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**Title:** Materials Lifecycle and Environmental Consideration at NASA

**Category:** Build Your Own Session

**Sub-Category:** Sustainability

**Abstract Text:** The aerospace community faces tremendous challenges with continued availability of existing material supply chains during the lifecycle of a program. Many obsolescence drivers affect the availability of materials: environmental safety and health regulations, vendor and supply economics, market sector demands, and natural disasters. Materials selection has become increasingly more critical when designing aerospace hardware. NASA and DoD conducted a workshop with subject matter experts to discuss issues and define solutions for materials selections during the lifecycle phases of a product/system/component. The three primary lifecycle phases were: Conceptualization/Design, Production & Sustainment, and End of life / Reclamation. Materials obsolescence and pollution prevention considerations were explored for the aforementioned lifecycle phases. The recommended solutions from the workshop are being presented.



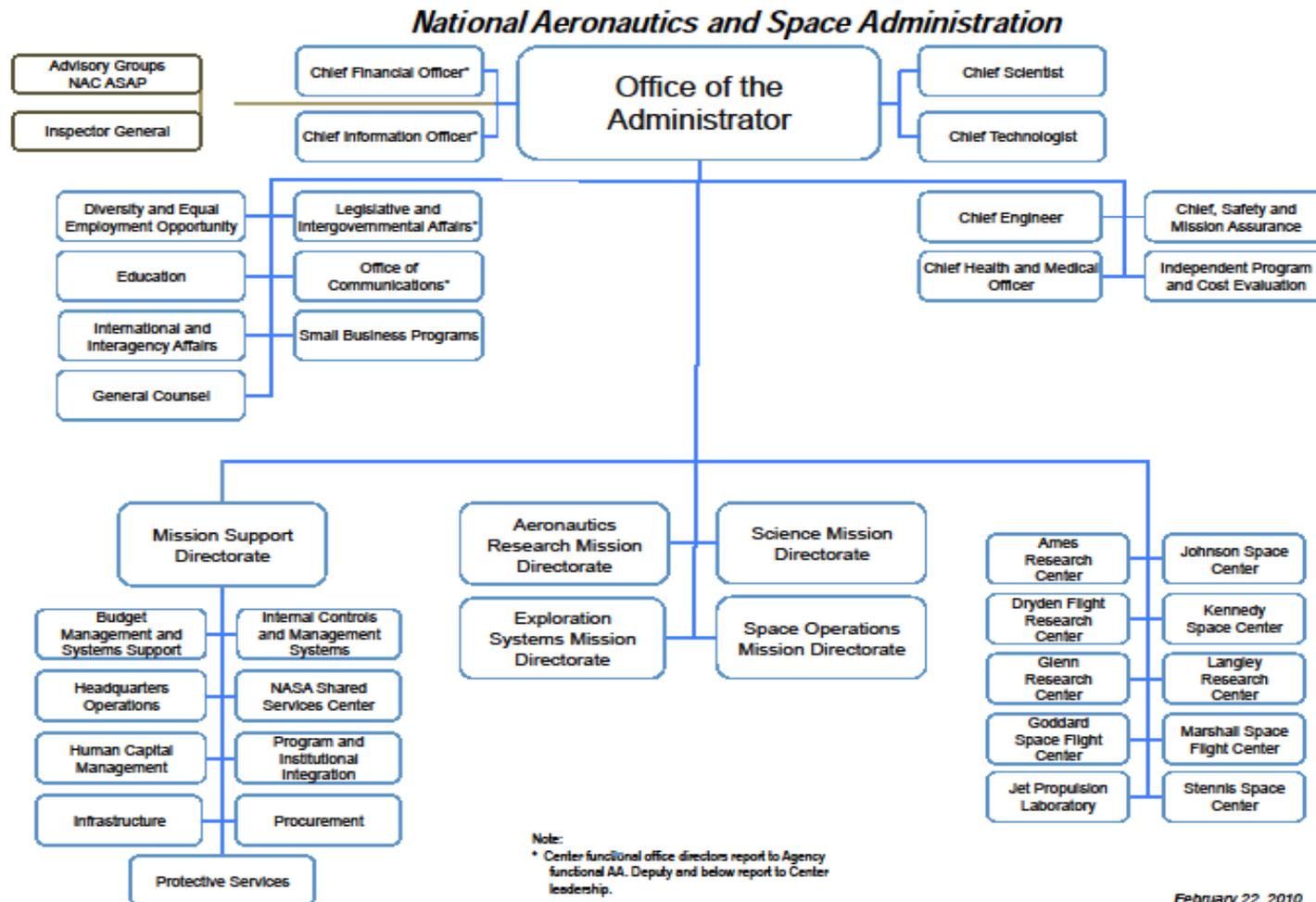
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# Materials Lifecycle and Environmental Considerations at NASA

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# National Aeronautics & Space Administration





# National Aeronautics & Space Administration

## NASA Facilities and Centers





# Background

- Dr. Carole LeBlanc, *Special Expert on Emerging Contaminants, for the Deputy Undersecretary of Defense (Installations and Environment)* presented NASA with an opportunity to develop a workshop on environmentally-driven materials obsolescence.
  - DoD and Aerospace Industries Association (AIA) held similar workshops prior to NASA's.
  - DOD, AIA and NASA were experiencing material supply chain concerns with environmental drivers.
  - These workshops provided future opportunities for knowledge-sharing and collaboration when seeking common solutions.
- This presentation will address the drivers that influenced the development of the NASA workshop and findings from the workshop.



# In the Past .....

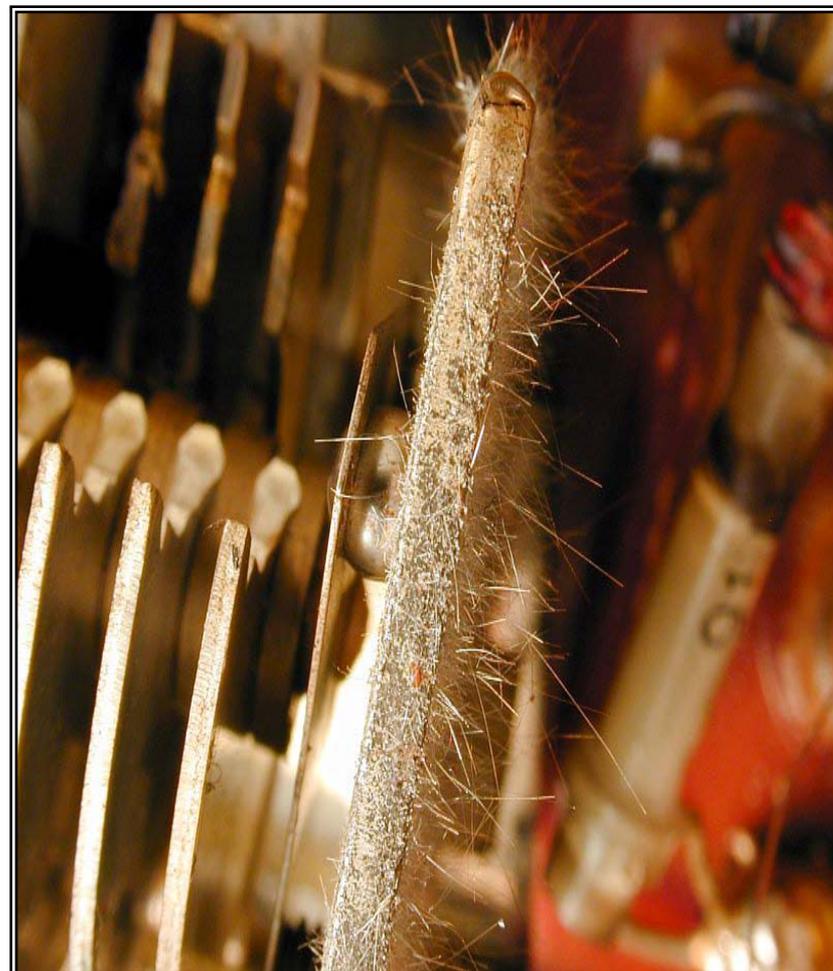
- Fewer environmental and obsolescence drivers influenced materials selection during Design, Development and Test of the Space Shuttle vehicle and the International Space Station (ISS).
  - Space Shuttle Program and the ISS were “operational” when regulatory and obsolescence drivers came about.
  - Montreal Protocol and Clean Air Act Amendments of 1990 raised awareness of hazardous air pollutants and phase -out of targeted materials.
  - NASA began proactively working with the EPA on solutions for phase-out of critical materials.
- Initially, sustainability of replacement materials/ processes was less of a consideration when seeking solutions.
  - Utilized stockpiles and waivers.
  - Larger pool of materials were available to consider as replacements.
  - Retirement of the Space Shuttle Program and near completion of ISS were factors when seeking replacements.
- Increased life-cycle costs due to waste disposal & clean-up.



# Material Obsolescence Drivers

- **Material Obsolescence Drivers** *impact material availability*
  - **Environmental Regulations**
  - **Vendor/Supplier Economics**
    - » **Plant closings**
  - **Market Sector Demands**
    - » **Termination of Product Lines**
    - » **Reformulation of Product Lines**
  - **Natural Disasters**
    - » **Hurricanes**

Tin Whisker Growth on Pure Tin





# Regulatory Drivers

United States and European environmental regulations are impacting traditional materials/ processes utilized in the manufacture of aerospace hardware.

## *United States*

- **Clean Air Act Amendments**
  - Ozone Depleting Substances
  - Hazardous Air Pollutants
  - Volatile Organic Compounds
- **Clean Water Act**
  - Effluent Concentrations
- **Occupational Safety & Health Administration (OSHA)**
  - Permissible Exposure Level (PEL)
- **Executive Order 13514**
  - Green House Gas Reductions
- **National Ambient Air Quality Standards**
  - Ambient Ozone Concentration

## *European Union*

- **Montreal Protocol**
  - Ozone Depleting Substances
- **Registration, Authorization and Restriction of Chemicals (REACH)**
  - Influencing the materials provided by domestic and global suppliers
  - Brominated Flame Retardants
- **Restrictions on Hazardous Substances (ROHS)**
  - Lead Free Electronics
- **Directive on Waste Electrical & Electronic Equipment (WEEE)**



# Geographical Drivers

- **NASA has many facilities and Centers in numerous geographical locations.**
- **Each location can present regulatory and manufacturing challenges that impact selection /use of materials and processes.**
  - **Regulatory Challenges & Manufacturing Challenges:**
    - » **States have different Environmental Management Agencies.**
    - » **Each state may have different state environmental regulations.**
    - » **Interpretation and implementation of federal regulations may vary.**
    - » **California has several air quality districts.**
    - » **NASA's aerospace hardware is oftentimes fabricated in more than one state by more than one contractor.**
    - » **Hardware is transported across many state boundaries.**
    - » **Vehicle Integration and launch occur in another state.**



# Materials Lifecycle Challenges

- The aerospace community faces tremendous challenges with continued availability of existing material supply chains during the lifecycle of a program.
  - *REACH* and other regulations are driving *Product reformulations* due to substitutions.
  - Our Original Equipment Manufacturers (OEM's) support an international marketplace.
  - NASA's demand does not drive the marketplace.
- Materials selection has become increasingly more critical when considering the *Design, Production* and *Termination* of aerospace hardware.
  - Utilizing heritage design on future space vehicles does not ensure continued material availability.
  - “Proven” heritage materials are increasingly unavailable.
  - Qualifying new, replacement materials.



# Shuttle Elements: Materials Obsolescence Concerns

Identified by Shuttle Environmental Assurance (SEA) Team

## External Tank

- HCFC-141b
- \*Cadmium
- Hexavalent Chromium
- \*High VOC coatings
- \*Cleaning and verification solvents
- \*Methyl ethyl ketone
- \*PFOA

## Orbiter

- HCFC-141b
- Trichloroethane
- \*Cadmium
- Hexavalent Chromium
- \*Methyl Ethyl Ketone
- \*High VOC coatings
- Lead-free electronics
- Hazardous Air Pollutant Inks
- \*Cleaning and verification solvents
- \*PFAS
- \*BFRs
- \*PFOA

## Space Shuttle Main Engines

- Hexavalent Chromium
- \*Cadmium
- Lead-free electronics
- \*Cleaning/verification solvents
- \*PFOA

## Solid Rocket Boosters

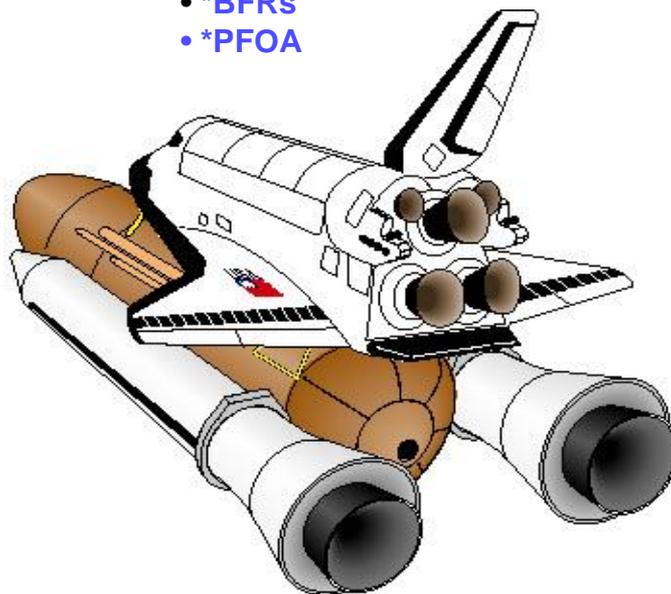
- HCFC-141b blowing agent
- Hexavalent Chromium
- \*Dry Film Lubricant
- \*High VOC Coatings
- \*Hypalon paint
- Lead-free electronics
- \*BFRs
- \*PFOA

## Flight Crew Equipment/Space Suit

- Hexavalent Chromium
- Lead-free electronics
- \*BFRs
- \*PFOA

\* Accepted concern

\* Closed concern -replacements qualified



## Reusable Solid Rocket Motors

- HCFC 141b
- Trichloroethane
- \*Cadmium
- Hexavalent Chromium
- \*High VOC Coatings
- \*Hypalon
- Lead-free electronics
- \*PFOA

## Ground Support

- \*Cadmium
- Hexavalent Chromium
- \*PFOA



# NASA's Workshop

## Materials Lifecycle & Environmental Considerations at NASA

### Statistics

- **Date:** February 23-24, 2010
- **Location:**
  - Jacobs Conference Center (Huntsville, AL)
- **Attendees: 45**
  - Government (DoD, NASA)
  - Industry (AIA, NASA & Aerospace Contractors)
  - Academia

### Break-out Groups

- **Group 1:** Requirements Definition, Conceptualization & Design
- **Group 2:** Production & Sustainment
- **Group 3:** Disposition & Pop-Ups

Aerospace Specialists, Scientists, Chemists, Engineers, Designers, Materials Scientists, Environmental Health & Safety Specialists, Procurement & Contracts



# Breakout Groups

## **Requirements Definition, Conceptualization & Design:**

*This group examined materials lifecycle and environmental issues that may cause technological challenges and concerns in earlier stages of the product/system/component lifecycle- with emphasis on requirements definition.*

**-Design Requirements** : Mission, Manufacturing Processes, Sustainment

## **Production and Sustainment:**

*This group examined materials lifecycle and environmental issues that may cause challenges and concerns related to products/components/systems during the production and sustainment phase of the product lifecycle.*

**Disposition and Pop-Ups:** *This group examined materials lifecycle and environmental issues such as reclamation of scarce materials, material removal/recovery considerations, space debris from “end-of –life” space craft, legacy systems, the transition to new programs and “pop-ups”.*  
**-”Pop –ups”** are unforeseen, disruptive and unexpected events.



# Identifying Key Issues

## Materials Lifecycle and Environmental Considerations at NASA

### Requirements Definition, Conceptualization & Design

- Time and Cost
- Awareness, Culture & Education
- Data, Information & Knowledge
- Materials Requirements & Performance
- Supplier & Supply Issues

### Production & Sustainment

- Time and Cost
- Awareness, Culture Education
- Data, Information & Knowledge
- Materials Characterization
- Materials Requirements & Performance
- Supplier & Supply Issues

### Disposition & Pop -Ups

- Time and Cost
- Awareness, Culture & Education
- Lifecycle Perspective
- Material Characterization
- Material Processing Capability
- Data, Information & Knowledge
- Materials Requirements & Performance
- Supplier & Supply Issues



# Summary of Key Findings & Solutions

- Key findings & solutions represent the top “**voting results**” from the 3 concurrent “break-out” sessions.
- Key findings encompass an assessment of the current state:
  - *Current Practices*
  - *Barriers & Deficiencies*
  - *Examples of Emerging Best Practices*
- Key findings also
  - *Utilized for development of a “Future Vision”.*
  - *Utilized for identification of **major issues** & development of **solutions**.*
- Key findings emphasized following concerns
  - *Increased need for development of future generation replacement materials*
  - *Impacts from fast pace of developing /emerging environmental regulations on material selections*
  - *Increased need for knowledge of materials/constituents in formulations*
  - *Vulnerabilities in critical materials supply chains*



# Preliminary Workshop Findings

- **Finding #1:** *There is a need for independent materials & research program to address future, next-generation, materials requirements.*
- **Finding #2:** *The fast pace of changing environmental regulations – and anticipated future changes – makes it difficult to develop sustainable alternative materials choices.*
- **Finding #3:** *NASA's need for certain critical materials may be such a small part of the market sector ---that sustained market support may not be guaranteed when relying on small or foreign suppliers / vendors.*
- **Finding #4:** *There is a lack of adequate funding for material obsolescence risks and mitigation efforts throughout the entire lifecycle.*



# Workshop Findings.... (Cont'd)

- **Finding #5:** *Valuable knowledge (e.g. lessons learned, failure analysis, incident reports, empirical data, alternative studies) may exist in databases, paper files, tribal knowledge...etc, but is not always accessible.*
- **Finding #6:** *There is a lack of system search capability for identifying materials and materials/processes within products to provide needed information.*
- **Finding #7:** *The sustainment of NASA systems is jeopardized by regulatory and market changes.*
  - *Environmental and health regulations are driving material obsolescence.*
  - *There is a need for earlier notification and involvement when a material is being scrutinized for regulation.*
  - *Vendors change material formulations but maintain the same product code.*
- **Finding #8:** *Engineers lack sufficient materials data and standard approach regarding environmental and life-cycle costs.*



# Preliminary Vision Statement

*“Every constituent of every material, the process that was used to make it, the vendor location, and the system in which it was used is known to all who need to know. This information is called out specifically in the product definition, and it is searchable from readily accessible knowledge access systems. The requirements-to-design process is an integrated system that evaluates all alternatives for optimized designs, including environmental issues and material and chemical selection. Materials understanding and access to needed information is a NASA priority.”*



# Recommended Solutions

- **Solution #1:** *Collaborate and strategize with stakeholders (Commercial Industry, EPA, Government, users and suppliers ) on the prioritization and development of next generation materials.*
- **Solution #2:** *Establish an agency-wide process and infrastructure that proactively anticipates, communicates and addresses materials and process sustainability and obsolescence issues.*
- **Solution #3:** *Create a NASA-wide list of critical materials that require assured sourcing measures. The list should be added to the NASA Risk System to help mitigate the issues.*
- **Solution #4:** *Conduct a study, and develop and publish a business case document that supports proactive, early mitigation of materials obsolescence issues over reactive efforts.*



# Recommended Solutions (Cont'd)

- **Solution #5:** *Evaluate other alternative information sources that could be utilized to make the needed information available. Explore using, enhancing, and/or expanding the “Materials and Processes Technical Information System (MAPTIS)”.*
- **Solution #6:** *Collaborate with the materials engineering stakeholders and system software engineers to develop capabilities for extracting chemical and substance constituent information in addition to the currently supported information from engineering documentation.*
- **Solution #7:** *Establish/ support mechanisms (such as the “Regulatory Risk Analysis and Communication Principal Center”) to assure that NASA actively participates in providing timely input to pending regulatory actions and, where appropriate, voice concerns about the impact of those actions.*
- **Solution #8:** *Provide systems that accurately model and evaluate costs based on requirements to determine major cost drivers and to support optimization early in the design process.*



# Moving Forward

- The workshop highlighted need to strategize with stakeholders (Commercial Industry, EPA, users & suppliers) and target the priorities.
- The workshop provided tremendous insight on “strengths” and “ areas to improve” .
  - *Communicate findings to NASA management.*
  - *Prioritize recommended solutions .*
  - *Seek buy-in and determine “Best Starting Point”.*
- NASA is participating in the “*Inter-Agency and Industry Sustainable Materials Management Workshop*”
  - *June 24 -25, 2010 in Arlington, Virginia*
  - *Interested in future opportunities for knowledge- sharing and collaboration when seeking common solutions.*



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