recently implemented. The reason for this is that the ALC wanted to maintain its competitive advantage over the other ALC in terms of emissions figures so that they are recognized for their good environmental performance. This could be one more factor in allowing them to remain open versus the other ALC.

iv) Unclear P2 directives and policies developed by Air Force Policy Level staff. Many of the P2 directives developed have good intentions but they do not come with the appropriate, if any, tools or enough information on how to accomplish them. For example, a life-cycle cost estimation for all projects has been mandated in the Air Force. However, no useable tool exists that the managers can use to perform a life cycle cost estimate. This has led managers to ignore many directives and policies and instead create their own goals and systems to accomplish them.

One communication channel that is basically non-existent is that between the ALC's and the Prime Contractors. There is no system to pass on lessons learned by the maintainers of a weapon system to the designers of the weapon system. If this system did exist, re-designs of that weapon system or next generation weapon systems could take these lessons in to consideration and make design and materials choices that would avoid the same issues for the maintainers in the future. The F-22 SPO, through its *Hazmat* Review Cycle, is attempting to create a system that will take into consideration the effect of material choices on the maintenance of the aircraft downstream.

This system, if successful, can hopefully be replicated by other SPO's during re-designs of their aircraft.

A critical barrier that has substantially hindered every SPO and ALC's ability to reduce hazmats, and use cleaner substitute chemicals, processes, and technologies is the Air Force's reliance on documents called Technical Orders (TO's) and Military Specifications (Milspecs). The TO's list the specific procedures, technologies, and chemicals that must be used in order to maintain a part of the aircraft. The TO's constrain the use of cleaner technologies because if the technology is not on the TO's list of acceptable technologies to use for that procedure then the cleaner technology can not be used. The Milspecs are a set of standards, which require certain levels of performance for the weapon system such as "ability to withstand a 500 hour salt bath." These standards have been established over the past 50 years of military aircraft production. Many of them were chosen originally because they met very broad "best guesses" by engineers forced to act under uncertainty. The result has been a set of standards that can often seem somewhat arbitrary. For instance, would system performance be hindered if a material could "withstand a 400 hour salt bath" instead of a 500 hour salt bath? Reducing a standard by this much might substantially increase the number of alternative materials and processes that could be considered, potentially reducing environmental impacts. The Air Force has recognized the substantial barrier that TO's and Milspecs create for implementation of P2 projects. Many SPO's and ALC's have instituted a system to identify, fund, and clean-up TO's so that the cleaner technologies are acceptable for use. Although there are problems with these systems, progress is being made.

The above discussion of critical barriers to P2 implementation was meant to serve as an introduction to the numerous issues in the tables to follow. There is a table for every problem that we have identified as hindering the implementation of P2 efforts. At the top of each table there is a general statement of the problem. Column 1 of the table describes one or more specific reasons for this general problem - these are the barriers. Column 2 explains the impact or result of these barriers. Column 3 gives examples of the barriers that we gathered from the overall case studies of the four weapon systems. Column 4 lists the practices that people associated with the Air Force have developed to try and overcome some of the barriers - some of these practices are

short-term alternatives that have been able to get around the barrier for the present but are not robust or permanent solutions, however, some of these practices are potential "best practices" that could be permanent solutions to the problem. The last column, column 5, lists the recommended enabling practices - those actions and changes that we believe would allow more people to overcome the barriers and enable them to develop exceptional P2 practices [iii].

Each entry in the table is a short bulleted summary statement. Attached to many of the summary statements is a more detailed note expanding the discussion. This format will allow the reader to look at the table and all its points, and gain an understanding of the overall issue that is being presented. Then, reading the notes attached to each point, will give the reader the important details which are necessary to gain a deeper understanding of the issue.

[iii] The recommendations, in column 5 of the tables, are not based on a particular model or theory, but rather have been developed based on our numerous conversations with Air Force managers and other staff at SPO's, ALC's, contractors, AFMC, ASC, and ESC. See Appendix B for a list of all the people we interviewed.

2.2 Resources

A. Financial

1. Problem Item: Funding Level for P2 projects- inadequate and/or unusable.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Color of Money Categories - restrictions and stipulations on the use of the funds [1]. • Culture of Compliance/ General goes to Jail [2].	• Many win-win P2 projects are not attempted. • Cultural barrier leads to the difficulty in justifying any P2 projects that are not directly related to compliance issues.	• P2 money can only be used for prototyping but not for final purchase of new production equipment [3]. • Culture: C-17 top managers feel that many top managers of other SPO's have a "we can't really tackle this problem" complex [4]. • Aircraft PSO does not have P2 pot of money - they use Engineering Change Proposal funds and Technical Order (TO) change funds for P2 projects [5]. • F-22 P2 manager states that no contingency funds have been allocated in case new EPA regulations force some change in the current F-22 program [6].	• C-17 SPO has sufficient P2 funds [7]. • Civil Engineering (CE) has started to offer some P2 funding [8]. • The F-16 has a large foreign military sales component. Some funding is put in by countries buying F-16s in order to help remove ODCs - especially from the countries that signed the Montreal Protocol [9]. • Proactive and "politically savvy" P2 manager, seeks environmental customers in order to justify funding [10]. • Tools IPT - developing funding estimation tool[11].	• Congressional Budget Reform [12]. • Incentives for top and middle-level managers that will lead them to encourage P2 efforts [13].

[1] "Color of Money" refers to the different categories of money that exist. What is meant by this is that when funding is allocated for projects it shows up in pots of different shapes, sizes, and colors. Each pot has specific rules governing the purpose for which the funding can be used, the length of time that it is available for, and who is allowed to dip their hands into the pot. See Appendix D for complete details on the different categories.

[2] The primary and sometimes only valid justification to obtain funding for an environmental project is if the funding is needed to make sure that the base remains in compliance with the law. If the base does break a law, then the head General of the base is liable. Hence, the General can go to jail just as the CEO of a company can go to jail if the company breaks the law.

[3] The P2 manager at WR-ALC wanted to buy a new de-painting technology called the BOSS (Bicarbonate of Soda Stripper). The P2 office had garnered funds to prototype this technology on base and found it to be highly successful in de-painting C-130's as well as significantly reducing the usage of the hazardous de-painting chemical Methylene Chloride (an EPA-17 chemical and suspected carcinogen). The P2 office had a fairly healthy budget in 1995, of $10-$11 million and wanted to buy several BOSS machines for the C-130 de-painting facilities. However, the color of the funding that the P2 office had was not appropriate for this use. The P2 office could use its funds to research, develop, test, evaluate, and prototype a technology, but it can not use it to make the final purchase. The final purchase of equipment that will be used by production staff must come from the production staff budget. This now entails that the P2 Manager has to convince the production staff that not only is it worth it to change technologies but that they have to spend money from their budget to buy the new equipment. For Production the main mission is getting planes fixed and operational as soon as possible. If they had a choice between buying spare parts and environmental equipment, 9 of 10 times environmental equipment would lose out. So the problem here is not the lack of funds, as WR-ALC had a healthy P2 budget of $10-11 million. The problem is that, despite the willingness of the P2 office to pay for the production equipment, the budgetary rules does not allow for it.

[4] The C-17 SPO has been relatively successful in obtaining funding for P2 projects. A C-17 top manager and the C-17 P2 manager feel that many SPO managers are not used to handling environmental problems and proactively trying to obtain funding to solve their programs environmental problems. Hence, they basically ignore them and only do environmental projects when they absolutely have to.

[5] The P2 manager for the Aircraft PSO has been unable to obtain funds specifically earmarked for P2 projects for the weapon systems under its jurisdiction. Hence, it has had to try and obtain funds for P2 projects from two separate pots of funds that have many other types of projects that compete for its funds. See Appendix A, the section on SPO's, if unclear about the functions of the Aircraft PSO.

[6] This means that if a new regulation is put in place then the F-22 will have no funding to deal with it right away. They will have to go through the channels to request for more funding and this may delay the production of the F-22.

[7] C-17 SPO claims to have sufficient funds dedicated to P2. This is unusual. Getting this funding was heavily dependent on the fact that the top management of the SPO, are more proactive and have a belief that environmental projects are worth doing because of short and long-term reduction in costs and liability. Hence, it was much easier to obtain P2 money from the discretionary money pot (initially through Engineering Change Proposal money) which is governed by the Business Investment Board (specific name to the C-17 SPO) because the P2 manager had sympathetic ears on the Board. The Business Investment Board consists of: the SM, and the leads of the 11 IPT's that make up the C-17 SPO.

[8] CE which has traditionally been remediation, restoration, and compliance oriented, has stated that they will fund some projects that involve P2 issues. However, these projects can not be specific to a single weapon system - many weapon systems must have this need in order for CE to contribute funds for that project.

[9] There is also a yearly international meeting held with all foreign countries purchasing F-16s in order to inform them of the environmental issues related to the F-16. However, some countries may not have the infrastructure to use/produce alternate chemicals that are being suggested for replacing the current ODCs on the aircraft. In effect this leaves open the possibility of a black market forming for ODCs, as these countries that buy the F-16s are still dependent on them.

[10] The F-22 will be manufactured at a government-owned site. This gives the SPO more power regarding environmental impacts during the production process. Thus, the F-22 P2 manager is trying to work with the P2 staff at the production site to determine what level of environmental performance is required by local and state regulations. He hopes to use this information in order to justify further funding for pollution prevention activities. The F-22 P2 manager has also worked with pollution prevention staff from the flight-test facilities at Edwards AFB. Previously, contractors have not disclosed the materials used during flight tests, despite the fact that these materials create costs and hazards for the government facility. By working with environmental staff from Edwards, the P2 manager may be able to justify additional pollution prevention funding.

[11] The Funding Estimation Tool: this is an algorithm that is being developed to be used by the Single Manager of a SPO in order to help them gain a rough order of magnitude funding estimate for their weapons system P2 program. The tool helps to identify which chemical/process needs addressing and an estimated cost and schedule impact. The tool was scheduled to be available as of May 1995. However, it is uncertain whether there is appropriate data to support the development of this tool, and it is also uncertain whether Single Manager's are really using this tool or not.

[12] A careful review of the current budget and accounting rules that govern the DOD should be made. Congressional Budget Reform is a large issue that needs to be more thoroughly studied; it is not the goal of this thesis to tackle this broad matter. However, I return to this issue up in order to bring more awareness to the fact that this appears to be one of the root causes of financial resource problems for the P2 community. We heard it mentioned over and over again by various employees as a source of frustration.

If the rules were more flexible in terms of allowing some of the top level managers to have more control of how they can spend their funds, they would be able to be more effective. Of course, Congress wants to guard against un-wise use of their funds and hence they maintain the current rules. However, a little more flexibility may go along way in curing many of the serious funding problems. It may particularly address one of the most frustrating situations which occurs when a P2 manager is trying to get a project done and money is available that is not being used, but it is the wrong color of money and the rules don't allow the P2 manager to use it for that particular project even if it is deemed by the *top manager* to be the best use of the funds.

[13] Top-level managers, like the SM of a SPO or the head of an ALC, as well as middle-level managers are unable to justify signing contracts that require large up-front costs in order to reduce hazmats in which they will only see savings more than 2 years down the road. The reason for this lies in:
i) Recognized Payback Periods - only projects with payback periods of less than 2 years are given the possibility of getting funded and implemented. Project that may be very environmentally beneficial but have payback periods of 5 to 10 years are rarely considered. One of the reasons these projects are not considered lies in the promotion system.
ii) Promotion System - managers at all levels are generally evaluated on their yearly performance. The evaluations tend to take a short-term view of issues. Hence, a manager that can show projects completed and good savings in the past year will probably get a better evaluation than a manager who has initiated projects that have not showed any savings in the last year or two.

It is necessary for the promotion system to reward long-term actions by the managers as well as short-term actions. Until this happens, even if managers know it is right to fund a certain long-term project they may opt against it for the sake of their careers.

2. Problem Item: Cycle-time to obtain funding is very long (5-6 years).

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• The Budget Cycle and the process of POMing for funds [14].	• Many P2 projects never tried or completed because individual who began process to get specific project done, often has been transferred to another position before that project is completed, and therefore his/her learning for that specific project is lost. • Many small P2 projects are not attempted as the same amount of time and effort must be expended to gain funding as for a big project.		• C-17 P2 manager submitted request in February of 1994 for a P2 line item in the budget, and had P2 pot for fiscal year 1995 [15].	• Congressional Budget Reform [16]. • Stabilize assignments to provide continuity of institutional knowledge and memory [17]. • Each SPO should have a small discretionary P2 pot of funds governed by the SM[18].

[14] POMing for funds - POM stands for Program Objective Memorandum. POMing is the term used to refer to the procedure that one must follow to present Congress with a line-item budget for projects for your program. The whole Budget Cycle - the time you start the process of asking for funds to the time you get the funding for that specific project - can take up to 6 years. See Appendix E for a more complete description of the Budget Cycle and the whole POM process.

[15] This is a very fast turn around time to get funding. The P2 manager probably had some help from SM's willingness to make some of the P2 projects a priority on the funding list, as well as making use of some connections.

[16] See footnote number 12 on page 29 for a discussion of Congressional Budget Reform.

[17] Pollution Prevention projects move from drawing board to prototype over time-frames which often extend well beyond the postings of pollution prevention heads. Transfer of leadership often leads to a loss of learning and new personnel may have little choice but to start afresh or may even be partial to new initiatives. A stability of assignments is necessary in order to ensure that already constrained resources are not wasted through such policies. Often work that had been started, funds that had been obtained and learning accrued were lost due to movement of personnel. One potential solution is as follows: civilians are not moved around as much as part of their

career development paths within the Air Force. This person does not have to be the P2 manager - but someone who is involved at least part time with P2 projects for that P2 office. In this manner, a long-term civilian P2 employee would be able to maintain a continuity of P2 efforts for the SPO or ALC.

[18] The SM then could have some jurisdiction over smaller P2 projects that are relevant to his/her SPO. In this manner, it will be less likely that small-scale projects are discouraged due to the current bureaucratic process which involves a high time investment and high-lag time in obtaining funds.

3. Problem Item: Ineffective use of received funding.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Obligation of funds required in a short-time span [19].	• Hard won funding is sometimes lost due to failure to obligate it on time.	• C-17 SPO had plenty of funds, but could not obligate all on time [20].	• TI loophole used by ALC's [21].	• Congressional Budget Reform [22].
• Sales Rate for ALC's may rise due to P2 projects	• Negative incentive for Production staff at ALC to try many P2 projects [23].			• Let ALC's see some of the cost savings from P2 projects - don't make it mandatory that they pass all the savings onto users in true non-profit style. This will give incentive to take risk and try more P2 projects.

[19] Obligation of funds refers to putting the funds received on contract to a specific party, whether that is in-house contracting or contracting out to another company. A lot of P2 funding has to be obligated within one-year, or else it is taken back.

[20] This is partially due to the fact that there is only one person dedicated to working on P2. Hence, they had some of their funds taken away and re-allocated to other projects, some of which needed more money because they were running over budget. This is an illustration of a P2 manager who is doing his job effectively, but because he is short of manpower, he is physically unable to obligate funds hard won funds for worthy P2 projects. Instead he loses the funds to a manager who is running another project over budget.

[21] TI Loophole: if a P2 manager at an ALC is unable to obligate current funds within the stipulated time, then one trick of the trade is to assign the money to a project done by the TI directorate. Then as soon as the P2 manager is ready to obligate those funds to a P2 project, she de-obligates the funds form TI and re-obligates the funds to the new project. In this manner the P2 manager does not lose this valuable funding that she had worked so hard to get. Some of the reasons that the P2 manager may not be able to obligate the funds on time is: a lack of manpower, and the possibility of a lengthy-process of finalizing a contract of work.

[22] See footnote number 12 on page 29 for a discussion of Congressional Budget Reform.

[23] If financial cost of P2 project ends up being greater than financial benefit, then the ALC has to increase the sales rate that they charge the users (ACC, AMC) for maintenance in order to cover their costs. In the current climate of potential privatization of some maintenance facilities, an increase in sales rate is viewed as decreasing an ALC's overall competitiveness. Hence, the production managers at the ALC's who ultimately make the final decision to buy more "environmentally friendly" equipment - has to be fully convinced that the project will save money within a short-time horizon. The managers are quite unwilling to take the risk of trying a P2 project that is not 100% guaranteed to show savings or has a longer payback time-horizon. In addition, if the P2 project does save money all the savings must go towards the lowering of the sales rate. This is good in terms of competitiveness, however, it does not allow the ALC to keep even a part of the savings to buffer against some projects that may increase the sales rate.

There needs to be some system of gain sharing by which there is sufficient incentive to innovate and respond to environmental concerns. One possibility that can be considered is allowing some of the savings from successful projects to lie with the depots. These can be used to tide over excesses resulting during failed projects.

B. Human

1. Problem Item: Lack of P2 staff hinder P2 initiatives (particularly at SPO level).

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Funds can not be converted to people [24]. • RIF process is on-going [25]. • Top management believes that one P2 staff per SPO is enough.	• Over-burdened P2 managers at SPO's [26]. • All funded projects are not always completed. • Institutional-ization of P2 goal is hindered [27].	• F-16 P2 manager has to ratify all decisions requiring environmental sign-off [28]. • C-17 SPO P2 sub-IPT is reducing Air Force staff from 6 or 7 people devoting about 10-30% of their time to only about 5% of their time. • C-17 SPO had plenty of funds, but because it was unable to convert some of it to human help, P2 manager could not use money as effectively [29]. • One of C-17 SPO's top management's perception of P2 work, and staffing needs: general belief that one P2 person per weapon system is enough, and that more people doing P2 will just get in each other's way (regardless of size of P2 budget or number of projects). • Aircraft PSO handles the needs of 22 mature and small weapons programs. There is only one P2 manager to handle the needs of all of these programs [30].	• Contractor involved with P2 issues: C-17 SPO P2 sub-IPT has eleven McDonnell Douglas (MDA) staff committed to P2 (up from 3 people a year ago) [31].	• Give P2 manager some discretion to use small part of money marked for a P2 project for personnel, even 10% of a person's time, so that project that may not get done otherwise, can get done. • Stabilize assignments to provide continuity of institutional knowledge and memory [32]. • Management philosophy change: More P2 staff are necessary at SPO level if goal of institutionalization of P2 is ever going to become a reality. ALC's seemed much better staffed in this respect [33]. • Each time a new Regulation requires added work to current load, then added personnel time should be estimated such that an additional person or part of a person can be hired to take care of new regulation appropriately.

[24] The rules dictate that funds that are allocated for specific projects, can only be used for research, development, prototyping, etc. for that project. No part of those funds can be used to hire a person. Hiring personnel works through a completely different channel.

[25] With the Reduction in Force process taking place it is hard to justify hiring more P2 staff in light of overall force reductions.

[26] The SPO P2 managers do not have any dedicated staff to work with. The ALC P2 managers have a P2 staff to work with. Hence, they are able to allocate some duties to staff members which would otherwise be overburdening.

[27] The ASC/EM staff has developed the goal that P2 should become institutionalized. This means that ultimately there should be no need for a specific P2 person, the P2 manager, whose task it is to implement P2 - instead every person should have P2 in their minds when they are doing their work and include it as one of the variables that they consider before making a decision. This goal involves a lot of education of Air Force staff on P2 issues, and ultimately a bit of a culture change in the way that environmental issues are viewed (see section 2.4 beginning on page 71 for more on cultural issues).

[28] As F-16 P2 manager is the only P2 person in the F-16 SPO, she is expected to be the environmental expert on every environmental issue. She feels that because of the lack of awareness on P2 issues, that currently more P2 staff are necessary to spread the awareness if institutionalization of P2 is ever going to become a reality.

[29] Essentially, because P2 manager did not have any help, he was unable to obligate funding by the deadline stipulated, and therefore, the C-17 P2 manager lost some hard earned P2 funds.

[30] See Appendix A, the section on SPO's, if unclear about the functions of the Aircraft PSO.

[31] The C-17 is the only weapon system being produced at the MDA Long Beach facility. This is an advantage as they have the sole focus of contractor.

[32] Pollution Prevention projects move from drawing board to prototype over time-frames which often extend well beyond the postings of pollution prevention heads. Transfer of leadership often leads to a loss of learning and new personnel may have little choice but to start afresh or may even be partial to new initiatives. A stability of assignments is necessary in order to ensure that already constrained resources are not wasted through such policies. It is essential that knowledge accrued by the workforce after working on specific projects is not lost. There should be a structured way by which new leadership assesses whether projects should be continued based on the amount of learning and the personnel and funding available.

[33] In order for awareness of P2 issues to be spread at the SPO's, more than one P2 staff at each of the big weapon system SPO's and at least one P2 staff at the smaller SPO's are necessary. Currently the single P2 staff that is present at some of the SPO's is so overworked that he/she has no time to share and spread ideas to other SPO staff. At many of the smaller SPO's there is no P2 staff person.

C. Technical

1. Problem Item: Matching research dollars with technology needs

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Difficult to evaluate the technical needs of all the different Air Force Organizations. • Prioritization of competing needs is difficult.	• Right technology is not developed in time.		• Environment Safety and Occupational Health Technology Planning Integrated Product Team (ESOH TPIPT) [34]. • C-17 P2 manager has put some money into investigating what other commercial R&D labs have developed as alternatives so that the list of potential substitutes for problem chemicals and processes can be more comprehensive [35].	• Develop practices to support the SAF *Air Force Pollution Prevention Strategy* (1995) objective #4: "Develop and transition innovative pollution prevention technologies to the field."

[34] ESOH TPIPT: is charged with identifying voids in technology that present obstacles to fulfilling the Air Force's environmental commitments. The ESOH Process was established to:
- Identify and prioritize users' environmental, safety and occupational health technology requirements,
- Coordinate research, development and acquisition (RD&A) programs in response to technology requirements,
- Expedite the delivery of needed technologies, and
- Offer decision makers a holistic view of USAF ESOH Programs.

The ESOH Process produces two major documents: the USAF ESOH Technology Needs Survey and the USAF ESOH RD&A Strategic Plan. The needs survey documents prioritized user requirements and the strategic plan documents the prioritized programs

that address user requirements. The ESOH Process leverages Research Development & Acquisition (RD&A) programs within the Department of Defense (DOD) by identifying common requirements and minimizing the occurrence of duplicate RD&A efforts (The information in this footnote was taken directly from the *USAF Environmental Quality Research, Development and Acquisition Strategic Plan* developed by HSC/XR, May 27, 1994).

[35] This move was prompted by the fact that the database of solutions for the C-17's P2 projects from the contractor's point of view is whatever knowledge MDA (the contractor) has among its internal databases, and past experience. Hence, the C-17 P2 manager felt that he may be able to increase the chances of filling the P2 projects technology needs by conducting a wider search.

2.3 Knowledge Flow

A. Information Flow

1. Problem Item: Project Prioritization System inadequate for P2 projects [36].

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
a) No clear tool to measure cost/benefit of P2 projects. b) P2 projects lumped together with other engineering projects in the prioritization process [37]. c) Not enough, and not right data collected and/or communicated to properly measure cost/benefits.	• Persistence and marketing measures used instead of a more equitable and unbiased measure [38].	• Badly designed Life Cycle Cost Estimator tool (LCCE) by HSC [39]. • F-16 and Halon 1301 - given a priority 3 by Flex board because the users input (ACC) did not get back to the board [40]. • Depots provide only aggregate data to the AFMC [41].	• Customization of LCCE tool for C-17 SPO's top 5 chemicals [42]. • ESC APPWG is making sincere evaluation of HSC LCCE tool [43]. • P2 Opportunity Assessments done by outside consultants at Ogden ALC [44]. • WR-ALC: Waste Management System [45].	• Need to develop an effective LCCE tool as it is essential to have a tool to convert the environmental risk value to $ terms to ensure that the decision authority has a yardstick to compare P2 projects [46]. • Involve Air Force Financial Management community early in the development of LCCE tool [47]. • Implement new system developed by ESC APPWG for reporting of data between ALC's and SPO's [48]. • The depots should report their emissions data on a "per part" basis [49]. • A clear Hazardous Material Management Plan (HMMP) developed for the weapon system. HMMP would require data to be collected that would allow an easier trade-off to be made between the risks and costs of a given hazmat [50].

[36] See Appendix F for full description of project prioritization system.

[37] This is a barrier because most engineering projects that are submitted for funding approval have a lot more supporting data available to present a full cost/benefit analysis of the proposed project. Whereas for P2 projects the data sometimes consists of best guesses by the P2 manager as all the relevant cost data is currently not tracked and reported.

[38] In essence, persistence, marketing and connections are the reason P2 projects get funded rather than a true evaluation of the projects merit.

[39] Many say that the prioritization should be done by Life Cycle Cost. The HSC LCCE Tool has been criticized, but not much constructive criticism has been offered back to them because P2 managers just don't have the time to do a full evaluation. One big criticism is that the tool bases its costs on a historical trend which in the past has been somewhat of a gradually upward sloping straight line. But recently LCC have exponentially grown, and this has not been taken into account appropriately by model. Hence the model has given estimates much lower than what is realistically calculated by back of the envelope estimates. Also, the model is not able to deal with the nuances of all the different chemicals and their specific issues. These problems in the model seems to be linked to the fact that the model is based on too small a set of data.

[40] The decision authority of the F-16, the Flex Board, on a scale of 1 to 3 gave the Halon 1301 problem that the F-16 is facing the lowest priority, meaning a 3. This was because the Flex Board did not receive a strong signal from the users that this is a big problem for the F-16. In reality, the users do think it is a big problem but they did not communicate this problem effectively.

[41] Depot-wide data on the use of EPA-17 chemicals does not provide the SPO with helpful feedback about which technologies or portions of an aircraft are the major problems. In addition, the P2 manager makes the crucial decisions about how much to spend to avoid environmental impacts that occur later in the life cycle. Without good feedback from the depots regarding environmental and technological needs, it is difficult for the SPO P2 manager to determine how to prioritize pollution prevention projects. Furthermore, the P2 manager has neither the funds nor the authority to make final funding decisions; he is constrained by the need to strongly justify his use of funds to the top management of the SPO, hence more data to back up the funding requests would be gladly received by the SPO P2 manager.

[42] C-17 P2 manager is funding HSC to customize LCCE tool for C-17's top 5 problem chemicals that it is dealing with. In this manner the LCC of each of these chemicals can accurately reflect its nuances (storage, availability, worker safety, liability, etc.), and deliver a much more accurate estimate.

[43] This is the only full evaluation of the LCCE tool that is being conducted. The ESC is doing this in order to determine whether their base should use the LCCE tool as is, recommend changes to it and then use it, or scrap it and develop another alternative for the purpose. They are providing feedback to the HSC developers of the tool, as well as involving them in the process to make the entire evaluation as useful as possible for both the ESC and the developers of the tool at HSC.

[44] In 1992, Engineering Science, Inc. was contracted to do a P2 Opportunity Assessment for Hill AFB which concentrated mainly on ODC elimination and some EPA-17 chemicals. It was found that 70 - 80% of all ODC's were present because of only 30% of the processes. Hence, Hill AFB really focused on these processes to eliminate ODC's. For example, they used 300,000 lbs. of 1-1-1 TCE almost entirely during maintenance of landing gear. At Hill AFB the LA (Aircraft) directorate and the LI (Landing gear, small munitions, and commodities) directorate are the largest producers of hazardous waste.

[45] Currently the base at Robins has a new waste management system that has been picked up from Edwards AFB. The impetus of this new waste management system is turning towards being able to exactly link a waste stream to a particular weapon system and standardizing the methodology across the AFMC. Each drum of waste is uniquely managed by the tracking system in place. The system is such that it allows for the quarterly billing of each drum of waste to the respective owner of that waste, which in the case of the weapon system is billed to the SPOs. The tracking of the waste in this manner will help in planning for its minimization in the further quarters.

There are also moves being made to track waste worldwide though this has not yet been hardwired. This would involve a greater emphasis on utilizing current information systems so as to collect and collate information across the continents.

[46] Hence, do one of three things:
i) create a simple back-of-envelope methodology for rough ball-park estimates
ii) create a detailed computer model but for a limited set of chemicals or processes that have been identified as major concerns
iii) spend the money to really do a detailed computer model with enough data to make it valid such that the needs of different weapons systems are considered.

[47] For any LCCE to be given legitimity, it needs to have the buy-in of the Financial Management Community.

[48] This newly developed policy has not yet been implemented, however, it is expected that it will be in the near future. The main aspects of the policy is as follows:

i) An ALC identifies its major pollution concerns: particular chemicals, particular processes, etc.
ii) The ALC then identifies the particular weapon system that is driving its use and contacts the SM of that weapon system.
iii) The SM and the ALC then work together to develop a proposal to try and change the use of the polluting chemical or process.
iv) The SM requests funding for this proposal and continues to keep in contact with the ALC as to the status of the funding and progress on the particular proposal.

The ALC generates 80 - 90% of the hazardous waste over the life cycle of an aircraft. Hence, by developing a system that will target the ALC, and designing an effective system by which the ALC can communicate its major problems to the respective generators of those problems, a good 60 - 80% of the life-cycle hazardous waste issues could begin to be identified, communicated, and addressed. The Air Force has been delaying in adopting this policy as they have been attempting to develop a system that communicates 100% of the hazardous waste issues from not only the ALC's, but all bases, and all major commands. They have not been able to develop an effective system to do this. In addition the complexity of such a system may take away from the ability to address the majority of the hazardous waste issues that are generated by the ALC's. The Air Force should really embrace a system that focuses on the 5 ALC's and perfect it before trying to go after a system that addresses every base around the world.

[49] This would enable the SPO P2 Manager to use this information to determine what design changes were most necessary. While determining "per part" pollution production would probably be an excessive burden on the depots, reporting the amount of waste produced by each process would not be as difficult, as at least some depots already collect their information in this format.

[50] For the F-22, Lockheed Martin (LM) is required to develop an HMMP that identifies every hazmat of relevance to the Air Force that is used by contractors and subcontractors. A hazmat is considered irrelevant to the Air Force, and thus not identified in the HMMP, if it is used only one time by the manufacturer and will not be required in the operation, maintenance, or disposal of the aircraft. The contractor is also required to identify which of these materials will have an impact for the Air Force. Contractors provide a list of these materials along with a list of possible alternative chemicals or processes. The SPO must then decide which of these alternatives should be utilized.

2a. Problem Item: Wasted, duplicated, and inefficient P2 efforts.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
a) Ineffective channels of communication between and amongst SPOs, bases, ALCs, and contractors.	• Wasted, duplicated, and inefficient P2 efforts.	• Joint Depot Environmental Panel (JDEP) is a good model, but it is not being used effectively or being given the importance that it should have in the eyes of the environmental community at the depots [51]. • ALC/EM (environmental management) reports to AFMC/CE (civil engineering). ALC P2 staff believe that an AFMC/EM needs to be created [52]. • The depots represented on the F-22 Environmental Working Group (EWG) have not provided much useful feedback regarding potential environmental problems [53]. • For the F-22: since the TO's and maintenance procedures are not identified until midway through EM&D, it is difficult to give the depots an accurate and early picture of exactly what the potential impacts might be. • Waste of money: Similar P2 study done by	• There is some intra-industry information sharing, i.e. Aerospace *Hazmat* Conferences. • F-22/F-119 Environmental and Hazardous Material Control Working Group (EWG) has regular meetings and brings together knowledge base of various collocates and people from the users and depots [56]. • Future ALC of C-17, sends list of chemicals that they have eliminated to the C-17 SPO [57]. • Joint Group on Acquisition Pollution Prevention (JGAPP) brings together weapon systems to try and solve their common environmental problems [58]. • Acquisition Pollution Prevention Center Working Group (APPWG) brings most of the Air Force P2	• Give more emphasis and publicity to the functions that JDEP provides[61]. • Develop long-term environmental goals for ALC's and provide incentives for the environmental managers at the ALC's to meet these goals. • Use new system developed by ESC APPWG for reporting of information between ALC's and SPO's (see footnote number 48 on page 41).

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
		MDA St. Louis and MDA Longbeach without any collaboration [54]. • Proprietary information issue between Air Force and Contractor causes some problems in freely sharing information. • Competition between ALC's hinders open communication and sharing of ideas between them [55].	community together four times a year [59]. • Ogden ALC identified the use of Cd-plated landing gear as a potential problem and communicated this information to the F-22 SPO [60].	• Develop an easily accessible database which acts as a repository for all projects completed or underway (see next problem item, 2b on page 48, for a further discussion of this).

[51] JDEP is a gathering of all the depots across all the forces four times a year. They meet at a different depot each time where they have meetings and demonstrations to exchange ideas on environmental technologies, substitute materials, and new processes. Each depot is supposed to send a representative to each meeting. Unfortunately, the depots don't have a person consistently going to each JDEP meeting. They also do not have a set system by which the information gathered by the JDEP representative is disseminated. Hence, the lessons that are being passed on between depots at the JDEP meetings do not get back to all the key people at the depots.

In addition the Technology Information Systems-Expanded (TIS-X) database created and maintained by JDEP has not been heard of by any depot or SPO P2 person that we spoke to. TIS-X seems to be an ideal solution to some of the communication problems that are being experienced by the P2 community - it is really shocking that no one knows about it or uses it effectively (See "Appendix F: P2 Project Approach and Prioritization System" on page 100 for more information). This may be due to poor "marketing" efforts by JDEP, or non-user friendly access to the database. TIS-X does reside on a Unix based computer system. The Unix computer operating system is one that is not familiar to as many people as in the DOS, Windows, or Macintosh operating systems. Lastly, competition between ALC's and between forces sometimes hinders JDEP's cooperative efforts.

[52] Mind set of AFMC/CE is more on facilities upkeep and infrastructure of base, and less on P2. Hence, the ALC/EM staff feel that they do not have any group truly representing their interests at the AFMC policy level. ALC/EM also takes some orders, does work for, or reports to AFMC/EN (TO clean-up), AFMC/LG (request for waiver), and AFMC/DR (Weapon Systems Metrics).

[53] The F-22 will not arrive at these depots for another 10 years or so, and given current regulations, the depots believe they will be able to meet their environmental restrictions even with the addition of the F-22. Thus, they don't have much incentive to provide P2 metrics or data that would help the F-22 EWG in reducing hazmats that would ultimately benefit the depots in the long-run.

[54] This is a case where a certain environmental study was commissioned by MDA St. Louis at the expense of the Air Force. A few months later a similar study was commissioned by MDA Longbeach and again the Air Force paid for it. If there was communication within the Air Force as to which studies were being conducted or already had been conducted then this sort of waste of time, money, and effort could be avoided. One sort of solution to this problem lies in developing an easily accessible database which acts as a repository for all projects completed or underway (see next problem item, 2b on page 48, for a further discussion of this).

[55] Enhanced competition between the ALC's, due to the following factors, has created a dis-incentive for them to communicate and share ideas with one another:
i) The Base Re-Alignment and Closure (BRAC) process has created antagonistic relationships between bases, and unhealthy levels of competition. This leads to an unwillingness to share knowledge, and hence there is greater tendency towards duplicating efforts rather than sharing information.
ii) If one ALC prototypes a new technology, they are hesitant to completely share their learning and information with other ALC's as each ALC competes for funding from AFMC. Hence, if more then one ALC asks for money for the same project one of the them might lose out temporarily.
iii) Bases compete on chemical release figures, as they want to look good. They also compete to be the ones who prototype a good technology. Hence, one base's ability to reduce or eliminate emissions of a certain chemical might be kept a secret for a while as they want to look good compared to the other bases.
iv) ALC's are competing for work. If your ALC is seen as being at the top of the curve or has functions that are not redundant at other ALCs, then it is more likely to keep work and not lose as many jobs. Workers feel that if they give up some of their processes or technologies their base will lose some work, and hence they might lose their jobs.

[56] The F-22/F-119 EWG is comprised of P2 manager of F-22, ASC/EM, AFMC/EM, SA/depot, ACC, Edwards AFB Flight Test Center, 4 contractor reps., and people from different home offices: Logistics, Contracts, Finance, Procurement, etc. Having people from the various home offices be a part of the contractual decision making process from the beginning is a good practice because it

allows for expertise to be provided in the contract before the contract is written. In this manner their concerns are being taken into consideration during the writing of the contract instead of the traditional practice of writing the contract and then trying to get everyone's approval.

[57] The ALC has been eliminating certain chemicals from the other weapon systems that it maintains. Hence, they want to make sure that those chemicals do not get into C-17's design so that the ALC after eliminating them from their maintenance operations does not have to deal with them again.

[58] JGAPP is a potentially good model for eliminating some of the duplication of effort. It attempts to bring SPOs that have common problem together and solve them jointly, instead of the traditional method of everyone trying to develop their own solutions. JGAPP is a very young group and its system is yet to be really tested. They have just started a joint project at MDA St. Louis which covers a number of weapon systems. However, many of the P2 managers that we spoke to are skeptical about the JGAPP process. There concerns are:
(i) Does a common solution exist for the many different types of aircraft? Even if an 80% common solution exists tweaking that last 20% for each weapon system such that the newly developed common part can fit all the weapon systems may create as large an expense and not as good a solution as compared to having each weapon system go at it individually.
(ii) Who pays what share of the joint solution - usually only the SPOs that have funding at that time so their may be unfair burdens on certain SPO's and other SPO's free-riding.
(iii) Those that have funding and a process to solve their problem, maybe delayed by years while waiting for the other weapon systems to come aboard in the JGAPP process.

[59] The APPWG began its operations in 1995 with its first meeting at Hanscom AFB, ESC headquarters. It is a group that brings representatives from all 5 ALC's, all 4 product centers, and AFMC P2 IPT together 4 times a year. It's goal is to bring the key P2 players in the Air Force together to facilitate joint solutions to common problems. Their first goal is to develop common policies across all the represented parties.

[60] Ogden ALC, the site for landing gear maintenance, is moving to eliminate the use of Cd-plating altogether, and suggested strongly to the F-22 SPO that an alternative plating process be used. Ogden's request was enough to convince the SM to authorize spending to consider ion-vapor-deposited Al (IVD Al) as an option to Cd-plating.

[61] This emphasis can be given through a policy directive from the Secretary of the Air Force level which makes it mandatory for all depots to take full part in JDEP. This may necessitate that one person at each depot is dedicated to attending JDEP activities, and

disseminating the information to the appropriate people at the depot. In addition, JDEP needs to "market" itself more aggressively to create a greater awareness of what it is providing to the Depot community.

2b. Problem Item: Wasted, duplicated, and inefficient P2 efforts.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Distinct databases are maintained by different organizations which are not compatible (database commonality problem).	• There is no single database that all parties can access to find out what projects are in progress, and what projects have been completed. Hence, many of the lessons learned are not kept in the system. • There is not a single consistent place to go to get the latest information on certain classes of chemicals that are being regulated [62].	• Depots all had distinct waste tracking systems that could not communicate with each other [63].	• DM-HMMS or Navy HSMS waste tracking system is soon to be the depot-wide standard [64]. • TIS-X database developed by JDEP [65]. • ODC hotline maintained by HSC at Brooks AFB [66]. • P2 managers contact each other via e-mail as an informal mechanism that is used to check if other similar projects have been done or are being done.	• Use of World Wide Web (WWW) architecture to solve database commonality problem [67]. • Expand ESOH TPIPT Technology Needs Database to include a Projects-in-work component, and Projects Completed component [68]. • The National Defense Center for Environmental Excellence (NDCEE), a non-profit group, maintains a database of information on chemicals. Could expand NDCEE's database by expanding NDCEE's role in collecting, and supplying information to all P2 staff. • Create hotline similar to ODC hotline for other groups of chemicals, i.e. EPA-17.

[62] There is a hotline for ODC chemicals that anyone can call to find out information on ODC's. This sort of an information source does not exist for many of the other groups of regulated chemicals.

[63] Sometime in 1994, the concept of managing and tracking one's hazmat was dictated by the AFMC. Many depots went about constructing their own electronic database tracking systems since the emphasis was on meeting the goals of the policy. No clear idea had been presented by the AFMC as to how to go about meeting the goals of the policy, and there were no efforts to coordinate the

development of such a waste tracking system. Therefore, a whole host of non-standardized systems for hazmat management were developed. Without some basic standardization none of the electronic systems could effectively exchange information. This makes it difficult to combine data across depots.

Some of the problem boils down to the fact that ultimately each base wants to be in charge of its own destiny, and so this does not always bode well for cooperative efforts. This is why there are distinct databases springing up to track projects, because each base is trying to make a system for themselves, and once they get going they do not want to let go of their project that they are most familiar with. What is exacerbating the problem is that no one (AFMC/Headquarters) is choosing the best system out there, and putting the resources into it and making it the standard for all bases. Also, often times politics determines which is the best existing system rather than the merit of the technology.

[64] There is a group within the Air Force called the J-LSC (Joint Logistics and Systems Command) which was given the task of deciding upon a system that should be followed across all the forces. After some amount of study, the J-LSC picked the DM-HMMS system developed at an Air Force depot as the best system.

There was another group within the DOD called the DESCIM (Defense Environment Security Corporation Information Management). This group was also looking at systems for hazwaste tracking. They came to the conclusion that a navy system called HSMS (Hazardous Substance Management System) which did a cradle to grave analysis of hazmats would be ideal. Though this system did have several shortcomings in comparison with the DM-HMMS, it was felt that by sufficient customization the HSMS could be brought up to speed. There are obviously some politics and Air Force - Navy rivalry apparent in the choosing of the final force-wide system.

Nevertheless, this kind of standardization across all depots will allow depots to exchange hazmat data more easily with each other, as well as provide Single Managers with a consistent set of data about the waste streams emanating from his particular weapon system.

[65] The TIS-X database combines information received from all depots DOD-wide into a single database (see "Appendix G: JDEP and TIS-X" on page 102). Unfortunately, TIS-X has not been heard of by any depot or SPO P2 person that we spoke to. TIS-X seems to be an ideal solution to some of the communication problems that are being experienced by the P2 community - it is unfortunate that no one knows about it or uses it effectively. This may be due to poor "marketing" efforts by JDEP, or non-user friendly access to the database. TIS-X does reside on a Unix based computer system. The Unix computer operating system is one that is not familiar to as many people as is the DOS, Windows, or Macintosh operating systems.

[66] The ODC hotline has been touted as a good source of information as most people who do some work with ODC's feed there information into the hotline. In this manner others benefit from previous work done. This sort of a system should be expanded to other chemicals besides ODC's.

[67] The WWW offers the outstanding capabilities of being easily accessible, easily updateable, and user-friendly. The Air Force could exploit this technology as a means to enhance communications between the entire environmental community. The goal of this database should be:
i) To make it easy to document projects that are completed, and projects that are in progress by the use of a few key words.
ii) To make it easy for a person on Base X to query the database on Chemical Y and find out all the projects that relate to that chemical.
iii) To make it easy for that person on Base X to get in touch with the person on Base Z who was in charge of the completed project done on Chemical Y.
An important thing to keep in mind is that the goal of the database is not to provide comprehensive information on every project. The goal is to provide just enough information so that anyone can find out that a project of a certain type has been done before and then the point of contact information serves as a means to allow communication with the appropriate person to be possible in order to find out whatever details are needed.

The database that is created on the WWW should be:
i) Simple - very few fields would need to be filled out. I suggest the following: chemical, process, component (or part), point of contact (POC), contact information, and some additional space for optional comments.
ii) Easily updateable - anyone should be able to walk up to their computer, access the homepage of the Air Force database on the WWW, and then input a new project into the database. This can be done by the use of a form that is placed on the Air Force database homepage. This form can have each of the fields mentioned above, and so the user can just type in the necessary information next to each field and then click the send button. The form then gets sent using the electronic mail system to one of the Air Force Computer Servers which will automatically update the database. The form will return an error message and will not be sent if the chemical name entered in the field does not match a pre-set list of acceptable spellings for each chemical. In this manner, the database will remain orderly and not have 50 different spellings of trichlorethylene in it.
iii) Easily searchable - through the use of a WWW browser software program, such as Netscape, any user can query the database by keyword. The keyword could be the name of a chemical, a process, a part, or a particular person responsible for a project. The WWW will then pull up all the projects that contained your keyword in it and display those projects' information.

In this manner, I believe that the Air Force can create a simple, low maintenance, low cost, highly useful database of projects that is accessible to all.

[68] The ESOH TPIPT Technology Needs Database consists of information gathered via interviews and questionnaires completed by various levels of Air Force personnel (including P2 managers) at each base. Hence, the infrastructure to collect certain information has been set in place and formalized. What is necessary is that the questionnaire be expanded to include questions on projects completed, and projects in progress. Each P2 manager should be required to input their project specific information on the questionnaires each year or each quarter. The database should be available on-line and have the ability to be queried for projects relating to X or Y chemical. This system is highly dependent on people filling out the questionnaires completely. With all the time pressure on P2 managers this could fall by the wayside unless the filling out of the questionnaires is *emphasized* as a critical path by which information can be shared, and efforts can be made more efficient.

2c. Problem Item: Wasted, duplicated, and inefficient P2 efforts.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Link between O&S stage and design stage is essentially non-existent or ineffective.	• P2 lessons learned at O&S stage are not in-corporated into next generation aircraft or re-designed aircraft.	• No P2 manager knew of a formalized manner in which ALC P2 lessons learned could be fed back to contractor, such that a current or future design decision may be effected. • A SPO has some control over the contractors, but not the subcontractors, and so they may not be able to see the technical and environmental aspects of the "subassemblies of subassemblies of subassemblies" [69]. • During the design of a brand new plane, engineers rely on "tried and true" materials and processes. Developing an entirely new process is exceedingly time consuming and costly.	• Lockheed-Martin in Marietta, GA has initiated contact with WR-ALC to share P2 information [70]. • The C-130 is a plane that has had numerous re-designs and is slated to come out with a new one (C-130J). C-130 staff have realized that it is important that the users and maintainers of the C-130 provide a list of *Hazmat*s that are being generated by the use and maintenance of the C-130 to the P2 manager at the SPO. Then there is at least a chance that this list may be worked on by the contractor to try and reduce some hazmats in the next re-design. • Aircraft PSO EWG representative's responsibility to: - ensure new contracts do not require ODC's - review existing contracts for ODC's - incorporate environmental management wording into Acquisition documents • *Hazmat* Review Cycle and *Hazmat* Review Board (HMRB) used in F-22 relationship with contractor and subcontractors [71].	• Design IPD is potentially the most effective place to incorporate P2 at the contractor level. • The F-22 EWG should be emphasized as an important forum for environmental information exchange and discussion. All weapon systems should convene an EWG following the F-22 model [72]. • The F-22 has learned many lessons through its process of attempting to institute P2 in Acquisition. These lessons are valuable for any plan for a new or re-designed weapon system [73].

[69] It is possible for a contractor to subcontract environmentally harmful processes to subcontractors inside or outside of the United States. These subcontractors may also use further subcontractors of their own. Hence, for some parts or materials, the contractor and SPO may not even be aware of all the hazmats used in its production (and subsequently, maintenance) by the subcontractor.

[70] The contact between LM in Marietta, GA and WR-ALC has just recently been initiated with the help of the P2 Assistance Division of a Georgia State Environmental Agency. The goal of this relationship is to share knowledge about P2 technologies and processes that either side is familiar with, and to generate ideas together to common problems. One example so far has been that WR-ALC had found a way to recycle their paint cans which they shared with LM and so LM is now pursuing the same paint can reduction strategy.

[71] The F-22 is the first program to try and institutionalize P2 at the aircraft development stage. One method that they are using is the *Hazmat* Review Cycle which goes through the following six steps:
i) Input - on hazmats in the different subsystems of the aircraft is collected from the IPTs (there is an IPT, made up of contractor and Air Force personnel, responsible for the final delivery of each of the aircraft's subsystems), from the contractor's Materials and Process personnel, from the SPO, from the ALC.
ii) Evaluation - the contractor's HMRB then reviews all of this input and identifies environmental compliance issues, hazmat issues, and substitution potential. The HMRB then makes its recommendations to the respective IPTs.
iii) Incorporation - the HMRB recommendations are incorporated into IPT Trade Studies along with other design parameters.
iv) Decision - IPT makes optimum program design decision.
v) Risk Documentation - is provided to the Air Force in the form of MHAR (Material Hazard Analysis Records), WSHMAR (Weapon System *Hazmat* Analysis Record) and LSA (Logistics Support Analysis) Database. The Air Force also has the F-22 EWG minutes which provides some risk documentation. (Hopefully, the risk documentation that is prepared by the contractor contains information on risks due to different materials choices that the Air Force will face during Operations and Maintenance).
vi) Risk Acceptance - the Air Force reviews documentation and decides what final hazmats residual risk/impacts to accept.

[72] The F-22 EWG includes representatives from: Contractors, ALCs, SPO, AFMC, among others. The representatives from the contractors should include at least one designer. In this manner important environmental information can flow between the ALCs, SPOs and the Contractors, including the Contractor's design team.

[73] F-22 Lessons Learned:
i) Submit *Hazmat* Priority List with RFP. This ensures that the contractor's proposal accounts for costs of hazmats substitutes. The F-22 did not do this and hence, they now have to pay separately for each hazmat substitution since the base-line was initially set and that was what the contractor bid on. The ASC *Hazmat* priority list was still under development when the F-22 contract was awarded. As a

result some subcontracts were awarded using materials allowed by Milstds but listed for elimination by the *Hazmat* Priority List (i.e. cadmium on landing gear). Now, in order to make any changes in contracts awarded prior to *Hazmat* priority list, they have to pay separately as the contract did not originally agree to this.

ii) Develop permanent *Hazmat* DIDs (Data Item Descriptions) which allow for: uniformity of information requested, and prevents various SPO's from developing DID over and over.

iii) Start *Hazmat* program in Dem/Val or Concept phase as it establishes procedures and hazmat priority list before EM&D, and allows for Dem/Val of proposed hazmat substitutes.

iv) Earmark additional funding for hazmat substitution as it helps programs pay for the substitution of newly identified hazmats.

3. Problem Item: Differentiation between energy, and health and safety, and environmental issues

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Lack of coordination between the Air Force's EM groups, and Civil Eng., who is responsible for energy conservation, and Surgeon general and Air Force Medical, who are responsible for occupational health and safety issues.	• Synergies between these three factors are lost: energy use, health impacts, and environmental. impacts are often driven by the same issues such as material choice. This commonality between the three issues is not exploited in the decision-making process.	• There is no existing organizational location within the AF that is tasked with integrating or making trade-offs between energy, OS&H, and P2 issues . • Turf battles have prevented previous attempts to integrate health and environmental efforts within the Air Force. • The AFMC has a command-wide P2 IPT. While the team supposedly incorporates health and safety issues, this IPT is not used as a place to integrate health, environmental, and safety issues [74].	• At the depot level, environmental, safety, and health staff often work closely together or are teamed [75].	• Integrating health, safety, and environmental responsibilities into one organization might facilitate more reasonable decision making about reducing impacts. Placing responsibility for these issues in one department would also make trade-off decisions between health and environmental impacts somewhat easier [76].

[74] Health issues, such as the use of beryllium, may arise in a P2 IPT context, but would then be passed on to a particular directorate to deal with. The P2 IPT is tasked only to deal with ODC and hazmats.

[75] Tinker AFB has an integrated Environmental Team that incorporates energy, health, environmental, and Defense Reutilization and Marketing Office staff (DRMO is responsible for the reuse, recycling, or disposal of all hazmats and waste). Hill AFB has a similar team.

[76] There has not been much of an effort to do this at many bases up until now. However this may change in the near future as the Secretary of the Air Force has outlined in the *Air Force Pollution Prevention Strategy* (1995) a goal to "integrate pollution prevention, system safety, health risk assessments, and environmental impact assessments into the entire life-cycle of weapon systems programs

from concept development to final disposal." If one integrated organization is formed it must include representatives from the health, safety, and environmental side such that each issue can be appropriately advocated.

B. Authority Flow: Rules/Policies/Directives

1. Problem Item: Regulations pushed in a short time-frame.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• High pressure from Congress/EPA/public. • High fines for not complying on time.	• Substitutes for the regulated chemicals may not be any better [77].	• The F-22 P2 Manager stated that: Quite often, the alternatives presented by the contractors in the HMMP have environmental impacts that are just as undesirable as those of the original materials and processes.	• EPA's new ENVEST program [78].	• Negotiate with the EPA for longer compliance time frames for certain chemicals [79].

[77] Following the Federal Facilities Compliance Act of 1992, the Air Force was required to comply with all the regulations that private facilities were subjected to. Hence, the Air Force had to comply with many new regulations in a shorter time frame than much of the private sector. This short-time frame for compliance forced the Air Force to use substitutes that some of its staff feels have not been tested enough to understand all of their harmful properties. Hence, there is an uncertainty as to whether the substitute chemicals are any better than the ones they replaced.

[78] The DOD and the EPA have signed a Memorandum of Understanding in the last 3 months regarding the ENVEST program. This program gives the option of using environmental funding in a smarter way. If DOD has a good idea for an environmental project not required by law and it can be shown that its benefits outweigh the benefits of a project required by law, than the non-required project can be considered for replacing the required project. The approval is up to the EPA, local regulators, and some public meetings must be held as well.

[79] This type of a strategy may be useful for all the regulations that were passed before the 1992 Federal Facilities Compliance Act. For the pre-1992 regulations the Air Force has had a smaller time-frame to reach compliance than private organizations, and hence, has had to rush its compliance efforts. For post-1992 regulations the Air Force has the same amount of time as all other organizations.

Negotiating with the EPA is currently a viable strategy because the EPA has shifted its regulatory paradigm from one of command and control to one where they are using more voluntary partnership type relationships. It is felt that these voluntary relationships between the regulator and the regulated can in the long-run boost an organizations overall environmental performance.

2. Problem Item: Directives from Air Force Policy Level are unclear and inconsistent.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Policies do not always have the necessary or appropriate tools to support their mandates. Hence, P2 managers are not able to follow many Air Force Directives and hence, they can not effectively do their job.	• P2 staff end up taking a lot longer time to complete certain jobs, or they have to do them over because they have not been clearly informed about some procedural nuances. • Confusion on how to get a mandated item accomplished without the appropriate tools. • Some Directives are ignored - particularly those that give no guidelines as to how to accomplish the mandate.	• Life-cycle cost estimation is mandated by a certain Air Force directive for all P2 projects. However, there is currently no usable tool to do LCC estimation [80]. • From a C-17 top manager's point of view there are many unclear and unhelpful directives coming down from the DOD and Air Force policy level. There needs to be clearer visions laid out in the directives, and "until this happens it does not matter how we are organized."	• The Tools IPT which is driven by the SAF/AQ Policy Memorandum 93M-011, reissued as 94A-003, "Pollution Prevention on AF Acquisition Programs." [81]	• To minimize confusion - do not mandate items before there is a set procedure to accomplish it that has been tested and validated [82]. • The Environmental IPT (EIPT) should get more involved in ferreting out discrepancies between mandates and what is achievable [83].

[80] LCC estimation should not have been made a requirement until there exists a functional tool that managers can use to perform it. This is one example of a mandate that can not be followed. Many of these types of confusing or unachievable mandates have led to P2 managers ignoring the system to a certain extent and creating their own ways of managing things.

[81] The Tools IPT was formed with the explicit purpose of developing tools that would assist single Managers in implementing P2 policy 94A-003. Some of the projects of the tools IPT is as follows:
i) Hazardous Material Data Repository (but not operational yet, and no one has heard of it)

ii) Contract Language and P2 guidance
iii) AF ODC Information exchange
iv) *Hazmat* LCCE Tool
v) Test and Evaluation Template

[82] Some of the confusion is unavoidable due to the fact that pollution prevention in the Air Force has a fairly recent birth. As P2 issues are relatively new, the Air Force is still uncertain about exactly how to tackle them. Hence, in the process of figuring out what is the most effective way of doing P2, the Air Force has issued many unclear directives. This has led to directives being used as "door-stops" rather than serving as guiding frameworks for P2.

In a desire to try and integrate P2 activities and give some more common direction to achieving P2 goals the following programs and documentation is now being mandated:

i) Programmatic Environmental Assessment (PEA) - the SPO's Environmental Program Statement or Management Plan.

ii) Statement of Objectives(SOO) - The SOO replaced the SOW as a sign that from here onwards the government would play the role of an agency offering insight and not oversight. Clearly more work would be downloaded to the contractors and the government dealings on a day-to-day basis would be curtailed with the desire to reduce manpower.

iii) Single Acquisition Management/Master Plan (SAMP) - this will replace all the other master plans associated with different offices (systems, manufacturing, procurement, test centers, etc.) and it will create one integrated master plan which will try and eliminate contradictions and confusion. The ASC weapons systems P2 IPT is writing the environmental portion of the SAMP.

[83] The EIPT at Wright-Patterson AFB is an IPT made up of experts from environment, funding, procurement, engineering, etc. Their goal is to understand the problems that are facing the different groups responsible for environmental issues and help develop solutions. The EIPT reports to the Acquisition Environmental Protection Committee (AEPC). The AEPC is made up of two-star generals. If the EIPT reported in a strong manner for example, that Life Cycle Costing should no longer be mandated until a tool is developed, then the AEPC could change this mandate. The EIPT needs to use their link to this higher power as a way to inform the policy makers of the frustrations that P2 staff are facing.

3. Problem Item: No directives or mechanism to incorporate learning.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Lessons learned system is not formalized or given a priority to be formalized or standardized across bases.	• Lessons are lost. • More duplication of efforts. • More money spent on same types of problems. • Wasted time, effort and money to go back up the learning curve each time.		• F-22 SPO is learning from the cleaned up F-16 TO's at Lockheed [84]. • C-17 has gained from some lessons learned by the C-5 staff [85].	• Develop a consistent system or forum to pass lessons learned between relevant parties. For example, the lessons learned by the F-22 SPO should in some consistent manner be passed on to any SPO in charge of a new or re-designed weapon system [86].

[84] The lessons learned during the F-16 Technical Order clean-up by Lockheed has been kept in Lockheed's system and is now being used to develop cleaner TO's for the F-22. It helps that the F-16 and the F-22 have the same prime-contractor (Lockheed-Martin).

[85] C-17 P2 Manager frequently asks for the assistance of some staff who work in the C-5 SPO, particularly for some technical reviews of P2 projects. The C-5 is a much older transport plane which has many similarities to the C-17. In this limited manner, lessons learned by the C-5 personnel are being passed on to the next generation transport aircraft.

[86] F-22 Lessons Learned:
i) Submit *Hazmat* Priority List with RFP. This ensures that the contractor's proposal accounts for costs of hazmats substitutes. The F-22 did not do this they now have to pay separately for each hazmat substitution since the base-line was initially set without such requirements and that was what the contractor bid on. The ASC *Hazmat* priority list was still under development when the F-22 contract was awarded. As a result, some subcontracts were awarded using materials allowed by Milstds but listed for elimination by the *Hazmat* Priority List (i.e. cadmium on landing gear). Now, in order to make any changes in contracts awarded prior to *Hazmat* priority list, the F-22 SPO has to pay separately as the contract did not originally agree to this.

ii) Develop permanent *Hazmat* DIDs (Data Item Descriptions) which allow for uniformity of information requested, and prevents various SPO's from developing DID over and over.
iii) Start the *Hazmat* program in Dem/Val or Concept phase as it establishes procedures and *Hazmat* priority list before EM&D, and hence, it will allow sufficient time for the demonstration and validation of proposed hazmat substitutes.
iv) Earmark additional funding for hazmat substitution as it helps programs pay for the substitution of newly identified hazmats.

4. Problem Item: Technical Orders (TO's) specify that certain wasteful steps must be taken

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Old way of doing business. • Use of TO's is a tried and true practice. Hence, moving away from this practice entails some amount of risk taking. • Process of changing TO is a very tedious one.	• Hard to substitute cleaner P2 technologies because TO specifies that only certain technologies are approved for use.	• Ogden ALC has a system in place to clean-up TO's, however the whole process is a very tedious one [87].	• F-16 SPO contracted with Lockheed to clean-up TO's as well as keep abreast of other contractors efforts to clean up TO's [88]. • An Air Force initiative has earmarked funds to identify, evaluate, and clean-up technical orders. • WR-ALC contracted out the task of cleaning-up TO's [89].	• Make it a top priority to identify, evaluate, and clean-up TO's as this is a major barrier to implementing cleaner substitute chemicals and processes. Make sure that funding for these efforts are not compromised.

[87] SPO's own the Engineering and Technical data. They are the only one's who can sign off on a TO change. So if an ALC wants a change in a TO, they must have the engineers responsible for that particular TO accept the new process and sign off on it. For SPO's that are on the base this is not as difficult, for example for the F-16 A/B the SPO is at Hill AFB, but for the C/D models the SPO is still at Wright-Patterson AFB. Some C-130's are maintained at Hill AFB (Ogden ALC), but the C130 SPO is at Robins, and so this at times makes it very difficult for some TO's to be changed.

Ogden ALC has contracted with BDM, Inc. for them to identify all TO's with hits in ODC's and EPA-17 chemicals. As these TO's are identified they are sent to Equipment Specialists (ES) in each directorate. The ES's are then supposed to fill out a work order form and send it to the Lab on base. The Lab on base has received funding from HQ AFMC to look at dirty TO's and try and identify and validate alternate processes.

The ALC Environmental Management Directorate does not own any TO's. EM can and has gotten money for review, validation, and even payment to directorates to implement new process, but this is as far as EM can go as they can not actually sign off on the final change to any TO. The SM's or Engineer Managers of the SPO's must sign of on it.

Often there is a lack of will or commitment to go through the motions or the paperwork to get the TO's to even the lab stage. For example, the Missiles Directorate is responsible for 2500 TO's. They have sent only 40 requests to Lab for them to validate substitutes. This is partially due to the fact that the Missiles Directorate staff, and especially the Equipment Specialist is overworked. However a large part of it is due to two things:
i) their priority is not P2, but it is to keep equipment (missiles) fixed and operationally ready, and
ii) they have an antagonistic relationship towards environmental requirements, and only view it as something that forces them to do more work.

[88] The TO clean-up is a collaborative effort of logistics and system command. There is a tremendous number of TO's for the F-16:
Westinghouse - 80 TO's of which 25 contain ODC chemicals
Lockheed - 7500 TO's of which 60 different chemicals are class I ODC chemicals
Thus while the first set of TO's are easier to handle the latter, due to the large volume, is much more difficult.

Information on TO's is shared in several fashions:
i) Logistics Support Analysis Records (LSAR) Database is maintained by Lockheed and is used to generate subsequent versions of clean TO's
ii) Any other parts of the aircraft which require the usage of these TO's would then get clean TO's
iii) It has been seen that the F-22 which uses some TO's from Lockheed's F-16 LSAR, will benefit from this shared information.

[89] One company is responsible for digitizing the present TO's and identifying the problem chemicals in each TO. While another company is looking at alternate process/materials that may aid in cleaning up the TO's and adding this to the TO database. All ALC's have similar efforts to clean-up TO's - some do it-in house some contract it out.

5. Problem Item: Military Standards constrain the use of alternative materials and processes.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Old Way of Doing Business. • Use of Milstds is a tried and true practice. Hence, moving away from this practice entails some amount of risk taking.	• The universe of alternatives that can be considered is constrained by the need to meet military standards [90].		• The Air Force is in the process of "privatizing" its specifications and standards. Rather than requiring contractors to adhere to DOD-defined standards, contracts will now be written to require that contractors meet Society of Automotive Engineers (SAE) standards for aerospace materials [91].	• Make it a priority to purge Military Standards of references to hazmats as it will help to ensure that contractor chooses least hazmats. This was one of the lessons learned by the F-22 SPO.

[90] These standards, which require performance such as "ability to withstand a 500 hour salt bath", have been established over the past 50 years of military aircraft production. Many of them were chosen originally because they met very broad "best guesses" by engineers forced to act under uncertainty. The result has been a set of standards that can often seem somewhat arbitrary. For instance, would system performance be hindered if a material could "withstand a 400 hour salt bath" instead of a 500 hour salt bath? Reducing a standard by this much might substantially increase the number of alternative materials and processes that could be considered, potentially reducing environmental impacts.

[91] The Air Force will participate in the formation of these SAE standards, but there will not be any differentiation between commercial and military standards. This is a potentially good avenue to develop more up to date standards. However, there are likely difficulties with this process: currently, many commercial SAE standards reference military standards. Once military standards are destroyed, these commercial standards will have to be redefined. In all likelihood, the reference to the military standard will just be replaced with the content of the old military standard.

SAE standards are developed by committee. The committee is open to any interested party, but producers of the materials in question are not allowed to vote on the final standard. Standards are reviewed every five years, unless there is a major technical change or a specific request for review. The review process involves a team of engineers looking over hundreds of different standards in a day. It

can be noted that the amount of time spent reviewing each particular standard is very small. Many of the standards were originally based on best guesses rather than on empirical studies, so requesting a major change to a standard becomes difficult because there is no "target" to argue against.

6. Problem Item: Mis-aligned incentives to do P2 for:

a) Top management
b) Middle Management
c) Shop workers
d) Contractors[92]

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Traditional incentive system not optimized for P2 for all levels of the workforce d) No policy requiring or giving incentives to contractor to consider downstream effects of its materials choices.	a) Rarely consider projects with payback period of greater than 2 years [93]. b) Often not recognized for good P2 work and may lose motivation to pursue P2 issues vigorously. c) Not involved or included by management in decision making process. d) no impetus for contractor to consider downstream environmental impacts of its design and materials choices.	d) For the F-22: Contractors do not consider what the long term environmental impacts are going to be, or how regulations may change over the life of the plane (30 years) [94].	b) and c) Some bases have instituted certificates of commendation recognizing good P2 work by managers and shop workers [95]. c) Education programs for shop-floor workers at ALC's [96]. c) Monetary benefits for Shop workers from Suggestion Box scheme [97]. d) Under Acquisition Reform: The risk of getting a plane with standard good performance has gone up because the Air Force is not giving contractors definite Milspecs and Milstds anymore. However, because we have given the contractors more latitude and more flexibility they may be able to come up with a better overall solution. d) F-22: effort was put on Contract (in 1991) with LM to provide a continuous P2 program from development through disposal.	• New incentive policies for each level of the workforce: a) Top management b) Middle Management [100]. c) Shop Workers [101]. d) New incentive policies for contractors so that some downstream effects are considered at design stage [102].

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
			d) The F-22 had many life-cycle hazmat requirements in their Statement of Work with the contractors [98]. d) F-22: Lockheed Martin Has Hazardous Materials Project Manager as a member of each IPT as a way of institutionalizing P2 in the development of the F-22 [99].	

[92] For contractors this holds with respect to P2 issues outside their firm's boundaries. As long as they are dealing with pollution issues in their own facilities, contractors have been good and systematic about considering P2 issues and reducing their hazmats. However, there is currently very little incentive for them to consider how a particular design or production decision they make effects the pollution levels at the Air Force bases and maintenance facilities.

[93] The new *Air Force Pollution Prevention Strategy* of 24 July 1995 directed by the Secretary of the Air Force may change this time horizon in the long-run. One of it goals states: "By 2005, identify and accomplish all energy and water conservation actions which pay back in ten years or less.

[94] Contractors do consider the environmental impacts from their own manufacturing sites (via a Hazardous Material Review Board, responsible to local, state, and federal EPA). However, contractors may subcontract their heaviest impact processes to elsewhere, thus exporting the manufacturing impacts. If this is the case, there may be some environmental impacts that do not become apparent in the pollution prevention process and are not noticed until the depot is forced to deal with it.

[95] The *Air Force Pollution Prevention Strategy* (1995) stated by the SAF has the sub-objective to "recognize outstanding individual, team, and installation pollution prevention contributions through the environmental awards, publicity, and recognition programs at all levels.

[96] These education programs emphasize that by taking part in these P2 initiatives the workers can help ensure themselves a healthier, safer future. The education programs aim to give the workers the understanding of why a certain project has been mandated from an environmental perspective, from a legal perspective, and a health and safety perspective. Due to educational programs run at Ogden ALC, the Environmental Compliance office has started receiving calls from workers when they see things that are not in compliance or are asked to do things that they believe to be against the safety or environmental laws.

[97] This Suggestion Box program was started with the goal of eliciting ideas from people who do not have ready access to the decision making authorities. If a person's suggestion is chosen for implementation, a certain percentage of the money saved from the implementation of the suggestion is given back to the employee who suggested it. The problem that one shop floor worker in Warner Robins ALC told us about with this program is that: the evaluators of the suggestions are engineers who do not work in the trenches. Hence, it is felt that some projects that workers feel will be real winners, are discarded by the engineers based on "white-collar" engineers tests. This particular worker felt that there should be somebody from the "blue-collar" level on the evaluation board. It was also felt that the evaluators played favorites - in the sense that if you had a connection to one of the evaluators they may vote for your project instead of someone else's.

[98] The wording in the contracts are as follows:
"Eliminate hazmats wherever possible"
"Mitigate Consequences as Appropriate"
"Address entire life cycle of weapon system"
"Comply with Regulatory Requirements"
"Summarize hazmat results in Environmental Impact Report and the Weapon System OS&H Assessment".

[99] An IPT is formed for each subsystem and is responsible for the ultimate production of that subsystem. The day to day design decisions are made at the IPT level and the hazmat program manager makes sure the entire life cycle impact of a hazmat is considered along with all other program parameters.

[100] Top-level managers, like the SM of a SPO or the head of an ALC, as well as middle-level managers are unable to justify signing contracts that require large up-front costs in order to reduce hazmats in which they will only see savings more than 2 years down the road. The reason for this lies in:

i) Recognized Payback Periods - only projects with payback periods of less than 2 years are given the possibility of getting funded and implemented. Project that may be very environmentally beneficial but have payback periods of 5 to 10 years are rarely considered. One of the reasons these projects are not considered lies in the promotion system.
ii) Promotion System - managers at all levels are generally evaluated on their yearly performance. The evaluations tend to take a short-term view of issues. Hence, a manager that can show projects completed and good savings in the past year will probably get a better evaluation than a manager who has initiated projects that have not showed any savings in the last year or two.

It is necessary for the promotion system to reward long-term actions by the managers as well as short-term actions. Until this happens, even if managers know it is right to fund a certain long-term project they may opt against it for the sake of their careers.

[101] Shop Workers on the facility and maintenance floors must be involved in environmental problem-solving teams. Their in-depth knowledge of the processes that they deal with should be sought and utilized to better solve problems and help develop a system of continuous improvement. In this manner the shop workers will feel a part of a management process, morale will be boosted, and they will feel part of a team that goes beyond their fellow shop workers.

[102] New management methods should be required, or through incentives made attractive for, Contractors to adopt them. For Example:
i) Under Acquisition reform past environmental performance of contractors may be one of the criteria in awarding contract.
ii) "Cost, Schedule, Performance, and Environment" - the Environment variable is in the contract equation - but it currently has a very small weight due to the fact that many downstream costs are unknown and data for this information is not collected. If proper data was collected, and appropriate cost accounting was instituted the environmental variable could be given more weight and it could make a difference in the final materials choice.
iii) Activity Based Costing (ABC) - traditional accounting systems have been criticized because they do not provide accurate environmental cost information. Two of the often-stated reasons for the inaccurate accounting data are the tendency to allocate environmental costs to overhead costs and to combine environmental costs in cost pools with non-environmental costs. This method hampers management's ability to assess environmental costs and make informed decisions. In comparison, ABC attempts to allocate all the environmental costs to the specific product or process that causes that cost. This would allow a product manager to know that his product is responsible for X% of the firm's wastewater treatment bill, and Y% of the solid waste bill, etc. This type of enhanced information on how environmental costs affect current product costs can lead to significantly better product management decisions (Epstein, 1996).
iv) Award Fee System: for each EPA-17 bad actor that contractor manages to replace, the contractor gains a certain monetary benefit from the Air Force.

2.4 Culture/Consciousness

1. Problem Item: Institutionalization of P2 may take longer than expected [103].

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Inadequate number of P2 staff (the Human Resources section beginning on page 34 covers details of this issue). • No recognition of the disparity between the P2 requirements thrust upon the personnel and the funds garnered and human resources made available. • Collocates (the P2 Managers) at each SPO sit in different positions .	• Not enough collocates can be placed at the various organizations throughout the base. • Unrealistic expectations that P2 staff can carry out there job of getting P2 projects done as well as trying to change culture. • Organizational complexity: Collocates could be a part of Project Management, or Civil Engineering for example. Hence, the organizational context that each P2 manager works in is quite different. A certain organizational system and information flow that works in one SPO may not work in another.	• There are 8-11 Collocates from ASC farmed out to the big weapon programs. There are about 150 different programs of all sizes. Many of them do not have an environmental collocate from ASC.	• Collocates are making some difference - as many state that awareness level of general staff has increased from two years ago. • P2 more institutionalized in F-22 program [104]. • F-22 overall plan for managing hazmats over the Life Cycle of the Weapon System [105].	• Initially hire more P2 staff until institutionalization is well on its way [106].

[103] The Air Force has a goal of institutionalizing Pollution Prevention. This goal is being led by the ASC weapon systems P2 IPT. The basic idea is that eventually there will not be a need for P2 managers and P2 staff as P2 issues will become a routine thing that all personnel consider and handle in their day to day activities.

[104] Since P2 activities have been integrated from the inception of the F-22 weapon system program there is less of a problem in introducing environmental concerns into the thought processes of the various parties involved as compared to other weapon systems.

[105] The F-22 SPO's Hazardous Materials Program has broken down the life-cycle into three distinct phases in order to better manage hazmats that will affect the Air Force. The first phase involves design and manufacturing choices that do not effect the Air Force in any way. These choices will not cause the Air Force to use hazmats later in the life-cycle. Manufacturing processes will not be recommended as a depot or operational base process for this phase. The second phase involves design and manufacturing choices that effect the Air Force. End items that contain hazmats or require hazmats to maintain them, or manufacturing processes that will eventually become a depot or operational base process are controlled by the F-22 Hazardous Materials Program. The third phase involves all depot and operational base procedures plus the disposal of the end item. For both the second and third phases a Hazardous Materials Analysis Report is prepared.

[106] It is possible that if there were too many P2 people hired, they may get in each others way and hence overall productivity of each person would go down. There is more than enough work for the P2 community to handle at the moment. If the Air Force wants to meet its goal of institutionalizing P2, where one-day it will not need to hire specific P2 staff, it will currently need to invest more up-front by hiring more P2 staff now. One of the most significant barriers they face is the overall mind set of other Air Force personnel who never really have had to think about environmental issues before. If there was at least one P2 staff in every weapon systems program office, and a few P2 staff in each of the big weapon programs, one would see a faster cultural shift in some of the people in these program offices, and this would bring the Air Force closer to the goal of institutionalizing P2.

2. Problem Item: Not enough proactive approach to environmental problems.

Barriers *(Reasons for Problem Item)*	**Impact of Barrier** *(Result of Barriers)*	**Examples of Barriers from Case Studies**	**Exceptions/ Best Practices/ Alternatives**	**Recommended Enablers** *(overcoming barriers and/or expanding ability to replicate best practice)*
• Environment is treated as an enemy, as a negative force, as something that just adds more paperwork.	•People, other then the P2 staff, are not as motivated to do P2 type work as they feel it just adds cost and no benefit to the program.		• *Hazmat* Pharmacy Program [107]. • Because P2 activities have been integrated from the inception of the F-22 weapon system program there is less of a problem in introducing environmental concerns into the thought processes of the various parties involved as compared to other weapon systems • 2-day functional training educational programs set-up by ASC and organized by tools IPT [108]. • APDP Certification Level I, II, and III process. It is a type of Acquisition Certification which may become a pre-requisite for certain employees in the future [109].	• Make the two-day version of the training course mandatory. • Create a certification process - and require a certain number of the staff in each SPO in the various divisions to be P2 certified - this would definitely help in the institutionalization goal.

[107] The Pharmacy program is a program that has been designed with the explicit purposes of:
i) reducing the usage of hazmats per task by disbursing out quantities of material in a measured and controlled fashion based on the task The amount of hazmat disbursed is logged into a computer in order to keep track of total usage.
ii) reducing the possibilities of spoilage during shelf life by monitoring the time spent by material in the inventory.
iii) ensuring that all workers who use a certain a material have prior training required for the safe handling of the material in question.

The Pharmacy program has been well organized and very effective and is an example of a proactive P2 program that can save a base a lot of money. It has saved the bases that have instituted it in the orders of tens of thousands of dollars a year because of less material

waste and less compliance costs. One problem that the Pharmacy program has run into is that some material issue points are not manned and so they may get abused - bases need more manpower to make the overall Pharmacy program even more effective.

[108] This educational program is designed to inform and enlighten employees on all the issues surrounding P2. It is attempting to convert one of the objectives of the *Air Force Pollution Prevention Strategy* (1995) laid out by the SAF into a reality. The objective states: "Permeate all mission areas with the pollution prevention ethic through comprehensive education, training, and awareness." A 2-day course is to be taught at the Air Force Institute of Technology (AFIT) at Wright-Patterson AFB. However, many SPOs say they cannot afford to send there staff to AFIT for 2 days - so instead a two hour course has been established as well. Two hours does not seem to be enough time to make a lasting impression or to be really effective.

[109] A certification process can always help to give more importance and credibility to a certain issue in the eyes of employees who are not as familiar with it.

END OF TABLES

Chapter III: Conclusions

Much information has been presented on the barriers to and enablers for effective pollution prevention in the Air Force. The critical barriers were discussed at the beginning of chapter 2, before all the tables. In this final chapter, I will review the key enablers that if adopted and implemented, would eliminate or alleviate the critical barriers to effective pollution prevention efforts in the Air Force. I will end with a section on additional research that is necessary to gain further insights in order to continue to improve the Air Force's environmental performance.

3.1 Key Enablers

Financial Resources

Inadequate financial resources is a critical barrier. There is an adequate amount of funding available for P2, however, rules constraining its use creates the situation of inadequate financial, resources. At a macro-level, reform of certain Congressional Budgetary rules would help alleviate this barrier. A careful review of the current budget and accounting rules that govern the DOD should be made. Congressional Budget Reform is a large issue that needs to be more thoroughly studied; it is not the goal of this thesis to tackle this broad matter. However, I return to this issue in order to bring more awareness to the fact that this appears to be one of the root causes of financial resource problems for the P2 community. We heard it mentioned over and over again by various employees as a source of frustration.

If the rules were more flexible in terms of allowing some of the top level managers to have more control of how they can spend their funds, they would be able to be more effective. Of course, Congress wants to guard against unwise use of their funds and hence they maintain the current rules. However, a little more flexibility may go along way in curing many of the serious funding problems. It may particularly address one of the most frustrating situations which occurs when a P2 manager is trying to get a project done and money is available that is not being used, but it is the wrong color of money and the rules don't allow the P2 manager to use it for that particular project even if it is deemed by the *top manager* to be the best use of the funds.

Although the Air Force does not have control of Congress's Budgetary rules, there is another key factor directly under the Air Force's control that they could change in order to alleviate the inadequate financial resources barrier. Currently incentives for top and middle level managers are not wholly aligned with implementing P2 projects. What is necessary are greater incentives for top and middle-level managers that will lead them to encourage P2 efforts.

Top-level managers, like the SM of a SPO or the head of an ALC, as well as middle-level managers are unable to justify signing contracts that require large up-front costs in order to reduce hazmats in which they will only see savings more than 2 years down the road. The reason for this lies in:

i) Recognized Payback Periods - usually, only projects with payback periods of less than 2 years are given the possibility of getting funded and implemented. Project that may be very environmentally beneficial but have payback periods of 5 to 10 years are rarely considered. One of the reasons these projects are not considered lies in the promotion system.

ii) Promotion System - managers at all levels are generally evaluated on their yearly performance. The evaluations tend to take a short-term view of issues. Hence, a manager that can show projects completed and good savings in the past year will probably get a better evaluation than a manager who has initiated projects that have not showed any savings in the last year or two.

It is necessary for the promotion system to reward long-term actions by the managers as well as short-term actions. Until this happens, even if managers know it is right to fund a certain long-term project they may opt against it for the sake of their careers.

Human Resources

Inadequate human resources is a critical barrier. The simple solution would be to hire more P2 staff. However, this is not so simple under the current political climate. The entire DOD is under pressure to cut the number of personnel it employs due to a lack of funding in this area and a belief that there is "too much fat" in the system. However, there are some key things that the Air Force can do to alleviate this barrier.

i) Stabilize assignments to provide continuity of institutional knowledge and memory. Pollution Prevention projects move from drawing board to prototype over time-frames which often extend well beyond the postings of pollution prevention heads. Transfer of leadership often leads to a loss of learning and new personnel may have little choice but to start afresh or may even be partial to new initiatives. A stability of assignments is necessary in order to ensure that already constrained resources are not wasted through such policies. It is essential that knowledge accrued by the workforce after working on specific projects is not lost. There should be a structured way by which new leadership assesses whether projects should be continued based on the amount of learning and the personnel and funding available.

ii) Allow P2 manager to convert small portion of P2 funds to hire P2 personnel. C-17 SPO had plenty of funds, but because P2 manager was unable to convert some of it to human help, he could not use the money effectively. Essentially he was unable to obligate funding by the deadline stipulated, and therefore, the C-17 P2 manager lost some hard earned P2 funds. The P2 manager should be given some discretion to use small part of money marked for a P2 project for personnel, even 10% of a person's time, so that project that may not get done otherwise, can get done.

iii) Disperse more P2 collocates to every SPO. There are 8-11 collocates from ASC farmed out to the big weapon programs. There are about 150 different programs of all sizes. Many of them do not have an environmental collocate from ASC. The big SPO's need at least 2 P2 collocates. The small programs need at least part of a P2 collocates time. This would greatly enhance the Air Force's ability to reach their goal of institutionalizing P2. Currently, most staff are not in contact enough with P2 staff. This makes it more difficult to try and change the culture of the organization - a goal that the Air Force is committed to as stated by the *Air Force Pollution Prevention Strategy* (July 1995).

Culture

The current culture of the organization is a critical barrier. One of the main ways that the Air Force is attempting to change the culture is through the administration of P2 training courses. This educational program is designed to inform and enlighten employees on all the issues surrounding P2. It is attempting to convert one of the objectives of the *Air Force Pollution Prevention Strategy* (1995) laid out by the SAF into a reality. The objective states: "Permeate all mission areas with the pollution prevention ethic through comprehensive education, training, and awareness." A 2-day course is to be taught at the Air Force Institute of Technology (AFIT) at Wright-Patterson AFB. However, many SPOs say they cannot afford to send there staff to AFIT for 2 days - so instead a two hour course has been established as well. Two hours does not seem to be enough time to make a lasting impression or to be really effective. The two-day version of the training course should be mandatory.

Project Evaluation and Prioritization

The inability to evaluate effectively and prioritize P2 projects is a critical barrier. One major reason for this is that there is no consistent system setup by which the top level managers (i.e. SM of SPO) or the P2 managers can gain the appropriate data that they need on their weapon systems in order to properly evaluate proposed P2 projects. One of the most promising systems that we examined is one developed by ESC APPWG for reporting of data between ALC's and SPO's. This newly developed policy has not yet been implemented. We recommend that it be implemented as soon as possible. The main aspects of the policy is:

i) An ALC identifies its major pollution concerns: particular chemicals, particular processes, etc.

ii) The ALC then identifies the particular weapon system that is driving its use and contacts the SM of that weapon system.

iii) The SM and the ALC then work together to develop a proposal to try and change the use of the polluting chemical or process.

iv) The SM requests funding for this proposal and continues to keep in contact with the ALC as to the status of the funding and progress on the particular proposal.

The ALC generates 80 - 90% of the hazardous waste over the life cycle of an aircraft. Hence, by developing a system that will target the ALC, and designing an effective system by which the ALC can communicate its major problems to the respective generators of those problems, a good 60 - 80% of the life-cycle hazardous waste issues could begin to be identified, communicated, and addressed. The Air Force has been delaying in adopting this policy as they have been attempting to develop a system that communicates 100% of the hazardous waste issues from not only the ALC's, but all bases, and all major commands. They have not been able to develop an effective system to do this. In addition the complexity of such a system may take away from the ability to address the majority of the hazardous waste issues that are generated by the ALC's. The Air Force should really embrace a system that focuses on the 5 ALC's and perfect it before trying to go after a system that addresses every base around the world.

Another important set of data that a manager evaluating and prioritizing a P2 project could use are life-cycle cost estimates for before and after the proposed project. This would allow the manager to compare all the costs associated with the use of a particular chemical or material in the weapon system, and determine whether there is truly a net benefit associated with implementing the project. Currently many costs associated with a specific chemical or material are not included (i.e. hazardous waste disposal costs, wastewater treatment costs, and worker medical bills associated with the use of a specific chemical) in the cost-benefit analysis because the appropriate data is not collected and an effective life-cycle cost estimating tool that can model all the costs has not been developed.

The HSC has developed a LCCE tool. This tool, however, has been widely criticized as being ineffective. One big criticism is that the tool bases its costs on a historical trend which in the past has been somewhat of a gradually upward sloping straight line. But recently LCC have exponentially grown, and this has not been taken into account appropriately by model. Hence the model has given estimates much lower than what is realistically calculated by back of the envelope estimates. Also, the model is not able to deal with the nuances of all the different chemicals and their specific issues. These problems in the model seems to be linked to the fact that the model is based on too small a set of data.

The Air Force needs to develop an effective LCCE tool as it is essential to have a tool to convert the environmental risk value of a chemical or material to dollar terms to ensure that the decision authority has a yardstick to truly compare P2 projects. Hence, do one of three things:

i) create a simple back-of-envelope methodology for rough ball-park estimates

ii) create a detailed computer model but for a limited set of chemicals or processes that have been identified as major concerns

iii) spend the money to really do a detailed computer model with enough data to make it valid such that the needs of different weapons systems are considered.

Information Flow

Along with the collection of relevant information, the lack of flow of this information between the various Air Force organizations is a critical barrier. There is no single database that all parties can access to find out what projects are in progress, and what projects have been completed. Hence, each organization essentially carries on as a "stovepipe" - just continuing down one path without finding out whether other organizations have completed similar projects to the one's they are attempting. In addition, many of the lessons learned are not kept in the system. A key enabling technology to overcome this problem would be the use of the World Wide Web (WWW) architecture.

The WWW offers the outstanding capabilities of being easily accessible, easily updateable, and user-friendly. The Air Force could exploit this technology as a means to enhance communications between the entire environmental community. The goal of this database should be:

i) To make it easy to document projects that are completed, and projects that are in progress by the use of a few key words.

ii) To make it easy for a person on Base X to query the database on Chemical Y and find out all the projects that relate to that chemical.

iii) To make it easy for that person on Base X to get in touch with the person on Base Z who was in charge of the completed project done on Chemical Y.

An important thing to keep in mind is that the goal of the database is not to provide comprehensive information on every project. The goal is to provide just enough information so that anyone can find out that a project of a certain type has been done before and then the point of contact information serves as a means to allow communication with the appropriate person to be possible in order to find out whatever details are needed.

The database that is created on the WWW should be:
i) Simple - very few fields would need to be filled out. I suggest the following: chemical, process, component (or part), point of contact (POC), contact information, and some additional space for optional comments.
ii) Easily updateable - anyone should be able to walk up to their computer, access the homepage of the Air Force database on the WWW, and then input a new project into the database. This can be done by the use of a form that is placed on the Air Force database homepage. This form can have each of the fields mentioned above, and so the user can just type in the necessary information next to each field and then click the send button. The form then gets sent using the electronic mail system to one of the Air Force Computer Servers which will automatically update the database. The form will return an error message and will not be sent if the chemical name entered in the field does not match a pre-set list of acceptable spellings for each chemical. In this manner, the database will remain orderly and not have 50 different spellings of trichlorethylene in it.
iii) Easily searchable - through the use of a WWW browser software program, such as Netscape, any user can query the database by keyword. The keyword could be the name of a chemical, a process, a part, or a particular person responsible for a project. The WWW will then pull up all the projects that contained your keyword in it and display those projects' information.

In this manner, I believe that the Air Force can create a simple, low maintenance, low cost, highly useful database of projects that is accessible to all.

Authority Flow

Unclear and inconsistent Air Force policy directives is a critical barrier. When these policies reach managers they create more confusion than clarity. One of the most confusing aspects of the directives as that they often mandate a specific item to be taken care of before there is a set procedure to accomplish it that has been tested and validated. Some of the confusion is unavoidable due to the fact that pollution prevention in the Air Force has a fairly recent birth. As P2 issues are relatively new, the Air Force is still uncertain about exactly how to tackle them. Hence, in the process of figuring out what is the most effective way of doing P2, the Air Force has issued many unclear directives. This has led to directives being used as "door-stops" rather than serving as guiding frameworks for P2. Managers follow the few directives that they can understand, and ignore most of the others. Managers create their own methods to get their job done rather then relying on a directive to help them find the way. This makes it very difficult to create consistent systems of doing things across organizations. To minimize the frustration and confusion of managers, the Air Force Policy Staff should be careful not to mandate items before there is a set procedure to accomplish it that has been tested and validated. This will move the Air Force in the direction of creating a more consistent system across organizations.

The Air Force's reliance on Technical Order's and Military Standards is a critical barrier. Make it a top priority to identify, evaluate, and clean-up TO's as this is a major barrier to implementing cleaner substitute chemicals and processes. Make sure that funding for these efforts are not compromised. Make it a priority to purge Military Standards of references to hazmats as it will help to ensure that contractor chooses least hazmats. This was one of the lessons learned by the F-22 SPO.

Lessons Learned

Finally, although the focus of this thesis is on aircraft that are already being operated, rather than new aircraft, the Air Force should pass on some of the valuable lessons learned by the SPO of one of its newest fighter aircraft, the F-22 (scheduled to become fully operational in the year 2004). The F-22 has learned many lessons through its process of attempting to institute P2 early

in its life-cycle. These lessons are valuable for any plan for a new or re-designed weapon system. The F-22 lessons learned are:

i) Submit *Hazmat* Priority List with RFP. This ensures that the contractor's proposal accounts for costs of hazmats substitutes. The F-22 did not do this and they now have to pay separately for each hazmat substitution since the base-line was initially set without such provisions and that was what the contractor bid on. The ASC *Hazmat* priority list was still under development when the F-22 contract was awarded. As a result, some subcontracts were awarded using materials allowed by Milstds but listed for elimination by the *Hazmat* Priority List (i.e. cadmium on landing gear). Now, in order to make any changes in contracts awarded prior to *Hazmat* priority list, the F-22 SPO has to pay separately as the contract did not originally agree to this.

ii) Develop permanent *Hazmat* DIDs (Data Item Descriptions) which allow for uniformity of information requested, and prevents various SPO's from developing DID over and over.

iii) Start the *Hazmat* program in Dem/Val or Concept phase as it establishes procedures and *Hazmat* priority list before EM&D, and hence, it will allow sufficient time for the demonstration and validation of proposed hazmat substitutes.

iv) Earmark additional funding for hazmat substitution as it helps programs pay for the substitution of newly identified hazmats.

3.2 Further Research

As a result of my research and many discussions with Air Force personnel I believe that a study which looks at the Commercial Aircraft Industry's Operation and Support practices and compares it to the Air Force's O&S practices will glean many lessons of value for the Air Force. The study should focus on specific pollution prevention issues that the Air Force is grappling with (i.e. halon 1301, database commonality, and life cycle cost estimating) and identify the policies and practices that various commercial players have developed to deal with these issues. Barriers to the transference of commercial practices to the military should also be identified.

The Commercial Aircraft Industry has had to deal with federal and state regulations for a greater time span than the Air Force has had to and has been thinking about and planning for some of

these issues for a longer time. For some issues, the Air Force may not need to "re-invent the wheel", as the answer may already lie in the procedures developed by the Commercial Aircraft Industry.

Appendix A: Organizations involved in the Operations & Support Stage

The overall responsibility for Operations and Support of the Air Force's aircraft falls under the Major Command of the Air Force Material Command (AFMC). The Air Force is organized under six Major Commands (see "Figure A.1: Air Force Organizational Structure" on page 88):

i) AFSPC - Air Force Space Command

ii) AMC - Air Mobility Command

iii) ACC - Air Combat Command

iv) PACAF - Pacific Air Forces

v) USAFE - United States Air Forces in Europe

vi) AFMC - Air Force Materiel Command.

The AMC, ACC, PACAF, and USAFE are the commands that use and fly all the aircraft. The AFMC is responsible for procuring and maintaining the aircraft, and doing research and development work. For these purposes the AFMC houses the System Program Offices (SPOs), the Air Logistic Centers (ALCs), the product centers responsible for development work, and laboratories responsible for research. Below is a brief description of the functions and responsibilities of the SPO and the ALC, which are the two major organizations that were dealt with in this study.

System Program Office (SPO)

There is one SPO for each major weapon system. The SPO is essentially the headquarters of the weapon system. The head of the SPO is referred to as the Single Manager (SM). Essentially all final decisions on the weapon system is the responsibility of the SM. During the time of purchasing a new weapon system, a SPO is created to coordinate all the functions necessary to bring this aircraft on-line. At this time the SPO is almost always housed at Wright-Patterson Air Force Base (WPAFB) which is the Aeronautics Systems Center (ASC) headquarters. Once the aircraft is operational the SPO's duties evolve into interacting with the users of that aircraft as well as the maintainers. The SPO also remains in contact with the original contractors of the aircraft as more aircraft may be produced or a re-design may be necessary. Hence, the SPO is the primary coordinating body between the users, maintainers, and contractors. Once the aircraft

becomes a mature system, part of the SPO may move to the base that its aircraft is maintained at. If the weapon system is not a major system or is a very old system in the Air Force's fleet (i.e. the C-130) it may not have an individual SPO. Instead it will fall under the direction of one of the System Program Directorates that are housed by the Aircraft Product Support Office (PSO) which is run by a committee of veteran leaders, referred to as "graybeards."

The ASC Environmental Management (ASC/EM) Office is the home of all the P2 staff at WPAFB. Each weapon system's SPO has one collocate[i] from ASC/EM who serves as that SPO's P2 manager. The P2 manager is the only P2 staff at the SPO. The rest of the ASC/EM staff is supposed to serve as a support structure for the SPO P2 manager.

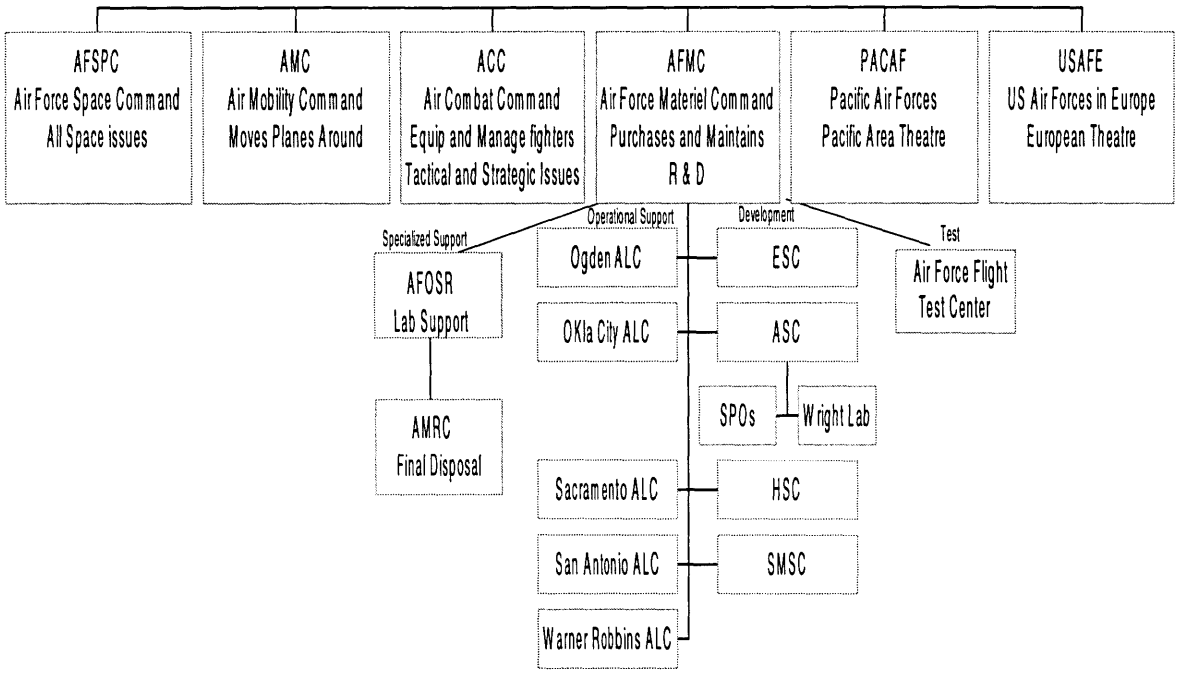
Air Logistic Centers

The ALC, also known as the depot, is the maintenance facility for aircraft. There are 5 ALCs in the Air Force located across the United States. Each type of aircraft is assigned to a specific ALC. For example all F-16 aircraft are to be maintained at Ogden ALC at Hill AFB in Utah. Sometimes an aircraft may have an alternate ALC that does some maintenance work on it. Also parts of an aircraft such as engines, are all maintained at one ALC. So all the engines of all aircraft are maintained at the Oklahoma City ALC.

Each ALC is broken down into several directorates that take care of the different maintenance functions necessary which include: wash and degrease parts, remove carbon build up, remove Cd and Chrome plating, re-plate, strip paint off airframe, repair airframe skin, and repaint the whole aircraft. The ALC houses the following directorates: Technology and Industrial Support, Landing Gear, Aircraft Production, Missile, Commodities, Engine Production, and Environmental Management (EM). The EM directorate houses compliance staff, remediation staff, and P2 staff.

[i] Collocate is the term used to refer to someone who is hired by one office, but who is physically located and works primarily for another office.

Figure A.1: Air Force Organizational Structure



Appendix B: Site Visits and Interviews

(1) Wright-Patterson Air Force Base (WPAFB) in Dayton, Ohio. We visited ASC headquarters, the F-16 SPO, F-22 SPO, C-17 SPO, the Aircraft PSO, and JDEP.

a) Capt. Mike Nelson, P2 Manager of C-17 SPO.

b) Mr. Eric Abell - Technical Director of C-17 SPO, Senior Executive Staff.

c) Ms. Samantha Durham - P2 Manager of F-16 SPO.

d) Mr. Donald Streeter - head of F-16 EWG.

e) Mr. Ted Grady - F-22 P2 Manager, Aircraft PSO Graybeard (in charge of C-130 P2 issues).

f) Joint Group on Acquisition Pollution Prevention - we met with the entire JGAPP team:

Larry Fry - Weapon System Integration Team (coordinates JGAPP functions)

Don Terrazano - Collocate from Materials Lab

Max Delgado - ASC/EMV

Charles Outlaw - Chief of Acquisition Logistics (deals with all ALCs)

Richard B. Lantis - ASC/EME Project Engineer

Chuck Valle - Integration Engineer

Charles Jones - ASC/EME Collocate Manufacturing Quality Assurance Specialist, LAI POC.

Mayank Patel - EM Collocate.

g) Capt. Lisa Kirk - ASC/EMV.

h) Lt. Col. Tim Brotherton - leads the Weapons System P2 IPT, ASC/EMV.

i) Mr. Surendra Joshi - Environmental Engineer with ASC/EMC.

j) Mr. Carl Adams - Logistics Management Specialist, JDEP.

(2) Robins Air Force Base in Warner Robins, Georgia. We visited many of the directorates that are a part of the Warner Robins Air Logistic Center.

a) Ms. Ellen Griffith - Chief of P2 and Hazardous Waste at ALC.

b) Mr. Perry Beaver - POC at ALC/EMP for weapon system staff. Robins AFB representative on Tools IPT.

c) Richard Slife - TI Directorate.

d) Ralph Maconville - one of two people in charge of Occupational Safety and Hazardous Waste for the C-130 maintenance facility.

(3) Hill Air Force Base in Ogden, Utah. We visited many of the directorates that are a part of the Ogden Air Logistic Center.

a) Mr. Craig Pessetto - ALC/EMP. He filled for Mr. Allan Dalpias, P2 Manager of ALC, who was off the base during the time that we were at the base.

b) Mr. Brad Christiansen - P2 collocate in Commodities Directorate.

c) Mr. John Vidic - P2 collocate in Aircraft Directorate.

d) Ms. Sue Barney - P2 collocate in Technology and Industrial Support Directorate.

e) Mr. Alan Raider - Engineer in Corrosion and Environmental Group in the Missiles Directorate.

f) Ms. Delores Nelson - LG representative on *Hazmat* Pharmacy Cell and Coordinator of Cell.

g) Mr. Dale Strebel - EM representative on *Hazmat* Pharmacy Cell.

h) Mr. Lynn Hill - EME (Compliance) Chief of ALC.

(4) Hanscom AFB near Boston, Massachusetts. We visited the Electronics System Center.

a) Acquisition Pollution Prevention Working Group (APPWG) - we have had four group discussions with several of the members of the APPWG.

Major Robert Lang - Program Manager of APPWG

Capt. Gerald Gendron - member

Mr. Richard LaMontagne- member, and employed by MITRE Corp.

Ms. Charlene MacMahon - member, and employed by MITRE Corp.

Ms. Judy Lau - member, and employed by Tecolote

Ms. Robin Jordan - member, and employed by ARINC

Mr. Ted Georgian, member and supervisor

Mr. Alan Bryson, Jr. - member, and employed by Booz, Allen, and Hamilton.

(5) Lockheed Martin in Marietta, Georgia. We visited with several people in Lockheed Martin's Aeronautical Systems Division.

a) Ms. Rochelle Routman - Environmental Coordinator, Safety and Environmental Division.

b) Mr. John Giles - Director of Safety and Environmental.

c) Mr. Dennis Edwards - Project Manager, Environmental Engineering.

d) Mr. Bob Floyd - Project Manager, Materials & Processing.

e) Mr. James Burke - Chief Systems Integration Engineer, ASC/EMV (he was visiting Lockheed Martin from WPAFB on the day that we were at Lockheed Martin).

Appendix C: Categories of Barriers

The findings of this project were organized into a framework that places each barrier to pollution prevention that we encountered into one of three categories: Resource Barriers, Knowledge Flow Barriers, and Cultural Barriers. The selection of these categories were based partially on preliminary observations of the types of problems the Air Force was facing, and partially based on the organizational theories discussed below.

Resource Barriers

Finance theory states that "the wealth of a firm's shareholders is highest if the firm accepts every project that has a positive net present value (NPV)" (Brealey and Myers, 1991). However, there may be limitations on the resources available to the organization to carry out each project:

- the organization may not have access to enough capital to undertake all positive NPV project opportunities at the given time.
- the organization may not have adequate human resources to undertake all positive NPV project opportunities at the given time.

Hence, any organization has to develop a method of selecting the package of projects that is within their resource limits yet gives them the highest overall economic benefits.

The Air Force certainly has a limit to the financial and human resources available. The Air Force generates the costs and benefits of each project that is proposed, and prioritizes this list of projects based on the benefit to cost ratio. They will continue to undertake projects from this list until all resources are fully utilized. The accurate valuation of the costs and benefits of any project are crucial in determining whether the project is selected or not. In the Air Force, as with most organizations, the environment is still a poorly valued commodity. Many of the benefits from environmental projects are not properly measured, if they are measured at all. Hence, the adoption of pollution prevention projects is slowed down because in an organization with limited resources those projects that show the greatest overall measurable benefits will be chosen.

Knowledge Flow Barriers

Every organization requires a certain level of information in order to make determinations that are consistent with its rational decision making process. When information on certain benefits is not gathered or not communicated to the appropriate decision making authority, that benefit is likely to be undervalued. In many cases, pollution prevention initiatives may be the correct rational choice for the Air Force to undertake. However, because the P2 manager does not receive all the appropriate supporting data to pass on to the final decision authority, the decision makers can not justify the allocation of resources for the P2 projects as many other projects show greater economic benefits. Due to information flow barriers, the decision authority remains unaware that P2 projects are generally being undervalued.

Cultural Barriers

Edgar Schein (1992) suggests that the cultural change process in an organization may be thought of in terms of three primary steps: "unfreezing" the old (undesired) behavior, defining and effecting the new (desired) behavior, and stabilizing the desired changes ("refreezing"). There are barriers associated with each of the three steps in the change model. Each is a function of learning, of which Schein describes three types (Knoll 1993):

- Cognitive learning. In other words, knowledge acquisition and insight. Members develop a vision of the organization to which they belong whether or not management is consciously aware of the fact. Effecting an organizational change implies changing the cognitive learning of the organization. Two challenges to this change exist. Past learning embodied in organizational culture may limit or bias ability to perceive the new (desired) vision, and sometimes the vision is too complex to be communicated effectively. Nevertheless, individuals within the organization to be changed must either have, or be provided with, a desire to change.

- Habit and skill learning. "Bad habits and cultural rules" are offered as examples of particularly difficult aspects of this type of learning to overcome. Overcoming them requires that members admit that they are temporarily incompetent by dropping protective barriers and exposing themselves to "loss of face". Agreeing to adopt new ways implies that one's old ways were at

best inapplicable to the new situation. Suggesting new ways, exposes one's ideas to examination or ridicule.

• Emotional conditioning and learned anxiety. Present culturally embedded habits, values and assumptions are the result of collective organizational memory of past successes. Emotional conditioning and learned anxiety is the fear of change learned from an organization's history of punishing past innovators whose deviations from standardized behavior have led to less than the desired results. The greater the array of behaviors subjected to past punishment, the narrower the range of changes the organization is likely to entertain.

As Meyer and Rowan state, "Institutionalized products, services, techniques, policies, and programs function as powerful myths, and many organizations adopt them ceremonially, but conformity to institutionalized rules often conflicts sharply with efficiency criteria and, conversely, to coordinate and control activity in order to promote efficiency undermines an organization's ceremonial conformity and sacrifices its support and legitimacy" (1992).

The Air Force is an organization that has a defined culture and entrenched way of doing things that has been developed and reinforced by generations of Air Force personnel. In this type of organization, making changes and introducing new concepts threaten the old, comfortable, way of doing business and meets with active resistance. Donald Schon has termed this type of resistance as "dynamic conservatism" - a tendency to fight to remain the same (Schon, 1971) [i].

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[i] In *Beyond the Stable State*, Donald Schon provides an excellent example of dynamic conservatism by describing a story provided by American historian Elting Morison in his book *Men, Machines, and Modern Times*. Morison tells the story of the introduction into the US Navy of continuous-aim firing - a method of keeping guns trained on an enemy ship when both your ship and the enemy's are moving up and down and steaming in different directions at the same time.

The Navy's standard method, in Theodore Roosevelt's time employed a very heavy set of gears and a highly trained crew with a kind of football coach/naval captain who gave directions to the crew. Although there was a gunsight, nobody dared put his eye to it because of the recoil of the gun. Sims, a young naval officer, developed a new method which took advantage of the inertial movement of the ship; he simplified the gearing procedure and isolated the sight from recoil, so that it became possible for the operator to keep his eye on the sight and move the gears at the same time. He tested his system and was able to effect a remarkable increase in accuracy.

Sims then wrote to Naval Headquarters, with the aim of having his device officially adopted throughout the fleet, and the navy wrote back that it was not interested. But Sims was persistent and finally persuaded the Navy to test his

Hence, it is easy to understand why a new paradigm such as pollution prevention has considerable cultural barriers to overcome.

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method of continuous-aim firing. The test, as devised by the Navy, consisted in strapping the device to a solid block in the Navy Yard in Washington where, deprived of the inertial movement of the ship, it failed, proving scientifically that continuous-aim firing was not feasible. Sims was not deterred. Finally, he reached President Theodore Roosevelt directly, and the President forced the device down the Navy's throat. Under these conditions the Navy accepted it, and achieved a remarkable increase in accuracy in all theaters.

Morison points out that the Navy understandably tried to protect the social system of the ship from a technology which was in fact destructive of it. By introducing continuous-aim firing, Sims threatened a specialized, highly trained team, replacing it with an operation in which, in effect, any recruit could serve.

Appendix D: Funding Categories

Appropriations [i]

• Appropriations represent permission to obligate the Treasury to pay for goods or services. Appropriations are laws passed by Congress which authorize the obligation and expenditure of specified amounts of money. These laws also specify the purposes for which the funds may be used. The Department of Defense (DOD) annually receives funding from approximately 85 of these appropriations. The funds received by DOD from these appropriations fall in five general areas:

- Military Personnel (3500),
- Operations and Maintenance (3400 and 7045),
- Procurement (3010, 3020, and 3080),
- Military Construction (3300), and
- Research, Development, Test and Evaluation (3600).

• Appropriations most commonly associated with ESOH activities are 3080, 3400, and 3600.

- **30XX** Appropriations are used to procure items and have a time span of three years. 3010 appropriation is for aircraft, 3020 is for missiles, and 3080 is for other appropriations. Appropriation 3080 provides for procuring the following categories of material with a unit cost of $50,000 or more:

- Munitions and associated equipment,
- Vehicular equipment,
- Electronic and telecommunication equipment, or
- Other base maintenance and support equipment.

[i] This information is taken directly from the *USAF Environmental Quality Research, Development and Acquisition Strategic Plan* developed by HSC/XR, May 27, 1994.

· **3400** Appropriations are for operations and maintenance and are valid for one year. 3400 appropriations provide for expenses, operation, maintenance and administration of the Air Force. They provide for the day-to-day operating and maintenance cost of activities and include contract services, fuel, supplies and repair parts.

· **3600** Appropriations are used for research, development, test and evaluation (RDT&E) of new systems, and have a time span of two years.

• The category associated with Research and Development is 3600. The types of 3600 money available for R&D are as follows:

6.1 Basic Research

6.2 Exploratory Development: Includes all effort directed toward the solution of specific military environmental problems, short of major development projects.

6.3A Advanced Development: Includes all projects which have moved into further development for experimental or operational testing.

6.3B Demonstration and Validation: Includes pilot-scale and pilot plant demonstrations and performance testing in as realistic an operating environment as possible to demonstrate the general military utility or cost-saving potential of the technology when applied in field situations.

6.4 Engineering and Manufacturing Development: Those development programs being engineered or planned for use, but which have not yet been approved for full operational fielding.

6.7 Operational Systems Development: Research and development efforts directed toward already fielded systems which have been accepted in a field context and have been tech-transferred but may have an ongoing or periodic development requirement.

Appendix E: Budget Cycle and POMing for Funds [i]

• The biennial Planning, Programming, and Budgeting System (PPBS) was created to formalize the decision process for weighing the costs associated with major weapons systems. The PPBS provides a Future-Year Defense Program (FYDP), a computerized database of Defense programs, approved by the Secretary of Defense.

• In April or May, each military department and Defense agency submits a Program Objective Memorandum (POM) to the Secretary of Defense. The POM presents a priority-ranked program and includes baseline force levels, support and activity levels, and deployments within the stated constraints of the Defense Planning Guidance (DPG). The DPG is the Department of Defense strategic plan for the development and employment of future forces. The DPG provides the Secretary of Defense's (SECDEF) threat assessment, policy, strategy, force planning, and resource planning guidance within broad fiscal constraints to all DOD organizations.

• The Office of the Secretary of Defense (OSD) provides fiscal guidance (an initial target) at the Total Obligational Authority (TOA) level for each of the six POM years. (TOA is the total money the Air Force will be able to allocate).

• The POM identifies total program requirements for a six year period (as constrained by OSD guidance), and provides justification for requested changes to the Future Year Defense Plan (FYDP) baseline. The FYDP is the official document and database which summarizes SECDEF-approved plans and programs for the DOD. It is updated five times every two-year PPBS cycle. It is based on the DPG's strategic concepts and guidance and includes an assessment of the risk associated with the current and proposed forces and support programs.

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[i] This information is taken directly from the *USAF Environmental Quality Research, Development and Acquisition Strategic Plan* developed by HSC/XR, May 27, 1994.

• A key objective of POM development is to provide requirement capabilities and meet critical needs within a balanced program weighted by mission need areas. As the world, domestic, fiscal and technological environments shift, these weights and subsequent balances may shift as directed by the Secretary of the Air Force (SAF) and Chief of Staff of the Air Force.

Appendix F: P2 Project Approach and Prioritization System

The following illustration is based on the system that is operating for the C-17 weapon system.

Project Approach

First: McDonnell Douglas, SPO or bases (the users, i.e. ACC) brings forth projects that they feel are needed and worthwhile.

Phase I: Then the project is fully reviewed (could take anywhere from 5 months to 3 years for this review depending on scope, magnitude, and complexity of project).
It is reviewed by: Technical staff at SPO - Nelson puts together a team to do this review. Also technical review done by C-5 staff at San Antonio as the C-5 is an old system which has many similarities to the C-17.
The Phase I Report will contain:
a) LCC Estimate
b) Risk Assessment - risk to program of continuing with *Hazmat* vs. elimination of it.
c) 3 critical parameters: Cost, Schedule (how long does cleaning take with new solvent), and Performance (Is it clean enough using new solvent?).
d) RM & A Analysis - Reliability, Maintainability, and Availability Analysis.
e) Lab Pilot Test - did it work in Lab?
f) Shop-floor evaluation or Production evaluation - do the workers using the job like the new system or not?
g) Occupational Safety and Health Administration (OSHA) standards for toxicity and worker safety considerations.

Phase II: This is the implementation phase.

Currently C-17 SPO has about 12 new projects in phase II on contract, about 40 in various stages of Phase I, and another 50 on the wish-list.

Project Prioritization

The System of Input from the users for prioritizing projects is:

a) Each Base lists all of its problems: transport related, C-17 related, F-16 related, etc.

b) Information passed on to their respective MAJCOM (i.e. ACC, AMC, AETC) and each MAJCOM screens and prioritizes their lists.

c) Those related to Acquisition and Weapon System Problems are sent to AFMC

d) AFMC then sends along the problems to the appropriate SPO's

e) The SPO's then have to find ways to fund these projects and get them done. These problems, that are coming from the user and have made it through all the different chains of command, are probably pretty important to deal with. They also have high publicity so it looks good for the SPO to handle these problems effectively.

JOINT DEPOT ENVIRONMENTAL PANEL (JDEP)

MISSION

The Joint Policy Coordinating Group on Depot Maintenance (JPCG-DM) chartered the JDEP in 1988 to facilitate information exchange on environmental issues, technologies, and processes with potential application in the depot maintenance community.

FUNCTIONS

- Review the depot's current environmental programs and compile information on techniques and processes with potential application at other activities.
- Facilitate cooperation and coordination between the Services to avoid unnecessary duplication of development and implementation costs.
- Identify and advocate environmental initiatives with the potential for reducing liability and improving capability and efficiency. Recommend a lead Service when appropriate.
- Establish liaison with federal agencies such as the Defense Logistics Agency (DLA), the Office of the Secretary of Defense (OSD), and the Environmental Protection Agency (EPA).

ORGANIZATION

The director of the Joint Depot Maintenance Analysis Group chairs the JDEP, which consists of a principal representative from each Service's logistics headquarters, the Office of the Deputy Under Secretary of Defense for Environmental Security, and DLA. The JDEP has established a network that includes designated points of contact at all Department of Defense (DOD) organic maintenance depots and Service laboratories. The panel holds each of its quarterly meetings at a different depot maintenance activity to facilitate briefings on new environmental efforts and encourage demonstrations of successful initiatives. Meetings are open to associated depot personnel.

ENVIRONMENTAL STRATEGY

In December 1989, the JPCG-DM adopted an pollution prevention strategy that provides a unified statement of policy and direction to the DOD depot maintenance community. The strategy was updated in March 1993. The objective is for the depot maintenance community to work continually toward a goal of protecting the environment by eliminating pollutants and promoting cultural change to instill an environmental ethic throughout the depot maintenance community. The strategy identifies these critical elements:

- Apply new and emerging technology to repair processes and develop environmentally safe alternatives to hazardous air emissions, soil and water contaminants, and hazardous waste. Fund research, development, testing, and evaluation (RDT&E) when no suitable technology exists.
- Obtain dedicated resources in support of pollution prevention programs.
- Foster technology transfer through interservice cooperation and coordination on environmental issues and solutions to provide rapid and economical development of pollution prevention technology.
- Promote environmental awareness through training.
- Achieve a harmonious relationship with regulators, federal agencies, and the local community through active outreach efforts.
- Work with the acquisition community to eliminate maintenance related hazardous materials and waste in existing repair requirements and new weapon systems.

PROJECTS

The JDEP monitors the progress of environmental projects and provides quarterly updates to the JPCG-DM. This process has been facilitated through the development of the following generic project groups: plating, cleaning, stripping, administration, material alternation, bioenvironmental, and RDT&E. The panel also has represented the depot maintenance community and its environmental program through presentations at various government and industry functions.

INFORMATION EXCHANGE

The JDEP's multimedia approach to exchanging information includes:

- Formal exchange through briefings and presentations at JDEP-sponsored environmental workshops and through quarterly meeting minutes.
- Informal exchange through networking during open discussions and demonstrations conducted as part of the quarterly meetings.
- Publishing environmental successes in the *Joint Depot Maintenance Circular*, which is distributed quarterly to the depot maintenance community, OSD, and each Service's logistics headquarters.
- Developing the Technology Information System-Expanded (TIS-X) on-line data base, which provides information on technology and environmental projects.
- Distributing, throughout the depot maintenance community, project reports and legal analyses of proposed rules, regulations, and court decisions with an impact on environmental law.
- Participating in meetings, conferences, and workshops sponsored by other government groups and industry.

Technology Information System-Expanded (TIS-X)

BACKGROUND

The Technology Information System data base was established in 1984 in response to a growing need for an information system tailored to the depot maintenance community. Because the Joint Policy Coordinating Group on Depot Maintenance (JPCG-DM) requested additional files and easier access, the data base was expanded. It also was developed as an on-line system accessible by computer and modem.

ADMINISTRATION

Administered by the Joint Depot Maintenance Analysis Group in Dayton, Ohio, the TIS-X uses Battelle's automated search and indexing system (BASISPlus). The TIS-X, which resides in a Unix-based computer system called the Application Support Environment (ASE), is operated by the 88th Communications-Computer Systems Group at Wright-Patterson AFB, Ohio.

AVAILABLE DATA

The ASE menu gives the TIS-X users access to several functions, including electronic mail, a user directory and a bulletin board. With a file structure that allows users to expand the search capability from key words to phrases, the TIS-X software features

- ☐ a menu-driven user option that displays prompts for needed information;
- ☐ a recall option that allows users to edit and execute previous commands, thus reducing the amount of typing required during searches or displays; and
- ☐ highlighted search terms displayed on the user's terminal.

In addition, the TIS-X can provide reports in many different formats or users can develop unique formats.

ORGANIZATION

The TIS-X consists of three technology information files:

Joint Depot Maintenance Notebook: A summary of the Services' significant depot maintenance technology and environmental projects, this notebook was the Joint Technology Exchange Group's (JTEG) original file. Each entry has key words to simplify search and retrieval. The name and phone number of the person responsible for the project are included. This file became accessible by on-line phone link in December 1987.

Technology Group Status Reports: These reports summarize the significant technology and environmental projects the JTEG and the Joint Depot Environmental Panel (JDEP) have found of interest to the JPCG-DM. The file includes the name and phone number of the person responsible for the project along with the JTEG or JDEP principal representative. It became available in January 1988.

Depot Capability Matrix: This file is a matrix that displays the significant capabilities and techniques of each of the organic depots. Developed in August 1988, it is a catalogue of capabilities across the depot maintenance community categorized by commodity, product, process, technology, and depot.

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