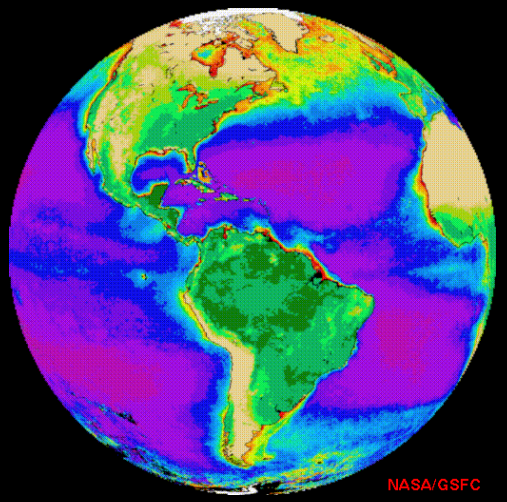
Advanced Space Flight and Environmental Concerns



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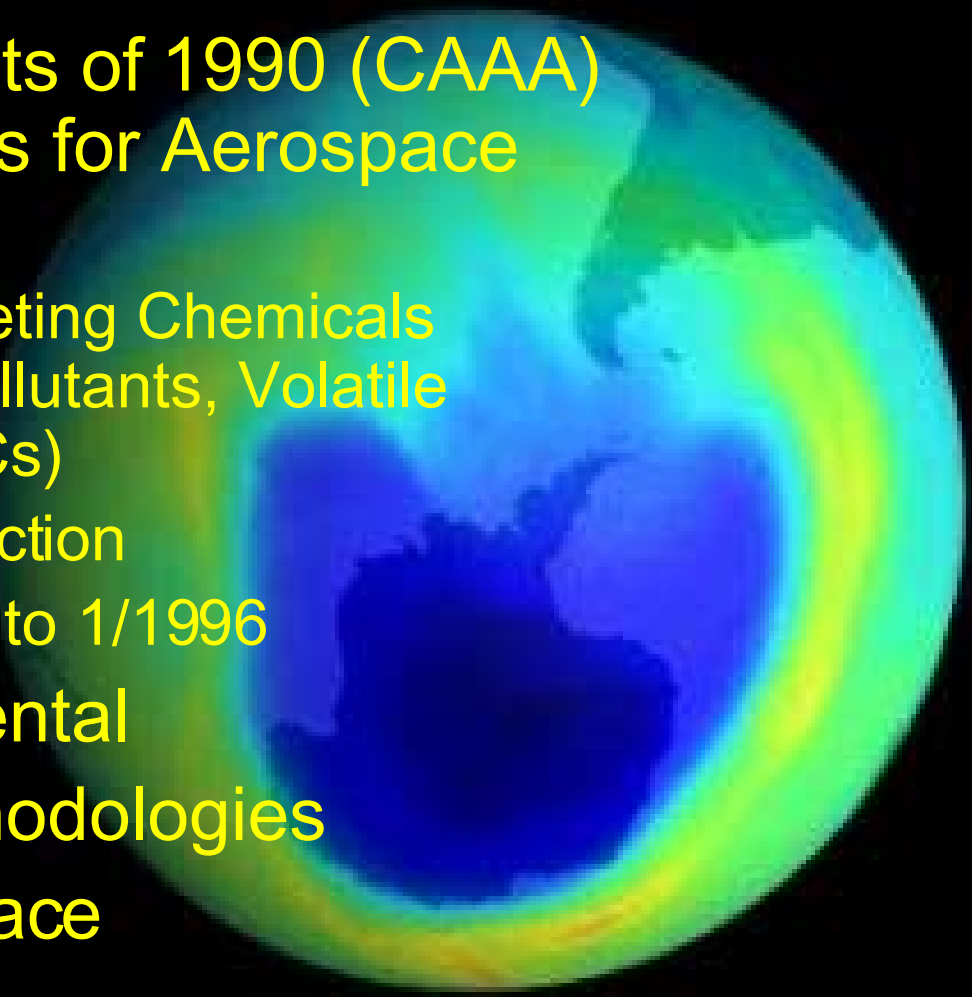
Environmental Challenges for Aerospace Industry

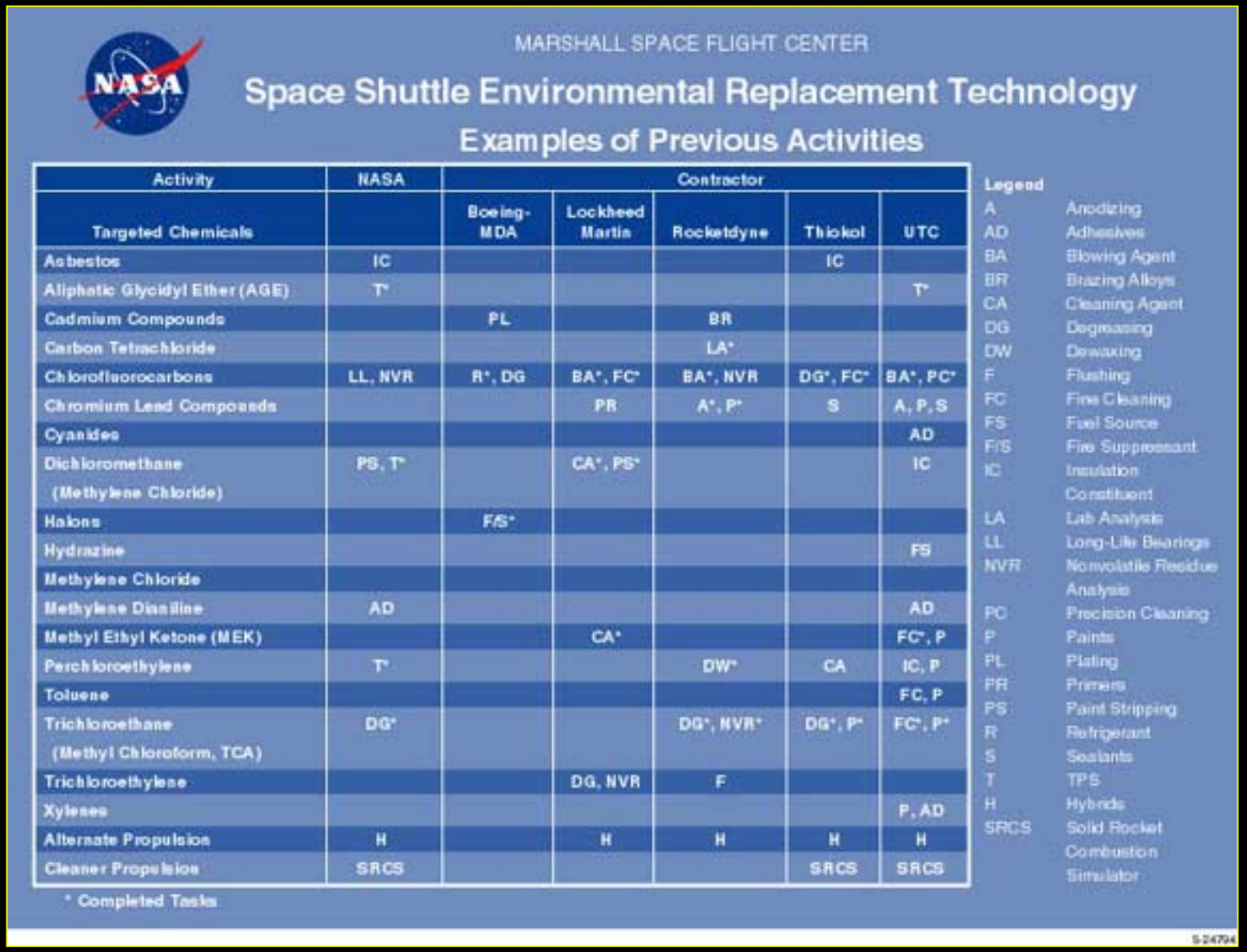
- Clean Air Act Amendments of 1990 (CAAA) presented new challenges for Aerospace Industry
  - Regulation of Ozone Depleting Chemicals (ODCs), Hazardous Air Pollutants, Volatile Organic Compounds (VOCs)
  - Acceleration of U.S. production ban of ODCs from 1/2000 to 1/1996
- Overwhelming environmental impact on traditional methodologies for manufacturing aerospace systems and vehicles



NASA Accepted the Challenge

- NASA Administrator, Mr. Daniel Goldin, established the NASA Operational Environment Team (NOET) in September 1992
  - Emphasis on development, test, production, and use of NASA's aerospace flight hardware
- NOET executed numerous technical forums
  - NASA Programs, Industry, Academia and Federal Agencies exchanged "lessons learned" on environmentally - driven materials replacement technology
- NOET continues to proactively serve as a champion of the "operational environment"

Examples of previous replacement activities



MARSHALL SPACE FLIGHT CENTER

Space Shuttle Environmental Replacement Technology

Examples of Previous Activities

Activity	NASA	Contractor				
Targeted Chemicals		Boeing-MDA	Lockheed Martin	Rocketdyne	Thiokol	UTC
Asbestos	IC				IC	
Aliphatic Glycidyl Ether (AGE)	T*					T*
Cadmium Compounds		PL		BR		
Carbon Tetrachloride				LA*		
Chlorofluorocarbons	LL, NVR	R*, DG	BA*, FC*	BA*, NVR	DG*, FC*	BA*, PC*
Chromium Lead Compounds			PR	A*, P*	S	A, P, S
Cyanides						AD
Dichloromethane (Methylene Chloride)	PS, T*		CA*, PS*			IC
Halons		F/S*				
Hydrazine						FS
Methylene Chloride						
Methylene Dianiline	AD					AD
Methyl Ethyl Ketone (MEK)			CA*			FC*, P
Perchloroethylene	T*			DW*	CA	IC, P
Toluene						FC, P
Trichloroethane (Methyl Chloroform, TCA)	DG*			DG*, NVR*	DG*, P*	FC*, P*
Trichloroethylene			DG, NVR	F		
Xylenes						P, AD
Alternate Propulsion	H		H	H	H	H
Cleaner Propulsion	SRCS				SRCS	SRCS

* Completed Tasks

Legend	
A	Anodizing
AD	Adhesives
BA	Blowing Agent
BR	Brazing Alloys
CA	Cleaning Agent
DG	Degreasing
DW	Dewaxing
F	Flushing
FC	Fine Cleaning
FS	Fuel Source
F/S	Fire Suppressant
IC	Insulation Constituent
LA	Lab Analysis
LL	Long-Life Bearings
NVR	Nonvolatile Residue Analysis
PC	Precision Cleaning
P	Paints
PL	Plating
PR	Primers
PS	Paint Stripping
R	Refrigerant
S	Sealants
T	TPS
H	Hybrids
SRCS	Solid Rocket Combustion Simulator

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NASA Assessed the Impact

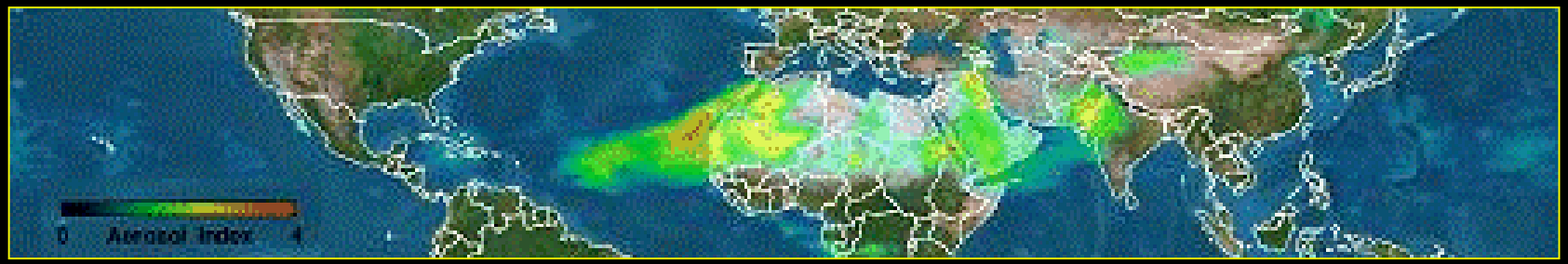
- NASA's ODC usage in 1992 was 3 million pounds
  - Primarily Chlorofluorocarbons (CFCs) and Trichloroethane (TCA) for manufacture of programmatic hardware
- NASA's ODC usage decreased 87% by 1996
  - ODC usage in 1996 was 400,000 pounds
- Decrease accomplished with implementation of environmentally- driven materials and processes
- NASA currently utilizes less than 75,000 pounds/year for the manufacture of aerospace hardware and systems
  - Critical requirements on the Space Shuttle Transportation System

NASA's Teaming Successes

- **Environmental challenges provided impetus for NASA to team with other Federal Agencies**
  - **Environmental Protection Agency (EPA)**
  - **Department of Defense (DoD)**
- **Interagency teaming resulted in collaborative working relationships that benefited the aerospace community**
  - **Cost Savings, Data Sharing and Technology Transfer**
  - **Rulemaking Process: Technically sound, Economically feasible and Environmentally friendly**
- **Teaming within NASA Centers and NASA programs resulted in resource savings and increasingly robust, advanced aerospace systems**

Resulting Efforts and Studies

- **NASA/EPA/DoD Interagency Depainting Study**
- **Non-ODC Surface Cleaning of Advanced Aerospace Systems**
- **Non-ODC Instrumentation for Cleanliness Verification**
- **2nd Generation Blowing Agent for Thermal Protection System on External Tank**
- **Wire Arc Sprayed Aluminum Coatings**
- **Hot Oil Dewaxing**
- **Ultrasonic Cleaning**
- **Aerospace Manufacturing and Rework: National Emission Standards for Hazardous Air Pollutants (NESHAP)**



Manifestation of Environmental Challenges

- Manifestation of environmental challenges
  - Materials, Processes & Manufacturing
- Materials subtleties have surfaced in some environmentally - driven materials replacement technology
  - Decreased strength of materials
  - Post-flight anomalies
  - Consideration of synergistic effects of materials replacement
  - Performance of materials

Current Challenges

- Environmental challenges of new millennium for the manufacture of advanced aerospace flight systems
  - Development of 3rd Generation Blowing Agent
  - Elimination of TCA Rubber Activation & Cleaning
  - Reduction of Chromium in Primers & Conversion Coatings
  - Search for Better Cleaning Verification Solvents
  - Development of Low VOC Coatings

Future Environmental Concerns

- **Approximately 35 out of 150 NESHAPs potentially impact the materials, processes and manufacture of advanced aerospace flight systems**
  - Rocket Engine Test Firing
  - Paint Stripping Operations
  - Miscellaneous Organic Chemical Production & Process Usages
- **Increasing environmentally - driven materials obsolescence as suppliers comply with regulations**
  - Materials unavailability for advanced aerospace systems
  - Different performance characteristics of reformulated materials
  - Unexpected formulation change of material

Conclusions

- **Aerospace industry has conquered numerous environmental challenges during the last decade**
- **Aerospace industry of today has evolved due in part to the environmental challenges**
  - stronger
  - more robust
  - pushing limits of technology – materials and manufacturing
  - performing “cutting edge” engineering
- **Aerospace Industry is viable and successful because of your commitment and contributions**