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EPA Office of Compliance Sector Notebook Project

Profile of the Aerospace Industry

November 1998

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Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
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*Spanish translations available.

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AIA-	Aerospace Industries Association
AFS -	AIRS Facility Subsystem (CAA database)
AIRS -	Aerometric Information Retrieval System (CAA database)
BIFs -	Boilers and Industrial Furnaces (RCRA)
BOD -	Biochemical Oxygen Demand
CAA -	Clean Air Act
CAAA -	Clean Air Act Amendments of 1990
CARB-	California Air Resources Board
CERCLA -	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS -	CERCLA Information System
CFCs -	Chlorofluorocarbons
CO -	Carbon Monoxide
COD -	Chemical Oxygen Demand
CSI -	Common Sense Initiative
CWA -	Clean Water Act
D&B -	Dun and Bradstreet Marketing Index
DOC-	Department of Commerce
DOD-	Department of Defense
DOE-	Department of Energy
ELP -	Environmental Leadership Program
EPA -	United States Environmental Protection Agency
EPCRA -	Emergency Planning and Community Right-to-Know Act
FIFRA -	Federal Insecticide, Fungicide, and Rodenticide Act
FINDS -	Facility Indexing System
GPS-	Global Positioning System
HAPs -	Hazardous Air Pollutants (CAA)
HSDB -	Hazardous Substances Data Bank
HVLP-	High Volume/Low Pressure
IDEA -	Integrated Data for Enforcement Analysis
LDR -	Land Disposal Restrictions (RCRA)
LEPCs -	Local Emergency Planning Committees
MACT -	Maximum Achievable Control Technology (CAA)
MCLGs -	Maximum Contaminant Level Goals
MCLs -	Maximum Contaminant Levels
MEK -	Methyl Ethyl Ketone
MSDSs -	Material Safety Data Sheets
NAAQS -	National Ambient Air Quality Standards (CAA)
NAFTA -	North American Free Trade Agreement
NAICS-	North American Industrial Classification System
NCDB -	National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP -	National Oil and Hazardous Substances Pollution Contingency Plan
NEC-	Not Elsewhere Classified
NEIC -	National Enforcement Investigation Center

NESHAP -	National Emission Standards for Hazardous Air Pollutants
NO_2 -	Nitrogen Dioxide
NOV -	Notice of Violation
NO_X -	Nitrogen Oxide
NPDES -	National Pollution Discharge Elimination System (CWA)
NPL -	National Priorities List
NRC -	National Response Center
NRMRL-	National Risk Management Research Laboratory
NSPS -	New Source Performance Standards (CAA)
OAQPS-	Office of Air Quality Planning and Standards
OAR -	Office of Air and Radiation
OECA -	Office of Enforcement and Compliance Assurance
OEM-	Original Equipment Manufacturer
OMB-	Office of Management and Budget
OPA -	Oil Pollution Act
OPPTS -	Office of Prevention, Pesticides, and Toxic Substances
OSHA -	Occupational Safety and Health Administration
OSW -	Office of Solid Waste
OSWER -	Office of Solid Waste and Emergency Response
OW -	Office of Water
P2 -	Pollution Prevention
PCS -	Permit Compliance System (CWA Database)
POTW -	Publicly Owned Treatments Works
RCRA -	Resource Conservation and Recovery Act
RCRIS -	RCRA Information System
SARA -	Superfund Amendments and Reauthorization Act
SDWA -	Safe Drinking Water Act
SEPs -	Supplementary Environmental Projects
SERCs -	State Emergency Response Commissions
SIC -	Standard Industrial Classification
SO_2 -	Sulfur Dioxide
SO_X -	Sulfur Oxides
TOC -	Total Organic Carbon
TRI -	Toxic Release Inventory
TRIS -	Toxic Release Inventory System
TCRIS -	Toxic Chemical Release Inventory System
TSCA -	Toxic Substances Control Act
TSS -	Total Suspended Solids
UIC -	Underground Injection Control (SDWA)
UST -	Underground Storage Tanks (RCRA)
VOCs -	Volatile Organic Compounds

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Environmental policies based upon comprehensive analysis of air, water and land pollution (such as economic sector, and community-based approaches) are becoming an important supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, compliance assurance, education/outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water and land) affect each other, and that environmental strategies must actively identify and address these interrelationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. Recognition of the need to develop the industrial "sector-based" approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was initiated by the Office of Compliance within the Office of Enforcement and Compliance Assurance (OECA) to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, states, the regulated community, environmental groups, and the public became interested in this project, the scope of the original project was expanded. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several interrelated topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community and the public.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is available. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further explored based upon the references listed at the end of this profile. As a check on the information included, each notebook went through an external document review process. The Office of

Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate and up-to-date summaries. Many of those who reviewed this notebook are listed as contacts in Section IX and may be sources of additional information. The individuals and groups on this list do not necessarily concur with all statements within this notebook.

I.B. Additional Information

Providing Comments

OECA's Office of Compliance plans to periodically review and update the notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project (2223-A), 401 M St., SW, Washington, DC 20460. Comments can also be sent via the web page or to notebook@epamail.epa.gov.

Adapting Notebooks to Particular Needs

The scope of the industry sector described in this notebook approximates the national occurrence of facility types within the sector. In many instances, industries within specific geographic regions or states may have unique characteristics that are not fully captured in these profiles. The Office of Compliance encourages state and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested states may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with state and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume. If you are interested in assisting in the development of new notebooks, please contact the Office of Compliance at 202-564-2395.

II. INTRODUCTION TO THE AEROSPACE INDUSTRY

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the aerospace industry. Facilities described within this document are described in terms of their Standard Industrial Classification (SIC) codes.

II.A. Introduction, Background, and Scope of the Notebook

This industry sector profile provides an overview of the aerospace industry as listed under SIC industry groups 372 and 376. Establishments listed under these codes primarily manufacture and assemble aircraft, space vehicles, guided missiles, and all the associated parts.

Within the industry groups 372, Aircraft and Parts, and 376, Guided Missiles and Space Vehicles and Parts, are the following SIC codes:

- 3721- Aircraft
- 3724- Aircraft Engines and Engine Parts
- 3728- Aircraft Parts and Auxiliary Equipment, Not Elsewhere Classified
- 3761- Guided Missiles and Space Vehicles
- 3764- Guided Missile and Space Vehicle Propulsion Units and Propulsion Unit Parts
- 3769- Guided Missile and Space Vehicle Parts and Auxiliary Equipment, Not Elsewhere Classified

While this notebook covers all of the SIC codes listed above, the large number and variability of the products will not allow a detailed description of each. Instead, commonalities in the industrial processes, pollutant outputs, and pollution prevention opportunities will be identified and described in more general terms. An overview of general manufacturing processes within the industry will be presented, along with descriptions of the actual products and information on the state of the industry. Although certain products covered under these SIC codes may not be specifically mentioned, the economic, pollutant output, and enforcement and compliance data in this notebook covers all establishments producing aerospace products.

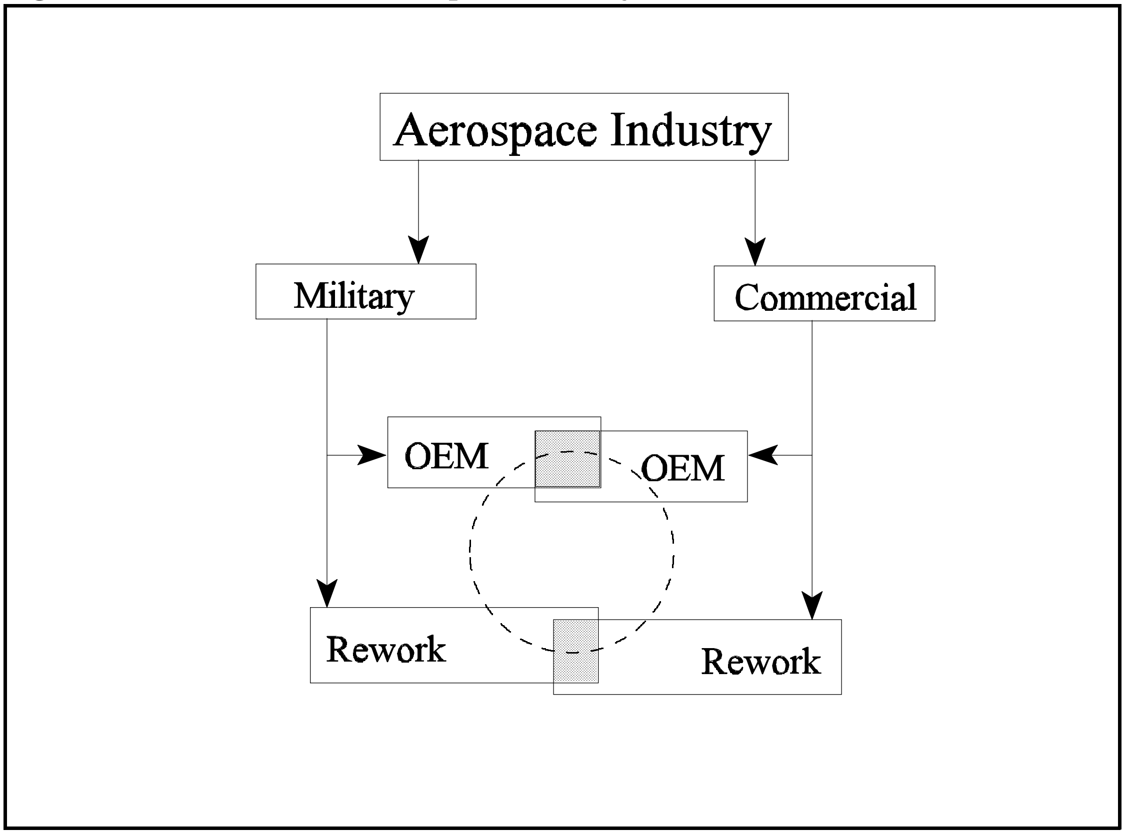
SIC codes were established by the Office of Management and Budget (OMB) to track the flow of goods and services within the economy. OMB is in the process of changing the SIC code system to a system based on similar production processes called the North American Industrial Classification System (NAICS). In the NAICS, the SIC codes for the aerospace industry correspond to the following NAICS codes:

SIC	Industry Sector	NAICS
3721	Aircraft	336411
3724	Aircraft Engines	336412
3728	Aircraft Parts	336413
3761	Guided Missiles and Space Vehicles	336414
3764	Space Vehicle Propulsion Units	336415
3769	Guided Missile and Space Vehicle Parts	336419

II.B. Characterization of the Aerospace Industry

There are many different aerospace products classified under the six aerospace SIC codes. The products produced, geographical distribution, and economic trends of the aerospace industry are discussed below. Figure 1 represents the general structure of the aerospace industry. The aerospace industry operations are often classified as either military or commercial and as either original equipment manufacturers (OEM) or rework. Most aerospace facilities specialize in either military or commercial and either rework or OEM. OEM facilities might do both military and commercial work, and likewise for rework facilities. Some facilities might even work in all areas of the industry, as indicated by the dotted circle in Figure 1.

Figure 1: Structure of the Aerospace Industry



Source: NESHAP BID, USEPA/OAQPS, May 1994.

II.B.1. Product Characterization

The aerospace industry consists of manufacturers of aircraft, aircraft engines, aircraft parts, guided missiles and space vehicles, and guided missile and space vehicle propulsion units and parts. Table 1 lists the products included in aircraft, aircraft engines, and space vehicle and missile categories. One source of manufacturer and model information is *The Aerospace Sourcebook*, published by *Aviation Week & Space Technology*.

Table 1: Products Included in the Aerospace Industry

Category	**Products**
Military Fixed-Wing Aircraft	Attack Bombers Cargo/Transport/Refueling Early Warning Electronic Warfare Fighters Observation Patrol ASW Reconnaissance Research/Test Bed Training Utility
Commercial Fixed-Wing Aircraft	Narrow Body Turbofans Wide Body Turbofans Turboprops
Rotary-Wing Aircraft	Naval Scout/Attack Tiltrotor Training Transport Utility
Business & General Aviation Aircraft	Turbofan Turboprop Reciprocating Engine-Powered
Gas Turbine Engines	
Unmanned Aerial Vehicles and Drones	
Space/Launch Vehicles	Manned Systems Unmanned Systems
Missiles	Air-to-Air Air-to-Surface Anti-Armor Anti-Ballistic Anti-Ship Anti-Submarine Surface-to-Air Surface-to-Surface

Source: Aerospace Source Book, Aviation Week & Space Technology, 1/12/98.

These manufacturing facilities are classified under SIC codes 372 and 376 as listed above. In order to discuss the production of these parts in a sequential manner, Sections II and III of this profile are divided into four categories: aircraft parts, aircraft assembly, aircraft rework and repair, and space vehicles and guided missiles.

The diverse nature of parts needed to produce these products requires the support of many other major U.S. industries. Many of the parts utilized by aerospace manufacturers are made by other industry sectors such as the plastics and rubber industry, the fabricated metal industry, the metal casting industry, the glass industry, the textile industry, and the electronic components industry. Manufacturing and assembling of complete units in the aerospace industry typically involves prime contractors and several tiers of subcontractors, as follows:

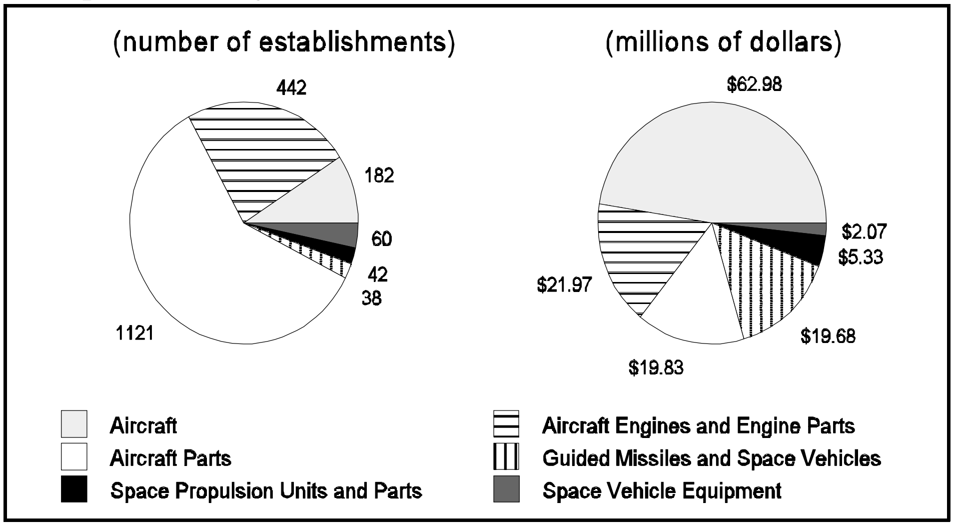
• Prime Contractors-	Design (develop) and assemble or manufacture complete units.
• First Tier Subcontractors-	Do major assembly and/or manufacture of sections of air/space craft without designing or assembling complete units.
• Second Tier Subcontractors-	Make various subassemblies and sections.
• Third Tier Subcontractors-	Produce machined components and sub-assemblies.
• Fourth Tier Subcontractors-	Specialize in the production of particular components and in specific processes.

Typically, those facilities designated as "prime contractors" are included in SIC codes 3721, 3724, 3761 and 3764. Both first and second tier subcontractors correspond to SIC codes 3728 and 3769. Third and fourth tier subcontractors may be included in a variety of industry SIC codes (EPA/OAQPS, 1994).

Figure 2 illustrates the distribution of manufacturing facilities and value of shipments within the aerospace industry. These figures show that while the aircraft parts sector of the aerospace industry is by far the largest in terms of number of establishments, the finished aircraft sector has the largest value of shipments.

The aircraft-related portion of the aerospace industry is much larger than the space vehicle and missile portion. The aircraft portion comprises 93 percent of the establishments and 79 percent of the value of shipments. However, considering the small percentage of facilities engaged in guided missile and space vehicle manufacturing (2 percent), the value of shipments is relatively high (15 percent). In general, facilities which are responsible for assembling the final aerospace products are few and their production rates are low, but the value of each of their products greatly surpasses that of the supporting industries.

Figure 2: Number of Establishments and Value of Shipments for the Aerospace Industry



Source: *1992 Census of Manufacturers,* USDOC, 1995.

Aircraft Engines and Engine Parts and Aircraft Parts and Equipment

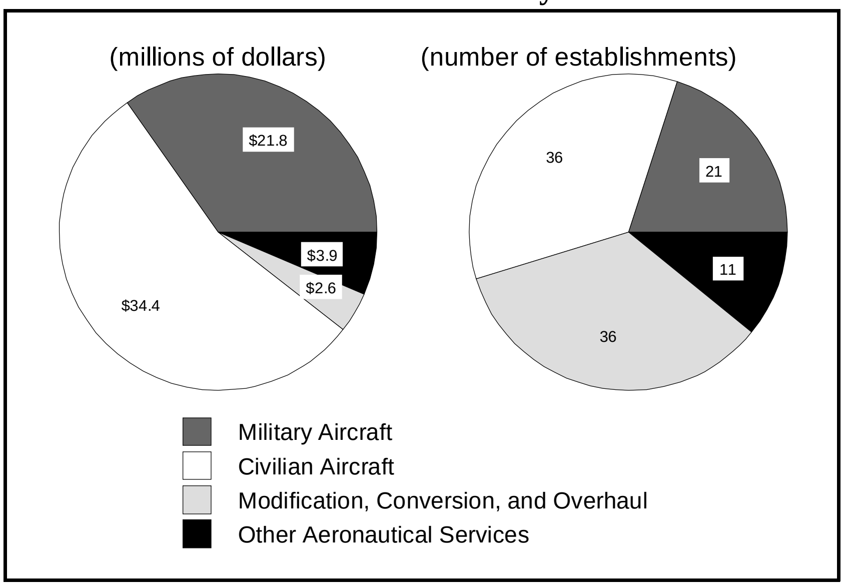
The aircraft engines, engine parts, and aircraft parts industry is classified under SIC 3724 and 3728. Facilities producing these parts employ processes similar to many other metal casting, fabricating, and finishing facilities, as well as processes from a wide range of other industries. Typical products manufactured by these facilities include: engines, exhaust systems, motors, brakes, landing gear, wing assemblies, propellers, and many other related products. The primary customers for these industries are the establishments involved in the assembly of aircraft, classified under SIC 3721.

Aircraft Assembly

The aircraft industry is made up of establishments primarily engaged in manufacturing or assembling complete aircraft and is classified under SIC 3721. This industry also includes establishments owned by aircraft manufacturers and primarily engaged in research and development on aircraft, whether from enterprise funds or on a contract or fee basis (Census, 1995). There are many different types of aircraft included in this industry, from airplanes and helicopters to blimps and balloons. However, this profile focuses primarily on the production of airplanes since they represent the largest portion of the industry. Typical products include fixed wing aircraft, helicopters, gliders, balloons, and research and development on aircraft.

The major customers of the aircraft industry are commercial airlines and transport companies and the military. Figure 3 shows the distribution within the industry of value of shipments and number of establishments. Civilian aircraft represents the largest percentages in value of shipments and number of establishments. Approximately one-third of the establishments in this industry are involved in the repair and rework of aircraft. These facilities will be discussed in Section III.

Figure 3: Value of Shipments and Number of Establishments for the Aircraft Industry



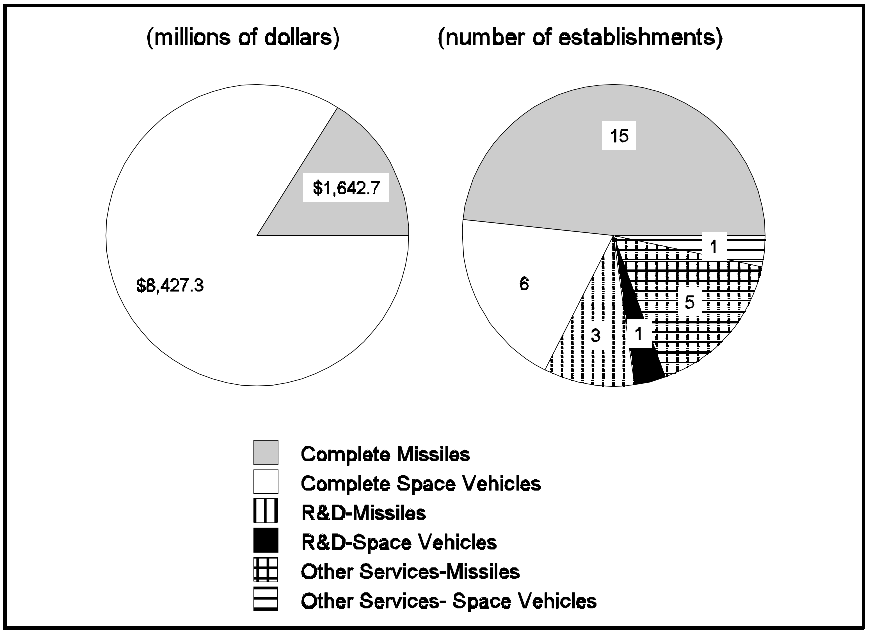
Source: 1992 Census of Manufacturers, USDOC, 1995.

Guided Missiles and Space Vehicles and Associated Parts

The guided missiles and space vehicles industry includes establishments primarily engaged in manufacturing and research and development on guided missiles and space vehicles, propulsion units, and parts. Typical products covered under SIC 3761, 3764, and 3769 include guided and ballistic missiles, space and military rockets, space vehicles, propulsion units and engines for missiles and space vehicles, airframe assemblies, and research and development on these products. The primary customer for this industry is the military, however space vehicles are also used by commercial entities for releasing communications satellites.

Figure 4 illustrates the specialization within the guided missile and space vehicle industry. The Census of Manufacturers identifies only 31 facilities in this sector. Value of shipment data is not available for facilities providing R&D and other services to protect individual facility confidentiality. Only six facilities, or less than a quarter of the facilities in this industry, are producing complete space vehicles. The value of shipments for these facilities, however, comprised more than three-quarters of the total value of shipments for the industry.

Figure 4: Value of Shipments and Number of Establishments for the Space Vehicles and Guided Missiles Industry

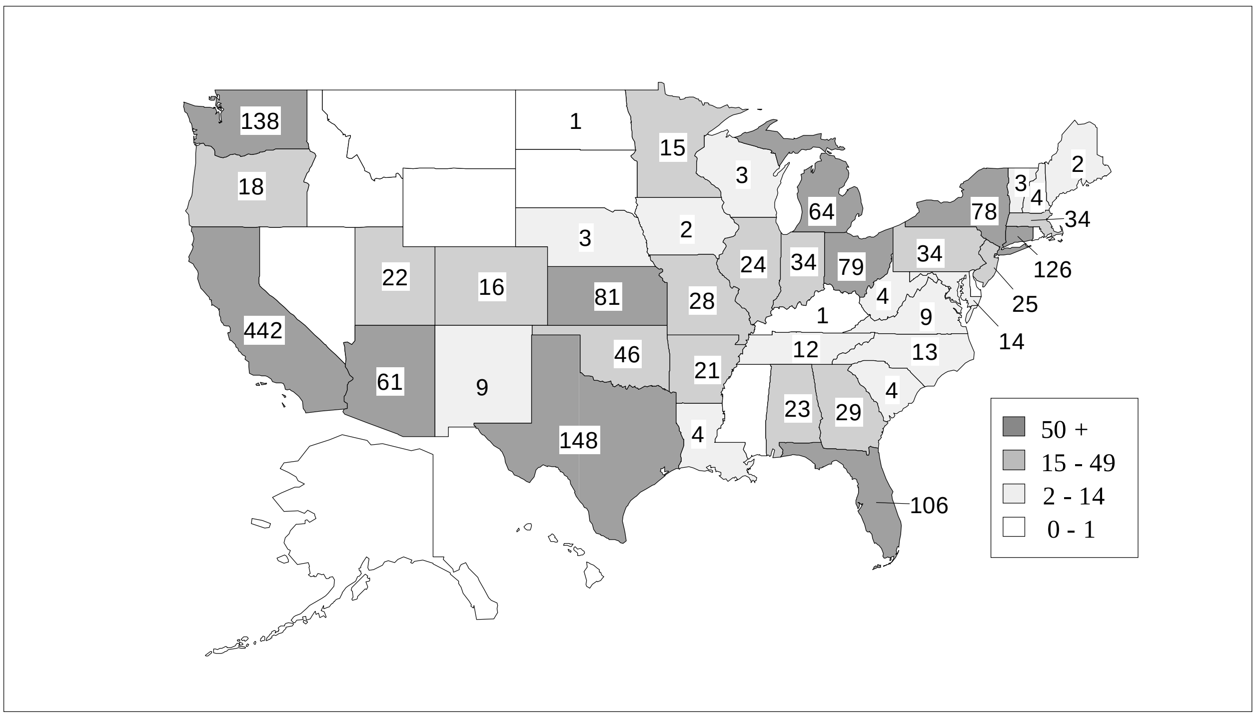


Source: *1992 Census of Manufacturers*, USDOC, 1995.

II.B.2. Industry Size and Geographic Distribution

Figure 5 shows the U.S. distribution of aerospace facilities. Generally, the geographic distribution of aerospace facilities is determined by the location of industrialized areas of the country. As with many manufacturing industries, the ease of transportation of materials, products, and skilled workers influence facility location.

Figure 5: Geographic Distribution of Aerospace Manufacturing Facilities



Source: *1992 Census of Manufacturers*, USDOC, 1995.

Table 2 lists the facility size distribution within the aerospace sectors. As previously mentioned, the aircraft and aircraft parts industry (1,745 facilities) is more than ten times larger than the space vehicles, guided missiles, and parts industry (140 facilities). Aircraft and aircraft part manufacturing generally employs less people per facility than space vehicle and guided missile manufacturing. However, the number of employees in the aircraft industries still overshadows that of the missile and space vehicle industries, 645.9 thousand and 149.6 thousand respectively.

Table 2: Facility Size Distribution for the Aerospace Industry

	Aircraft and Aircraft Engines and Parts (SIC 372)		**Aircraft (SIC 3721)**		**Aircraft Engines and Engine Parts (SIC 3724)**		**Aircraft Parts and Equipment (SIC 3728)**	
Employees per Facility	Number of Facilities	Percentage of Facilities	Number of Facilities	Percentage of Facilities	Number of Facilities	Percentage of Facilities	Number of Facilities	Percentage of Facilities
1-9	652	37%	60	33%	112	26%	480	43%
10-49	543	31%	42	23%	130	29%	371	33%
50-249	340	19%	29	16%	129	29%	182	16%
250-2499	173	10%	32	18%	63	14%	78	7%
2500 +	37	2%	19	10%	8	2%	10	1%
Total	**1,745**	100%	182	100%	442	100%	1,121	100%
	Space Vehicles, Guided Missiles, and Parts (SIC 376)		**Space Vehicles and Guided Missiles (SIC 3761)**		**Space Propulsion Units and Parts (SIC 3764)**		**Space Vehicle and Guided Missiles Parts (SIC 3769)**	
Employees per Facility	Number of Facilities	Percentage of Facilities	Number of Facilities	Percentage of Facilities	Number of Facilities	Percentage of Facilities	Number of Facilities	Percentage of Facilities
1-9	26	19%	4	10%	6	14%	16	27%
10-49	27	19%	5	13%	8	19%	14	23%
50-249	31	22%	5	13%	8	19%	18	30%
250-2499	37	26%	12	32%	15	36%	10	17%
2500 +	19	14%	12	32%	5	12%	2	3%
Total	**140**	100%	38	100%	42	100%	60	100%

Source: 1992 Census of Manufacturers, Industry Series: Aerospace Equipment, Including Parts, US Department of Commerce, Bureau of the Census, 1995.
Note: 1992 Census of Manufacturers data are the most recent available. Changes in the number of facilities, location, and employment figures since 1992 are not reflected in these data.

Table 3 further divides the geographic distribution of aerospace facilities. The top states in which the aerospace industries are concentrated are given along with their respective number of establishments.

Table 3: States with the Largest Number of Aerospace Manufacturing Facilities				
	Aircraft and Aircraft Parts (SIC 372)		**Space Vehicles, Guided Missiles and Associated Parts (SIC 376)**	
	Top States	Establishments	Top States	Establishments
States in which industry is concentrated, based on number of establishments	California Texas Washington Connecticut	393 140 136 126	California Arizona Texas Alabama	49 9 8 7
Percent of Total	45%		52%	
Source: *1992 Census of Manufacturers, Industry Series: Aerospace Equipment, Including Parts,* US Department of Commerce, Bureau of the Census, 1995.				

Dun & Bradstreet's *Million Dollar Directory*, compiles financial data on U.S. companies including those operating within the aerospace industry. Dun & Bradstreet ranks U.S. companies, whether they are a parent company, subsidiary or division, by sales volume within their assigned 4-digit SIC code. Table 4 lists the top 10 aerospace companies by sales.

Table 4: Top U.S. Aerospace Companies			
Rank	Company	1997 Sales (millions of dollars)	SIC Code(s) Reported
1	General Electric Co.- Fairfield, CT	79,179	3724, 3511, 3612, 3641, 3632, 4833
2	Lockheed Martin Co.- Bethesda, MD	26,875	3721, 3761, 3663, 3764. 3812, 3728
3	United Technologies Corp.- Hartford, CT	23,273	3724, 3585, 3534, 3721, 3842, 3714
4	The Boeing Co.- Seattle, WA	22,681	3721, 3663, 3761, 3764, 3812, 3728
5	Hughes Electronics Corp.- Los Angeles, CA	14,772	3761, 3812, 3714, 3651, 3663, 3699
6	Allied Signal Inc.- Morristown, NJ	13,971	3724, 3812, 3728, 3761, 3714, 2824, 2821
7	McDonnell Douglas Corp*-Saint Louis, MO	13,834	3721, 3761, 3764, 3812, 6159
8	Textron Inc.- Providence, RI	9,274	3721, 3714, 3452, 3711, 6141, 6159
9	Northrop Grumman Corp.- Los Angeles, CA	8,071	3721, 3761, 3728, 3812, 3825, 4581
10	The BF Goodrich Co.- Richfield, OH	2,238	3728, 3724, 7699, 2821, 2843
Source: Dunn & Bradstreet's Million Dollar Directory, 1997. Note: Not all sales can be attributed to the companies' aerospace operations. *McDonnell Douglas Corp. is now part of The Boeing Co.			

Readers should note that: (1) companies are assigned a 4-digit SIC code that resembles their principal industry most closely; and (2) sales figures include total company sales, including subsidiaries and operations (possibly not related to aerospace). Additional sources of company specific financial information include Standard & Poor's *Stock Report Service*, *Ward's Business Directory of U.S. Public and Private Companies*, Moody's Manuals, and company annual reports.

The Bureau of the Census publishes concentration ratios, which measure the degree of competition in a market. They compute the percentage of the value of products shipped by establishments classified within an industry of the total value of these products shipped from any establishment. Within the aerospace industry, the aircraft industry and the space vehicle and guided missile industry had the greatest coverage ratios in 1992: 97 percent each. The aircraft engine, aircraft parts, propulsion units, and auxiliary space vehicle equipment coverage ratios were 95, 74, 86, and 40 percent respectively.

II.B.3. Economic Trends

Growth in the U.S. aerospace industry will be influenced by several key factors, including constrained defense spending by the U.S. and foreign governments, increased productivity and technological innovation, foreign competition, continuing expansion of the global economy, investment in research and development, offsets and outsourcing, and support by foreign governments for their industries.

Domestic Trends

In recent years there has been considerable consolidation of aerospace companies, especially those supplying the military. This has resulted in some reductions in labor force and closing of some aerospace facilities in the U.S. However, in constant 1992 dollars, the value of U.S. shipments in 1996 of complete aircraft (all types, civil and military) rose by about six percent over the value of shipments in 1995. The value of those shipments was expected to rise further by about thirty percent in 1997 and about five percent in 1998.

<u>Military</u>

In September 1996, Congress passed a DOD budget for FY 1997 that, for the first time in more than a decade, did not reduce spending from the previous year. In addition, the legislation provided more funding for procurement of aircraft and missiles than DOD had requested. Also, DOD reduced funding for R&D, which means that private companies will have to increase their share of the total amount spent on R&D if the overall level of technology investment and advancement is to be maintained.

In the missiles sector, air-to-surface weapons should experience the most growth relative to other types of missiles. Strong focus will be placed on improving guidance capabilities, mainly through the use of the U.S. Global Positioning System (GPS) (USDOC, 1998).

Commercial

Of all the aerospace sectors, the large civil transport aircraft sector is expected to experience the fastest rate of growth from 1997 through 2001. With the significant increase in production rates undertaken by Boeing in 1996, the value of shipments in 1997 of large civil transports could be as much as sixty percent higher than that of 1996, with another increase of about ten percent expected in 1998 (USDOC, 1998).

Even as U.S. aerospace workers are being laid off because of consolidation in some companies, workers are being hired by other firms because of increasing orders. Sales of large transport aircraft are expected to come from the retirement and replacement of aircraft plus additional aircraft to allow for air traffic growth (USDOC, 1998).

The aircraft engines and parts sectors also should see production and shipments increase as suppliers respond to increased production rates by the manufacturers of commercial transports. The market for commercial transport engines alone is expected to total from $150 billion to $175 billion between 1996 and 2005 (USDOC, 1998).

International Trends

The internationalization of aerospace programs is increasing, and the U.S. aerospace industry is dependent on exports for a third of its market. The U.S. aerospace industry is affected significantly by the economies of foreign countries. The average annual increase in world GDP is expected to be three percent from 1996 through 2005. The main barriers facing U.S. manufacturers are foreign government support for their aerospace industries through direct and indirect subsidies, tariffs, and difficult and expensive licensing procedures. Additional access could be guaranteed if efforts succeed to expand membership and broaden the disciplines of several aircraft-related trade agreements (USDOC, 1998).

Military

The situation for firms in the defense industry is mixed. While some governments, such as those of North America and Europe (with the largest defense budgets), continue to seek ways to reduce their military expenditures, governments in South America (with relatively small defense budgets) are maintaining or increasing their defense spending. However, current economic crises in Asia may reduce exports to some countries. The pace of consolidation in Europe of aerospace and defense companies, which began later than in the U.S., is escalating just as the merger rate in the U.S. appears to be slowing (USDOC, 1998).

Commercial

Overall improvement in the global economy has buoyed the fortunes of the world's airlines. World air passenger traffic rose each year from 1994 to 1996, and increased traffic by airlines all over the world produced a significant turnaround in the large transport aircraft market, the largest part of the aircraft industry. The civil aircraft sector exports 60 percent of its total production and represents about 20 percent of the overall U.S. aerospace industry (USDOC, 1998).

Asian economic problems have not had serious widespread impacts on the aerospace industry to date. Companies such as Lockheed Martin and Boeing estimate that about five percent of their contracts for the next five years are tied to that region. It is possible that, considering the strength of the industry and the economy outside of Asia, other customers may step in and eliminate lower production rates (Smith, 1998).

Commercial space launch providers also are benefiting from the improved economic situation. Consumer demand for direct-to-home television, voice and data transmission, and other satellite services is increasing the demand for satellites and therefore for space launch vehicles to place them in orbit (USDOC, 1998).

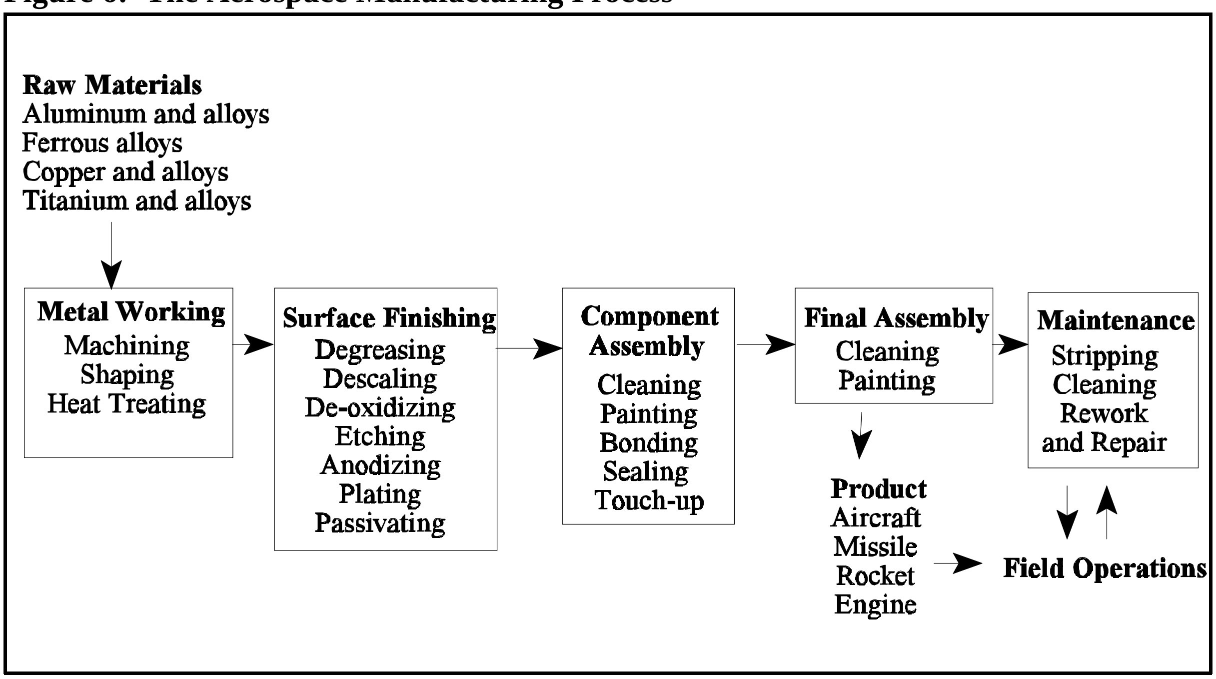
III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the major industrial processes within the aerospace industry, including the materials and equipment used, and the processes employed. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section IX for a list of resource materials and contacts that are available.

It is important to note that the FAA places very strict "airworthiness" guidelines on manufacturing and rework facilities for safety and quality control purposes, thus new pollution prevention alternatives may require a full evaluation and permitting process before they may be used.

This section contains a description of commonly used production processes, associated raw materials, by-products produced or released, and materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide a concise description of where wastes may be produced in the process. This section also describes the potential fate (via air, water, and soil pathways) of these waste products. Figure 6 shows a general aerospace manufacturing process diagram.

Figure 6: The Aerospace Manufacturing Process



Source: Aerospace Industries Association Newsletter, October 1994.

III.A. Aircraft Engines and Parts Industry

Manufacturing processes for aircraft engines and parts may consist of the following basic operations: materials receiving, metal fabricating, machining and mechanical processing, coating application, chemical milling, heat treating, cleaning, metal processing and finishing, coating removal (depainting), composite processing, and testing. Many facilities employ all of these processes in their operations, however, a facility may also employ only a subset of these operations, as with a facility that produces a single component or a facility that provides a service such as painting (EPA/OAQPS, 1997).

In addition, there are a number of operations that may be used at aircraft engine and parts facilities but are not typical and are performed in conjunction with a variety of industries, such as foundry operations and manufacturing of electronic components. For more information on foundry operations, see the *Profile of the Metal Casting Industry*, EPA, 1997. For more information on electronics and computers, see the *Profile of the Electronics and Computer Industry*, EPA, 1995.

III.A.1. Materials

There are many different materials involved in the production of engines and parts. The most common materials are alloys of aluminum, which are used primarily for aircraft structural components and exterior skin sections. Other materials are titanium, stainless steel, magnesium, and non-metallics such as plastics, fabrics, and composite materials. Typical forms of materials are honeycomb, wire mesh, plate, sheet stock, bar cast, and forged materials.

Metallic Alloys

Aluminum is used as a primary structural material in the aerospace industry because of its light weight, and because its alloys can equal the strength of steel. The ability to resist atmospheric corrosion also favors the use of aluminum. The type of alloy metal used depends on the desired characteristics of the finished product such as strength, corrosion resistance, machinability, ductility, or weldability (Horne, 1986).

High strength alloys typically contain copper, magnesium, silicon, and zinc as their alloying elements. Other alloying agents that may be used are: lithium for lightness; nickel for strength and ductility; chromium for tensile strength and elastic limit; molybdenum for strength and toughness; vanadium for tensile strength, ductility, and elastic limit; silicon as a deoxidizer; and powder metallurgy alloys for strength, toughness, and corrosion resistance (Horne, 1986).

The development of the gas turbine and the evolution of engines required materials with great resistance to temperature, stress, and oxidation. Nickel-based alloys have a high resistance to oxidation and are used for compressor blades and guide vanes, discs, turbine blades, shafts, casings, combustion chambers, and exhaust systems. Titanium alloys have excellent toughness, fatigue strength, corrosion resistance, temperature resistance, and a lower density than steel. Titanium alloys are frequently used to make hot-end turbine components and turbine rotor blades (Horne, 1986).

Non-Metallic Materials

Plastics, carbon and glass fibers, and synthetic resins and polymers are all used in aerospace manufacturing. There are two types of plastics used, thermoplastics and thermosetting materials. Thermoplastic materials are softened by heating and will harden on cooling and can be extruded (material is pressure forced through a shaped hole), injection molded (soft material is forced into a mold through a screw injector and pressure), or thermoformed (material is cast in a mold with heat and pressure). Thermosetting plastics are hardened by heating and form rigid three dimensional structures through chemical reactions. They are typically compression molded (Horne, 1986). For more information on non-metallic materials, refer to the *Profile of the Rubber and Plastic Industry*, EPA, 1995.

Carbon and glass fibre strands are used to reinforce plastics for strength and stiffness while remaining lightweight. Synthetic resins and polymers are used as adhesives which produce smooth bonds and a stiff structure which propagates cracks more slowly than in a riveted structure (Horne, 1986).

III.A.2. Metal Shaping

Another major process in the manufacturing of aircraft and other aerospace equipment is metal shaping. Shaping operations take raw materials and alter their form to make the intermediate and final product shapes. There are two phases of shaping operations: primary and secondary. Primary shaping consists of forming the metal from its raw form into a sheet, bar, plate, or some other preliminary form. Secondary shaping consists of taking the preliminary form and further altering its shape to an intermediate or final version of the product. Examples of primary and secondary shaping are listed in Table 5 below. Brief descriptions of the most common operations follow the table.

Table 5: Primary and Secondary Shaping Operations

Primary Shaping Operations	Secondary Shaping Operations
Abrasive Jet Machining	Stamping
Casting	Turning
Drawing	Drilling
Electrochemical Machining	Cutting and Shaping
Electron Beam Machining	Milling
Extruding	Reaming
Forging	Threading
Impact Deformation	Broaching
LASER Beam Machining	Grinding
Plasma Arc Machining	Polishing
Pressure Deformation	Planing
Sand Blasting	Deburring
Ultrasonic Machining	

Source: Pollution Prevention Options in Metal Fabricated Products, USEPA, January 1992.

Primary Shaping Operations

The most common primary shaping operations include casting, forging, extruding, rolling, cutting, coining, shearing, drawing, and spinning. Each of these operations is briefly described below.

Metal casting involves the introduction of molten metal into a mold or die having the external shape of the desired cast part. The mold or die is removed when the metal has cooled and solidified. Metal casting operations can be classified as either foundries or diecasters. The primary difference is that foundries pour molten metal relying on gravity to fill the mold and die casters use machines to inject molten metal under pressure into the mold. Foundry molds are typically used only once for each part. They are often made of sand grains bound together with chemicals or clay. Die casting molds are often reused thousands of times and are part of a larger diecasting machine that can achieve very high production rates. Foundries typically produce larger airplane parts such as engine blocks, turbine and compressor parts, and other mechanical parts from both ferrous and non-ferrous metals. Die casters typically produce smaller intricate parts from non-ferrous metals (EPA/OECA, 1995). For a more detailed discussion of metal casting operations see the *Profile of the Metal Casting Industry*, USEPA, 1997.

Once the molten metal is formed into a workable shape, shearing and forming operations are usually performed. Shearing operations cut materials into a desired shape and size, while forming operations bend or form materials into specified shapes. Shearing operations include punching, piercing, blanking, cutoff, parting, and trimming. These operations produce holes, openings, blanks, or parts. Forming operations shape parts by forcing them into a specific configuration, and include bending, extruding, drawing, spinning, coining, and forging. Bending is the simplest forming operation; the part is simply bent to a specific angle or shape and normally produce flat-shapes (EPA/OECA, 1995).

Extruding is the process of forming a specific shape from a solid blank by forcing the blank through a die of the desired shape. Complicated and intricate cross-sectional shapes can be produced by extruding. Rolling is a type of extruding that passes the material through a set or series of rollers that bend and form the part into the desired shape. Coining, another type of extruding, alters the form of the part by changing its thickness, producing a three-dimensional relief on one or both sides of the part, as found on coins (EPA/OECA, 1995).

Drawing and spinning form sheet stock into three-dimensional shapes. Drawing uses a punch to force the sheet stock into a die, where the desired part shape is formed in the space between the punch and die. In spinning, pressure is applied to the sheet while it spins on a rotating form so that the sheet acquires the shape of the form (EPA/OECA, 1995).

Forging operations produce a specific part shape, much like casting. The forging process is used in the aerospace industry when manufacturing parts such as pistons, connecting rods, and the aluminum and steel portion of wheels. However, rather than using molten materials, forging uses externally applied pressure that either strikes or squeezes a heated blank into a die of the required shape. Forging operations use machines that apply repeated hammer blows to a red-hot blank to force the material to conform to the shape of the die opening. Squeezing acts in much the same way, except it uses pressure to squeeze rather than strike the blank. Forging typically uses a series of die cavities to change the shape of the blank in increments. Depending on the shape, a forging die can have from one to over a dozen individual cavities (EPA/OECA, 1995).

Secondary Shaping Operations

Shearing (or cutting) operations include punching, piercing, blanking, cutoff, parting, shearing, and trimming. Basically, these are operations that produce holes or openings, or that produce blanks or parts. The most common hole-making operation is punching. Piercing is similar to punching, but produces a raised-edge hole rather than a cut hole. Cutoff, parting, and shearing are similar operations with different applications: parting produces both a part and scrap pieces; cutoff and shearing produce parts with no scrap; shearing is used where the cut edge is straight; and cutoff produces an edge shape rather than a straight edge. Trimming is performed to shape or remove excess material from the edges of parts (EPA/OECA, 1995).

Turning, drilling, and reaming processes typically use a lathe, which holds and spins the workpiece against the edge of a cutting tool. Drilling machines are designed for making holes and for reaming, or enlarging or finishing existing holes. Milling machines use multiple edge cutters to cut unusual or irregular shapes into the workpiece (EPA/ORD, 1990).

Broaching is a process whereby internal surfaces such as holes of circular, square or irregular shapes, or external surfaces like keyways are finished. A many-toothed cutting tool called a broach is used in this process. The broach's teeth are graded in size in such a way that each one cuts a small chip from the workpiece as the tool is pushed or pulled either past the workpiece surface, or through a leader hole. Broaching of round holes often gives greater accuracy and better finish than reaming (EPA/ORD, 1990).

Deburring involves removing metal shavings and burrs clinging to the cut edges of parts after machining has been completed. Deburring is typically done by one of two processes. Small parts can be deburred in a tumbler where the burrs are smoothed off the part by the constant friction with the tumbling media. This process, however, is not appropriate for long parts. Instead, long parts are scrubbed with an abrasive pad by hand or buffed with a power tool. The buffing operation can be performed either by hand or in an automatic operation (EPA/OAQPS, 1994).

Parts may also be honed and buffed to smooth their surfaces; spray-washed with an alkaline cleaner; and blown dry using compressed air. A protective coating of oil may be applied to parts that are stored on-site or shipped off-site to a heat-treating facility (EPA/NRMRL, 1995).

The metal working process creates much heat and friction. If the heat and friction are not reduced, the tools used in the process are quickly damaged and/or destroyed. Also, the quality of the products made is diminished because of inefficient tools and damage to the product while it is being manufactured. Coolants reduce friction at the tool/substrate interface and transfer heat away from the tools and the material being processed, reducing the time to process the metal, increasing the quality of the workmanship, and increasing tool life. The ability to transfer the heat away from the metal working process is why metal working fluids are often called coolants (Ohio EPA, 1993).

Oils are natural lubricants and provide this quality to coolants that are petroleum-based. Other coolants' ability to reduce friction comes from lubricating additives. During the metal working process, heat diffuses into the coolant. The heated coolant flows off the work area into a collection container or sump, where it cools off and then enters the cycle again. Water has excellent cooling characteristics and many coolants contain water or are primarily water. Soluble oils and semi-synthetic oils have both water and oil components. Coolants containing both oil and water require surfactants to form and maintain emulsions, a mixture of the oil and water, so that both properties can work together (Ohio EPA, 1993).

Heat Treating

Heat treating is the modification of the material's or part's metallurgical properties through the application of controlled heating and cooling cycles. For example, aluminum outer skin panels undergo a low temperature oven bake after forming to provide greater stress tolerance. Heat treating can be performed either before or after machining and includes carburizing (impregnating the surface with carbon), annealing (softening), stress relief, tempering, air furnace treating, and salt pot treating. Chemicals, such as methanol, are often used in heat treating ovens to maintain a chemically reducing atmosphere in order to obtain the proper metallurgical properties on the surface of the part being treated. After heat treating, the parts can either be cooled in ambient air or placed in a liquid quenching bath. The quench bath is typically a glycol solution, a chromate solution, or an oil (EPA/OAQPS, 1994).

Heat-treated parts can also be machined, honed, and deburred after they are returned to the plant. After machining, the parts are typically sprayed with a protective oil coating that controls corrosion until they are further processed (EPA/NRMRL, 1995).

III.A.3. Metal Finishing

Metal finishing and electroplating activities are performed on a number of metals and serve a variety of purposes; the primary purpose being protection against corrosion. Without metal finishing, products made from metals would last only a fraction of their unfinished life-span. Metal finishing alters the surface of metal products to enhance properties such as corrosion resistance, wear resistance, electrical conductivity, electrical resistance, reflectivity, appearance, torque tolerance, solderability, tarnish resistance, chemical resistance, ability to bond to rubber (vulcanizing), and a number of other special properties (e.g. electropolishing sterilizes stainless steel) (EPA/ORD, 1994).

These plating processes involve immersing the article to be coated or plated into a series of baths consisting of acids, bases, salts, etc. A wide variety of materials, processes, and products are used to clean, etch, and plate metallic and non-metallic surfaces. Typically, metal parts or work pieces undergo one or more physical, chemical, and electrochemical processes. Physical processes include buffing, grinding, polishing, and blasting. Chemical processes include degreasing, cleaning, pickling, milling, etching, polishing, and electroless plating. Electrochemical processes include plating, electropolishing, and anodizing (EPA/ORD, 1994).

Cleaning/Preparing

Cleaning

Aerospace components are cleaned frequently during manufacturing to remove contaminants such as dirt, grease, and oil, and to prepare the components for the next operation. Cleaning is important in order to ensure the successful application of later surface treatments. There are three main types of cleaning: aqueous, organic solvent, and abrasive. Aqueous cleaning covers a wide variety of cleaning methods such as detergents, acids, and alkaline compounds to displace soil rather than dissolving it as in organic solvent cleaning. Aqueous cleaners are either sprayed or used in cleaning baths, ultrasonic baths, and in steam cleaning. Three types of aqueous cleaning favored by the aerospace industry are:

- emulsification cleaning- emulsification cleaning uses water-immiscible solvents, surfactants, and emulsifiers.
- acid cleaning- sulfuric acid or hydrochloric acid is used to remove scale from metal; acid cleaning is sometimes known as pickling baths.
- alkaline cleaning- alkaline cleaning solutions (usually hot) contain builders (sodium salts of phosphate, carbonate, and hydroxide) and surfactants (detergents and soap) (CARB, 1997).

Abrasive cleaning is mechanical cleaning using abrasives such as rough fabric scrubbing pads, sandpaper, tumbling barrels, buffing wheels, and blasting equipment. Abrasives may be added to acid or alkaline cleaning solutions to improve cleaning action (CARB, 1997).

Masking

Maskants are coatings that are applied to a part to protect the surface from chemical milling and surface treatment processes such as anodizing, plating, and bonding. Maskants are typically rubber- or polymeric-based substances applied to an entire part or subassembly by brushing, dipping, spraying, or flow coating. Two major types of maskants are used: solvent-based and waterborne. After an adequate thickness of maskant has been applied to the part, the maskant is cured in a bake oven. The maskant is then cut following a specific pattern and manually stripped away from selected areas of the part where metal is to be removed. The maskant remaining on the part protects those areas from the etching solution.

Chemical Milling

Chemical milling is used to reduce the thickness of selected areas of metal parts in order to reduce weight. The process is typically used when the size or shape of parts precludes mechanical milling or when chemical milling is advantageous due to shorter processing time or its batch capability. Chemical milling is accomplished by submerging the component in an appropriate etchant. Commonly used etchants are sodium hydroxide for aluminum, nitric acid and hydrofluoric acid for titanium, dilute sulfuric acid for magnesium, and aqua regia (a mixture of nitric and hydrochloric acids) for stainless steel. The depth of the cut is closely controlled by the length of time the component is in the etchant and the concentration of the etchant. When the milling has been completed, the part is removed from the etchant and rinsed with water. Some metals may develop a smutty discoloration during the chemical milling process. A brightening solution, such as dilute nitric acid, is typically used as a final step in the process to remove the discoloration. After desmutting, the part either goes back to chemical milling for further metal removal or to the stripping area to have the maskant removed. The maskant may be softened in a solvent solution and then stripped off by hand (EPA/OAQPS, 1994).

Anodizing

Anodizing uses the piece to be coated, generally with an aluminum surface, as an anode in an electrolytic cell. Anodizing provides aluminum parts with a hard abrasion- and corrosion-resistant film. This coating is porous, allowing it to be dyed or to absorb lubricants. This method is used both in decorative application and in engineering applications such as aircraft landing gear struts. Anodizing is usually performed using either sulfuric, boric-sulfuric, or chromic acid often followed by a hot water bath, though nickel acetate or sodium potassium dichromate seal may also be used (EPA/OECA, 1995).

Passivation

Passivation is a chemical process in which parts are immersed in a solution containing a strong oxidizing agent. This forms a thin oxide layer on the part surface, providing corrosion protection and increasing adhesion of subsequent coatings. It is often used before maskant application in the chemical milling process (EPA/OAQPS, 1994).

Pickling

Pickling is a process of chemical abrasion/etching which prepares surfaces for good paint adhesion. The pickling process is used mainly for preparing pipe systems and small parts for paint. However, the process and qualities will vary by facility. The process involves a system of dip tanks. In pickling steel parts, The first tank is used to remove any oil, grease, flux, and other contaminants on the surface being pickled. The part is then immersed into a 5-8% caustic soda and water mixture (pH 8-13) maintained at temperatures of between 180°-200°F. Next, the steel is dipped into a 6-10% acid/water mixture maintained between 140°-160°F (EPA/OECA, 1997). Most carbon steel is pickled with sulfuric or hydrochloric acid, while stainless steel is pickled with hydrochloric, nitric, and hydrofluoric acids (EPA/OECA, 1995).

The fourth tank contains an acid rinse tank that is maintained at a pH of 5-7. Finally, the steel part is immersed in a rust preventative 5% phosphoric mixture. The part is then allowed to fully dry prior to paint application (EPA/OECA, 1997).

Polishing

Polishing is used at some facilities to clean and finish the outer skin of the aircraft. The polish is a lightly abrasive metal cleaner that is buffed on the metal surface, then wiped off. The polish gives a mirror-like surface finish and is usually applied instead of paint. Polishing can also be used on other metal parts as a cleaning step.

Conversion Coatings

Conversion coating is the process of changing a metal's surface characteristics by applying a reactive chemical to the metal's surface or by reacting the metal in a chemical bath. The desired result is improved coating adhesion, increased corrosion resistance, or both (EPA/OAQPS, 1994).

Aluminum surfaces are treated with various conversion coatings depending upon the anticipated environmental conditions or performance requirements such as corrosion, electrochemical insulation, and abrasion. Conversion coatings are also used to enhance bond and paint adhesion. Typical treatments include chromate phosphates, chromate oxides, anodizing, and non-chromate formulations (CARB, 1997).

Cadmium surfaces require either a phosphate or a chromate conversion coating prior to painting. The phosphate conversion is designed to be painted; the chromate conversion is designed to add corrosion resistance to the cadmium and it may also be painted (CARB, 1997).

Magnesium must be treated with a conversion coating or anodized before painting to prevent corrosion and to prevent environmental damage by abrasion. Magnesium coatings utilize sodium dichromate solutions (CARB, 1997).

Titanium must be treated with a conversion coating or anodized to protect it from corrosion and to improve adhesion bonding strength. Emersion baths for applying a conversion coating to titanium typically contain sodium phosphate, potassium fluoride, and hydrofluoric acid (CARB, 1997).

Coating/Painting

A coating is a material that is applied to the surface of a part to form a decorative or functional solid film. Coatings are used for corrosion resistance, aircraft identification and improved visibility, and friction reduction. The most common coatings are nonspecialized primers and topcoats, however there are also many specialized primers that provide characteristics such as fire resistance, flexibility, substrate compatibility, antireflection, sealing, adhesion, and enhanced corrosion protection (EPA/OAQPS, 1997).

Coatings are applied by spraying, brushing, rolling, flow coating, and dipping using a variety of application equipment including conventional air spray, high volume low pressure (HVLP) spray, and electrostatic spray. Many of the conventional methods such as rolling, flow coating, dip coating, and brushing are limited to the size and configuration of the part being painted (CARB, 1997).

Painting involves the application of predominantly organic coatings to a work piece for protective and/or decorative purposes. It is applied in various forms, including dry powder, solvent-diluted formulations, and water-borne formulations. Various methods of application are used, the most common being spray painting and electrodeposition. Electrodeposition is the process of coating a work piece by either making it anodic or cathodic in a bath that is generally an aqueous emulsion of the coating material. When applying the paint as a dry powder, some form of heating or baking is necessary to ensure that the powder adheres to the metal. These processes may result in solvent waste (and associated still bottom wastes generated during solvent distillation), paint sludge wastes, paint-bearing wastewaters, and paint solvent emissions (EPA/OECA, 1995).

Spray painting is a process by which paint is placed into a pressurized cup or pot and is atomized into a spray pattern when it is released from the vessel and forced through an orifice. Differences in spray-painting equipment are based on how the equipment atomizes paint. The more highly atomized the paint, the more likely transfer efficiency is to decrease. Transfer efficiency is the amount of paint applied to the object being painted, divided by the amount of paint used. Highly atomized paint spray can more readily drift away from the painting surface due to forces such as air currents and gravity (Ohio EPA, 1994). Cleaning solvent can only be sprayed through a gun for nonatomized and atomized cleaning using specific equipment as specified in the NESHAP.

The viscosity of paint may need adjustment before it can be sprayed. This is accomplished by reduction with organic solvents, or with water for certain water-based coatings. Using solvents for reduction requires the purchase of additional materials and increases air emissions. An alternative method of reducing the viscosity is to use heat. Benefits from the purchase of paint heaters include lower solvent usage, lower solvent emissions, more consistent viscosities, and faster curing rates (Ohio EPA, 1994).

The following types of spray application equipment may be used in the aerospace industry:

- Conventional Spray
- High-Volume/Low-Pressure (HVLP)
- Airless
- Air-Assisted
- Electrostatics
- Rotary Atomization
- Spray Booths

Electroplating

The metals used in electroplating operations (both common and precious metal plating) include cadmium, lead, chromium, copper, nickel, zinc, gold, and silver. Cyanides are also used extensively in electroplating solutions and in some stripping and cleaning solutions (EPA/OECA, 1995).

Electroless plating is the chemical deposition of a metal coating onto a metal object, by immersion of the object in an appropriate plating solution. In electroless nickel plating, the source of nickel is a salt, and a reducer is used to hold the metal ion in the solution. Immersion plating produces a metal deposit by chemical displacement. Immersion plating baths are usually formulations of metal salts, alkalies, and complexing agents (typically cyanide or ammonia) (EPA/OECA, 1995).

Occasionally, touch-up plating is done on an in-house plating line that consists of six separate tanks for cleaning, rinsing, and plating. Following touch-up plating, the parts are typically cleaned in a cold solvent-cleaning tank (EPA/NRMRL, 1995).

Equipment/Line Cleaning

Spray guns and coating lines used to apply the various coatings used at aerospace facilities must be cleaned when switching from one coating to another and when they are not going to be immediately reused. Spray guns can be cleaned either manually or with enclosed spray gun cleaners. Manual cleaning involves disassembling the gun and placing the parts in a vat containing an appropriate cleaning solvent. The residual paint is brushed or wiped off the parts. After reassembling, the cleaning solvent may be sprayed through the gun for a final cleaning. Paint hoses/coating lines are cleaned by passing the cleaning solvent through the lines until all coating residue is removed. Enclosed spray gun cleaners are self-contained units that pump the cleaning solvent through the gun within a closed chamber. After the cleaning cycle is complete, the guns are removed from the chamber and typically undergo some manual cleaning to remove coating residue from areas not exposed to the cleaning solvent, such as the seals under the atomizing cap (EPA/OAQPS, 1997).

III.A.4. Composites Processing

The aerospace industry is increasingly substituting composites for metals in aircraft and space vehicles due to the superior strength-to-weight ratio, corrosion resistance, and fatigue life of composites. Composites are comprised of a resin matrix that bonds together layers of reinforcing material. The resultant structure has mechanical properties superior to each individual component. The resin matrix is usually a polymeric material such as epoxy, polyester, nylon, or phenolic. The reinforcing material or fiber is usually carbon (graphite), fiberglass, or Kevlar. The fibers are oriented at specific angles within the matrix to achieve desired strength characteristics. Methods of forming composites include: injection molding, compression molding, and hand lay-up (or wet lay-up). Hand lay-up can involve applying resin on pre-woven fibers or can involve stacking thin sheets of pre-impregnated (prepreg) fiber material. Steps in hand lay-up are typically: lay-up, debulking, curing, and tear-down (break-out).

Injection molding is the process of shaping a material by applying heat and utilizing the pressure created by injecting a resin into a closed mold. Compression molding is the process of filling a mold with molding compound, closing the mold, and applying heat and pressure until the material has cured. Lay-up is the process of assembling composite parts by positioning reinforcing material in a mold and impregnating the material with resin. With hand lay-up, reinforcing material with resin or prepreg can be added to an open mold until the design thickness and contours are achieved. Debulking is the simultaneous application of low-level heat and pressure to composite materials to force out excess resin, trapped air, vapor, and volatiles from between the layers of the composite, thus removing voids within the composite.

Curing is the process of changing the resin into a solid material so that the composite part holds its shape. This is accomplished by heating the lay-up assembly in order to initiate a polymerization reaction within the resin. Once the reaction is complete, the resin solidifies and bonds the layers of composite materials together. The curing process is typically performed in an autoclave (a pressurized oven), with the composite lay-up enclosed in a bag so that a vacuum can be applied. The vacuum removes air and volatilized components of the resin from within the composite structure which may otherwise be trapped and create voids. Key parameters for curing are time, pressure, vacuum, temperature, and heating and cooling rates.

Break-out is the removal of the composite materials from the molds or curing fixtures (includes the application of release agents prior to filling the mold).

III.B. Aircraft Assembly

Aircraft assembly requires the coordination of thousands of parts coming together to form one large final product. The total assembly process of a complete aircraft can be close to two years. The relatively small number of finished products does not allow for a great deal of automation in the assembly process. Considerable coordination is needed between materials delivery and the production schedule in order to achieve efficient assembly.

Assembly Equipment

Typical materials handling equipment includes conveyors, cranes, industrial vehicles (e.g., forklifts, flatbeds, carts, special lift vehicles, etc.), and containers (EPA/OECA, 1997). Assembly facilities may also use jigs to aid in lining up or joining pieces.

Assembly jigs are essential for the successful assembly or large aerospace products. Their main function is to identify the precise location of fittings for attachment of one component to another. Assembly jigs should be constructed in a manner which allows them to be removed upon completion of the work without breaking down the entire jig structure. They require materials which will not bend or distort over a period of time or during assembly operations. They must also provide easy access to locations where manual joining operations are needed (Horne, 1986).

Pin jigs are used to assemble the curved sheets that form the outside of the fuselage's curved surface. The pin jig is simply a series of vertical screw jacks that support curved pieces during construction. A pin jig is set up specifically for the curved piece under construction. The jig heights are determined from the engineering drawings and plans (EPA/OECA, 1997).

Specially designed locating jigs are required for skins to which stiffeners are to be riveted, such as airplane wings. Stiffeners are first placed in the jigs and then locked in the required position on the completed wings. Wing skins are then placed on the jig and held to a contoured shape with metal bands in order to make contact with the stringers. Holes are drilled through the skin and stringers by using templates to locate hole positions. When all of the holes have been drilled, they are filled with clamping bolts and the metal bands are released. The skin is taken out of the jig and the clamping bolts hold the skin in the desired shape until it is riveted together (Horne, 1986).

Fuselage assembly operations may follow these steps:

- bond stringers to fuselage skin
- fit formers to assembly jig
- assemble skin, drill flanges, and fit riveting clamps

- replace clamps with rivets and remove panel from the jig
- assemble panels and formers on fuselage assembly jig (Horne, 1986).

Welding/Riveting

Fusion Welding

Fusion welding is performed with a metal arc in the presence of an inert gas which prevents the oxidation of the metals to be welded. An alternating or direct current, depending on the type and thickness of the metal, is typically applied through an electrode. The ideal current and pulse duration is selected according to the wire composition, shielding gas, welding position, and wire size (Horne, 1986).

Resistance Welding

Resistance welding requires: a primary electrical circuit from a transformer; a secondary circuit and electrodes to conduct the current to the desired spot; a mechanical system to hold the components and apply force; and control equipment to measure duration and magnitude of the electrical current. Press-type machines have a moveable welding head and force is applied by air through hydraulic cylinders. Seam welding is performed by power-driven roller electrodes instead of the pointed electrodes used for spot welding. Leak-proof and pressure-tight welds are formed by the seam welding process, where each weld overlaps the previous one (Horne, 1986).

Pre-pressure jig welding uses a jig to clamp the components together to relieve the electrodes from clamping stress. This ensures that the desired electrode pressure is available (Horne, 1986).

Electron Beam Welding

Electron beam welding is achieved by concentrating a beam of high velocity electrons onto the surfaces to be joined. The electrons are produced and accelerated by an electron beam gun which consists of a filament emitter, a bias electrode, and a positively charged anode. The electrons are generated by thermionic emission from a filament. Their attraction to an anode gives them speed and direction, and a bias electrode cup surrounding the emitter electrostatically shapes ejected electrons into a beam. An electromagnetic lens system reconverges the beam once its left the anode and focusses it on the work piece (Horne, 1986).

Riveting

Riveted joints are usually in sheet metal parts where the rivets take a shearing load. Riveted joints may be in single, double, triple, or quadruple rows and either chain or zigzag (Horne, 1986).

Sealing/Bonding

Sealants, predominantly composed of polysulfide, are applied throughout the aerospace vehicle structure primarily to seal out moisture and contaminants. This helps prevent corrosion, particularly on faying (i.e., closely or tightly fitting) surfaces, inside holes and slots, and around installed fasteners. Sealants are also used to seal fuel tanks and pressurized components. They are applied using tubes, spatulas, brushes, rollers, or spray guns. Sealants are often stored frozen and thawed before use, and many are two-component mixtures that cure after mixing. Typically, a sealant is applied before assembly or fastener installation, and the excess is squeezed out or extruded from between the parts as the assembly is completed. This ensures a moisture-tight seal between the parts (EPA/OAQPS, 1997).

Adhesive bonding involves joining together two or more metal or nonmetal components. This process is typically performed when the joints being formed are essential to the structural integrity of the aerospace vehicle or component. Bonding surfaces are typically roughened mechanically or etched chemically to provide increased surface area for bonding and then treated chemically to provide a stable corrosion-resistant oxide layer. The surfaces are then thinly coated with an adhesive bonding primer to promote adhesion and protect from subsequent corrosion. Structural adhesives are applied as either a thin film or as a paste. The parts are joined together and cured either at ambient temperature, in an oven, or in an autoclave to cure the adhesive and provide a permanent bond between the components (EPA/OAQPS, 1997).

Nonstructural adhesives are used to bond materials that are not critical to the structural integrity of the aerospace vehicle or component, such as gaskets around windows and carpeting or to nonstructurally joined components. These adhesives are applied using tubes, brushes, and spray guns (EPA/OAQPS, 1997).

Testing

A wide variety of tests are performed by the aerospace industry to verify that parts meet manufacturing specifications. Leak tests are performed on assemblies such as wing fuel tanks. These parts are filled with an aqueous solution or a gas to check seams and seals. Dye penetrant is used following chemical milling and other operations to check for cracks, flaws, and fractures. Many different kinds of penetrants, fluids, dyes, and etchants can be applied to the surface of metal parts to aid in the detection of defects. Hydraulic and fuel system checks are other typical testing operations. Weight checks are performed to verify the balance of certain structures, such as propeller blades and vertical tail rudders. Some critical areas on the assembled components are checked for flaws, imperfections, and proper alignment of parts by X-ray (EPA/OAQPS, 1994).

III.C. Repair/Rework Operations

Repair operations generally include all conversions, overhauls, maintenance programs, major damage repairs, and minor equipment repairs. Although specific repair methods vary from job to job, many of the operations are identical to new construction operations. Repair operations, however, are typically on a smaller scale and are performed at a faster pace. Jobs can last anywhere from one day to over a year. Repair jobs often have severe time constraints requiring work to be completed as quickly as possible in order to get the aircraft, missile, or space vehicle back in service. In many cases, piping, ventilation, electrical, and other machinery are prefabricated prior to the major product's arrival. Typical maintenance and repair operations include:

- Cleaning and repainting the aircraft's surfaces, superstructure, and interior areas
- Major rebuilding and installation of equipment such as turbines, generators, etc.
- Systems overhauls, maintenance, and installation
- System replacement and new installation of systems such as navigational systems, combat systems, communication systems, etc.
- Propeller and rudder repairs, modification, and alignment (EPA/OECA, 1997)

The depainting operation involves the removal of coatings from the outer surface of the aircraft. The two basic types are chemical depainting and blast depainting. Methylene chloride is the most common chemical stripper solvent; however, the particular solvent used is highly dependent on the type of coating to be removed. Chemical depainting agents are applied to the aircraft, allowed to degrade the coating, and then scraped or washed off with the coating residue. Blast depainting methods utilize a media such as plastic, wheat starch, carbon dioxide (dry ice), or high pressure water to remove coatings by physically abrading the coatings from the surface of the aircraft. Grit blasting and sand/glass blasting are also included in this category. High intensity ultraviolet light stripping has been developed for use in conjunction with carbon dioxide methods and is under development at several facilities (EPA/OAQPS, 1994). However, FAA has strict guidelines for safety and quality control purposes which dictate the types of solvents and materials that may be used in aerospace operations. Thus, any alternative must go through a comprehensive study before it is approved for use. *(See Section V- Pollution Prevention Opportunities)*

In addition, some larger facilities are capable of large repair and conversion projects that could include: converting passenger planes to cargo planes, replacing segments of an aircraft that has been damaged, structural reconfiguration and outfitting of combat systems, major remodeling of interiors or exteriors (EPA/OECA, 1997).

III.D. Space Vehicles and Guided Missiles

Many of the industrial processes involved in the production of space vehicles and guided missiles are similar to those discussed above in the production of aircraft parts and assembly. Because the number of establishments involved in the production of space vehicles, guided missiles, and their associated parts is less than 10 percent of the total industry, no additional information on industrial processes will be presented here. Also, due to the confidential nature of some of these products, there is little information available on production technologies.

III.E. Raw Materials Inputs and Pollution Outputs

The Aerospace Industries Association estimates that there are 15,000 to 30,000 different materials used in manufacturing, many of which may be potentially toxic, highly volatile, flammable, contain chloroflourocarbons, or contribute to global warming (AIA, 1994). Material inputs for aerospace manufacturing include metals, solvents, paints and coatings, and plastics, rubbers, and fabrics. Metals used in manufacturing include steel, aluminum, titanium, and many specialty alloys. There is also a wide variety of paints, solvents, and coatings available to the aerospace industry. Many of these materials are specifically required by FAA guidelines.

Pollutants from metal fabricating processes are dependant on the metal and machining techniques being used. Larger pieces of scrap metal are usually recovered and reintroduced to the process, while smaller shavings may be sent off-site for disposal or recovery.

Surface preparation operations generate wastes contaminated with solvents and/or metals depending on the type of cleaning operation. Degreasing operations may result in solvent-bearing wastewaters, air emissions, and materials in solid form. Chemical surface treatment operations can result in wastes containing metals. Alkaline, acid, mechanical, and abrasive cleaning methods can generate waste streams such as spent cleaning media, wastewaters, and rinse waters. Such wastes consist primarily of the metal complexes or particles, the cleaning compound, contaminants from the metal surface, and water. In many cases, chemical treatment operations are used in conjunction with organic solvent cleaning systems. As such, many of these wastes may be cross-contaminated with solvents (EPA/OECA, 1995).

Surface finishing and related washing operations account for a large volume of wastes associated with aerospace metal finishing. Metal plating and related waste account for the largest volumes of metal (e.g., cadmium, chromium, copper, lead, mercury, and nickel) and cyanide bearing wastes (EPA/OECA, 1995).

Air Emissions

Air emissions, primarily volatile organic compounds (VOCs), result mainly from the sealing, painting, depainting, bonding, finishing application processes including material storage, mixing, applications, drying, and cleaning. These emissions are composed mainly of organic solvents which are used as carriers for the paint or sealant and as chemical coating removers. Most aerospace coatings are solvent-based, which contain a mixture of organic solvents, many of which are VOC's. The most common VOC solvents used in coatings are trichloroethylene, 1,1,1-trichloroethane, toluene, xylene, methyl ethyl ketone, and methyl isobutyl ketone. The most common VOC solvent used for coating removal is methylene chloride. The VOC content ranges differ for the various coating categories. Air emissions from cleaning and degreasing operations may result through volatilization during storage, fugitive losses during use, and direct ventilation of fumes. Releases to the air from metal shaping processes contain products of combustion (such as fly ash, carbon, metallic dusts) and metals and abrasives (such as sand and metallic particulates).

Wastewater

Wastewater is produced by almost every stage of the manufacturing process. Metalworking fluids, used in machining and shaping metal parts, are a common source of wastewater contamination. Metalworking fluids can be petroleum-based, oil-water emulsions, or synthetic emulsions that are applied to either the tool or the metal being tooled to facilitate the shaping operation. Waste cooling waters can be contaminated with metalworking fluids (EPA/OECA, 1995).

Surface preparation, cleaning, and coating removal often involves the use of solvents which can also contribute to wastewater pollution. The nature of the waste will depend upon the specific cleaning application and manufacturing operation. Solvents may be rinsed into wash waters and/or spilled into floor drains (EPA/OECA, 1995).

Wastewater may also be generated in operations such as quenching and deburring. Such wastewater can be high in oil and suspended solids. Wastewater from metal casting and shaping mainly consists of cooling water and wet scrubber effluent. The scrubber water is typically highly alkaline (EPA/OECA, 1997).

Wastewater contaminated with paints and solvents may be generated during equipment cleaning operations; however, water is typically only used in cleaning water-based paints. Wastewater is also generated when water curtains (water wash spray booths) are used during painting. Wastewater from painting water curtains commonly contains organic pollutants as well as certain metals (EPA/OECA, 1997).

Electroplating operations can result in solid and liquid waste streams that contain toxic constituents. Aqueous wastes result from work piece rinses and process cleanup waters. In addition to these wastes, spent process solutions and quench baths are discarded periodically when the concentrations of contaminants inhibit proper function of the solution or bath. When discarded, process baths usually consist of solid-phase and liquid-phase wastes that may contain high concentrations of toxic constituents, especially cyanide. Rinse water from the electroplating process may contain zinc, lead, cadmium, or chromium (EPA/OECA, 1995).

Solid/Hazardous/Residual Waste

Solid, hazardous, and residual wastes generated during aerospace manufacturing include contaminated metalworking fluids, scrap metal, waste containers, and spent equipment or materials. Scrap metal is produced by metal shaping operations and may consist of metal removed from the original piece (e.g., steel or aluminum). Scrap may be reintroduced into the process as a feedstock or recycled off-site.

Various solid and liquid wastes, including waste solvents, blast media, paint chips, and spent equipment may be generated throughout painting and depainting operations. These solid and liquid wastes are usually the result of the following operations:

- Paint applications- paint overspray caught by emissions control devices (e.g., paint booth collection systems, ventilation filters, etc.)
- Depainting- spent blast media, chips, and paint and solvent sludges
- Cleanup operations- cleaning of equipment and paint booth area
- Disposal- discarding of leftover and unused paint as well as containers used to hold paints, paint materials, and overspray

Solvents are also used during cleanup processes to clean spray equipment between color changes, and to clean portions of the spray booth. The solvent utilized during cleaning is generally referred as “purge solvent” and is often composed of a mixture of dimethyl-benzene, 2-propanone (acetone), 4-methyl-2-pentanone, butyl ester acetic acid, light aromatic solvent naphtha, ethyl benzene, hydrotreated heavy naphtha, 2-butanone, toluene, and 1-butanol (EPA/OECA, 1995).

Metalworking fluids typically become contaminated and spent with extended use and reuse. When disposed, these oils may contain toxics, including metals (cadmium, chromium, and lead), and therefore must be tested to determine if they are considered a RCRA hazardous waste. Many fluids may contain chemical additives such as chlorine, sulfur, phosphorous compounds, phenols, cresols, and alkalines. In the past, such oils have commonly been mixed with used cleaning fluids and solvents (including chlorinated solvents) (EPA/OECA, 1995).

If metal coating operations use large quantities of molding sand, spent sand may be generated. The largest waste by volume from metal casting operations is waste sand. Other residual wastes may include dust from dust collection systems, slag, and off-spec products. Dust collected in baghouses may include zinc, lead, nickel, cadmium, and chromium. Slag is a glassy mass composed of metal oxides from the melting process, melted refractories, sand, and other materials (EPA/OECA, 1997).

Centralized wastewater treatment systems are common and can result in solid-phase wastewater treatment sludges. Any solid wastes (e.g., wastewater treatment sludges, still bottoms, cleaning tank residues, machining fluid residues, etc.) generated by the manufacturing process may also be contaminated with solvents (EPA/OECA, 1995).

Table 6 summarizes the material inputs and pollutant outputs from the various aerospace manufacturing operations.

Table 6: Material Input and Pollutant Outputs

Process	Material Input	Air Emissions	Wastewater	Solid/Hazardous/ Residual Wastes
Metal Shaping	Cutting oils, degreasing and cleaning solvents, acids, metals	Solvent wastes (e.g., 1,1,1-trichloroethane, acetone, xylene, toluene, etc.)	Acid/alkaline wastes (e.g., hydrochloric, sulfuric, and nitric acids), waste coolant water with oils, grease, and metals	Scrap metal, waste solvents
Grinding/ Polishing	Metals, abrasive materials, machining oils	Metal shavings/ particulates, dust from abrasive materials	Wastewaters with oil, grease, and metal from machining	Abrasive waste (e.g., aluminum oxide, silica, metal), metal shavings, dust
Plating	Acid/alkaline solutions, metal bearing and cyanide bearing solutions	Volatized solvents and cleaners	Waste rinse water containing acids/alkalines cyanides, and solvents	Metal wastes, solvent wastes, filter sludges (silica, carbides) wasted plating material (copper, chromium, and cadmium)
Painting	Solvent based or water based paints	Paint overspray, solvents	Cleaning water containing paint and stripping solutions	Waste paint, empty containers, spent paint application equipment
Cleaning, depainting, and vapor degreasing	Acid/alkaline cleaners and solvents	Solvent wastes, acid aerosols, paint chips and particulates	Wastewater containing acids/alkalines, spent solvents	Spent solvents, paint/solvent sludges, equipment and abrasive materials, paint chips

Source*: Pollution Prevention Assessment for a Manufacturer of Aircraft Landing Gear*, EPA, August 1995 and *Guides to Pollution Prevention, The Fabricated Metal Products Industry*, EPA, July 1990.

III.F. Management of Chemicals in Wastestream

The Pollution Prevention Act of 1990 (PPA) requires facilities to report information about the management of Toxic Release Inventory (TRI) chemicals in waste and efforts made to eliminate or reduce those quantities. These data have been collected annually in Section 8 of the TRI reporting Form R beginning with the 1991 reporting year. The data summarized below cover the years 1994-1997 and are meant to provide a basic understanding of the quantities of waste handled by the industry, the methods typically used to manage this waste, and recent trends in these methods. TRI waste management data can be used to assess trends in source reduction within individual industries and facilities, and for specific TRI chemicals. This information could then be used as a tool in identifying opportunities for pollution prevention and compliance assistance activities.

While the quantities reported for 1995 and 1996 are estimates of quantities already managed, the quantities listed by facilities for 1997 and 1998 are projections only. The PPA requires these projections to encourage facilities to consider future source reduction, not to establish any mandatory limits. Future-year estimates are not commitments that facilities reporting under TRI are required to meet

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Table 7 shows that the TRI reporting aerospace facilities managed about 37 million pounds of production related wastes (total quantity of TRI chemicals in the waste from routine production operations in column B) in 1996. Production related wastes were projected to continue to decrease slightly in 1997 and 1998. Note that the effects of production increases and decreases on the quantities of wastes generated are not evaluated here, but production has generally been increasing in recent years.

In 1995, about 34 percent of the industry's TRI wastes were managed on-site through recycling, energy recovery, or treatment as shown in columns C, D, and E, respectively. This decreased to 25 percent in 1996 and was expected to slightly increase to over 30 percent in 1998. The majority of these on-site managed wastes were recycled on-site in 1995. About 39 percent of the industry's TRI wastes were transferred off-site for recycling, energy recovery, or treatment as shown in columns F, G, and H. This increased to 50 percent in 1996. Most of the off-site managed wastes were recycled as well. The remaining portion of the production related wastes, shown in column I, (31 percent in 1995 and 27 percent in 1996) is either released to the environment through direct discharges to air, land, water, and underground injection, or is transferred off-site for disposal.

Table 7: Source Reduction and Recycling Activity for Aerospace Manufacturers Facilities (SICs 372 or 376) as Reported within TRI

A	B	On-Site			Off-Site			I
		C	D	E	F	G	H	
Year	Quantity of Production-Related Waste (10^6 lbs.)[a]	% Recycled	% Energy Recovery	% Treated	% Recycled	% Energy Recovery	% Treated	% Released and Disposed[c] Off-site
1995	40.6	22%	0%	12%	26%	3%	10%	31%
1996	36.5	14%	0%	11%	36%	4%	10%	27%
1997	35.2	14%	0%	12%	36%	4%	10%	24%
1998	33.3	19%	0%	12%	33%	3%	10%	21%

Source: *1996 Toxics Release Inventory Database.*
[a] Within this industry sector, non-production related waste < 1% of production related wastes for 1995.
[b] Total TRI transfers and releases as reported in Section 5 and 6 of Form R as a percentage of production related wastes.
[c] Percentage of production related waste released to the environment and transferred off-site for disposal.

IV. CHEMICAL RELEASE AND TRANSFER PROFILE

This section is designed to provide background information on the pollutant releases that are reported by this industry. For industries that are required to report, the best source of comparative pollutant release information is the Toxic Release Inventory (TRI). A component of the Emergency Planning and Community Right-to-Know Act, TRI includes self-reported facility release and transfer data for over 600 toxic chemicals. Facilities within SIC Codes 20 through 39 (manufacturing industries) that have more than 10 employees, and that are above weight-based reporting thresholds are required to report TRI on-site releases and off-site transfers. The information presented within the sector notebooks is derived from the most recently available (1996) TRI reporting year (which includes over 600 chemicals), and focuses primarily on the on-site releases reported by each sector. Because TRI requires consistent reporting regardless of sector, it is an excellent tool for drawing comparisons across industries. TRI data provide the type, amount and media receptor of each chemical released or transferred.

Although this sector notebook does not present historical information regarding TRI chemical releases over time, please note that in general, toxic chemical releases have been declining. In fact, according to the 1996 Toxic Release Inventory Public Data Release, reported onsite releases of toxic chemicals to the environment decreased by 5 percent (111.6 million pounds) between 1995 and 1996 (not including chemicals added and removed from the TRI chemical list during this period). Reported releases dropped by 48 percent between 1988 and 1996. Reported transfers of TRI chemicals to off-site locations increased by 5 percent (14.3 million pounds) between 1995 and 1996. More detailed information can be obtained from EPA's annual Toxics Release Inventory Public Data Release book (which is available through the EPCRA Hotline at 800-535-0202), or directly from the Toxic Release Inventory System database (for user support call 202-260-1531).

Wherever possible, the sector notebooks present TRI data as the primary indicator of chemical release within each industrial category. TRI data provide the type, amount and media receptor of each chemical released or transferred. When other sources of pollutant release data have been obtained, these data have been included to augment the TRI information.

TRI Data Limitations

Certain limitations exist regarding TRI data. Within some sectors, (e.g. dry cleaning, printing and transportation equipment cleaning) the majority of facilities are not subject to TRI reporting because they are not considered manufacturing industries, or because they are below TRI reporting thresholds. For these sectors, release information from other sources has been included.

Reported chemicals are limited to the approximately 600 TRI chemicals. A portion of the emissions from aerospace facilities, therefore, are not captured by TRI.

In addition, many facilities report more than one SIC code reflecting the multiple operations carried out on-site. Therefore, reported releases and transfers may or may not all be associated with the industrial operations described in this notebook.

The reader should also be aware that TRI "pounds released" data presented within the notebooks is not equivalent to a "risk" ranking for each industry. Weighting each pound of release equally does not factor in the relative toxicity of each chemical that is released or the potential exposure to surrounding populations. The Agency is in the process of developing an approach to assign toxicological weightings to each chemical released so that one can differentiate between pollutants with significant differences in toxicity. As a preliminary indicator of the environmental impact of the industry's most commonly released chemicals, the notebook briefly summarizes the toxicological properties of the top five chemicals (by weight) reported by the industry.

Definitions Associated With Section IV Data Tables

General Definitions

SIC Code -- is the Standard Industrial Classification (SIC) code, a statistical classification standard used for all establishment-based Federal economic statistics. The SIC codes facilitate comparisons between facility and industry data.

TRI Facilities -- are manufacturing facilities that have 10 or more full-time employees and are above established chemical throughput thresholds. Manufacturing facilities are defined as facilities in Standard Industrial Classification primary codes 20-39. Facilities must submit estimates for all chemicals that are on the EPA's defined list and are above throughput thresholds.

Data Table Column Heading Definitions

The following definitions are based upon standard definitions developed by EPA's Toxic Release Inventory Program. The categories below represent the possible pollutant destinations that can be reported.

Releases -- are on-site discharges of a toxic chemical to the environment. This includes emissions to the air, discharges to bodies of water, releases at the facility to land, as well as contained disposal into underground injection wells.

Releases to Air (Point and Fugitive Air Emissions) -- include all air emissions from industry activity. Point emissions occur through confined air streams as found in stacks, vents, ducts, or pipes. Fugitive emissions include equipment leaks, evaporative losses from surface impoundments and spills, and releases from building ventilation systems.

Releases to Water (Surface Water Discharges) -- encompass any releases going directly to streams, rivers, lakes, oceans, or other bodies of water. Releases due to runoff, including storm water runoff, are also reportable to TRI.

Releases to Land -- occur within the boundaries of the reporting facility. Releases to land include disposal of toxic chemicals in landfills, land treatment/application farming, surface impoundments, and other disposal on land (such as spills, leaks, or waste piles).

Underground Injection -- is a contained release of a fluid into a subsurface well for the purpose of waste disposal. Wastes containing TRI chemicals are injected into either Class I wells or Class V wells. Class I wells are used to inject liquid hazardous wastes or dispose of industrial and municipal wastewaters beneath the lowermost underground source of drinking water. Class V wells are generally used to inject non-hazardous fluid into or above an underground source of drinking water. TRI reporting does not currently distinguish between these two types of wells, although there are important differences in environmental impact between these two methods of injection.

Transfers -- are transfers of toxic chemicals in wastes to a facility that is geographically or physically separate from the facility reporting under TRI. Chemicals reported to TRI as transferred are sent to off-site facilities for the purpose of recycling, energy recovery, treatment, or disposal. The quantities reported represent a movement of the chemical away from the reporting facility. Except for off-site transfers for disposal, the reported quantities do not necessarily represent entry of the chemical into the environment.

Transfers to POTWs -- are wastewater transferred through pipes or sewers to a publicly owned treatments works (POTW). Treatment or removal of a chemical from the wastewater depends on the nature of the chemical, as well as the treatment methods present at the POTW. Not all TRI chemicals can be treated or removed by a POTW. Some chemicals, such as metals, may be removed but not destroyed and may be disposed of in landfills or discharged to receiving waters.

Transfers to Recycling -- are wastes sent off-site for the purposes of regenerating or recovery by a variety of recycling methods, including solvent recovery, metals recovery, and acid regeneration. Once these chemicals have been recycled, they may be returned to the originating facility or sold commercially.

Transfers to Energy Recovery -- are wastes combusted off-site in industrial furnaces for energy recovery. Treatment of a chemical by incineration is not considered to be energy recovery.

Transfers to Treatment -- are wastes moved off-site to be treated through a variety of methods, including neutralization, incineration, biological destruction, or physical separation. In some cases, the chemicals are not destroyed but prepared for further waste management.

Transfers to Disposal -- are wastes taken to another facility for disposal, generally as a release to land or as an injection underground.

IV.A. EPA Toxic Release Inventory for the Aerospace Industry

This section summarizes TRI data of aerospace facilities reporting SIC codes within 372 and 376 as the primary SIC code for the facility.

According to the 1996 Toxics Release Inventory (TRI) data, 199 aerospace facilities released (to the air, water, or land) and transferred (shipped off-site or discharged to sewers) a total of approximately 27 million pounds of 65 different toxic chemicals during calendar year 1996. This represents approximately one half of one percent of the 5.6 billion pounds of releases and transfers from all manufacturers (SICs 20-39) reporting to TRI that year. Facilities released an average of 43,862 pounds per facility and transferred and average of 93,503 pounds per facility. The top four chemicals released by weight are solvents-- methyl ethyl ketone, 1,1,1-trichloroethane, trichloroethylene, and toluene. These four account for about 66 percent (5.8 million pounds) of the industry's total releases. Nickel, chromium, sulfuric acid, and methyl ethyl ketone were the four top chemicals transferred by weight. These four account for 55 percent (10.2 million pounds) of the total TRI chemicals transferred by the aerospace industry. Only 22 percent of the 65 chemicals reported to TRI as releases or transfers were reported by more than 10 facilities, evidence of the many different materials used by the industry and the variance between facilities on choice of these materials.

Releases

Table 8 presents the number and weights of chemicals released by aerospace facilities reporting SIC 372 and 376. The total quantity of releases was 8.7 million pounds or 32 percent of the total weight of chemicals released and transferred. The vast majority of air releases were solvents. Air emissions account for 98 percent of total releases, 44 percent as fugitive air emissions and 54 percent as point air releases. Methyl ethyl ketone was the top chemical released by the aerospace industry, accounting for 25 percent of total releases. Releases of 1,1,1-trichloroethane were the second greatest, representing 20 percent of the total. Twenty-four percent of fugitive air emissions were of 1,1,1-trichloroethane, and 32 percent of the point air releases were methyl ethyl ketone. Nitrate compounds accounted for 74 percent of water discharges.

Transfers

Table 9 presents the number and weights of chemicals transferred off-site by aerospace facilities reporting SIC 372 or 376 in 1996. The total amount of transfers was 18.6 million pounds or 68 percent of the total releases and transfers reported to the 1996 TRI by aerospace facilities. Transfers to recycling facilities accounted for the largest percentage, 70 percent, of transfers. The next greatest percentage was 17 percent to treatment facilities. The majority of transfers consisted of metals, spent acids, and solvents. Sixty-six percent (12.3 million pounds) of the total transfers were metals. Nickel represented the largest quantity of transfers, 5.3 million pounds or 29 percent of the total. Chromium composed the second largest quantity of transfers with 12 percent of the total. The chemical with the largest quantity of releases, methyl ethyl ketone, accounted for about 6 percent of the total transfers.

Table 8: 1996 TRI Releases for Aerospace Chemicals Facilities (SICs 372 or 376), By Number of Facilities Reporting (Releases Reported in Pounds/year)

Chemical Name	# Reporting Chemical	Fugitive Air	Point Air	Water Discharges	Underground Injection	Land Disposal	Total Releases	Avg. Releases Per Facility
Methyl Ethyl Ketone	67	704,499	1,484,499	505	0	0	2,189,503	32,679
Nitric Acid	58	7,530	57,219	165	0	0	64,914	1,119
Nickel	48	15,778	8,421	972	0	20,557	45,728	953
Chromium	39	12,829	2,813	1,322	0	3,343	20,307	521
1,1,1-trichloroethane	36	938,383	769,346	5	0	11,280	1,719,014	47,750
Trichloroethylene	29	671,880	268,358	11	0	2,640	942,889	32,513
Chromium Compounds	25	1,685	9,815	422	0	15,866	27,788	1,112
Toluene	23	129,305	776,295	260	0	4,128	909,988	39,565
Tetrachloroethylene	21	237,547	388,663	34	0	0	626,244	29,821
Dichloromethane	20	591,048	99,403	18	0	0	690,469	34,523
Cobalt	18	740	1,905	476	0	2,774	5,895	328
Hydrogen Fluoride	16	2,841	14,889	0	0	0	17,730	1,108
Ammonia	14	3,166	205,300	21,646	0	0	230,112	16,437
Copper	12	311	255	26	0	0	592	49
Nitrate Compounds	10	145	499	77,000	0	0	77,644	7,764
Xylene (Mixed Isomers)	10	15,356	211,057	55	0	0	226,468	22,647
Nickel Compounds	9	265	616	58	0	0	939	104
Phosphoric Acid	9	923	1,301	0	0	0	2,224	247
Methanol	8	13,247	32,566	0	0	0	45,813	5,727
Aluminum (Fume or Dust)	8	282	112	0	0	0	394	49
Sulfuric Acid (1994 and after "Acid Aerosols" Only)	8	16	331	0	0	0	347	43
Hydrochloric Acid (1995 and after "Acid Aerosols" Only)	7	190,257	54,062	0	0	0	244,319	34,903
Diisocyanates	6	390	230	0	0	0	620	103
Certain Glycol Ethers	6	11,170	10,785	0	0	0	21,955	3,659
Freon 113	6	114,487	34,782	0	0	0	149,269	24,878
Methyl Isobutyl Ketone	6	26,191	78,205	0	0	0	104,396	17,399
Phenol	6	118	2,997	0	0	0	3,115	519
Lead	6	0	200	4	0	0	204	34
Manganese	5	15	11	250	0	0	276	55
Copper Compounds	4	0	281	543	0	0	824	206
Cobalt Compounds	3	0	250	0	0	0	250	83
Cyanide Compounds	3	0	0	0	0	0	0	0
Lead Compounds	3	65	96	0	0	0	161	54
Benzene	3	16,997	119,768	0	0	0	136,765	45,588
Naphthalene	3	65,993	250	0	0	0	66,243	22,081
Aluminum Oxide (Fibrous Forms)	3	290	784	0	0	45,000	46,074	15,358
Chlorine	3	0	0	98	0	0	98	33
Manganese Compounds	2	15	45	0	0	0	60	30
Zinc Compounds	2	0	250	0	0	0	250	125
Methyl Methacrylate	2	2,951	1,400	0	0	0	4,351	2,176
Styrene	2	11,488	16,500	0	0	0	27,988	13,994
Antimony	2	0	0	0	0	0	0	0
Zinc (Fume or Dust)	2	5	5	18	0	0	28	14
Antimony Compounds	1	5	4	0	0	0	9	9
Barium Compounds	1	0	1	0	0	0	1	1
Polychlorinated Alkanes	1	0	0	0	0	0	0	0
Formaldehyde	1	0	0	0	0	0	0	0
Isopropyl Alcohol (Manufacturing, Strong-acid Process Only, No Supplies)	1	90	2,172	0	0	0	2,262	2,262
N,n-dimethylformamide	1	250	250	0	0	0	500	500
N-butyl Alcohol	1	0	15,233	0	0	0	15,233	15,233
Bromotrifluoromethane	1	1,641	0	0	0	0	1,641	1,641
Trichlorofluoromethane	1	3,500	430	0	0	0	3,930	3,930
Sec-butyl Alcohol	1	14,000	8,800	0	0	0	22,800	22,800
Picric Acid	1	0	0	0	0	0	0	0
Biphenyl	1	0	0	0	0	0	0	0
1,2-dichlorobenzene	1	0	1,400	0	0	0	1,400	1,400
Ethylbenzene	1	0	0	0	0	0	0	0
Ethylene Glycol	1	0	0	0	0	0	0	0
Cyclohexane	1	0	904	0	0	0	904	904
Methyl Tert-butyl Ether	1	1,200	0	0	0	0	1,200	1,200
1,1-dichloro-1-fluoroethane	1	22,000	0	0	0	0	22,000	22,000
Mercury	1	0	0	0	0	0	0	0
Silver	1	0	0	0	0	0	0	0
Sodium Nitrite	1	250	4,200	0	0	0	4,450	4,450
Aluminum Phosphide	1	0	0	0	0	0	0	0
	199**	3,831,144	4,687,958	103,888	0	105,588	8,728,578	43,862

**Total number of facilities (not chemical reports) reporting to TRI in this industry sector.

Table 9: 1996 TRI Transfers for Aerospace Chemicals Facilities (SICs 372 or 376), By Number of Facilities Reporting (Transfers Reported in Pounds/year)

Chemical Name	# Reporting Chemical	Potw Transfers	Disposal Transfers	Recycling Transfers	Treatment Transfers	Energy Recovery	Total Transfers	Avg Transfers Per Facility
Methyl Ethyl Ketone	67	10,350	2,368	85,457	98,407	905,400	1,101,982	16,447
Nitric Acid	58	50,018	13,963	122,824	741,790	0	928,595	16,010
Nickel	48	1,201	59,938	5,220,398	66,968	0	5,348,505	111,427
Chromium	39	906	23,073	2,130,107	46,840	423	2,201,349	56,445
1,1,1-trichloroethane	36	13	19,879	188,170	45,743	39,549	293,354	8,149
Trichloroethylene	29	10	215	154,717	55,071	5,542	215,555	7,433
Chromium Compounds	25	3,140	50,811	540,602	145,257	6,560	746,370	29,855
Toluene	23	25	5,244	13,660	18,302	153,115	190,346	8,276
Tetrachloroethylene	21	16	88	224,131	4,397	14,438	243,070	11,575
Dichloromethane	20	30	3,684	4,932	50,424	90,028	149,098	7,455
Cobalt	18	564	11,683	716,388	4,103	0	732,738	40,708
Hydrogen Fluoride	16	534	0	41,234	89,974	0	131,742	8,234
Ammonia	14	5	0	7,475	1,355	0	8,835	631
Copper	12	406	39,121	770,166	332	0	810,025	67,502
Nitrate Compounds	10	357,214	106,700	112	92,382	0	556,408	55,641
Xylene (Mixed Isomers)	10	0	160	7,420	27,148	26,723	61,451	6,145
Nickel Compounds	9	325	30,566	481,291	5,703	0	525,531	58,392
Phosphoric Acid	9	2,291	20,725	20,304	1,100	0	44,420	4,936
Methanol	8	0	2	24	295	25,192	25,513	3,189
Aluminum (Fume or Dust)	8	0	10,401	80,089	8,950	0	99,440	12,430
Sulfuric Acid (1994 and after "Acid Aerosols" Only)	8	250	55,261	0	1,490,000	0	1,545,511	193,189
Hydrochloric Acid (1995 and after "Acid Aerosols" Only)	7	250	77	0	250	0	577	82
Diisocyanates	6	0	0	51,000	15,050	0	66,050	11,008
Certain Glycol Ethers	6	23,200	505	2,505	925	15,113	42,248	7,041
Freon 113	6	0	0	2,224	5,900	690	8,814	1,469
Methyl Isobutyl Ketone	6	6	561	56	11,709	25,774	38,106	6,351
Phenol	6	15	939	0	16,859	16,487	34,300	5,717
Lead	6	250	2,543	942,255	3,550	5	948,603	158,101
Manganese	5	10	255	107,855	0	0	108,120	21,624
Copper Compounds	4	98	13,642	290,391	122	0	304,253	76,063
Cobalt Compounds	3	268	0	86,360	5	0	86,633	28,878
Cyanide Compounds	3	12	4,603	0	6,380	0	10,995	3,665
Lead Compounds	3	42	941	252,145	50,094	0	303,222	101,074
Benzene	3	0	0	0	0	0	0	0
Naphthalene	3	0	0	5	0	250	255	85
Aluminum Oxide (Fibrous Forms)	3	0	127,153	0	0	0	127,153	42,384
Chlorine	3	0	27	0	0	146	173	58
Manganese Compounds	2	0	3,600	170,481	6,550	0	180,631	90,316
Zinc Compounds	2	250	0	24,000	0	0	24,250	12,125
Methyl Methacrylate	2	0	0	16,000	0	0	16,000	8,000
Styrene	2	0	0	0	0	1,553	1,553	777
Antimony	2	0	5	135,000	1,958	0	136,963	68,482
Zinc (Fume or Dust)	2	251	90	14,000	0	0	14,341	7,171
Antimony Compounds	1	0	6,700	35,000	2	0	41,702	41,702
Barium Compounds	1	0	0	550	0	0	550	550
Polychlorinated Alkanes	1	0	0	0	23,495	15,079	38,574	38,574
Formaldehyde	1	0	0	0	0	0	0	0
Isopropyl Alcohol (Manufacturing, Strong-acid Process Only, No Supplies)	1	0	0	0	0	0	0	0
N,n-dimethylformamide	1	0	820	250	0	0	1,070	1,070
N-butyl Alcohol	1	0	209	0	460	5,025	5,694	5,694
Bromotrifluoromethane	1	0	0	0	0	0	0	0
Trichlorofluoromethane	1	0	0	8,300	0	0	8,300	8,300
Sec-butyl Alcohol	1	0	0	0	0	0	0	0
Picric Acid	1	0	0	0	0	0	0	0
Biphenyl	1	0	0	0	0	0	0	0
1,2-dichlorobenzene	1	0	0	0	9,200	0	9,200	9,200
Ethylbenzene	1	0	0	0	0	0	0	0
Ethylene Glycol	1	30,613	0	0	0	0	30,613	30,613
Cyclohexane	1	0	0	0	0	40,268	40,268	40,268
Methyl Tert-butyl Ether	1	0	0	0	0	0	0	0
1,1-dichloro-1-fluoroethane	1	0	0	0	460	0	460	460
Mercury	1	0	0	0	0	0	0	0
Silver	1	0	0	0	0	0	0	0
Sodium Nitrite	1	0	17,600	0	0	0	17,600	17,600
Aluminum Phosphide	1	0	0	0	0	0	0	0
	199**	482,563	634,152	12,947,878	3,147,510	1,387,360	18,607,109	93,503

**Total number of facilities (not chemical reports) reporting to TRI in this industry sector.

The TRI database contains a detailed compilation of self-reported, facility-specific chemical releases only and not transfers. The top reporting facilities for the aerospace industry are listed below in Tables 10 and 11. Facilities that have reported the primary SIC codes covered under this notebook appear on the first list. Table 11 contains additional facilities that have reported the SIC codes covered within this report, and one or more SIC codes that are not within the scope of this notebook. Therefore, the second list includes facilities that conduct multiple operations -- some that are under the scope of this notebook, and some that are not. However, only one additional facility appears on the second list, implying that the processes directly relating to the production of aerospace equipment is responsible for releases and transfers reported by aerospace facilities. Currently, the facility-level data do not allow pollutant releases to be broken apart by industrial process.

Table 10: Largest Quantity TRI Releasing Facilities Reporting Only 372 or 376 SIC Codes to TRI[1]

Rank	Facility	SIC Codes Reported in TRI	Total TRI Releases in Pounds
1	Boeing Commercial Airplane, Everett, WA	3721	784,581
2	Chem-fab Corp., Hot Springs, AR	3728	433,630
3	Raytheon Aircraft Co., Wichita, KS	3721	393,324
4	Douglas Aircraft Co.*, Long Beach, CA	3721	347,420
5	Pemco Aeroplex Inc., Birmingham, AL	3721	330,130
6	Thiokol Propulsion Group, Promontory,	3764	330,000
7	U.S. Air Force Plant 06 GA, Marietta, GA	3721	305,149
8	Cessna Aircraft, Wichita, KS	3721	266,709
9	Aerostructures Corp., Nashville, TN	3728, 3769	252,299
10	Menasco, Euless, TX	3728	240,000
	TOTAL		3,683,242

Source: *US EPA Toxics Release Inventory Database, 1996.*
*Douglas Aircraft Co. is now part of The Boeing Company.

[1] Being included on this list does not mean that the release is associated with non-compliance with environmental laws.

Table 11: Largest Quantity TRI Releasing Facilities Reporting Aerospace SIC Codes to TRI[2]			
Rank	**Facility**	**SIC Codes Reported in TRI**	**Total TRI Releases in Pounds**
1	Boeing Wichita, Wichita, KS	3728,3679,3721,3724	1,254,080
2	Boeing Commercial Airplane, Everett, WA	3721	784,581
3	Chem-fab Corp., Hot Springs, AR	3728	433,630
4	Raytheon Aircraft Co., Wichita, KS	3721	393,324
5	Douglas Aircraft Co., Long Beach, CA	3721	347,420
6	Pemco Aeroplex Inc., Birmingham, AL	3721	330,130
7	Thiokol Propulsion Group, Promontory,	3764	330,000
8	U.S. Air Force Plant 06 GA, Marietta, GA	3721	305,149
9	Cessna Aircraft, Wichita, KS	3721	266,709
10	Aerostructures Corp., Nashville, TN	3728, 3769	252,299
	TOTAL		4,697,322

Source: *US EPA Toxics Release Inventory Database, 1996.*
*Douglas Aircraft Co. is now part of The Boeing Company.

[2] Being included on this list does not mean that the release is associated with non-compliance with environmental laws.

IV.B. Summary of Selected Chemicals Released

The following is a synopsis of current scientific toxicity and fate information for the top chemicals (by weight) that facilities within this sector self-reported as released to the environment based upon 1995 TRI data. Because this section is based upon self-reported release data, it does not attempt to provide information on management practices employed by the sector to reduce the release of these chemicals. Information regarding pollutant release reduction over time may be available from EPA's TRI and 33/50 programs, or directly from the industrial trade associations that are listed in Section IX of this document. Since these descriptions are cursory, please consult these sources for a more detailed description of both the chemicals described in this section, and the chemicals that appear on the full list of TRI chemicals appearing in Section IV.A.

The brief descriptions provided below were taken from the Hazardous Substances Data Bank (HSDB) and the Integrated Risk Information System (IRIS). The discussions of toxicity describe the range of possible adverse health effects that have been found to be associated with exposure to these chemicals. These adverse effects may or may not occur at the levels released to the environment. Individuals interested in a more detailed picture of the chemical concentrations associated with these adverse effects should consult a toxicologist or the toxicity literature for the chemical to obtain more information. The effects listed below must be taken in context of these exposure assumptions that are explained more fully within the full chemical profiles in HSDB. For more information on TOXNET[3] , contact the TOXNET help line at 1-800-231-3766.

1,1,1-Trichloroethane (CAS: 71-55-6)

Sources. 1,1,1-Trichloroethane is used as an equipment and parts cleaning and degreasing solvent in aerospace manufacturing and is also used as a paint solvent.

[3] TOXNET is a computer system run by the National Library of Medicine that includes a number of toxicological databases managed by EPA, National Cancer Institute, and the National Institute for Occupational Safety and Health. For more information on TOXNET, contact the TOXNET help line at 800-231-3766. Databases included in TOXNET are: CCRIS (Chemical Carcinogenesis Research Information System), DART (Developmental and Reproductive Toxicity Database), DBIR (Directory of Biotechnology Information Resources), EMICBACK (Environmental Mutagen Information Center Backfile), GENE-TOX (Genetic Toxicology), HSDB (Hazardous Substances Data Bank), IRIS (Integrated Risk Information System), RTECS (Registry of Toxic Effects of Chemical Substances), and TRI (Toxic Chemical Release Inventory). HSDB contains chemical-specific information on manufacturing and use, chemical and physical properties, safety and handling, toxicity and biomedical effects, pharmacology, environmental fate and exposure potential, exposure standards and regulations, monitoring and analysis methods, and additional references.

Toxicity. Repeated contact of 1,1,1-Trichloroethane (TCA) with skin may cause serious skin cracking and infection. Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations.

Exposure to high concentrations of TCA causes reversible mild liver and kidney dysfunction, central nervous system depression, gait disturbances, stupor, coma, respiratory depression, and even death. Exposure to lower concentrations of TCA leads to light-headedness, throat irritation, headache, disequilibrium, impaired coordination, drowsiness, convulsion and mild changes in perception.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Releases of TCA to surface water or land will almost entirely volatilize. Releases of TCA to air may be transported long distances and may partially return to earth in rain. In the lower atmosphere, TCA degrades very slowly by photo oxidation and slowly diffuses to the upper atmosphere where photodegradation is rapid.

Any TCA that does not evaporate from soils leaches to groundwater. Degradation in soils and water is slow. TCA does not hydrolyze in water, nor does it significantly bioconcentrate in aquatic organisms.

Physical Properties. TCA is a clear, colorless liquid with a mild, chloroform-like odor and slight solubility.

Methyl Ethyl Ketone (CAS: 78-93-3)

Sources. Methyl ethyl ketone (MEK) is used as an equipment and parts cleaning and degreasing solvent and as a paint solvent.

Toxicity. Breathing moderate amounts of methyl ethyl ketone for short periods of time can cause adverse effects on the nervous system ranging from headaches, dizziness, nausea, and numbness in the fingers and toes to unconsciousness. Its vapors are irritating to the skin, eyes, nose, and throat and can damage the eyes. Repeated exposure to moderate to high amounts may cause liver and kidney effects.

Carcinogenicity. EPA does not consider methyl ethyl ketone to be a carcinogen.

Environmental Fate. Most of the MEK released to the environment will end up in the atmosphere. MEK can contribute to the formation of air pollutants in the lower atmosphere. It can be degraded by microorganisms living in water and soil.

Physical Properties. Methyl ethyl ketone is a clear, colorless, flammable liquid which decomposes explosively at 230°F. It has a fragrant mint-like odor detectable at 2 to 85 parts per million.

Trichloroethylene (CAS: 79-01-6)

Sources. Trichloroethylene is used extensively as an equipment and parts cleaning and degreasing solvent and as a paint solvent.

Toxicity. Trichloroethylene was once used as an anesthetic, though its use caused several fatalities due to liver failure. Short term inhalation exposure to high levels of trichloroethylene may cause rapid coma followed by eventual death from liver, kidney, or heart failure. Short-term exposure to lower concentrations of trichloroethylene causes eye, skin, and respiratory tract irritation. Ingestion causes a burning sensation in the mouth, nausea, vomiting and abdominal pain. Delayed effects from short-tern trichlorethylene poisoning include liver and kidney lesions, reversible nerve degeneration, and psychic disturbances. Long-term exposure can produce headache, dizziness, weight loss, nerve damage, heart damage, nausea, fatigue, insomnia, visual impairment, mood perturbation, sexual problems, dermatitis, and rarely jaundice. Degradation products of trichloroethylene (particularly phosgene) may cause rapid death due to respiratory collapse.

Carcinogenicity. Trichloroethylene is considered by EPA to be a probable human carcinogen via both oral and inhalation exposure, based on limited human evidence and sufficient animal evidence.

Environmental Fate. Trichloroethylene breaks down slowly in water in the presence of sunlight and bioconcentrates moderately in aquatic organisms. The main removal of trichloroethylene from water is via rapid evaporation. Trichloroethylene does not photodegrade in the atmosphere, though it breaks down quickly under smog conditions, forming other pollutants such as phosgene, dichloroacetyl chloride, and formyl chloride. In addition, trichloroethylene vapors may be decomposed to toxic levels of phosgene in the presence of an intense heat source such as an open arc welder. When spilled on land, trichloroethylene rapidly volatilizes from surface soils. Some of the remaining chemical may leach through the soil to groundwater.

Physical Properties. Trichloroethylene is a colorless liquid with a chloroform-like odor. It is a combustible liquid, but burns with difficulty, and it has a very low solubility.

Toluene (CAS: 108-88-3)

Sources. Toluene is used as an equipment and parts cleaning and degreasing solvent and as a paint solvent.

Toxicity. Inhalation or ingestion of toluene can cause headaches, confusion, weakness, and memory loss. Toluene may also effect the way the kidneys and liver function.

Reactions of toluene (see environmental fate) in the atmosphere contribute to the formation of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Some studies have shown that unborn animals were harmed when high levels of toluene were inhaled by their mothers, although the same effects were not seen when the mothers were fed large quantities of toluene. Note that these results may reflect similar difficulties in humans.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. The majority of releases of toluene to land and water will evaporate. Toluene may also be degraded by microorganisms. Once volatized, toluene in the lower atmosphere will react with other atmospheric components contributing to the formation of ground-level ozone and other air pollutants.

Physical Properties. Toluene, a volatile organic chemical (VOC), is a colorless liquid with a sweet, benzene-like odor. It is a Class IB flammable liquid.

IV.C. Other Data Sources

The toxic chemical release data obtained from TRI captures only about 237 of the facilities in the aerospace industry. However, it allows for a comparison across years and industry sectors. Reported chemicals are limited to the approximately 600 TRI chemicals. A significant portion of the emissions from aerospace facilities, therefore, are not captured by TRI. The EPA Office of Air Quality Planning and Standards has compiled air pollutant emission factors for determining the total air emissions of priority pollutants (e.g., total hydrocarbons, SOx, NOx, CO, particulates, etc.) from many manufacturing sources.

The Aerometric Information Retrieval System (AIRS) contains a wide range of information related to stationary sources of air pollution, including the emissions of a number of air pollutants which may be of concern within a particular industry. With the exception of volatile organic compounds (VOCs), there is little overlap with the TRI chemicals reported above. Table 12 summarizes annual releases (from the industries for which a Sector Notebook Profile was prepared) of carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter of 10 microns or less (PM10), total particulates (PT), sulfur dioxide (SO_2), and volatile organic compounds (VOCs).

Table 12: Air Pollutant Releases by Industry Sector (tons/year)

Industry Sector	CO	NO_2	PM10	PT	SO_2	VOC
Metal Mining	4,951	49,252	21,732	9,478	1,202	119,761
Oil and Gas Extraction	132,747	389,686	4,576	3,441	238,872	114,601
Non-Fuel, Non-Metal Mining	31,008	21,660	44,305	16,433	9,183	138,684
Textiles	8,164	33,053	1,819	38,505	26,326	7,113
Lumber and Wood Products	139,175	45,533	30,818	18,461	95,228	74,028
Wood Furniture and Fixtures	3,659	3,267	2,950	3,042	84,036	5,895
Pulp and Paper	584,817	365,901	37,869	535,712	177,937	107,676
Printing	8,847	3,629	539	1,772	88,788	1,291
Inorganic Chemicals	242,834	93,763	6,984	150,971	52,973	34,885
Plastic Resins and Man-made Fibers	15,022	36,424	2,027	65,875	71,416	7,580
Pharmaceuticals	6,389	17,091	1,623	24,506	31,645	4,733
Organic Chemicals	112,999	177,094	13,245	129,144	162,488	17,765
Agricultural Chemicals	12,906	38,102	4,733	14,426	62,848	8,312
Petroleum Refining	299,546	334,795	25,271	592,117	292,167	36,421
Rubber and Plastic	2,463	10,977	3,391	24,366	110,739	6,302
Stone, Clay, Glass and Concrete	92,463	335,290	58,398	290,017	21,092	198,404
Iron and Steel	982,410	158,020	36,973	241,436	67,682	85,608
Metal Castings	115,269	10,435	14,667	4,881	17,301	21,554
Nonferrous Metals	311,733	31,121	12,545	303,599	7,882	23,811
Fabricated Metal Products	7,135	11,729	2,811	17,535	108,228	5,043
Electronics and Computers	27,702	7,223	1,230	8,568	46,444	3,464
Motor Vehicle Assembly	19,700	31,127	3,900	29,766	125,755	6,212
Aerospace	**4,261**	**5,705**	**890**	**757**	**3,705**	**10,804**
Shipbuilding and Repair	109	866	762	2,862	4,345	707
Ground Transportation	153,631	594,672	2,338	9,555	101,775	5,542
Water Transportation	179	476	676	712	3,514	3,775
Air Transportation	1,244	960	133	147	1,815	144
Fossil Fuel Electric Power	399,585	5,661,468	221,787	13,477,367	42,726	719,644
Dry Cleaning	145	781	10	725	7,920	40

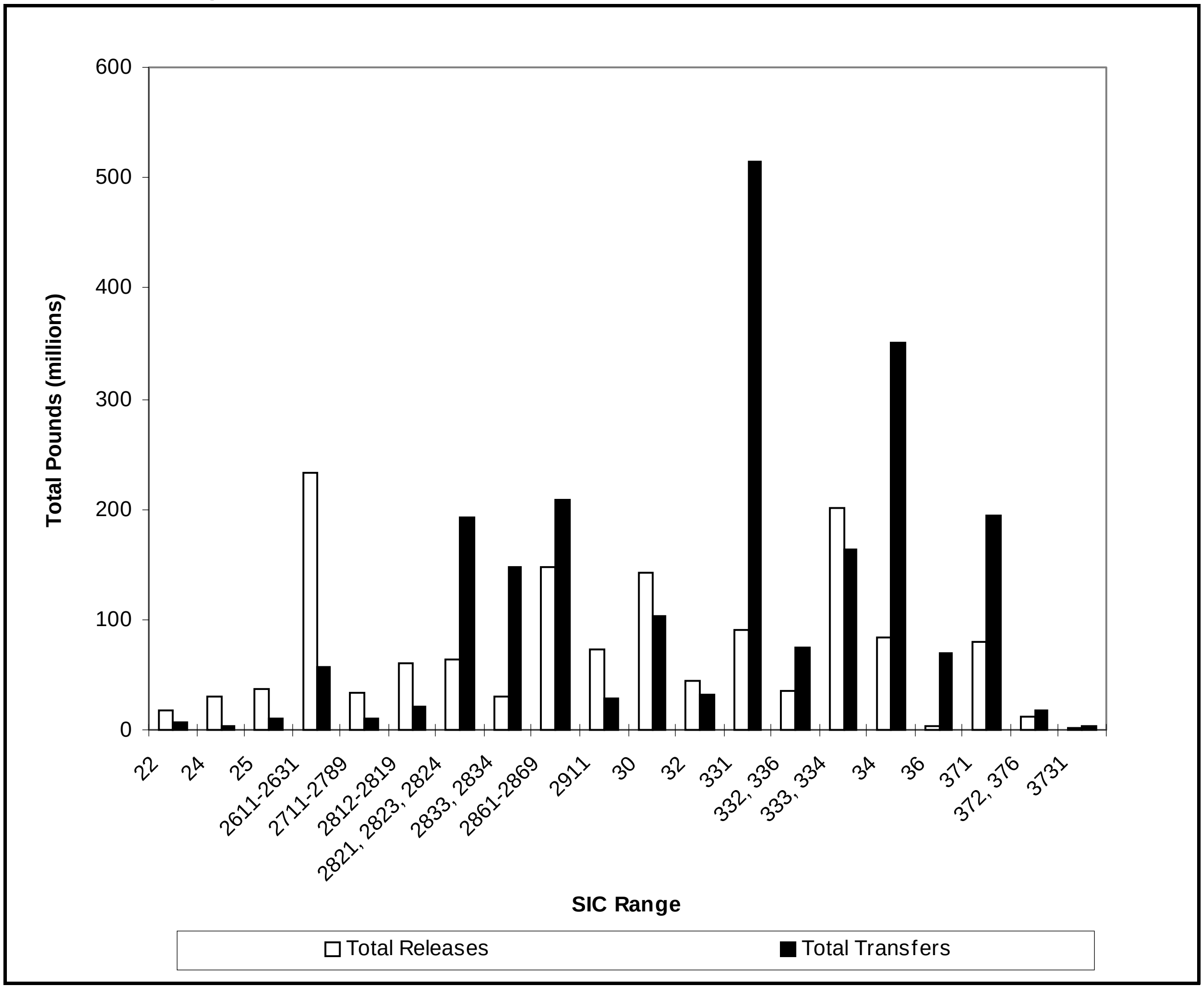
Source: U.S. EPA Office of Air and Radiation, AIRS Database, 1997.

IV.D. Comparison of Toxic Release Inventory Between Selected Industries

The following information is presented as a comparison of pollutant release and transfer data across industrial categories. It is provided to give a general sense as to the relative scale of TRI releases and transfers within each sector profiled under this project. Please note that the following figures and tables do not contain releases and transfers for industrial categories that are not included in this project, and thus cannot be used to draw conclusions regarding the total release and transfer amounts that are reported to TRI. Similar information is available within the annual TRI Public Data Release Book.

Figure 7 is a graphical representation of a summary of the TRI data for the aerospace industry and the other sectors profiled in separate notebooks. The bar graph presents the total TRI releases and total transfers on the vertical axis. Industry sectors are presented in the order of increasing SIC code. The graph is based on the data shown in Table 13 and is meant to facilitate comparisons between the relative amounts of releases and transfers both within and between these sectors. Table 13 also presents the average releases per facility in each industry. The reader should note that differences in the proportion of facilities captured by TRI exist between industry sectors. This can be a factor of poor SIC matching and relative differences in the number of facilities reporting to TRI from the various sectors. In the case of the aerospace industry, the 1995 TRI data presented here covers 237 facilities. These facilities listed SIC 3721, 3724, 3728, 3761, 3764, or 3769 (aerospace industry) as a primary SIC code(s).

Figure 7: Summary of TRI Releases and Transfers by Industry



Source: US EPA 1995 Toxics Release Inventory Database.

Key to Standard Industrial Classification Codes

SIC Range	Industry Sector	SIC Range	Industry Sector	SIC Range	Industry Sector
22	Textiles	2833, 2834	Pharmaceuticals	333, 334	Nonferrous Metals
24	Lumber and Wood Products	2861-2869	Organic Chem. Mfg.	34	Fabricated Metals
25	Furniture and Fixtures	2911	Petroleum Refining	36	Electronic Equip. and Comp.
2611-2631	Pulp and Paper	30	Rubber and Misc. Plastics	371	Motor Vehicles, Bodies, Parts, and Accessories
2711-2789	Printing	32	Stone, Clay, and Concrete	372, 376	Aerospace
2812-2819	Inorganic Chemical Manufacturing	331	Iron and Steel	3731	Shipbuilding and Repair
2821, 2823, 2824	Resins and Plastics	332, 336	Metal Casting		

Table 13: 1995 Toxics Release Inventory Data for Selected Industries

Industry Sector	SIC Range	# TRI Facilities	TRI Releases: Total Releases (million lbs.)	TRI Releases: Average Releases per Facility (lbs.)	TRI Transfers: Total Transfers (million lbs.)	TRI Transfers: Average Transfers per Facility (lbs.)	Total Releases + Transfers (million lbs.)	Average Releases + Transfers per Facility (lbs.)
Textiles	22	339	17.8	53,000	7.0	21,000	24.8	74,000
Lumber and Wood Products	24	397	30.0	76,000	4.1	10,000	34.1	86,000
Furniture and Fixtures	25	336	37.6	112,000	9.9	29,000	47.5	141,000
Pulp and Paper	2611-2631	305	232.6	763,000	56.5	185,000	289.1	948,000
Printing	2711-2789	262	33.9	129,000	10.4	40,000	44.3	169,000
Inorganic Chem. Mfg.	2812-2819	413	60.7	468,000	21.7	191,000	438.5	659,000
Resins and Plastics	2821,2823, 2824	410	64.1	156,000	192.4	469,000	256.5	625,000
Pharmaceuticals	2833, 2834	200	29.9	150,000	147.2	736,000	177.1	886,000
Organic Chemical Mfg.	2861-2869	402	148.3	598,000	208.6	631,000	946.8	1,229,000
Agricultural Chemicals	287	236	77.1	327,000	11.4	48,000	88.5	375,000
Petroleum Refining	2911	180	73.8	410,000	29.2	162,000	103.0	572,000
Rubber and Misc. Plastics	30	1,947	143.1	73,000	102.6	53,000	245.7	126,000
Stone, Clay, and Concrete	32	623	43.9	70,000	31.8	51,000	75.7	121,000
Iron and Steel	331	423	90.7	214,000	513.9	1,215,000	604.6	1,429,000
Metal Casting	332, 336	654	36.0	55,000	73.9	113,000	109.9	168,000
Nonferrous Metals	333, 334	282	201.7	715,000	164	582,000	365.7	1,297,000
Fabricated Metals	34	2,676	83.5	31,000	350.5	131,000	434.0	162,000
Electronic Equip. and Comp.	36	407	4.3	11,000	68.8	169,000	73.1	180,000
Motor Vehicles, Bodies, Parts, and Accessories	371	754	79.3	105,000	194	257,000	273.3	362,000
Aerospace	**372, 376**	**237**	**12.5**	**53,000**	**17.1**	**72,000**	**29.6**	**125,000**
Shipbuilding	3731	43	2.4	56,000	4.1	95,000	6.5	151,000

Source: *US EPA Toxics Release Inventory Database, 1995.*

V. POLLUTION PREVENTION OPPORTUNITIES

The best way to reduce pollution is to prevent it in the first place. Some companies have creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts. This can be done in many ways such as reducing material inputs, re-engineering processes to reuse by-products, improving management practices, and employing substitution of toxic chemicals. Some smaller facilities are able to actually get below regulatory thresholds just by reducing pollutant releases through aggressive pollution prevention policies.

The Pollution Prevention Act of 1990 established a national policy of managing waste through source reduction, which means preventing the generation of waste. The Pollution Prevention Act also established as national policy a hierarchy of waste management options for situations in which source reduction cannot be implemented feasibly. In the waste management hierarchy, if source reduction is not feasible the next alternative is recycling of wastes, followed by energy recovery, and waste treatment as a last alternative.

In order to encourage these approaches, this section provides both general and company-specific descriptions of some pollution prevention advances that have been implemented within the aerospace industry. While the list is not exhaustive, it does provide core information that can be used as the starting point for facilities interested in beginning their own pollution prevention projects. This section provides summary information from activities that may be, or are being implemented by this sector. When possible, information is provided that gives the context in which the technique can be used effectively. Please note that the activities described in this section do not necessarily apply to all facilities that fall within this sector. Facility-specific conditions must be carefully considered when pollution prevention options are evaluated, and the full impacts of the change must examine how each option affects air, land and water pollutant releases.

Pollution Prevention Techniques

This section lists many pollution prevention techniques geared toward the aerospace industry and its related processes. Some techniques may be applicable to a number of different processes such as materials substitution of low-solvent and less hazardous materials exist, while others are specific to a single phase of aerospace manufacturing. Many of the techniques discussed below were obtained from the *Profile of the Shipbuilding and Repair Industry*, EPA, 1997. It is important to note that the FAA places very strict “airworthiness” guidelines on manufacturing and rework facilities for safety and quality control purposes, thus new pollution prevention alternatives may require a full evaluation and permitting process before they may be used.

Because military facilities are not subject to FAA guidelines, they have a greater opportunity to implement P2 alternatives. As a result, studies have been conducted at various Air Force, Coast Guard, and Naval facilities which are referenced in Section IX. Excellent information on military facility P2 activities can be found at web sites of the Air Force Center for Environmental Excellence (http://www.afcee.brooks.af.mil), and at the Navy's P2 Library web site (http://enviro.nfesc.navy.mil/p2library).

V.A. Machining and Metalworking

Coolant, or metalworking, fluids account for the largest waste stream generated by machining operations. Waste metalworking fluids are created when the fluids are no longer usable due to contamination by oils or chemical additives. If the contamination rate of the metalworking fluids is reduced, the need to replace them will be less frequent. This will reduce the waste generated.

Preventing Fluid Contamination

Fluid can become hazardous waste if it is contaminated. Although it is not possible to eliminate contamination, it is possible to reduce the rate of contamination and thereby prolong its use.

The primary contaminant in these waste fluids is tramp oil. One way to postpone contamination is to promote better maintenance of the wipers and seals. A preventative maintenance program should be installed and enforced in the machine shop. Scheduled sump and machine cleaning as well as periodic inspections of the wipers and oil seals should be carried out. The responsibility for this should be assigned to some person or group in a position of authority to ensure its success.

Synthetic Fluids

Synthetic fluids have many advantages over their non-synthetic counterparts. Usually the synthetic varieties do not lubricate as effectively, but they are less susceptible to contamination and highly resistant to biological breakdown. Most synthetic fluids have superior longevity and can operate over a large temperature range without adverse side effects. Straight oils should be replaced with synthetic ones when possible.

Recycling Fluids

Once all of the source reduction options have been considered, it is time to explore the possibilities of reuse. It should be noted that in many cases, after the majority of the contaminants have been removed, further treatment with chemicals or concentrated fluid is necessary before the fluids can be recirculated through the machines.

Filtration Filtration is a common way to remove particles from the fluid as well as tramp oils or other contaminants. Many different types of filters can be used depending on the medium to be filtered and the amount of filtration desired. Contaminated cutting fluids can be passed through a bag, disc, or cartridge filter or separated in a centrifuge.

Skimming and Flotation Although it is a slow process, skimming of contaminants is inexpensive and can be very effective. The principle is to let the fluid sit motionless in a sump or a tank, and after a predetermined amount of time, the unwanted oils are skimmed off the surface and the heavier particulate matter is collected off the bottom. A similar technique, flotation, injects high pressure air into contaminated cutting fluid. As the air comes out of solution and bubbles to the surface, it attaches itself to suspended contaminants and carries them up to the surface. The resulting sludge is skimmed off the surface and the clean fluid is reused.

Centrifugation Centrifugation uses the same settling principles as flotation, but the effects of gravity are multiplied thousands of times due to the spinning action of the centrifuge. This will increase the volume of fluids which can be cleaned in a given amount of time.

Pasteurization Pasteurization uses heat treatment to kill microorganisms in the fluid and reduce the rate at which rancidity (biological breakdown) will occur. Unfortunately, heat can alter the properties of the fluid and render it less effective. Properties lost in this way are usually impossible to recover.

Downgrading Sometimes it is possible to use high quality hydraulic oils as cutting fluids. After the oils have reached their normal usable life, they no longer meet the high standards necessary for hydraulic components. At this time they are still good enough to be used for the less demanding jobs. It may be necessary to treat the fluid before it can be reused, but changing fluid's functions in this manner has proven successful in the past.

V.B. Surface Preparation

The majority of wastes generated during surface preparation are spent abrasives and solvents mixed with paint chips. One way the volume of waste generated can be reduced is by using blast media that is relatively easy to reuse.

Improving Recyclability of Abrasive Blasting Media

Often, air powered cleaning equipment is used to screen abrasive to separate it from large paint particles. These systems may also remove lighter dust from the heavy abrasive. This media separation can be especially important when the paint being removed contains heavy metals. An alternative to on-site reclamation is to send it for processing off-site. It is very important that waste streams, especially hazardous waste, are not mixed with used blasting media. Outside debris and other waste could render the media unfit for reuse.

Plastic Media Blasting

As a substitute for other blast media, the military has experimented extensively with plastic media stripping. This process is particularly good for stripping coatings from parts with fragile substrates often found in the aerospace industry such as zinc, aluminum, and fiberglass. It can be a lengthy process because it strips paint layer by layer. The same types and quantities of waste are generated as with grit blasting, but the plastic medium is more recyclable with the use of pneumatic media classifiers that are part of the stripping equipment. The only waste requiring disposal is the paint waste itself. However, the use of plastic media is fairly limited. Plastic blasting media do not work well on epoxy paints. In addition, the blasting equipment is expensive and requires trained operators.

Water Jet Stripping (Hydroblasting)

Hydroblasting is a cavitating high pressure water jet stripping system that can remove most paints. These system may use pressures as high as 50,000 psig. Hydroblasting is an excellent method for removing even hard coatings from metal substrates. Some systems automatically remove the paint chips or stripped material from the water and reuse the water for further blasting. By recirculating the water in this manner, the amount of waste is greatly reduced. Wastewater from this process is usually suitable for sewer disposal after the paint particles are removed. Although this process produces very little waste, it is not always as efficient as other blasting methods, has relatively high capital and maintenance costs, and may not be adequate for fragile substrates.

V.C. Solvent Cleaning and Degreasing

Aerospace manufacturers often use large quantities of solvents in a variety of cleaning and degreasing operations including parts cleaning, process equipment cleaning, and surface preparation for coating applications. The final cost of solvent used for various cleanup operations is nearly twice the original purchase price of the virgin solvent. The additional cost is primarily due to the fact that for each drum purchased, extra disposal cost, hazardous materials transportation cost, and manifesting time and expense are incurred. With the rising cost of solvents and waste disposal services, combined with continuously developing regulation, reducing the quantities of solvents used and solvent wastes generated can be extremely cost effective.

Eliminating the Use of Solvents

Eliminating the use of solvents avoids any waste generation associated with spent solvent. Elimination can be achieved by utilization of non-solvent cleaning agents or eliminating the need for cleaning altogether. Solvent elimination applications include the use of water-soluble cutting fluids, protective peel coatings, aqueous cleaners, and mechanical cleaning systems (USEPA/OECA, 1997).

Water-soluble Cutting Fluids Water-soluble cutting fluids can often be used in place of oil-based fluids. The cutting oils usually consist of an oil-in-water emulsion used to reduce friction and dissipate heat. If these fluids need to be removed after the machining process is complete, solvents may be needed.

In efforts to eliminate solvent degreasing and its subsequent waste, special water-soluble cutting fluids have been developed. Systems are available that can clean the cutting fluid and recycle the material back to the cutting operation. Obstacles to implementing this method are: cost (water-soluble fluids are generally more expensive), procurement (there are only a few suppliers available), and the inability to quickly switch between fluid types without thoroughly cleaning the equipment (USEPA/OECA, 1997).

Aqueous Cleaners Aqueous cleaners, such as alkali, citric, and caustic base, are often useful substitutes for solvents. There are many formulations that are suited for a variety of cleaning requirements. Many aqueous cleaners have been found to be as effective as the halogenated solvents that are commonly employed.

Aqueous stripping agents, such as caustic soda (NaOH), are often employed in place of methylene chloride based strippers. Caustic solutions have the advantage of eliminating solvent vapor emissions. A typical caustic bath consists of about 40 percent caustic solution heated to about 200 degrees Fahrenheit. Caustic stripping is generally effective on alkyl resins and oil paints (EPA, March 1997).

The Douglas Aircraft Division of McDonnell Douglas used a chromic acid solution to clean aluminum parts. However, the solution began to corrode the steel cleaning equipment parts. A scientist at McDonnell Douglas developed a sodium hydroxide-based process which cleaned parts sufficiently to detect cracks in the aluminum parts during testing. The new process saves an estimated $28,000 per year in chemical costs (Boeing, 1998).

In 1990, the Martin Marietta Astronautics Group (now Lockheed Martin) eliminated the use of 1,1,1-trichloroethane (TCA) and methyl ethyl ketone (MEK) for vapor degreasing. Six alternative aqueous cleaners were subjected to a screening process that evaluated health hazards, treatability of wastewater, corrosion potential, degreasing performance, and salt fog corrosion resistance. From this study, Lockheed Martin selected a nontoxic aqueous terpene cleaner. The substitution of this cleaner saves hundreds of thousands of dollars every year in material cost savings and ozone depletion taxes (Dykema, 1993).

Lockheed Martin Tactical Aircraft Systems in Fort Worth, Texas, has substituted low vapor pressure solvent and aqueous cleaning for CFC-113 in all aspects of aircraft manufacturing. The low vapor pressure solvent is a blend of propylene glycol methyl ether acetate, isoparaffins, and butyl acetate. The solvent is effective on a variety of organic soils and is used for wiping the surfaces of aircraft components and assemblies. The substitution of this cleaner completely eliminated CFC emissions and reduced solvent use, solvent cost, VOC emissions, and total air emissions (Evanoff, 1993).

The advantages of substituting aqueous cleaners include minimizing worker's exposure to solvent vapors, reducing liability and disposal problems associated with solvent use, and cost. Aqueous cleaners do not volatilize as quickly as other solvents, thereby reducing losses due to evaporation. Since most aqueous cleaners are biodegradable, disposal is not a problem once the organic or inorganic contaminants are removed (USEPA, March 1997).

The use of aqueous cleaners can also result in cost savings. Although some aqueous cleaners may cost less than an equivalent amount of solvent, the purchase price of each is about the same. The cost of disposal, loss due to evaporation, and associated liabilities, however, favor aqueous cleaners.

The disadvantages of aqueous cleaners in place of solvents may include: possible incompatibilities with FAA guidelines, possible inability of the aqueous cleaners to provide the degree of cleaning required, incompatibility between the parts being cleaned and the cleaning solution, need to modify or replace existing equipment, longer required cleaning time, and problems associated with moisture left on parts being cleaned. Oils removed from the parts during cleaning may float on the surface of the cleaning solution and may interfere with subsequent cleaning. Oil skimming is usually required (USEPA/OECA, 1997).

Mechanical Cleaning Systems Utilizing mechanical cleaning systems can also replace solvents in degreasing and cleaning operations. In many cases, a high pressure steam gun or high pressure parts washer can clean parts and surfaces quicker and to the same degree of cleanliness as that of the solvents they replace. Light detergents can be added to the water supply for improved cleaning. The waste produced by these systems is usually oily wastewater. This wastewater can be sent through an oil/water separator, the removed water discharged to the sewer, and the oil residue sent to a petroleum recycler. Some hot water wash and steam systems can be supplemented by emulsifying solutions to speed the process. Although these additives speed the cleaning process, they can make separation of the oil from the water very difficult and create problems with disposal of the waste.

Cryogenic stripping utilizes liquid nitrogen and non-abrasive plastic beads as blasting shot. This method relies on the freezing effect of the liquid nitrogen and the impact of the plastic shot. Subjecting the surface to extremely low temperatures creates stress between the coating and the substrate causing the coating to become brittle. When the plastic shot hits the brittle coating, debonding occurs. The process is non-abrasive, and will not damage the substrate, but effects of the metal shrinkage, due to extremely low temperatures, should be monitored. The process does not produce liquid wastes, and nitrogen, chemically inert, is already present in the atmosphere (USEPA/OECA, 1997).

Thermal stripping methods can be useful for objects that cannot be immersed. In this process, superheated air is directed against the surface of the object. The high temperatures cause some paints to flake off. The removal results from the drying effects of the air and the uneven expansion of the paint and the substrate. Some paints will melt at high temperatures, allowing the paint to be scraped off manually or with abrasives. Hand-held units are available that produce a jet of hot air. Electric units and open flame or torch units are also used. While this system is easy to implement, it is limited to items that are not heat sensitive and to coatings that are affected by the heat (USEPA/OECA, 1997).

McDonnell Douglas has developed two thermal stripping techniques. The first one, known as FLASHJET™, uses a high-intensity xenon lamp to heat the surface paint and disintegrate it. A stream of dry ice pellets follows to carry away the paint chips. FLASHJET™ was developed for use and tested on helicopters at the McDonnell Douglas Helicopter Systems plant in Mesa, Arizona. FLASHJET™ reduced the manual work required by 10 to 15 percent (Boeing, 1998).

The second technique was adapted from a technique to remove hydrocarbons from engines. The Hot Gaseous Nitrogen (GN2) Purge heats the critical engine surfaces, driving off the volatile hydrocarbons, which then leave the engine through the flow of nitrogen. This method eliminates the use of 1,1,1-trichloroethane for this type of engine cleaning (Boeing, 1998).

Hughes Aircraft Company developed a supercritical carbon dioxide ($SCCO_2$) cleaning system to be used in many cleaning applications in the aerospace industry. At temperatures and pressures close to or above its critical point (88°F and 1,073 psia), CO_2 acts as an ideal solvent. It is also inexpensive and inert, non-combustible, naturally occurring, and does not contribute to smog. Efficient removal of oils, greases, fingerprints, solder flux residues have been achieved by the SUPERSCRUB™ unit at Hughes (Chao).

Reducing the Use of Solvent

By eliminating the use or need for solvent cleaning, the problems associated with disposal of spent solvent are also eliminated. In cases where the elimination of solvent use is not possible or practical, utilization of various solvent waste reduction techniques can lead to a substantial savings in solvent waste.

Methods of reducing solvent usage can be divided into three categories: source control of air emissions, efficient use of solvent and equipment, and maintaining solvent quality. Source control of air emissions addresses ways in which more of the solvent can be kept inside a container or cleaning tank by reducing the chances for evaporation loss. Efficient use of solvent and equipment through better operating procedures can reduce the amount of solvent required for cleaning. Maintaining the quality of solvent will extend the life cycle effectiveness of the solvent.

<u>Source Control of Air Emissions</u> Source control of air emissions can be achieved through equipment modification and proper operation of equipment. Some simple control measures include installation and use of lids, an increase of freeboard height of cleaning tanks, installation of freeboard chillers, and taking steps to reduce solvent drag-out.

All cleaning units, including cold cleaning tanks and dip tanks, should have some type of lid installed. When viewed from the standpoint of reducing air emissions, the roll-type cover is preferable to the hinge type. Lids that swing down can cause a piston effect and force the escape of solvent vapor. In operations such as vapor degreasing, use of lids can reduce solvent loss from 24 percent to 50 percent. For tanks that are continuously in use, covers have been designed that allow the work pieces to enter and leave the tank while the lid remains closed.

In an open top vapor degreaser, freeboard is defined as the distance from the top of the vapor zone to the top of the tank. Increasing the freeboard will substantially reduce the amount of solvent loss. A freeboard chiller may also be installed above the primary condenser coil. This refrigerated coil, much like the cooling jacket, chills the air above the vapor zone and creates a secondary barrier to vapor loss. Reduction in solvent usage, by use of freeboard chillers, can be as high as 60 percent. The major drawback with a freeboard chiller is that it can introduce water (due to condensation from air) into the tank.

In addition to measures that reduce air emissions through equipment modification, it is also possible to reduce emissions through proper equipment layout, operation, and maintenance. Cleaning tanks should be located in areas where air turbulence and temperature do not promote vapor loss.

Maximize the Dedication of the Process Equipment In addition to reduction in vapor loss, reducing the amount of solvent used can be achieved through better operating practices that increase the efficiency of solvent cleaning operations. Maximizing the dedication of the process equipment reduces the need for frequent cleaning. By using a mix tank consistently for the same formulation, the need to clean equipment between batches is eliminated.

Avoid Unnecessary Cleaning Avoiding unnecessary cleaning also offers potential for waste reduction. For example, paint mixing tanks for two-part paints are often cleaned between batches of the same product. The effect of cross-contamination between batches should be examined from a product quality control viewpoint to see if the cleaning step is always necessary.

Proper Production Scheduling Proper production scheduling can reduce cleaning frequency by eliminating the need for cleaning between the conclusion of one task and the start of the next. A simple example of this procedure is to have a small overlap between shifts that perform the same operation with the same equipment. This allows the equipment that would normally be cleaned and put away at the end of each shift, such as painting equipment, to be taken over directly by the relief.

Clean Equipment Immediately Cleaning equipment immediately after use prevents deposits from hardening and avoids the need for consuming extra solvent. Letting dirty equipment accumulate and be cleaned later can also increase the time required for cleaning.

Better Operating Procedures Better operating procedures can minimize equipment clean-up waste. Some of the methods already discussed are examples of better operating procedures. Better operator training, education, closer supervision, improved equipment maintenance, and increasing the use of automation are very effective in waste minimization.

Reuse Solvent Waste Reuse of solvent waste can reduce or eliminate waste and result in a cost savings associated with a decrease in raw material consumption. The solvent from cleaning operations can be reused in other cleaning processes in which the degree of cleanliness required is much less. This will be discussed in more detail in the next section.

Solvent Recycling

Although not as preferable as source reduction, solvent recycling may be a viable alternative for some facilities. The goal of recycling is to recover from the waste solvent, a solvent of a similar purity to that of the virgin solvent for eventual reuse in the same operation, or of a sufficient purity to be used in another application. Recycling can also include the direct use of solvent waste from one waste stream in another operation. There are a number of techniques that facilities can use onsite to separate solvents from contaminants including distillation, evaporation, sedimentation, decanting, centrifugation, filtering, and membrane separation.

V.D. Metal Plating and Surface Finishing

Pollution prevention opportunities in metal plating and surface finishing operations are discussed in the *Profile of the Fabricated Metal Products Industry Sector Notebook*. Readers are encouraged to consult this document for pollution prevention information relating to metal plating and surface finishing. An additional resource for pollution prevention information regarding metal finishing can be found at the National Metal Finishing Resource Center (http://www.nmfrc.org).

V.E. Painting and Coating

Painting and coating operations are typically the largest single source of VOC emissions from aerospace manufacturing and rework facilities. In addition, paint waste can account for more than half of the total hazardous waste generated. Paint waste may include leftover paint in containers, overspray, paint that is no longer usable (Non-spec paint), and rags and other materials contaminated with paint. In many cases, the amount of paint waste generated can be reduced through the use of improved equipment, alternative coatings, and good operating practices. An additional resource for pollution prevention information regarding painting and coating can be found at the Paint and Coatings Resource Center (http://www.paintcenter.org).

Application Equipment

In order to effectively reduce paint waste and produce a quality coating, proper application techniques should be supplemented with efficient application equipment. Through the use of equipment with high transfer efficiencies, the amount of paint lost to overspray is minimized.

High Volume Low Pressure (HVLP) Spray Guns The HVLP spray gun is basically a conventional air spray gun with modifications and special nozzles that atomize the paint at very low air pressures. The atomizing pressure of HVLP systems is often below 10 psi. The design of this gun allows better transfer efficiency and reduced overspray than that of conventional air guns. The low application pressure decreases excessive bounceback and allows better adhesion of the coating to the substrate.

Although improvements are consistently being made to overcome its limitations, most HVLP systems have some definite drawbacks, including difficulty atomizing viscous coatings, sensitivity to variations in incoming pressure, sensitivity to wind, and slow application rates.

Airless Spray Guns Instead of air passing through the spray gun, an airless system applies static pressure to the liquid paint. As the paint passes through the nozzle, the sudden drop in pressure atomizes the paint and it is carried to the substrate by its own momentum. Pressure is applied to the paint by a pump located at a remote supply. These systems have become favorable over conventional air-spray systems for three main reasons:

1) reduced overspray and rebound,
2) high application rates and transfer efficiency,
3) permits the use of high-build coatings with the result that fewer coats are required to achieve specific film thickness.

One major disadvantage of some airless spray systems is the difficulty applying very thin coats. If coatings with less than a millimeter in thickness are required, such as primers applied to objects that require weldability, it may be difficult to use an airless system.

Electrostatic Spray Electrostatic spray systems utilize paint droplets that are given a negative charge in the vicinity of a positively charged substrate. The droplets are attracted to the substrate and a uniform coating is formed. This system works well on cylindrical and rounded objects due to its "wrap-around" effect that nearly allows the object to be coated from one side. Very little paint is lost to overspray, and it has been noted to have a transfer efficiency of over 95%.

In order for an electrostatic system to operate properly, the correct solvent balance is needed. The evaporation rate must be slow enough for the charged droplets to reach the substrate in a fluid condition to flow out into a smooth film, but fast enough to avoid sagging. The resistivity of the paint must also be low enough to enable the paint droplets to acquire the maximum charge.

Although the operating costs of electrostatic spray systems are relatively low, the initial capital investment can be high. This system has been found to work extremely well in small parts painting applications. Sometimes the installation of an electrostatic powder coating system can replace a water curtain spray paint booth.

Heated Spray When paint is heated, its viscosity is reduced allowing it to be applied with a higher solids content, thus requiring less solvent. When the paint is heated in a special container and supplied to the gun at 140° to 160°F, coatings of 2 to 4 millimeters dry-film thickness can be applied in one operation, resulting in considerable savings in labor cost. In addition, much of the associated solvent emissions are eliminated.

Heating the coating prior to application can be used with both conventional and airless spray applications. An in-line heater is used to heat the coating before it reaches the gun. As the coating is propelled through the air, it cools rapidly and increases viscosity after it hits the surface, allowing for better adhesion to the substrate.

<u>Plural Component Systems</u> A common problem that facilities face when working with two-part coatings is overmixing. Once the component parts of a catalyst coating are mixed, the coating must be applied. Otherwise, the excess unused coating will cure and require disposal. Additionally, the coating equipment must be cleaned immediately after use.

One large advantage of plural component technology is the elimination of paint waste generated by mixing an excess amount of a two part coating. This is achieved through the use of a special mixing chamber that mixes the pigment and catalyst seconds before the coating is applied. Each component is pumped through a device that controls the mixing ratio and then is combined in a mixing chamber. From the mixing chamber, the mixed coating travels directly to the spray guns. The only cleaning that is required is the mixing chamber, gun, and the length of supply hose connecting them.

<u>Wet Booth</u> Generally, small-volume painting operations will find the lower purchase cost of a dry filter booth will meet their requirements. One disadvantage in the use of a dry-filter booth is in the disposal of the waste. Typically the majority of this waste is the filter media itself which has been contaminated by a relatively small amount of paint. Reusable filters may decrease waste volume and reduce disposal cost. In some applications, overspray can be collected for reuse.

If overall painting volume can justify the investment, a wet booth eliminates disposal of filter media and allows waste to be reduced in weight and volume. This is achieved by separating the paint from the water through settling, drying, or using a centrifuge or cyclone (Ohio EPA, 1994).

<u>Recycle Paint Booth Water</u> Various methods and equipment are used to reduce or eliminate the discharge of the water used in water-wash booths (water curtain). These methods and equipment prevent the continuous discharge of booth waters by conditioning (i.e., adding detacifiers and paint-dispersing polymers) and removing paint solids. The most basic form of water maintenance is the removal of paint solids by manual skimming and/or raking. This can be performed without water conditioning since some portion of

solvent-based paints usually float and/or sink. With the use of detacifiers and paint-dispersing polymer treatments, more advanced methods of solids removal can be implemented. Some common methods are discussed below.

Wet-Vacuum Filtration Wet-vacuum filtration units consist of an industrial wet-vacuum head on a steel drum containing a filter bag. The unit is used to vacuum paint sludge from the booth. The solids are filtered by the bag and the water is returned to the booth. Large vacuum units are also commercially available that can be moved from booth to booth by forklift or permanently installed near a large booth.

Tank-Side Weir A weir can be attached to the side of a side-draft booth tank, allowing floating material to overflow from the booth and be pumped to a filtering tank for dewatering.

Consolidator A consolidator is a separate tank into which booth water is pumped. The water is then conditioned by the introduction of chemicals. Detacified paint floats to the surface of the tank, where it is skimmed by a continuously moving blade. The clean water is recycled to the booth.

Filtration Various types of filtration units are used to remove paint solids from booth water. This is accomplished by pumping the booth water to the unit where the solids are separated and returning the water to the booth. The simplest filtration unit consists of a gravity filter bed utilizing paper or cloth media. Vacuum filters are also employed, some of which require precoating with diatomaceous earth.

Centrifuge Methods Two common types of centrifugal separators are the hydrocyclone and the centrifuge. The hydrocyclone is used to concentrate solids. The paint booth water enters a cone-shaped unit under pressure and spins around the inside surface. The spinning imparts an increased force of gravity, which causes most of the solid particles to be pulled outward to the walls of the cone. Treated water exits the top of the unit and the solids exit from the bottom. Some systems have secondary filtration devices to further process the solids. The centrifuge works in a similar manner, except that the booth water enters a spinning drum, which imparts the centrifugal force needed for separating the water and solids. Efficient centrifugation requires close control of the booth water chemistry to ensure a uniform feed. Also, auxiliary equipment such as booth water agitation equipment may be needed (EPA, 1995).

Alternative Coatings

The use of solvent-based coatings can lead to high costs to meet air and water quality regulations. In efforts to reduce the quantity and toxicity of waste paint disposal, alternative coatings have been developed that do not require the use of solvents and thinners. FAA guidelines may prohibit use of such coatings.

Powder Coatings Metal substrates can be coated with certain resins by applying the powdered resin to the surface, followed by application of heat. The heat melts the resin, causing it to flow and form a uniform coating. The three main methods in use for applying the powder coating are fluidized bed, electrostatic spray, and flame spraying.

In flame spraying, the resin powder is blown through the gun by compressed air. The particles are melted in a high temperature flame and propelled against the substrate. This process is used widely with epoxy powders for aluminum surfaces.

The electrostatic application method uses the same principles as the electrostatic spray. The resin powder is applied to the surface electrostatically. Heat is applied to the covered surface and the powder melts to form the coating. The transfer efficiency and recyclability of this method is very high.

The elimination of environmental problems associated with many liquid based systems is one of the major advantages of powder coatings. The use of powder coatings eliminates the need for solvents and thereby emits negligible volatile organic compounds (VOCs). Powder coatings also reduce the waste associated with unused two-part coatings that have already been mixed. Since powder overspray can be recycled, material utilization is high and solid waste generation is low. Recent case studies demonstrate that powder coating systems can be cleaner, more efficient, and more environmentally acceptable, while producing a higher quality finish than many other coating systems.

Water-Based Paints Water-based coatings are paints containing a substantial amount of water instead of volatile solvents. Alkyd, polyester, acrylic, and epoxy polymers can be dissolved and dispersed by water. In addition to reduction in environmental hazards due to substantially lower air emissions, a decrease in the amount of hazardous paint sludge generated can reduce disposal cost.

UV / EB Coatings Powder coatings require high temperatures for their cure and hence are not applicable to temperature sensitive substrates, such as paper, wood or plastics. For such materials, the use of coatings systems curable by ultra violate light or electron beams (UV/EB) have been developed. The resins used in these coatings are basically the same as those used in conventional high performance coatings which have been modified to make them polymerizable by UV or EB energy. Thus they are liquids that can be applied by conventional techniques such as spraying, roller coating, curtain coating, etc. (in contrast to powder coating which requires specialized application techniques). When exposed to the low level radiant energy, they are instantly and completely cured with no heat application. Because of the diversity of raw materials that can be adapted to this technology, a tremendous range of performance characteristics can be achieved. In addition, because no solvents are used in the coating formulations, there are virtually no volatile organic compounds (VOCs) emitted, making them ecologically preferred. Other advantages include the elimination of curing ovens and incinerators which further aid the cleansing of the air as well as substantial savings of space and fuel costs. The rapid curing cycle without the need of a cool-down cycle allows for higher production rates and therefore lower costs. UV/EB coatings can be used on metals, and are especially useful when coating complex metal products that might contain paper, plastic or wood parts, because of the low temperature curing required by UV/EB. In addition, these, and other advantages which UV/EB provides, have led to rapid increase in their use in the manufacture of electronic components.

Good Operating Practices

In many cases, simply altering a painting process can reduce wastes through better management.

A good manual coating application technique is very important in reducing waste. If not properly executed, spraying techniques have a high potential for creating waste; therefore, proper application techniques are very important.

<u>Reducing Overspray</u> One of the most common means of producing paint waste at facilities is overspray. Overspray not only wastes some of the coating, it also presents environmental and health hazards. It is important that facilities try to reduce the amount of overspray as much as possible. Techniques for reducing overspray include:

1) triggering the paint gun at the end of each pass instead of carrying the gun past the edge of the surface before reversing directions,
2) avoiding excessive air pressure,
3) keeping the gun perpendicular to the surface being coated.

<u>Uniform Finish</u> Application of a good uniform finish provides the surface with quality coating with a higher performance than an uneven finish. An uneven coating does not dry evenly and commonly results in using excess paint.

<u>Overlap</u> An overlap of 50 percent can reduce the amount of waste by increasing the production rate and overall application efficiency. Overlap of 50 percent means that for every pass that the operator makes with the spray

gun, 50 percent of the area covered by the previous pass is also sprayed. If less than a 50 percent overlap is used, the coated surface may appear streaked. If more than a 50 percent overlap is used, the coating is wasted and more passes are required to coat the surface.

Paint Proportioning Mixing batches of paint on an as-needed basis, whether through the use of a paint proportioning machine or otherwise, can reduce the amount of paint wasted. Recordkeeping requirements to track the amount of paint and thinner used can also help conserve materials and prevent waste.

General Housekeeping Small quantities of paint and solvents are frequently lost due to poor housekeeping techniques. There are a variety of ways that can be implemented to control and minimize spills and leaks. Specific approaches to product transfer methods and container handling can effectively reduce product loss.

The potential for accidents and spills is at the highest point when thinners and paints are being transferred from bulk drum storage to the process equipment. Spigots, pumps, and funnels should be used whenever possible.

Evaporation can be controlled by using tight fitting lids, spigots, and other equipment. The reduction in evaporation will increase the amount of available material and result in lower solvent purchase cost.

Paint Containers A significant portion of paint waste is the paint that remains inside a container after the container is emptied, and paint that is placed in storage, not used, and becomes outdated or non-spec. By consolidating paint use and purchasing paint in bulk, large bulk containers have less surface area than an equivalent volume of small cans, and the amount of drag-on paint waste is reduced. Large bulk containers can sometimes be returned to the paint supplier to be cleaned for reuse.

If the purchase of paint in bulk containers is not practical, the paint should be purchased in the smallest amount required to minimize outdated or non-spec paint waste. Workers should not have to open a gallon can when only a quart is required. Usually, any paint that is left in the can will require disposal as hazardous waste.

VI. SUMMARY OF FEDERAL STATUTES AND REGULATIONS

This section discusses the Federal regulations that may apply to this sector. The purpose of this section is to highlight and briefly describe the applicable Federal requirements, and to provide citations for more detailed information. The three following sections are included:

- Section VI.A. contains a general overview of major statutes
- Section VI.B. contains a list of regulations specific to this industry
- Section VI.C. contains a list of pending and proposed regulations

The descriptions within Section VI are intended solely for general information. Depending upon the nature or scope of the activities at a particular facility, these summaries may or may not necessarily describe all applicable environmental requirements. Moreover, they do not constitute formal interpretations or clarifications of the statutes and regulations. For further information, readers should consult the Code of Federal Regulations and other state or local regulatory agencies. EPA Hotline contacts are also provided for each major statute.

VI.A. General Description of Major Statutes

Resource Conservation and Recovery Act

The Resource Conservation And Recovery Act (RCRA) of 1976 which amended the Solid Waste Disposal Act, addresses solid (Subtitle D) and hazardous (Subtitle C) waste management activities. The Hazardous and Solid Waste Amendments (HSWA) of 1984 strengthened RCRA's waste management provisions and added Subtitle I, which governs underground storage tanks (USTs).

Regulations promulgated pursuant to Subtitle C of RCRA (40 CFR Parts 260-299) establish a "cradle-to-grave" system governing hazardous waste from the point of generation to disposal. RCRA hazardous wastes include the specific materials listed in the regulations (commercial chemical products, designated with the code "P" or "U"; hazardous wastes from specific industries/sources, designated with the code "K"; or hazardous wastes from non-specific sources, designated with the code "F") or materials which exhibit a hazardous waste characteristic (ignitability, corrosivity, reactivity, or toxicity and designated with the code "D").

Regulated entities that generate hazardous waste are subject to waste accumulation, manifesting, and record keeping standards. Facilities must obtain a permit either from EPA or from a State agency which EPA has authorized to implement the permitting program if they store hazardous wastes for more than 90 days before treatment or disposal. Facilities may treat hazardous wastes stored in less-than-ninety-day tanks or containers without a permit. Subtitle C permits contain general facility standards such as contingency plans, emergency procedures, record keeping and reporting requirements, financial assurance mechanisms, and unit-specific standards. RCRA also contains provisions (40 CFR Part 264 Subpart S and §264.10) for conducting corrective actions which govern the cleanup of releases of hazardous waste or constituents from solid waste management units at RCRA-regulated facilities.

Although RCRA is a Federal statute, many States implement the RCRA program. Currently, EPA has delegated its authority to implement various provisions of RCRA to 47 of the 50 States and two U.S. territories. Delegation has not been given to Alaska, Hawaii, or Iowa.

Most RCRA requirements are not industry specific but apply to any company that generates, transports, treats, stores, or disposes of hazardous waste. Here are some important RCRA regulatory requirements:

•**Identification of Solid and Hazardous Wastes** (40 CFR Part 261) lays out the procedure every generator must follow to determine whether the material in question is considered a hazardous waste, solid waste, or is exempted from regulation.

•**Standards for Generators of Hazardous Waste** (40 CFR Part 262) establishes the responsibilities of hazardous waste generators including obtaining an EPA ID number, preparing a manifest, ensuring proper packaging and labeling, meeting standards for waste accumulation units, and recordkeeping and reporting requirements. Generators can accumulate hazardous waste for up to 90 days (or 180 days depending on the amount of waste generated) without obtaining a permit.

•**Land Disposal Restrictions** (LDRs) (40 CFR Part 268) are regulations prohibiting the disposal of hazardous waste on land without prior treatment. Under the LDRs program, materials must meet LDR treatment standards prior to placement in a RCRA land disposal unit (landfill, land treatment unit, waste pile, or surface impoundment). Generators of waste subject to the LDRs must provide notification of such to the designated TSD facility to ensure proper treatment prior to disposal.

•**Used Oil Management Standards** (40 CFR Part 279) impose management requirements affecting the storage, transportation, burning, processing, and re-refining of the used oil. For parties that merely generate used oil, regulations establish storage standards. For a party considered a used oil processor, re-refiner, burner, or marketer (one who generates and sells off-specification used oil directly to a used oil burner), additional tracking and paperwork requirements must be satisfied.

• RCRA contains unit-specific standards for all units used to store, treat, or dispose of hazardous waste, including **Tanks and Containers**. Tanks and containers used to store hazardous waste with a high volatile organic concentration must meet emission standards under RCRA. Regulations (40 CFR Part 264-265, Subpart CC) require generators to test the waste to determine the concentration of the waste, to satisfy tank and container emissions standards, and to inspect and monitor regulated units. These regulations apply to all facilities that store such waste, including large quantity generators accumulating waste prior to shipment off-site.

• **Underground Storage Tanks** (USTs) containing petroleum and hazardous substances are regulated under Subtitle I of RCRA. Subtitle I regulations (40 CFR Part 280) contain tank design and release detection requirements, as well as financial responsibility and corrective action standards for USTs. The UST program also includes upgrade requirements for existing tanks that must be met by December 22, 1998.

• **Boilers and Industrial Furnaces** (BIFs) that use or burn fuel containing hazardous waste must comply with design and operating standards. BIF regulations (40 CFR Part 266, Subpart H) address unit design, provide performance standards, require emissions monitoring, and restrict the type of waste that may be burned.

EPA's RCRA, Superfund and EPCRA Hotline, *at (800) 424-9346, responds to questions and distributes guidance regarding all RCRA regulations. The RCRA Hotline operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.*

Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a 1980 law known commonly as Superfund, authorizes EPA to respond to releases, or threatened releases, of hazardous substances that may endanger public health, welfare, or the environment. CERCLA also enables EPA to force parties responsible for environmental contamination to clean it up or to reimburse the Superfund for response costs incurred by EPA. The Superfund Amendments and Reauthorization Act (SARA) of 1986 revised various sections of CERCLA, extended the taxing authority for the Superfund, and created a free-standing law, SARA Title III, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA).

The CERCLA hazardous substance release reporting regulations (40 CFR Part 302) direct the person in charge of a facility to report to the National Response Center (NRC) any environmental release of a hazardous substance which equals or exceeds a reportable quantity. Reportable quantities are listed in 40 CFR §302.4. A release report may trigger a response by EPA, or by one or more Federal or State emergency response authorities.

EPA implements hazardous substance responses according to procedures outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300). The NCP includes provisions for permanent cleanups, known as remedial actions, and other cleanups referred to as removals. EPA generally takes remedial actions only at sites on the National Priorities List (NPL), which currently includes approximately 1300 sites. Both EPA and states can act at sites; however, EPA provides responsible parties the opportunity to conduct removal and remedial actions and encourages community involvement throughout the Superfund response process.

EPA's RCRA, Superfund and EPCRA Hotline, at (800) 424-9346, answers questions and references guidance pertaining to the Superfund program. The CERCLA Hotline operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.

Emergency Planning And Community Right-To-Know Act

The Superfund Amendments and Reauthorization Act (SARA) of 1986 created the Emergency Planning and Community Right-to-Know Act (EPCRA, also known as SARA Title III), a statute designed to improve community access to information about chemical hazards and to facilitate the development of chemical emergency response plans by State and local governments. EPCRA required the establishment of State emergency response commissions (SERCs), responsible for coordinating certain emergency response activities and for appointing local emergency planning committees (LEPCs).

EPCRA and the EPCRA regulations (40 CFR Parts 350-372) establish four types of reporting obligations for facilities which store or manage specified chemicals:

•**EPCRA §302** requires facilities to notify the SERC and LEPC of the presence of any extremely hazardous substance (the list of such substances is in 40 CFR Part 355, Appendices A and B) if it has such substance in excess of the substance's threshold planning quantity, and directs the facility to appoint an emergency response coordinator.

•**EPCRA §304** requires the facility to notify the SERC and the LEPC in the event of a release equaling or exceeding the reportable quantity of a CERCLA hazardous substance or an EPCRA extremely hazardous substance.

•**EPCRA §311 and §312** require a facility at which a hazardous chemical, as defined by the Occupational Safety and Health Act, is present in an amount exceeding a specified threshold to submit to the SERC, LEPC and local fire department material safety data sheets (MSDSs) or lists of MSDS's and hazardous chemical inventory forms (also known as Tier I and II forms). This information helps the local government respond in the event of a spill or release of the chemical.

•**EPCRA §313** requires manufacturing facilities included in SIC codes 20 through 39, which have ten or more employees, and which manufacture, process, or use specified chemicals in amounts greater than threshold quantities, to submit an annual toxic chemical release report. This report, known commonly as the Form R, covers releases and transfers of toxic chemicals to various facilities and environmental media, and allows EPA to compile the national Toxic Release Inventory (TRI) database.

All information submitted pursuant to EPCRA regulations is publicly accessible, unless protected by a trade secret claim.

EPA's RCRA, Superfund and EPCRA Hotline, at (800) 424-9346, answers questions and distributes guidance regarding the emergency planning and community right-to-know regulations. The EPCRA Hotline operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.

Clean Water Act

The primary objective of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA), is to restore and maintain the chemical, physical, and biological integrity of the nation's surface waters. Pollutants regulated under the CWA include "priority" pollutants, including various toxic pollutants; "conventional" pollutants, such as biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, oil and grease, and pH; and "non-conventional" pollutants, including any pollutant not identified as either conventional or priority.

The CWA regulates both direct and indirect discharges. The National Pollutant Discharge Elimination System (NPDES) program (CWA §502) controls direct discharges into navigable waters. Direct discharges or "point source" discharges are from sources such as pipes and sewers. NPDES permits, issued by either EPA or an authorized State (EPA has authorized 42 States to administer the NPDES program), contain industry-specific, technology-based and/or water quality-based limits, and establish pollutant monitoring requirements. A facility that intends to discharge into the nation's waters must obtain a permit prior to initiating its discharge. A permit applicant must provide quantitative analytical data identifying the types of pollutants present in the facility's effluent. The permit will then set the conditions and effluent limitations on the facility discharges.

A NPDES permit may also include discharge limits based on Federal or State water quality criteria or standards, that were designed to protect designated uses of surface waters, such as supporting aquatic life or recreation. These standards, unlike the technological standards, generally do not take into account technological feasibility or costs. Water quality criteria and standards vary from State to State, and site to site, depending on the use classification of the receiving body of water. Most States follow EPA guidelines which propose aquatic life and human health criteria for many of the 126 priority pollutants.

Storm Water Discharges

In 1987 the CWA was amended to require EPA to establish a program to address storm water discharges. In response, EPA promulgated the NPDES storm water permit application regulations. These regulations require that facilities with the following storm water discharges apply for an NPDES permit: (1) a discharge associated with industrial activity; (2) a discharge from a large or medium municipal storm sewer system; or (3) a discharge which EPA or the State determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

The term "storm water discharge associated with industrial activity" means a storm water discharge from one of 11 categories of industrial activity defined at 40 CFR 122.26. Six of the categories are defined by SIC codes while the other five are identified through narrative descriptions of the regulated industrial activity. If the primary SIC code of the facility is one of those identified in the regulations, the facility is subject to the storm water permit application requirements. If any activity at a facility is covered by one of the five narrative categories, storm water discharges from those areas where the activities occur are subject to storm water discharge permit application requirements.
Those facilities/activities that are subject to storm water discharge permit application requirements are identified below. To determine whether a particular facility falls within one of these categories, consult the regulation.

Category i: Facilities subject to storm water effluent guidelines, new source performance standards, or toxic pollutant effluent standards.

Category ii: Facilities classified as SIC 24-lumber and wood products (except wood kitchen cabinets); SIC 26-paper and allied products (except paperboard containers and products); SIC 28-chemicals and allied products (except drugs and paints); SIC 291-petroleum refining; and SIC 311-leather tanning and finishing.

Category iii: Facilities classified as SIC 10-metal mining; SIC 12-coal mining; SIC 13-oil and gas extraction; and SIC 14-nonmetallic mineral mining.

Category iv: Hazardous waste treatment, storage, or disposal facilities.

Category v: Landfills, land application sites, and open dumps that receive or have received industrial wastes.

Category vi: Facilities classified as SIC 5015-used motor vehicle parts; and SIC 5093-automotive scrap and waste material recycling facilities.

Category vii: Steam electric power generating facilities.

Category viii: Facilities classified as SIC 40-railroad transportation; SIC 41-local passenger transportation; SIC 42-trucking and warehousing (except public warehousing and storage); SIC 43-U.S. Postal Service; SIC 44-water transportation; SIC 45-transportation by air; and SIC 5171-petroleum bulk storage stations and terminals.

Category ix: Sewage treatment works.

Category x: Construction activities except operations that result in the disturbance of less than five acres of total land area.

Category xi: Facilities classified as SIC 20-food and kindred products; SIC 21-tobacco products; SIC 22-textile mill products; SIC 23-apparel related products; SIC 2434-wood kitchen cabinets manufacturing; SIC 25-furniture and fixtures; SIC 265-paperboard containers and boxes; SIC 267-converted paper and paperboard products; SIC 27-printing, publishing, and allied industries; SIC 283-drugs; SIC 285-paints, varnishes, lacquer, enamels, and allied products; SIC 30-rubber and plastics; SIC 31-leather and leather products (except leather and tanning and finishing); SIC 323-glass products; SIC 34-fabricated metal products (except fabricated structural metal); SIC 35-industrial and commercial machinery and computer equipment; SIC 36-electronic and other electrical equipment and components; SIC 37-transportation equipment (except ship and boat building and repairing); SIC 38-measuring, analyzing, and controlling instruments; SIC 39-miscellaneous manufacturing industries; and SIC 4221-4225-public warehousing and storage.

Pretreatment Program

Another type of discharge that is regulated by the CWA is one that goes to a publicly-owned treatment works (POTWs). The national pretreatment program (CWA §307(b)) controls the indirect discharge of pollutants to POTWs by "industrial users." Facilities regulated under §307(b) must meet certain pretreatment standards. The goal of the pretreatment program is to protect municipal wastewater treatment plants from damage that may occur when hazardous, toxic, or other wastes are discharged into a sewer system and to protect the quality of sludge generated by these plants. Discharges to a POTW are regulated primarily by the POTW itself, rather than the State or EPA.

EPA has developed technology-based standards for industrial users of POTWs. Different standards apply to existing and new sources within each category. "Categorical" pretreatment standards applicable to an industry on a nationwide basis are developed by EPA. In addition, another kind of pretreatment standard, "local limits," are developed by the POTW in order to assist the POTW in achieving the effluent limitations in its NPDES permit.

Regardless of whether a State is authorized to implement either the NPDES or the pretreatment program, if it develops its own program, it may enforce requirements more stringent than Federal standards.

Spill Prevention, Control and Countermeasure Plans

The 1990 Oil Pollution Act requires that facilities that could reasonably be expected to discharge oil in harmful quantities prepare and implement more rigorous Spill Prevention Control and Countermeasure (SPCC) Plan required under the CWA (40 CFR §112.7). There are also criminal and civil penalties for deliberate or negligent spills of oil. Regulations covering response to oil discharges and contingency plans (40 CFR Part 300), and Facility Response Plans to oil discharges (40 CFR §112.20) and for PCB transformers and PCB-containing items were revised and finalized in 1995.

EPA's Office of Water, at (202) 260-5700, will direct callers with questions about the CWA to the appropriate EPA office. EPA also maintains a bibliographic database of Office of Water publications which can be accessed through the Ground Water and Drinking Water resource center, at (202) 260-7786.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) mandates that EPA establish regulations to protect human health from contaminants in drinking water. The law authorizes EPA to develop national drinking water standards and to create a joint Federal-State system to ensure compliance with these standards. The SDWA also directs EPA to protect underground sources of drinking water through the control of underground injection of liquid wastes.

EPA has developed primary and secondary drinking water standards under its SDWA authority. EPA and authorized States enforce the primary drinking water standards, which are, contaminant-specific concentration limits that apply to certain public drinking water supplies. Primary drinking water standards consist of maximum contaminant level goals (MCLGs), which are non-enforceable health-based goals, and maximum contaminant levels (MCLs), which are enforceable limits set as close to MCLGs as possible, considering cost and feasibility of attainment.

The SDWA Underground Injection Control (UIC) program (40 CFR Parts 144-148) is a permit program which protects underground sources of drinking water by regulating five classes of injection wells. UIC permits include design, operating, inspection, and monitoring requirements. Wells used to inject hazardous wastes must also comply with RCRA corrective action standards in order to be granted a RCRA permit, and must meet applicable RCRA land disposal restrictions standards. The UIC permit program is primarily State-enforced, since EPA has authorized all but a few States to administer the program.

The SDWA also provides for a Federally-implemented Sole Source Aquifer program, which prohibits Federal funds from being expended on projects that may contaminate the sole or principal source of drinking water for a given area, and for a State-implemented Wellhead Protection program, designed to protect drinking water wells and drinking water recharge areas.

EPA's Safe Drinking Water Hotline, at (800) 426-4791, answers questions and distributes guidance pertaining to SDWA standards. The Hotline operates from 9:00 a.m. through 5:30 p.m., ET, excluding Federal holidays.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) granted EPA authority to create a regulatory framework to collect data on chemicals in order to evaluate, assess, mitigate, and control risks which may be posed by their manufacture, processing, and use. TSCA provides a variety of control methods to prevent chemicals from posing unreasonable risk.

TSCA standards may apply at any point during a chemical's life cycle. Under TSCA §5, EPA has established an inventory of chemical substances. If a chemical is not already on the inventory, and has not been excluded by TSCA, a premanufacture notice (PMN) must be submitted to EPA prior to manufacture or import. The PMN must identify the chemical and provide available information on health and environmental effects. If available data are not sufficient to evaluate the chemicals effects, EPA can impose restrictions pending the development of information on its health and environmental effects. EPA can also restrict significant new uses of chemicals based upon factors such as the projected volume and use of the chemical.

Under TSCA §6, EPA can ban the manufacture or distribution in commerce, limit the use, require labeling, or place other restrictions on chemicals that pose unreasonable risks. Among the chemicals EPA regulates under §6 authority are asbestos, chlorofluorocarbons (CFCs), and polychlorinated biphenyls (PCBs).

EPA's TSCA Assistance Information Service, at (202) 554-1404, answers questions and distributes guidance pertaining to Toxic Substances Control Act standards. The Service operates from 8:30 a.m. through 4:30 p.m., ET, excluding Federal holidays.

Clean Air Act

The Clean Air Act (CAA) and its amendments, including the Clean Air Act Amendments (CAAA) of 1990, are designed to "protect and enhance the nation's air resources so as to promote the public health and welfare and the productive capacity of the population." The CAA consists of six sections, known as Titles, which direct EPA to establish national standards for ambient air quality and for EPA and the States to implement, maintain, and enforce these standards through a variety of mechanisms. Under the CAAA, many facilities will be required to obtain permits for the first time. State and local governments oversee, manage, and enforce many of the requirements of the CAAA. CAA regulations appear at 40 CFR Parts 50-99.

Pursuant to Title I of the CAA, EPA has established national ambient air quality standards (NAAQSs) to limit levels of "criteria pollutants," including carbon monoxide, lead, nitrogen dioxide, particulate matter, VOCs, ozone, and sulfur dioxide. Geographic areas that meet NAAQSs for a given pollutant are classified as attainment areas; those that do not meet NAAQSs are classified as non-attainment areas. Under section 110 of the CAA, each State must develop a State Implementation Plan (SIP) to identify sources of air pollution and to determine what reductions are required to meet Federal air quality standards. Revised NAAQSs for particulates and ozone were proposed in 1996 and will become effective in 2001.

Title I also authorizes EPA to establish New Source Performance Standards (NSPSs), which are nationally uniform emission standards for new stationary sources falling within particular industrial categories. NSPSs are based on the pollution control technology available to that category of industrial source (see 40 CFR 60).

Under Title I, EPA establishes and enforces National Emission Standards for Hazardous Air Pollutants (NESHAPs), nationally uniform standards oriented towards controlling particular hazardous air pollutants (HAPs). Title I, section 112(c) of the CAA further directed EPA to develop a list of sources that emit any of 189 HAPs, and to develop regulations for these categories of sources. To date EPA has listed 174 categories and developed a schedule for the establishment of emission standards. The emission standards will be developed for both new and existing sources based on "maximum achievable control technology" (MACT). The MACT is defined as the control technology achieving the maximum degree of reduction in the emission of the HAPs, taking into account cost and other factors.

Title II of the CAA pertains to mobile sources, such as cars, trucks, buses, and planes. Reformulated gasoline, automobile pollution control devices, and vapor recovery nozzles on gas pumps are a few of the mechanisms EPA uses to regulate mobile air emission sources.

Title IV of the CAA establishes a sulfur dioxide nitrous oxide emissions program designed to reduce the formation of acid rain. Reduction of sulfur dioxide releases will be obtained by granting to certain sources limited emissions allowances, which, beginning in 1995, will be set below previous levels of sulfur dioxide releases.

Title V of the CAA of 1990 created a permit program for all "major sources" (and certain other sources) regulated under the CAA. One purpose of the operating permit is to include in a single document all air emissions requirements that apply to a given facility. States are developing the permit programs in accordance with guidance and regulations from EPA. Once a State program is approved by EPA, permits will be issued and monitored by that State.

Title VI of the CAA is intended to protect stratospheric ozone by phasing out the manufacture of ozone-depleting chemicals and restrict their use and distribution. Production of Class I substances, including 15 kinds of chlorofluorocarbons (CFCs) and chloroform, were phased out (except for essential uses) in 1996.

EPA's Control Technology Center, at (919) 541-0800, provides general assistance and information on CAA standards. The Stratospheric Ozone Information Hotline, at (800) 296-1996, provides general information about regulations promulgated under Title VI of the CAA, and EPA's EPCRA Hotline, at (800) 535-0202, answers questions about accidental release prevention under CAA §112(r). In addition, the Technology Transfer Network Bulletin Board System (modem access (919) 541-5742)) includes recent CAA rules, EPA guidance documents, and updates of EPA activities.

VI.B. Industry Specific Requirements

The aerospace industry is affected by several major federal environmental statutes. A summary of the major federal regulations affecting the aerospace industry follows. Other resources which are useful in understanding industry specific requirements are:

1. The Paint and Coatings Resource Center web page (http://www.paintcenter.org)
2. The Self Audit & Inspection Guide; For Facilities Conducting Cleaning, Preparation, and Organic Coating of Metal Parts, published by the EPA.
3. California EPA Air Resources Board Web Pages;
   Compliance Handbooks and Pamphlets
   - http://www.arb.ca.gov/cd/cap/handbks.htm

   Compliance Training Courses
   - http://www.arb.ca.gov/cd/training.htm
   - http://www.arb.ca.gov/html/all.htm

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act (RCRA) was enacted in 1976 to address problems related to hazardous and solid waste management. RCRA gives EPA the authority to establish a list of solid and hazardous wastes and to establish standards and regulations for the treatment, storage, and disposal of these wastes. Regulations in Subtitle C of RCRA address the identification, generation, transportation, treatment, storage, and disposal of hazardous wastes. These regulations are found in 40 CFR Part 124 and 40 CFR Parts 260-279. Under RCRA, persons who generate waste must determine whether the waste is defined as solid waste or hazardous waste. Solid wastes are considered hazardous wastes if they are listed by EPA as hazardous or if they exhibit characteristics of a hazardous waste: toxicity, ignitability, corrosivity, or reactivity.

Some wastes potentially generated at aerospace facilities that are considered hazardous wastes are listed in 40 CFR Part 261. Some of the handling and treatment requirements for RCRA hazardous waste generators are covered under 40 CFR Part 262 and include the following: determining what constitutes a RCRA hazardous waste (Subpart A); manifesting (Subpart B); packaging, labeling, and accumulation time limits (Subpart C); and record keeping and reporting (Subpart D).

Several common aerospace manufacturing operations have the potential to generate RCRA hazardous wastes. Some of these wastes are identified below by process.

Machining and Other Metalworking
•Metalworking fluids contaminated with oils, phenols, creosol, alkalies, phosphorus compounds, and chlorine

Cleaning and Degreasing
•Solvents (F001, F002, F003, F004, F005)
•Alkaline and Acid Cleaning Solutions (D002)
•Cleaning filter sludges with toxic metal concentrations

Metal Plating and Surface Finishing and Preparation
•Wastewater treatment sludges from electroplating operations (F006)
•Spent cyanide plating bath solutions (F007)
•Plating bath residues from the bottom of cyanide plating baths (F008)
•Spent stripping and cleaning bath solutions from cyanide plating operations (F009)

Surface Preparation, Painting and Coating
•Paint and paint containers containing paint sludges with solvents or toxic metals concentrations
•Solvents (F002, F003)
•Paint chips with toxic metal concentrations
•Blasting media contaminated with paint chips

Aerospace manufacturing and rework facilities may also generate used lubricating oils which are regulated under RCRA but may or may not be considered a hazardous waste (40 CFR 266).

Many aerospace facilities store some hazardous wastes at the facility for more than 90 days, and are therefore, a storage facility under RCRA. Storage facilities are required to have a RCRA treatment, storage, and disposal facility (TSDF) permit (40 CFR Part 262.34). Some aerospace facilities are considered TSDF facilities and therefore may be subject to the following regulations covered under 40 CFR Part 264: contingency plans and emergency procedures (40 CFR Part 264 Subpart D); manifesting, record keeping, and reporting (40 CFR Part 264 Subpart E); use and management of containers (40 CFR Part 264 Subpart I); tank systems (40 CFR Part 264 Subpart J); surface impoundments (40 CFR Part 264 Subpart K); land treatment (40 CFR Part 264 Subpart M); corrective action of hazardous waste releases (40 CFR Part 264 Subpart S); air emissions standards for process vents of processes that process or generate hazardous wastes (40 CFR Part 264 Subpart AA); emissions standards for leaks in hazardous waste handling equipment (40 CFR Part 264 Subpart BB); and emissions standards for containers, tanks, and surface impoundments that contain hazardous wastes (40 CFR Part 264 Subpart CC).

Many aerospace manufacturing and rework facilities are also subject to the underground storage tank (UST) program (40 CFR Part 280). The UST regulations apply to facilities that store either petroleum products or hazardous substances (except hazardous waste) identified under the Comprehensive Environmental Response, Compensation, and Liability Act. UST regulations address design standards, leak detection, operating practices, response to releases, financial responsibility for releases, and closure standards.

A number of RCRA wastes have been prohibited from land disposal unless treated to meet specific standards under the RCRA Land Disposal Restriction (LDR) program. The wastes covered by the RCRA LDRs are listed in 40 CFR Part 268 Subpart C and include a number of wastes that could potentially be generated at aerospace manufacturing facilities. Standards for the treatment and storage of restricted wastes are described in Subparts D and E, respectively.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) provide the basic legal framework for the federal "Superfund" program to clean up abandoned hazardous waste sites (40 CFR Part 305). Metals and metal compounds often found in the aerospace industry's air emissions, water discharges, or waste shipments for off-site disposal include chromium, manganese, aluminum, nickel, copper, zinc, and lead. Metals are frequently found at CERCLA's problem sites. When Congress ordered EPA and the Public Health Service's Agency for Toxic Substances and Disease Registry (ATSDR) to list the hazardous substances most commonly found at problem sites and that pose the greatest threat to human health, lead, nickel, and aluminum were all included.

Title III of the 1986 SARA amendments (also known as Emergency Response and Community Right-to-Know Act, EPCRA) requires all manufacturing facilities, including aerospace facilities, to report annual information to the public about over 600 toxic substances as well as release of these substances into the environment (42 U.S.C. 9601). This is known as the Toxic Release Inventory (TRI). EPCRA also establishes requirements for Federal, State, and local governments regarding emergency planning.

Clean Air Act (CAA)

Under Title III of the 1990 Clean Air Act Amendments (CAAA), EPA is required to develop national emission standards for 189 hazardous air pollutants (NESHAP). EPA is developing maximum achievable control technology (MACT) standards for all new and existing sources. The National

Emission Standards for Aerospace Manufacturing and Rework Facilities (40 CFR Part 63 Subpart GG) were finalized in 1996 and apply to major source aerospace manufacturing and rework facilities. Facilities that emit ten or more tons of any one HAP or 25 or more tons of two or more HAPs combined are major sources, and therefore are subject to the MACT (NESHAP) requirements. The MACT requirements apply to solvent cleaning operations, primer and topcoat application operations, depainting operations, chemical milling maskant application operations, and handling and storage of waste. The standards set VOC emissions and content limits for different types of solvents, chemical strippers and coatings. In addition, performance standards are set to reduce spills, leaks, and fugitive emissions. Aerospace facilities may also be subject to National Emissions Standards for: Chromium Emissions From Hard and Decorative Chromium Electroplating and Chromium Anodizing Tanks (40 CFR Part 63 Subpart N) if they perform chromium electroplating or anodizing; and Halogenated Solvent Cleaning if they operate a solvent cleaning machine using a halogenated HAP solvent. These NESHAPs require emission limits, work practice standards, record keeping, and reporting.

Under Title V of the CAAA 1990 (40 CFR Parts 70-72) all of the applicable requirements of the Amendments are integrated into one federal renewable operating permit. Facilities defined as "major sources" under the Act must apply for permits within one year from when EPA approves the state permit programs. Since most state programs were not approved until after November 1994, Title V permit applications, for the most part, began to be due in late 1995. Due dates for filing complete applications vary significantly from state to state, based on the status of review and approval of the state's Title V program by EPA.

A facility is designated as a major source for Title V if it releases a certain amount of any one of the CAAA regulated pollutants (SOx, NOx, CO, VOC, PM_{10}, hazardous air pollutants, extremely hazardous substances, ozone depleting substances, and pollutants covered by NSPSs) depending on the region's air quality category. Title V permits may set limits on the amounts of pollutant emissions; require emissions monitoring, and record keeping and reporting. Facilities are required to pay an annual fee based on the magnitude of the facility's potential emissions. It is estimated that as many as 2,869 aerospace facilities will be designated as major sources and therefore must apply for a Title V permit.

Under section 112(r) of CAA, owners and operators of stationary sources who produce, process, handle, or store substances listed under CAA section 112(r)(3) or any other extremely hazardous substance have a "general duty" to initiate specific activities to prevent and mitigate accidental releases. Since the general duty requirements apply to stationary sources regardless of the quantity of substances managed at the facility, many aerospace manufacturing and reworking facilities are subject. Activities such as identifying hazards which may result from accidental releases using appropriate hazard assessment techniques; designing, maintaining and operating a safe facility; and minimizing the consequences of accidental releases if they occur are considered essential activities to satisfy the general duty requirements. These statutory requirements have been in affect since the passage of the Clean Air Act Amendments in 1990. Although there is no list of "extremely hazardous substances," EPA's Chemical Emergency Preparedness and Prevention Office provides some guidance at its website: http://www.epa.gov/swercepp.html.

Also under section 112(r), EPA was required to develop a list of at least 100 substances that, in the event of an accidental release, could cause death, injury, or serious adverse effects to human health or the environment. The list promulgated by EPA is contained in 40 CFR 68.130 and includes acutely toxic chemicals, flammable gases and volatile flammable liquids, and Division 1.1 high explosive substances as listed by DOT in 49 CFR 172.101. Under section 112(r)(7), facilities handling more than a threshold quantity (ranging from 500 to 20,000 pounds) of these substances are subject to chemical accident prevention provisions including the development and implementation of a risk management program (40 CFR 68.150-68.220). The requirements in 40 CFR Part 68 begin to go into effect in June 1999. Some of the chemicals on the 112(r) list could be handled by aerospace manufacturers and reworkers in quantities greater than the threshold values.

Clean Water Act

Aerospace manufacturing and rework facility wastewater released to surface waters is regulated under the CWA. National Pollutant Discharge Elimination System (NPDES) permits must be obtained to discharge wastewater into navigable waters (40 Part 122). Facilities that discharge to a POTW may be required to meet National Pretreatment Standards for some contaminants. General pretreatment standards applying to most industries discharging to a POTW are described in 40 CFR Part 403. In addition, effluent limitation guidelines, new source performance standards, pretreatment standards for new sources, and pretreatment standards for existing sources may apply to some aerospace manufacturing and rework facilities that carry out electroplating or metal finishing operations. Requirements for the Electroplating Point Source Category and the Metal Finishing Point Source Category are listed under 40 CFR Part 413 and 40 CFR Part 433, respectively.

Storm water rules require certain facilities with storm water discharge from any one of 11 categories of industrial activity defined in 40 CFR 122.26 be subject to the storm water permit application requirements (see Section VI.A). Many aerospace facilities fall within these categories. To determine whether a particular facility falls within one of these categories, the regulation should be consulted.

VI.C. Pending and Proposed Regulatory Requirements

Clean Water Act

Effluent limitation guidelines for wastewater discharges from metal products and machinery (MP&M) industries are being developed. MP&M industries have been divided into two groups that originally were to be covered under two separate phases of the rulemaking. Effluent guidelines for Phase I industries and Phase II industries (which includes the aerospace industry) will now be covered under a single regulation to be proposed in October 2000 and finalized in December 2002. (Steven Geil, U.S. EPA, Office of Water, Engineering and Analysis Division, (202)260-9817, email: geil.steve@epamail.epa.gov)

Clean Air Act

In December 1997, EPA published Control Technique Guidelines (CTG) for the control of VOC emissions from coating operations at aerospace manufacturing and rework operations. The CTG was issued to assist states in analyzing and determining reasonably available control technology (RACT) standards for major sources of VOCs in the aerospace manufacturing and rework operations located within ozone NAAQS nonattainment areas. EPA estimates that there are approximately 2,869 facilities that could fall within this category. Within one year of the publication of the CTG, states must adopt a RACT regulation at least as stringent as the limits recommended in the CTG. Under Section 183(b)(3) of the Clean Air Act, EPA is required to issue the CTG for aerospace coating and solvent application operations based on "best available control measures" (BACM) for emissions of VOCs. (Barbara Driscoll, U.S. EPA, Office of Air Quality Planning and Standards, (919) 541-0164)

Several National Emission Standards for Hazardous Air Pollutants (NESHAPs) relating to the aerospace industry are being developed for promulgation by November of 2000. They include: Rocket Engine Test Firing, Engine Test Facilities, Miscellaneous Metal Parts and Products, and Plastic Parts and Products. (Contact: In the U.S. EPA Office of Air Quality Planning and Standards, George Smith for information pertaining to the former two, (919)541-1549; and Bruce Moore for the latter two, (919)541-5460)

VII. COMPLIANCE AND ENFORCEMENT HISTORY

Background

Until recently, EPA has focused much of its attention on measuring compliance with specific environmental statutes. This approach allows the Agency to track compliance with the Clean Air Act, the Resource Conservation and Recovery Act, the Clean Water Act, and other environmental statutes. Within the last several years, the Agency has begun to supplement single-media compliance indicators with facility-specific, multimedia indicators of compliance. In doing so, EPA is in a better position to track compliance with all statutes at the facility level, and within specific industrial sectors.

A major step in building the capacity to compile multimedia data for industrial sectors was the creation of EPA's Integrated Data for Enforcement Analysis (IDEA) system. IDEA has the capacity to "read into" the Agency's single-media databases, extract compliance records, and match the records to individual facilities. The IDEA system can match Air, Water, Waste, Toxics/Pesticides/EPCRA, TRI, and Enforcement Docket records for a given facility, and generate a list of historical permit, inspection, and enforcement activity. IDEA also has the capability to analyze data by geographic area and corporate holder. As the capacity to generate multimedia compliance data improves, EPA will make available more in-depth compliance and enforcement information. Additionally, sector-specific measures of success for compliance assistance efforts are under development.

Compliance and Enforcement Profile Description

Using inspection, violation and enforcement data from the IDEA system, this section provides information regarding the historical compliance and enforcement activity of this sector. In order to mirror the facility universe reported in the Toxic Chemical Profile, the data reported within this section consists of records only from the TRI reporting universe. With this decision, the selection criteria are consistent across sectors with certain exceptions. For the sectors that do not normally report to the TRI program, data have been provided from EPA's Facility Indexing System (FINDS) which tracks facilities in all media databases. Please note, in this section, EPA does not attempt to define the actual number of facilities that fall within each sector. Instead, the section portrays the records of a subset of facilities within the sector that are well defined within EPA databases.

As a check on the relative size of the full sector universe, most notebooks contain an estimated number of facilities within the sector according to the Bureau of Census (See Section II). With sectors dominated by small businesses, such as metal finishers and printers, the reporting universe within the EPA databases may be small in comparison to Census data. However, the group selected for inclusion in this data analysis section should be consistent with this sector's general make-up.

Following this introduction is a list defining each data column presented within this section. These values represent a retrospective summary of inspections and enforcement actions, and reflect solely EPA, State, and local compliance assurance activities that have been entered into EPA databases. To identify any changes in trends, the EPA ran two data queries, one for the past five calendar years (April 1, 1992 to March 31, 1997) and the other for the most recent twelve-month period (April 1, 1996 to March 31, 1997). The five-year analysis gives an average level of activity for that period for comparison to the more recent activity.

Because most inspections focus on single-media requirements, the data queries presented in this section are taken from single media databases. These databases do not provide data on whether inspections are state/local or EPA-led. However, the table breaking down the universe of violations does give the reader a crude measurement of the EPA's and states' efforts within each media program. The presented data illustrate the variations across EPA Regions for certain sectors.[4] This variation may be attributable to state/local data entry variations, specific geographic concentrations, proximity to population centers, sensitive ecosystems, highly toxic chemicals used in production, or historical noncompliance. Hence, the exhibited data do not rank regional performance or necessarily reflect which regions may have the most compliance problems.

Compliance and Enforcement Data Definitions

General Definitions

Facility Indexing System (FINDS) -- assigns a common facility number to EPA single-media permit records. The FINDS identification number allows EPA to compile and review all permit, compliance, enforcement and pollutant release data for any given regulated facility.

Integrated Data for Enforcement Analysis (IDEA) -- is a data integration system that can retrieve information from the major EPA program office databases. IDEA uses the FINDS identification number to link separate data records from EPA's databases. This allows retrieval of records from across media or statutes for any given facility, thus creating a "master list" of

[4] EPA Regions include the following states: I (CT, MA, ME, RI, NH, VT); II (NJ, NY, PR, VI); III (DC, DE, MD, PA, VA, WV); IV (AL, FL, GA, KY, MS, NC, SC, TN); V (IL, IN, MI, MN, OH, WI); VI (AR, LA, NM, OK, TX); VII (IA, KS, MO, NE); VIII (CO, MT, ND, SD, UT, WY); IX (AZ, CA, HI, NV, Pacific Trust Territories); X (AK, ID, OR, WA).

records for that facility. Some of the data systems accessible through IDEA are: AFS (Air Facility Indexing and Retrieval System, Office of Air and Radiation), PCS (Permit Compliance System, Office of Water), RCRIS (Resource Conservation and Recovery Information System, Office of Solid Waste), NCDB (National Compliance Data Base, Office of Prevention, Pesticides, and Toxic Substances), CERCLIS (Comprehensive Environmental and Liability Information System, Superfund), and TRIS (Toxic Release Inventory System). IDEA also contains information from outside sources such as Dun and Bradstreet and the Occupational Safety and Health Administration (OSHA). Most data queries displayed in notebook sections IV and VII were conducted using IDEA.

Data Table Column Heading Definitions

Facilities in Search -- are based on the universe of TRI reporters within the listed SIC code range. For industries not covered under TRI reporting requirements (metal mining, nonmetallic mineral mining, electric power generation, ground transportation, water transportation, and dry cleaning), or industries in which only a very small fraction of facilities report to TRI (e.g., printing), the notebook uses the FINDS universe for executing data queries. The SIC code range selected for each search is defined by each notebook's selected SIC code coverage described in Section II.

Facilities Inspected -- indicates the level of EPA and state agency inspections for the facilities in this data search. These values show what percentage of the facility universe is inspected in a one-year or five-year period.

Number of Inspections -- measures the total number of inspections conducted in this sector. An inspection event is counted each time it is entered into a single media database.

Average Time Between Inspections -- provides an average length of time, expressed in months, between compliance inspections at a facility within the defined universe.

Facilities with One or More Enforcement Actions -- expresses the number of facilities that were the subject of at least one enforcement action within the defined time period. This category is broken down further into federal and state actions. Data are obtained for administrative, civil/judicial, and criminal enforcement actions. A facility with multiple enforcement actions is only counted once in this column, e.g., a facility with 3 enforcement actions counts as 1 facility.

Total Enforcement Actions -- describes the total number of enforcement actions identified for an industrial sector across all environmental statutes. A facility with multiple enforcement actions is counted multiple times, e.g., a facility with 3 enforcement actions counts as 3.

State Lead Actions -- shows what percentage of the total enforcement actions are taken by state and local environmental agencies. Varying levels of use by states of EPA data systems may limit the volume of actions recorded as state enforcement activity. Some states extensively report enforcement activities into EPA data systems, while other states may use their own data systems.

Federal Lead Actions -- shows what percentage of the total enforcement actions are taken by the United States Environmental Protection Agency. This value includes referrals from state agencies. Many of these actions result from coordinated or joint state/federal efforts.

Enforcement to Inspection Rate -- is a ratio of enforcement actions to inspections, and is presented for comparative purposes only. This ratio is a rough indicator of the relationship between inspections and enforcement. It relates the number of enforcement actions and the number of inspections that occurred within the one-year or five-year period. This ratio includes the inspections and enforcement actions reported under the Clean Water Act (CWA), the Clean Air Act (CAA) and the Resource Conservation and Recovery Act (RCRA). Inspections and actions from the TSCA/FIFRA/ EPCRA database are not factored into this ratio because most of the actions taken under these programs are not the result of facility inspections. Also, this ratio does not account for enforcement actions arising from non-inspection compliance monitoring activities (e.g., self-reported water discharges) that can result in enforcement action within the CAA, CWA, and RCRA.

Facilities with One or More Violations Identified -- indicates the percentage of inspected facilities having a violation identified in one of the following data categories: In Violation or Significant Violation Status (CAA); Reportable Noncompliance, Current Year Noncompliance, Significant Noncompliance (CWA); Noncompliance and Significant Noncompliance (FIFRA, TSCA, and EPCRA); Unresolved Violation and Unresolved High Priority Violation (RCRA). The values presented for this column reflect the extent of noncompliance within the measured time frame, but do not distinguish between the severity of the noncompliance. Violation status may be a precursor to an enforcement action, but does not necessarily indicate that an enforcement action will occur.

Media Breakdown of Enforcement Actions and Inspections -- four columns identify the proportion of total inspections and enforcement actions within EPA Air, Water, Waste, and TSCA/FIFRA/EPCRA databases. Each column is a percentage of either the "Total Inspections," or the "Total

Actions" column.

VII.A. Aerospace Industry Compliance History

Table 14 provides an overview of the reported compliance and enforcement data for the aerospace industry over the past five years (April 1992 to April 1997). These data are also broken out by EPA Regions thereby permitting geographical comparisons. A few points evident from the data are listed below.

• Region IX and Region I had the most enforcement actions (43 and 36 respectively), accounting for 62 percent of the total enforcement actions and only 29 percent of the total inspections. Thus, these two Regions had the highest enforcement/inspection ratios (0.26 and 0.19).

• Region IV had significantly more inspections (325) than the other Regions, 27 percent of the total, but only 13 percent of enforcement actions.

• Enforcement actions were primarily state-lead (75 percent), especially in Regions with the greatest number of enforcement actions.

• Region V had the highest average time between inspections (23 months), which means that fewer inspections, in relation to the number of facilities, were done in Region V than in other Regions.

Table 14: Five-Year Enforcement and Compliance Summary for the Aerospace Industry									
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Region	**Facilities in Search**	**Facilities Inspected**	**Number of Inspections**	**Average Months Between Inspections**	**Facilities with 1 or More Enforcement Actions**	**Total Enforcement Actions**	**Percent State Lead Actions**	**Percent Federal Lead Actions**	**Enforcement to Inspection Rate**
I	34	28	185	11	16	36	50%	50%	0.19
II	7	6	29	14	3	3	67%	33%	0.10
III	12	9	117	6	4	6	83%	17%	0.05
IV	38	34	325	7	12	16	94%	6%	0.05
V	37	27	97	23	2	3	67%	33%	0.03
VI	37	27	134	17	7	14	79%	21%	0.10
VII	8	7	54	9	2	2	50%	50%	0.04
VIII	7	4	29	14	2	2	100%	0%	0.03
IX	47	33	163	17	17	43	93%	7%	0.26
X	10	9	73	8	2	2	0%	100%	0.03
TOTAL	237	184	1206	12	67	127	75%	25%	0.10

VII.B. Comparison of Enforcement Activity Between Selected Industries

Tables 15 and 16 allow the compliance history of the aerospace sector to be compared to the other industries covered by the industry sector notebooks. Comparisons between Tables 15 and 16 permit the identification of trends in compliance and enforcement records of the various industries by comparing data covering the last five years (April 1992 to April 1997) to that of the past year (April 1996 to April 1997). Some points evident from the data are listed below.

- The one-year enforcement/inspection ratio (0.05) is only half of the five-year ratio (0.10).

- The aerospace industry data approximate the averages of the industries shown for enforcement/inspection ratios, state-lead versus federal-lead actions, and facilities with one or more violations and enforcement actions.

Tables 17 and 18 provide a more in-depth comparison between the aerospace industry and other sectors by breaking out the compliance and enforcement data by environmental statute. As in the previous Tables (Tables 15 and 16), the data cover the last five years (Table 17) and the last one year (Table 18) to facilitate the identification of recent trends. A few points evident from the data are listed below.

- The aerospace industry has the highest percentage of RCRA inspections (54 percent of total) of any industry.

- The one-year versus five-year breakdowns in terms of percent of total inspections do not differ significantly. However, the percent of total actions pertaining to RCRA increased from 42 percent to 55 percent in the past year. CWA actions decreased from 11 percent to zero percent in the last year.

Table 15: Five-Year Enforcement and Compliance Summary for Selected Industries

A	B	C	D	E	F	G	H	I	J
Industry Sector	**Facilities in Search**	**Facilities Inspected**	**Number of Inspections**	**Average Months Between Inspections**	**Facilities with 1 or More Enforcement Actions**	**Total Enforcement Actions**	**Percent State Lead Actions**	**Percent Federal Lead Actions**	**Enforcement to Inspection Rate**
Metal Mining	1,232	378	1,600	46	63	111	53%	47%	0.07
Coal Mining	3,256	741	3,748	52	88	132	89%	11%	0.04
Oil and Gas Extraction	4,676	1,902	6,071	46	149	309	79%	21%	0.05
Non-Metallic Mineral Mining	5,256	2,803	12,826	25	385	622	77%	23%	0.05
Textiles	355	267	1,465	15	53	83	90%	10%	0.06
Lumber and Wood	712	473	2,767	15	134	265	70%	30%	0.10
Furniture	499	386	2,379	13	65	91	81%	19%	0.04
Pulp and Paper	484	430	4,630	6	150	478	80%	20%	0.10
Printing	5,862	2,092	7,691	46	238	428	88%	12%	0.06
Inorganic Chemicals	441	286	3,087	9	89	235	74%	26%	0.08
Resins and Manmade Fibers	329	263	2,430	8	93	219	76%	24%	0.09
Pharmaceuticals	164	129	1,201	8	35	122	80%	20%	0.10
Organic Chemicals	425	355	4,294	6	153	468	65%	35%	0.11
Agricultural Chemicals	263	164	1,293	12	47	102	74%	26%	0.08
Petroleum Refining	156	148	3,081	3	124	763	68%	32%	0.25
Rubber and Plastic	1,818	981	4,383	25	178	276	82%	18%	0.06
Stone, Clay, Glass and Concrete	615	388	3,474	11	97	277	75%	25%	0.08
Iron and Steel	349	275	4,476	5	121	305	71%	29%	0.07
Metal Castings	669	424	2,535	16	113	191	71%	29%	0.08
Nonferrous Metals	203	161	1,640	7	68	174	78%	22%	0.11
Fabricated Metal Products	2,906	1,858	7,914	22	365	600	75%	25%	0.08
Electronics	1,250	863	4,500	17	150	251	80%	20%	0.06
Automobile Assembly	1,260	927	5,912	13	253	413	82%	18%	0.07
Aerospace	**237**	**184**	**1,206**	**12**	**67**	**127**	**75%**	**25%**	**0.10**
Shipbuilding and Repair	44	37	243	9	20	32	84%	16%	0.13
Ground Transportation	7,786	3,263	12,904	36	375	774	84%	16%	0.06
Water Transportation	514	192	816	38	36	70	61%	39%	0.09
Air Transportation	444	231	973	27	48	97	88%	12%	0.10
Fossil Fuel Electric Power	3,270	2,166	14,210	14	403	789	76%	24%	0.06
Dry Cleaning	6,063	2,360	3,813	95	55	66	95%	5%	0.02

Table 16: One-Year Enforcement and Compliance Summary for Selected Industries									
A	B	C	D	E		F		G	H
				Facilities with 1 or More Violations		Facilities with 1 or more Enforcement Actions			
Industry Sector	**Facilities in Search**	**Facilities Inspected**	**Number of Inspections**	**Number**	**Percent***	**Number**	**Percent***	**Total Enforcement Actions**	**Enforcement to Inspection Rate**
Metal Mining	1,232	142	211	102	72%	9	6%	10	0.05
Coal Mining	3,256	362	765	90	25%	20	6%	22	0.03
Oil and Gas Extraction	4,676	874	1,173	127	15%	26	3%	34	0.03
Non-Metallic Mineral Mining	5,256	1,481	2,451	384	26%	73	5%	91	0.04
Textiles	355	172	295	96	56%	10	6%	12	0.04
Lumber and Wood	712	279	507	192	69%	44	16%	52	0.10
Furniture	499	254	459	136	54%	9	4%	11	0.02
Pulp and Paper	484	317	788	248	78%	43	14%	74	0.09
Printing	5,862	892	1,363	577	65%	28	3%	53	0.04
Inorganic Chemicals	441	200	548	155	78%	19	10%	31	0.06
Resins and Manmade Fibers	329	173	419	152	88%	26	15%	36	0.09
Pharmaceuticals	164	80	209	84	105%	8	10%	14	0.07
Organic Chemicals	425	259	837	243	94%	42	16%	56	0.07
Agricultural Chemicals	263	105	206	102	97%	5	5%	11	0.05
Petroleum Refining	156	132	565	129	98%	58	44%	132	0.23
Rubber and Plastic	1,818	466	791	389	83%	33	7%	41	0.05
Stone, Clay, Glass and Concrete	615	255	678	151	59%	19	7%	27	0.04
Iron and Steel	349	197	866	174	88%	22	11%	34	0.04
Metal Castings	669	234	433	240	103%	24	10%	26	0.06
Nonferrous Metals	203	108	310	98	91%	17	16%	28	0.09
Fabricated Metal	2,906	849	1,377	796	94%	63	7%	83	0.06
Electronics	1,250	420	780	402	96%	27	6%	43	0.06
Automobile Assembly	1,260	507	1,058	431	85%	35	7%	47	0.04
Aerospace	**237**	**119**	**216**	**105**	**88%**	**8**	**7%**	**11**	**0.05**
Shipbuilding and Repair	44	22	51	19	86%	3	14%	4	0.08
Ground Transportation	7,786	1,585	2,499	681	43%	85	5%	103	0.04
Water Transportation	514	84	141	53	63%	10	12%	11	0.08
Air Transportation	444	96	151	69	72%	8	8%	12	0.08
Fossil Fuel Electric Power	3,270	1,318	2,430	804	61%	100	8%	135	0.06
Dry Cleaning	6,063	1,234	1,436	314	25%	12	1%	16	0.01

**Percentages in Columns E and F are based on the number of facilities inspected (Column C). Percentages can exceed 100% because violations and actions can occur without a facility inspection.*

Table 17: Five-Year Inspection and Enforcement Summary by Statute for Selected Industries

Industry Sector	Facilities Inspected	Total Inspections	Total Enforcement Actions	Clean Air Act: % of Total Inspections	Clean Air Act: % of Total Actions	Clean Water Act: % of Total Inspections	Clean Water Act: % of Total Actions	RCRA: % of Total Inspections	RCRA: % of Total Actions	FIFRA/TSCA/: % of Total Inspections	FIFRA/TSCA/: % of Total Actions
Metal Mining	378	1,600	111	39%	19%	52%	52%	8%	12%	1%	17%
Coal Mining	741	3,748	132	57%	64%	38%	28%	4%	8%	1%	1%
Oil and Gas Extraction	1,902	6,071	309	75%	65%	16%	14%	8%	18%	0%	3%
Non-Metallic Mineral Mining	2,803	12,826	622	83%	81%	14%	13%	3%	4%	0%	3%
Textiles	267	1,465	83	58%	54%	22%	25%	18%	14%	2%	6%
Lumber and Wood	473	2,767	265	49%	47%	6%	6%	44%	31%	1%	16%
Furniture	386	2,379	91	62%	42%	3%	0%	34%	43%	1%	14%
Pulp and Paper	430	4,630	478	51%	59%	32%	28%	15%	10%	2%	4%
Printing	2,092	7,691	428	60%	64%	5%	3%	35%	29%	1%	4%
Inorganic Chemicals	286	3,087	235	38%	44%	27%	21%	34%	30%	1%	5%
Resins and Manmade Fibers	263	2,430	219	35%	43%	23%	28%	38%	23%	4%	6%
Pharmaceuticals	129	1,201	122	35%	49%	15%	25%	45%	20%	5%	5%
Organic Chemicals	355	4,294	468	37%	42%	16%	25%	44%	28%	4%	6%
Agricultural Chemicals	164	1,293	102	43%	39%	24%	20%	28%	30%	5%	11%
Petroleum Refining	148	3,081	763	42%	59%	20%	13%	36%	21%	2%	7%
Rubber and Plastic	981	4,383	276	51%	44%	12%	11%	35%	34%	2%	11%
Stone, Clay, Glass and Concrete	388	3,474	277	56%	57%	13%	9%	31%	30%	1%	4%
Iron and Steel	275	4,476	305	45%	35%	26%	26%	28%	31%	1%	8%
Metal Castings	424	2,535	191	55%	44%	11%	10%	32%	31%	2%	14%
Nonferrous Metals	161	1,640	174	48%	43%	18%	17%	33%	31%	1%	10%
Fabricated Metal	1,858	7,914	600	40%	33%	12%	11%	45%	43%	2%	13%
Electronics	863	4,500	251	38%	32%	13%	11%	47%	50%	2%	7%
Automobile Assembly	927	5,912	413	47%	39%	8%	9%	43%	43%	2%	9%
Aerospace	**184**	**1,206**	**127**	**34%**	**38%**	**10%**	**11%**	**54%**	**42%**	**2%**	**9%**
Shipbuilding and Repair	37	243	32	39%	25%	14%	25%	42%	47%	5%	3%
Ground Transportation	3,263	12,904	774	59%	41%	12%	11%	29%	45%	1%	3%
Water Transportation	192	816	70	39%	29%	23%	34%	37%	33%	1%	4%
Air Transportation	231	973	97	25%	32%	27%	20%	48%	48%	0%	0%
Fossil Fuel Electric Power	2,166	14,210	789	57%	59%	32%	26%	11%	10%	1%	5%
Dry Cleaning	2,360	3,813	66	56%	23%	3%	6%	41%	71%	0%	0%

Table 18: One-Year Inspection and Enforcement Summary by Statute for Selected Industries

Industry Sector	Facilities Inspected	Total Inspections	Total Enforcement Actions	Clean Air Act		Clean Water Act		RCRA		FIFRA/TSCA/ EPCRA/Other	
				% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions
Metal Mining	142	211	10	52%	0%	40%	40%	8%	30%	0%	30%
Coal Mining	362	765	22	56%	82%	40%	14%	4%	5%	0%	0%
Oil and Gas Extraction	874	1,173	34	82%	68%	10%	9%	9%	24%	0%	0%
Non-Metallic Mineral Mining	1,481	2,451	91	87%	89%	10%	9%	3%	2%	0%	0%
Textiles	172	295	12	66%	75%	17%	17%	17%	8%	0%	0%
Lumber and Wood	279	507	52	51%	30%	6%	5%	44%	25%	0%	40%
Furniture	254	459	11	66%	45%	2%	0%	32%	45%	0%	9%
Pulp and Paper	317	788	74	54%	73%	32%	19%	14%	7%	0%	1%
Printing	892	1,363	53	63%	77%	4%	0%	33%	23%	0%	0%
Inorganic Chemicals	200	548	31	35%	59%	26%	9%	39%	25%	0%	6%
Resins and Manmade Fibers	173	419	36	38%	51%	24%	38%	38%	5%	0%	5%
Pharmaceuticals	80	209	14	43%	71%	11%	14%	45%	14%	0%	0%
Organic Chemicals	259	837	56	40%	54%	13%	13%	47%	34%	0%	0%
Agricultural Chemicals	105	206	11	48%	55%	22%	0%	30%	36%	0%	9%
Petroleum Refining	132	565	132	49%	67%	17%	8%	34%	15%	0%	10%
Rubber and Plastic	466	791	41	55%	64%	10%	13%	35%	23%	0%	0%
Stone, Clay, Glass and Concrete	255	678	27	62%	63%	10%	7%	28%	30%	0%	0%
Iron and Steel	197	866	34	52%	47%	23%	29%	26%	24%	0%	0%
Metal Castings	234	433	26	60%	58%	10%	8%	30%	35%	0%	0%
Nonferrous Metals	108	310	28	44%	43%	15%	20%	41%	30%	0%	7%
Fabricated Metal	849	1,377	83	46%	41%	11%	2%	43%	57%	0%	0%
Electronics	420	780	43	44%	37%	14%	5%	43%	53%	0%	5%
Automobile Assembly	507	1,058	47	53%	47%	7%	6%	41%	47%	0%	0%
Aerospace	**119**	**216**	**11**	**37%**	**36%**	**7%**	**0%**	**54%**	**55%**	**1%**	**9%**
Shipbuilding and Repair	22	51	4	54%	0%	11%	50%	35%	50%	0%	0%
Ground Transportation	1,585	2,499	103	64%	46%	11%	10%	26%	44%	0%	1%
Water Transportation	84	141	11	38%	9%	24%	36%	38%	45%	0%	9%
Air Transportation	96	151	12	28%	33%	15%	42%	57%	25%	0%	0%
Fossil Fuel Electric Power	1,318	2,430	135	59%	73%	32%	21%	9%	5%	0%	0%
Dry Cleaning	1,234	1,436	16	69%	56%	1%	6%	30%	38%	0%	0%

VII.C. Review of Major Legal Actions

Major Cases/Supplemental Environmental Projects

This section provides summary information about major cases that have affected this sector, and a list of Supplemental Environmental Projects (SEPs).

VII.C.1. Review of Major Cases

As indicated in EPA's *Enforcement Accomplishments Report, FY1995 and FY1996* publications, one significant enforcement action was resolved between 1995 and 1996 for the aerospace industry.

U.S. v. General Electric Company General Electric (GE) operates a facility in Lynn, MA at which the company tests and manufactures aircraft. The enforcement issues arose from GE's failure to obtain prevention of significant deterioration (PSD) permits for one boiler and for four test cells used for the testing of jet engines. The boiler and the test cells emit NOx in quantities that trigger the PSD new source review requirements of the Clean Air Act. GE installed/constructed two new test cells in the early 1980s and modified two test cells in the late 1980s, without obtaining required permits. GE installed/constructed the boiler without obtaining an adequate permit. The boiler also emitted NOx in excess of the levels permissible in EPA's New Source Performance Standards (NSPS).

VII.C.2. Supplementary Environmental Projects (SEPs)

SEPs are compliance agreements that reduce a facility's non-compliance penalty in return for an environmental project that exceeds the value of the reduction. Often, these projects fund pollution prevention activities that can reduce the future pollutant loadings of a facility. Information on SEP cases can be accessed via the internet at the SEP National Database, http://es.epa.gov/oeca/sep/sepdb.

Aerospace Techniques, Inc., in Cromwell, Connecticut, performed a SEP in return for failing to submit a Toxic Release Inventory Form R for 1,1,1-trichloroethane. Aerospace Techniques achieved a 4,500 pound reduction in 1,1,1-trichloroethane releases by replacing the larger of its two vapor degreasers with jet washing machines using heated aqueous cleaning solution. They also plan to scale back degreasing operations to final rinses and replace six interim part-rinsing stations that utilize aqueous cleaner. The cost of this project was $9,766.

VIII. COMPLIANCE ASSURANCE ACTIVITIES AND INITIATIVES

This section highlights the activities undertaken by this industry sector and public agencies to voluntarily improve the sector's environmental performance. These activities include those initiated independently by industrial trade associations. In this section, the notebook also contains a listing and description of national and regional trade associations.

VIII.A. Sector-related Environmental Programs and Activities

VIII.A.1. Federal Activities

Propulsion Environmental Working Group

The Propulsion Environmental Working Group (PEWG) was formally chartered in 1994 by the Joint Propulsion Coordinating Committee (JPCC), a consortium of industry and Department of Defense participants. PEWG is composed of members from the Army, Navy, and Air Force, and of companies such as Allied Signal, GE Aircraft Engines, Allison Engine, Williams Intl., P&W UTC, Teledyne, Continental, and Sundstrand.

PEWG's chartered objectives include:

- providing an open forum for information exchange on possible technologies to eliminate HAZMATs,
- assisting team members with decisions regarding HAZMATs, identifying HAZMATs, and assisting in prevention and control of HAZMATs,
- assisting engine manufacturers and reworkers with compliance of state and federal regulations,
- ensuring and assisting in the completion of required environmental documentation such as EAs or EIAs,
- establishing committees to address topics of interest for the team members.

Propulsion Product Group

The Air Force Propulsion Product Group (PPG) works to incorporate environmental, safety, and occupational health concerns into multiple weapon systems. The PPG is a participant in the Propulsion Environmental Working Group discussed above. Some of the accomplishment of the PPG are:

- eliminating the use of Class I Ozone Depleting Substances (ODS)
- reducing the use of EPA-17 materials
- facilitating the annual reduction of EPA-17 materials and Class I ODS's used by OEM's.

Airworthiness Assurance Center of Excellence

The FAA created the Airworthiness Assurance Center of Excellence (AACE) in September 1997 in an effort to "make a significant contribution to the reduction of accident rates over the next five years." AACE is based at Iowa State University and Ohio State University. The five principal areas of research are maintenance, inspection and repair, propulsion and fuel systems safety, crashworthiness, advanced materials, and landing gear systems performance and safety. A focus of the work is to develop crack detection methods for particularly small cracks which may be under several layers of skin. Major airlines are also pushing for inspection techniques which do not require disassembly, thus preserving sealants and coatings (*AW&ST*, 3/30/98).

Joint EPA/NASA/USAF Interagency Depainting Study

NASA is conducting a technical assessment of alternative technologies for aerospace depainting operations on behalf of the EPA and the US Air Force. Such technologies are to be used as paint stripping processes which do not adversely affect the environment and which specifically do not involve the use of methylene chloride. The nine techniques subdivided into five removal method categories (abrasive, impact, cyrogenic, thermal, and molecular bonding disassociation).

Thai Airways/Government of Thailand/USEPA Solvent Elimination Project

The Government of Thailand, Thai Airways, and the USEPA Solvent Elimination Project studied methods of eliminating CFC-113 and methyl chloroform use. This project was undertaken as part of the World Bank Global Solvents Project under the Multilateral Fund of the Montreal Protocol. The manual developed under this project describes a step-by-step approach for characterizing the use of ozone-depleting solvents and identifying and evaluating alternatives. For case studies on this topic, see *Eliminating CFC-113 and Methyl Chloroform in Aircraft Maintenance Procedures*, published by the Office of Air and Radiation of the USEPA in October 1993.

VIII.B. EPA Voluntary Programs

33/50 Program

The 33/50 Program is a groundbreaking program that has focused on reducing pollution from seventeen high-priority chemicals through voluntary partnerships with industry. The program's name stems from its goals: a 33% reduction in toxic releases by 1992, and a 50% reduction by 1995, against a baseline of 1.5 billion pounds of releases and transfers in 1988. The results have been impressive: 1,300 companies joined the 33/50 Program (representing over 6,000 facilities) and reached the national targets a year ahead of schedule. The 33% goal was reached in 1991, and the 50% goal -- a reduction of 745 million pounds of toxic wastes -- was reached in 1994. The 33/50 Program can provide case studies on many of the corporate accomplishments in reducing waste (Contact 33/50 Program Director David Sarokin -- 202-260-6396).

Table 19 lists those companies participating in the 33/50 program that reported four-digit SIC codes within 372 and 376 to TRI. Some of the companies shown also listed facilities that are not producing aerospace products. The number of facilities within each company that are participating in the 33/50 program and that report aerospace SIC codes is shown. Where available and quantfiable against 1988 releases and transfers, each company's 33/50 goals for 1995 and the actual total releases and transfers and percent reduction between 1988 and 1995 are presented. Thirteen of the seventeen 33/50 target chemicals were reported to TRI by aerospace facilities in 1995. These 13 chemicals accounted for 77 percent of the total releases and 65 percent of the total transfers reported to the 1995 TRI by aerospace facilities.

Table 19 shows that 47 companies comprised of 506 facilities reporting SIC 372 and 376 participated in the 33/50 program. For those companies shown with more than one aerospace facility, all facilities may not have participated in 33/50. The 33/50 goals shown for companies with multiple aerospace facilities, however, are company-wide, potentially aggregating more than one facility and facilities not carrying out aerospace operations. In addition to company-wide goals, individual facilities within a company may have had their own 33/50 goals or may be specifically listed as not participating in the 33/50 program. Since the actual percent reductions shown in the last column apply to all of the companies' aerospace facilities and only aerospace facilities, direct comparisons to those company goals incorporating non-aerospace facilities or excluding certain facilities may not be possible. For information on specific facilities participating in 33/50, contact David Sarokin (202-260-6907) at the 33/50 Program Office.

With the completion of the 33/50 program, several lessons were learned. Industry and the environment benefitted by this program for several reasons. Companies were willing to participate because cost savings and risk reduction were measurable and no additional record keeping and reporting was required. The goals of the program were clear and simple and EPA allowed industry to achieve the goals in whatever manner they could. Therefore, when companies can see the benefits of environmental programs and be an active part of the decision-making process, they are more likely to participate.

Table 19: Aerospace Industry Participation in the 33/50 Program

Parent Company (Headquarters Location)	Company-Owned Aerospace Facilities Reporting 33/50 Chemicals	Company-Wide % Reduction Goal[1] (1988-1995)	1988 TRI Releases and Transfers of 33/50 Chemicals (pounds)[2]	1995 TRI Releases and Transfers of 33/50 Chemicals (pounds)[2]	Actual % Reduction for Aerospace Facilities (1988-1995)
Aeroforce Corp.- Muncie, IN	1	0	1,500	8,601	-473%
Aerothrust Corp.- Miami, FL	1	100	72,500	9,995	86%
Allied-Signal Inc.- Morristown, NJ	91	50	6,018,249	1,535,148	74%
Aluminum Co. of America- Pittsburgh, PA	1	51	220,733	83,830	62%
Arkwin Industries- Westbury, NY	1	50	134,100	0	100%
Arrowhead Holdings Corp.- Bala Cynwyd, PA	1	0	39,855	24,800	38%
BF Goodrich Co.- Akron, OH	30	49	2,251,997	1,109,800	51%
Boeing Commercial Airplane- Seattle, WA	24	50	13,471,898	2,251,461	83%
Chemical Milling Intl. Corp.- Rosamond, CA	2	0	234,356	0	100%
Chrysler Corp.- Auburn Hills, MI	2	80	43,155	154,561	-258%
Ciba-Geigy Corp.- Tarrytown, NY	1	50	81,555	17,650	78%
Dassault Falcon Jet Corp.- Paramus, NJ	2	40	355,070	34,005	90%
Dynamic Metal Prods. Co.- Manchester, CT	1	0	0	0	---
Eaton Corp.- Cleveland, OH	1	50	22,199	0	100%
FR Holdings Inc.- Aurora, CO	2	32	124,250	0	100%
Gencorp Inc.- Akron, OH	14	33	7,639,190	3,412,754	55%
General Dynamics Corp.- Falls Church, VA	3	81	291,110	24,755	91%
General Electric Corp.- Fairfield, CT	130	50	19,129,041	4,557,753	76%
General Motors Corp.- Detroit, MI	3	0	483,255	0	100%
Globe Engineering Co.- Wichita, KS	1	0	0	15,740	---
Howmet Corp.- Greenwich, CT	5	0	56,240	15,905	72%
Interlake Corp.- Lisle, IL	1	37	224,486	5,116	98%
JT Slocomb Co.- South Glastonbury, CT	2	50	41,001	0	100%
K Systems Inc.- Foster City, CA	2	0	0	0	---
Kimberly-Clark Corp.- Irving, TX	1	50	0	0	---
Large Structrals Business Ops.- Portland, OR	5	26	89,890	68,538	24%
Lockheed Martin Corp.- Bethesda, MD	41	42	6,121,565	520,120	92%
Lucas Industries- Troy, MI	7	14	229,051	47,555	79%
McDonnell Douglas Corp.- St. Louis, MO	14	50	4,619,458	903,626	80%
Meco Inc. Paris, IL	1	0	36,162	78,792	118%
NMB USA Inc.- Chatsworth, CA	1	0	0	0	---
Northrop Grumman Corp.- Los Angeles, CA	11	35	2,339,803	731,032	69%
Pall Rai Inc.- Hauppauge, NY	2	31	43,900	46,763	-7%
Parker Hannifin Corp.- Cleveland, OH	6	50	143,380	0	100%
Raytheon Co.- Lexington, MA	3	50	1,036,083	355,298	66%
Rockwell Intl. Corp.- Seal Beach, CA	2	50	150,513	0	100%

Parent Company (Headquarters Location)	Company-Owned Aerospace Facilities Reporting 33/50 Chemicals	Company-Wide % Reduction Goal[1] (1988-1995)	1988 TRI Releases and Transfers of 33/50 Chemicals (pounds)[2]	1995 TRI Releases and Transfers of 33/50 Chemicals (pounds)[2]	Actual % Reduction for Aerospace Facilities (1988-1995)
Rohr Industries Inc.- Chula Vista, CA	7	25	1,849,382	436,056	76%
SEGL Inc.- Los Angeles, CA	1	13	75,000	23,005	69%
SKF USA Inc.- King of Prussia, PA	1	0	0	0	---
Skyline Products- Harrisburg, OR	1	0	0	0	---
Sundstrand Corp.- Rockford, IL	3	0	494,750	4,293	85%
Talley Industries Inc.- Phoenix, AZ	9	0	133,323	177,213	-33%
Thiokol Corp.- Ogden, UT	14	40	2,687,295	788,979	71%
Trinova Corp.- Maumee, OH	1	50	0	14,400	---
United Technologies Corp.- Hartford, CT	60	50	8,496,888	952,497	89%
US Air Force- Washington, DC	4	0	1,643,050	460,159	72%
Total	**517**	**---**	**81,125,233**	**18,940,200**	**77%**

Source: U.S. EPA 33/50 Program Office, 1996.

1 Company-Wide Reduction Goals aggregate all company-owned facilities which may include facilities not producing aerospace products.

2 Releases and Transfers are from aerospace facilities only.

Project XL

Project XL was initiated in March 1995 as a part of President Clinton's *Reinventing Environmental Regulation* initiative. The projects seek to achieve cost effective environmental benefits by providing participants regulatory flexibility on the condition that they produce greater environmental benefits. EPA and program participants will negotiate and sign a Final Project Agreement, detailing specific environmental objectives that the regulated entity shall satisfy. EPA will provide regulatory flexibility as an incentive for the participants' superior environmental performance. Participants are encouraged to seek stakeholder support from local governments, businesses, and environmental groups. EPA hopes to implement fifty pilot projects in four categories, including industrial facilities, communities, and government facilities regulated by EPA. Applications will be accepted on a rolling basis. For additional information regarding XL projects, including application procedures and criteria, see the May 23, 1995 Federal Register Notice. (Contact: Fax-on-Demand Hotline 202-260-8590, Web: http://www.epa.gov/ProjectXL, or Christopher Knopes in EPA's Office of Reinvention 202-260-9298)

Energy Star® Buildings and Green Lights® Partnership

In 1991, EPA introduced Green Lights®, a program designed for businesses and organizations to proactively combat pollution by installing energy-efficient lighting technologies in their commercial and industrial buildings. In April 1995, Green Lights® expanded into Energy Star® Buildings-- a strategy that optimizes whole-building energy-efficiency opportunities.

The energy needed to run commercial and industrial buildings in the United States produces 19 percent of U.S. carbon dioxide emissions, 12 percent of nitrogen oxides, and 25 percent of sulfur dioxide, at a cost of 110 billion dollars a year. If implemented in every U.S. commercial and industrial building, Energy Star® Buildings' upgrade approach could prevent up to 35 percent of the emissions associated with these buildings and cut the nation's energy bill by up to 25 billion dollars annually.

The over 2,500 participants include corporations, small businesses, universities, health care facilities, nonprofit organizations, school districts, and federal and local governments. As of January 1, 1998, Energy Star®Buildings and Green Lights® Program participants have reduced their annual energy use by 7 billion kilowatt hours and annually save more than 517 million dollars. By joining, participants agree to upgrade 90 percent of their owned facilities with energy-efficient lighting and 50 percent of their owned facilities with whole-building upgrades, where profitable, over a seven-year period. Energy Star participants first reduce their energy loads with the Green Lights approach to building tune-ups, then focus on "right sizing" their heating and cooling equipment to march their new energy needs. EPA predicts this strategy will prevent more than 5.5 MMTCE of carbon dioxide by the year 2000. EPA's Office of Air and Radiation is responsible for operating the Energy Star Buildings and Green Lights Program. (Contact the Energy Star Hotline number, 1-888-STAR-YES (1-888-872-7937) or Maria Tikoff Vargas, Co-Director at (202) 564-9178 or visit the website at http://www.epa.gov/buildings.)

WasteWi$e Program

The WasteWi$e Program was started in 1994 by EPA's Office of Solid Waste and Emergency Response. The program is aimed at reducing municipal solid wastes by promoting waste prevention, recycling collection and the manufacturing and purchase of recycled products. As of 1998, the program had about 700 business, government, and institutional partners. Partners agree to identify and implement actions to reduce their solid wastes setting waste reduction goals and providing EPA with yearly progress reports for a three year period. EPA, in turn, provides partners with technical assistance, publications, networking opportunities, and national and regional recognition. (Contact: WasteWi$e Hotline at 1-800-372-9473 or Joanne Oxley, EPA

Program Manager, 703-308-0199)

NICE^3

The U.S. Department of Energy sponsors a grant program called *National Industrial Competitiveness through Energy, Environment, and Economics* (NICE^3). The NICE^3 program provides funding to state and industry partnerships (large and small business) for projects demonstrating advances in energy efficiency and clean production technologies. The goal of the NICE^3 program is to demonstrate the performance and economics of innovative technologies in the U.S., leading to the commercialization of improved industrial manufacturing processes. These processes should conserve energy, reduce waste, and improve industrial cost-competitiveness. Industry applicants must submit project proposals through a state energy, pollution prevention, or business development office. The following focus industries, which represent the dominant energy users and waste generators in the U.S. manufacturing sector, are of particular interest to the program: Aluminum, Chemicals, Forest Products, Glass, Metal-casting, and Steel. Awardees receive a one-time, three-year grant of up to $400,000, representing up to 50 percent of a project's total cost. In addition, up to $25,000 is available to support the state applicant's cost share. (Contact: http//www.oit.doe.gov/Access/nice3, Steve Blazek, DOE, 303-275-4723 or Eric Hass, DOE, 303-275-4728)

Design for the Environment (DfE)

DfE is working with several industries to identify cost-effective pollution prevention strategies that reduce risks to workers and the environment. DfE helps businesses compare and evaluate the performance, cost, pollution prevention benefits, and human health and environmental risks associated with existing and alternative technologies. The goal of these projects is to encourage businesses to consider and use cleaner products, processes, and technologies. For more information about the DfE Program, call (202) 260-1678. To obtain copies of DfE materials or for general information about DfE, contact EPA's Pollution Prevention Information Clearinghouse at (202) 260-1023 or visit the DfE Website at http://www.epa.gov/dfe.

Several DfE projects have been completed pertaining to the aerospace industry. Brief descriptions follow.

The National Science Foundation (NSF), the State of Massachusetts, the Biodegradable Polymer Research Center, the Toxics Use Reduction Institute, and the Center for Environmentally Advanced Materials were partners in a DfE project on aerospace metal degreasing.

EPA established an interagency agreement with the Department of Energy, in partnership with the Joint Association for the Advancement of Supercritical Technology, to determine the suitability of supercritical carbon dioxide as an alternative method for cleaning and degreasing parts. The degree of contaminant removal of the cleaners as well as human health and environmental effects were evaluated under this project. In another agreement with the Department of Energy, EPA obtained the services of the Oak Ridge National Laboratory to perform research and prepare toxicity summaries in support of EPA risk assessment activities conducted on all segments of the aerospace DfE project.

The Experimental Aircraft Association (EAA) was awarded by the EPA for a demonstration project in small aircraft paint stripping. This project, begun as a DfE project jointly run by OPPT and the Coast Guard, explored alternatives to methylene chloride and other hazardous solvent paint strippers. In the summer of 1997, the EAA completely stripped and repainted a small plane using products that contained no chemicals on the EPA's Hazardous Air Pollutant list and that met the definition of low volatile organic chemical (VOC) releases (P2 Newsletter, 1997).

Small Business Compliance Assistance Centers

The Office of Compliance, in partnership with industry, academic institutions, environmental groups, and other federal and state agencies, has established national Compliance Assistance Centers for four specific industry sectors heavily populated with small businesses that face substantial federal regulation. These sectors are printing, metal finishing, automotive services and repair, agriculture, painted coatings, small chemical manufacturers, municipalities, and transportation.

The purpose of the Centers is to improve compliance of the customers they serve by increasing their awareness of the pertinent federal regulatory requirements and by providing the information that will enable them to achieve compliance. The Centers accomplish this by offering the following:

•"First-Stop Shopping" - serve as the first place that small businesses and technical assistance providers go to get comprehensive, easy to understand compliance information targeted specifically to industry sectors.

•"Improved Information Transfer" - via the Internet and other means, create linkages between the small business community and providers of technical and regulatory assistance and among the providers themselves to share tools and knowledge and prevent duplication of efforts.

•"Compliance Assistance Tools" - develop and disseminate plain-English guides, consolidated checklists, fact sheets, and other tools where needed by small businesses and their information providers.

• "Links Between Pollution Prevention and Compliance Goals" - provide easy access to information and technical assistance on technologies to help minimize waste generation and maximize environmental performance.

• "Information on Ways to Reduce the Costs of Compliance" - identify technologies and best management practices that reduce pollution while saving money.

For general information regarding EPA's compliance assistance centers, contact Lynn Vendinello at (202)564-7066, or go to http://www.epa.gov/oeca/mfcac.html.

VIII.C. Trade Association/Industry Sponsored Activity

VIII.C.1. Industry Research Programs

NASA Langley Research Center and the Tidewater Interagency P2 Program

NASA's Langley Research Center (LaRC) is devoted to aeronautics and space research and has initiated a broad-based pollution prevention program guided by a Pollution Prevention Program Plan and implemented through specific projects. The Program Plan contains an environmental baseline, opportunities for P2, and establishes a framework to plan, implement, and monitor specific prioritized P2 projects. LaRC is one of the participants in the Tidewater Interagency Pollution Prevention Program (TIPPP). TIPPP was developed under an interagency agreement and designed to integrate P2 concepts and practices at Federal installations in the Tidewater, Virginia area.

Air Force Center for Environmental Excellence

The Air Force Center for Environmental Excellence (AFCEE) is working toward environmental leadership and pollution prevention. The Environmental Quality Directorate of the AFCEE has developed a Base Pollution Prevention Management Action Plan (PPMAP). Each base environmental manager must submit a PPMAP for his/her shop. Many Air Force Bases have also completed Pollution Prevention Opportunity Assessment Reports (OARs) which outline alternative approaches that a Base can use for P2 in Base-specific operations, including rework of aircraft.

Lean Aircraft Initiative Program

The Lean Aircraft Initiative (LAI) is a three-year program which strives to define and foster dynamic, fundamental change in both the U.S. defense aircraft industry and government operations over the next decade. LAI is a cooperative venture of private industry, the U.S. Air Force, and the EPA, supported by the analytical and research expertise of the Massachusetts Institute of Technology. By building on and extending the "lean" paradigm through an organized process of research, the program seeks to develop the knowledge base that will lead to greater affordability of systems, higher quality, and increased efficiency including efficient use of materials.

Chemical Strategies Partnership

The Chemical Strategies Partnership (CSP), funded by the Pew Charitable Trusts, began a pilot project with Hughes Missile Systems Company and Nortel. The CSP project aims to reduce their use and release of toxic chemicals in manufacturing while improving production efficiency and competitiveness.

Joint Depot Environmental Panel (JDEP)

The Joint Policy Coordinating Group on Depot Maintenance in the Department of Defense chartered the Joint Depot Environmental Panel (JDEP) in 1988 to facilitate information exchange on environmental issues, technologies, and processes with potential application in the depot maintenance community. The JDEP's functions are to review the depot's current environmental program, compile information on techniques and processes with potential application, coordinate the development and implementation of environmental initiatives, and establish liaisons with federal agencies. The JDEP has hosted over 37 meetings and distributed over 500 technical briefings. Total dismantling of JDEP will occur in October 1998. *(see JASPPA below.)*

Joint Group on Acquisition Pollution Prevention (JGAPP)

The Department of Defense has developed the Joint Group on Acquisition Pollution Prevention (JGAPP) as a military/industry initiative to reduce the use of hazardous material in manufacturing processes. The initiative involves seven major corporations and their related services. The JGAPP is working with manufacturers at their facilities to reduce the use of specific hazardous materials in all of the programs at the facility.

Joint Acquisition & Sustainment Pollution Prevention Activity (JASPPA)

The Joint Logistics Commanders of the Department of Defense tasked the JGAPP and JDEP to explore the possibility of a single pollution prevention activity. Since then the JDEP and the Joint Pollution Prevention Advisory Board (JPPAB, which JGAPP is part of) have been working and meeting together to develop various avenues of consideration for that tasking. As a result, the JDEP and JPPAB have decided to merge to form a single integrated group called the Joint Acquisition & Sustainment Pollution Prevention Activity (JASPPA). The JASPPA will function as a single integrating activity for all pollution prevention efforts for both the acquisition and sustainment communities. (For more information, contact Carl Adams in the Joint Depot Maintenance Activities Group, (937)656-2771.)

Aerospace Environmental Roundtable

The Aerospace Environmental Roundtable is an informal monthly meeting coordinated by the Aerospace Industries Association(AIA). Attendees include other trade associations, contractors, and anyone else interested in discussing environmental issues, increasing awareness, and sharing information pertaining to the aerospace industry. (For more information, contact Glynn Rountree, (202)371-8401.)

VIII.C.2. Trade Associations

Aerospace Industries Association of America (AIA)
1250 Eye St. NW, Suite1200 (202)371-8400
Washington, DC 20005 (202)371-8401 FAX
John Douglass, Pres.

AIA was founded in 1919 as a trade association which represents the nation's manufacturers of commercial, military and business aircraft, helicopters, aircraft engines, missiles, space craft, and related components and equipment. AIA maintains the AIA Aerospace Research Center to compile statistics on the industry. AIA's annual budget is roughly seven million dollars. They publish *Aerospace Facts and Figures* annually which contains statistical and analytical information on aircraft production, missile programs, space programs, and air transportation, as well as an annual report and an AIA newsletter.

Aircraft Electronics Association (AEA)
PO Box 1963 (816)373-6565
Independence, MO 64055-0963 (816)478-3100 FAX
Monte Mitchell, Pres.

AEA was founded in 1958 by companies engaged in the sales, engineering, installation, and service of electronic aviation equipment and systems. AEA works to advance the science of aircraft electronics, promote uniform and stable regulations and standards of performance, gather and disseminate technical data, and educate the aircraft electronics community and the public. They publish *Avionics News*, a monthly trade magazine. The annual budget is one million dollars.

American Helicopter Society (AHS)
217 N. Washington St. (703)684-6777
Alexandria, VA 22314 (703)739-9279 FAX
Morris E. Flatter, Exec. Dir.

AHS was founded in 1943 and is composed of aircraft designers, engineers, government personnel, operators, and industry executives in over forty countries interested in V/STOL aircraft. AHS conducts research and educational and technical meetings concerning professional training and updated information. They publish an annual composite of technical papers presented at the AHS forum, a quarterly journal, *Journal of the American Helicopter Society,* A bimonthly magazine, *VertFlite*, and other technical papers. They operate on a one million dollar budget.

Aviation Distributors and Manufacturers Association (ADMA)
1900 Arch St. (215)564-3484
Philadelphia, PA 19103-1498 (215)564-2175 FAX
Patricia A. Lilly, Exec. Dir.

ADMA was founded in 1943 as an association of wholesalers and manufacturers of general aviation aircraft parts, supplies, and equipment. They publish *ADMA News* bimonthly, *Aviation Education News Bulleting* bimonthly, and an annual directory.

Council of Defense and Space Industry Associations (CODSIA)
2111 Wilson Blvd., Suite 400 (703)247-9490
Arlington, VA 22201-3061
Peter Scrivner, Exec. Sec.

CODSIA was founded in 1964 and is comprised of the Aerospace Industries Association of America, Contract Services Association of America, Electronic Industries Association, National Security Industrial Association, Shipbuilders Council of America, American Electronics Association, Professional Services Council, and Manufacturers' Alliance for Productivity and Innovation. CODSIA holds three meetings per year in order to simplify, expedite, and improve industry-wide communications regarding policies, regulations, and problems.

Flight Safety Foundation (FSF)
2200 Wilson Blvd. Ste. 500 (703)522-8300
Arlington, VA 22201 (703)525-6047 FAX
Stuart Matthews, Pres.

FSF was founded in 1945 to represent aerospace manufacturers, domestic and foreign airlines, insurance companies, fuel and oil companies, schools, and miscellaneous organizations having an interest in the promotion of safety in flight. They have an annual budget of 2.5 million dollars and publish several bimonthly newsletters, studies, and an annual membership directory.

General Aviation Manufacturers Association (GAMA)
1400 K St. NW, Ste. 801 (202)393-1500
Washington, DC 20005 (202)842-4063 FAX
Edward W. Simpson, Pres.

GAMA was founded in 1970 as an association of manufacturers of aviation airframes, engines, avionics, and components. They strive to create a better climate for the growth of general aviation. GAMA publishes quarterly and annual reports as well as films and printed material on the aviation industry.

Helicopter Safety Advisory Conference (HSAC)
PO Box 60220 (713)960-7654
Houston, TX 77205 (713)960-7660 FAX
Dick Landrum, Chm.

HSAC is comprised of helicopter operators, manufacturers, and others involved in the transport of workers by helicopter. HSAC promotes safety and seeks to improve operations through establishment of standards of practice. HSAC was founded in 1979.

International Society of Transport Aircraft Trading (ISTAT)
5517 Talon Ct. (703)978-8156
Fairfax, VA 22032-1737 (703)503-5964 FAX
Dawn O'Day Foster, Exec. Dir.

ISTAT was founded in 1983 as a society of professionals engaged in the purchase, sale, financing, manufacturing, appraising, and leasing of new and used commercial aircraft. ISTAT publishes a quarterly newsletter, *JeTrader*, and an annual membership directory.

Light Aircraft Manufacturers Association (LAMA)
22 Deer Oaks Ct. (510)426-0771
Pleasanton, CA 94588
Lawrence P. Burke, Pres.

LAMA was founded in 1984 as an association of manufacturers of experimental and ultralight aircraft, suppliers to the homebuilt aircraft community, media and other professionals involved with the light aircraft industry. LAMA works to assure that the interests of the industry are properly represented to the FAA and to Congress and provides uniform standards of manufacturing quality and airworthiness. Lama publishes newsletters, standards, and a membership directory.

IX. CONTACTS/ACKNOWLEDGMENTS/RESOURCE MATERIALS

For further information on selected topics within the aerospace industry a list of contacts and publications are provided below.

Contacts[5]

Name	Organization	Telephone	Subject
Anthony Raia	USEPA, OECA	(202)564-6045	General notebook contact
Linda Nunn	California Air Resources Board	(916)323-1070	Risk Reduction
Glynn Rountree	Aerospace Industries Association	(202)371-8401	Industry Activities
Steven Geil	USEPA, OW	(202)260-9817	Clean Water Act
Barbara Driscoll	USEPA, OAQPS	(919)541-0164	Clean Air Act
George Smith	USEPA, OAQPS	(919)541-1549	Rocket Engine Test Firing/ Engine Test Facilities NESHAPs
Bruce Moore	USEPA, OAQPS	(919)541-5460	Micellaneous Metal Parts/ Plastic Parts NESHAPs
Ric Peri	National Air Transport Association	(703)845-9000	Industry Activities
Mary Dominiak	USEPA	(202)260-7768	Design for the Environment
Lieutenant Commander Michelle Fitzpatrick	US Coast Guard	(860)441-2859	Aircraft Rework P2

[5] Many of the contacts listed above have provided valuable information and comments during the development of this document. EPA appreciates this support and acknowledges that the individuals listed do not necessarily endorse all statements made within this notebook.

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