



# **Environmental Considerations for Future Space Vehicles**

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*NASA Clean Air Act Principal Center*

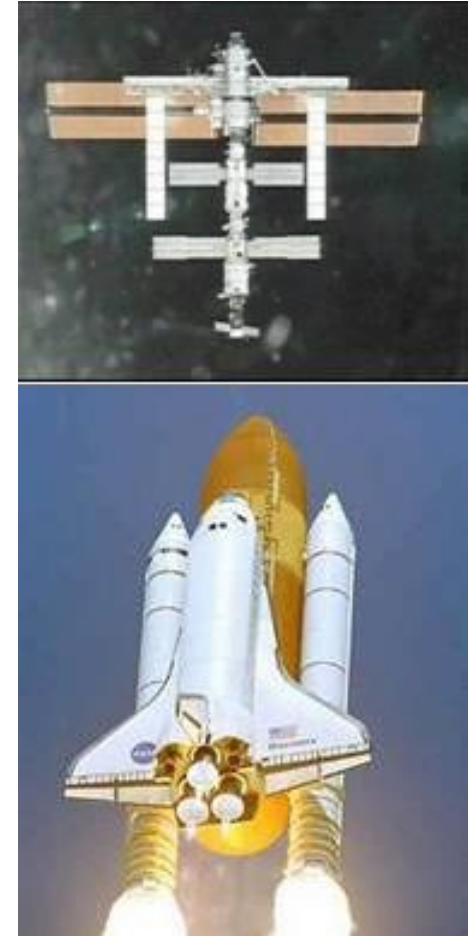
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# Overview

- **Clean Air Act Principal Center Background**
- **Plan for Human Space Flight**
- **Designing for Sustainability**



# NASA Clean Air Act Principal Center (CAAPC)

- Serves as NASA's lead in assessing and documenting applicability of emerging CAA and multimedia regulations and related policies to NASA operations and facilities.
- The CAAPC provides environmental support in the continuing operations of the Space Shuttle Program (SSP) and is examining environmental issues and approaches as NASA plans for the design and execution of future space vehicle programs.

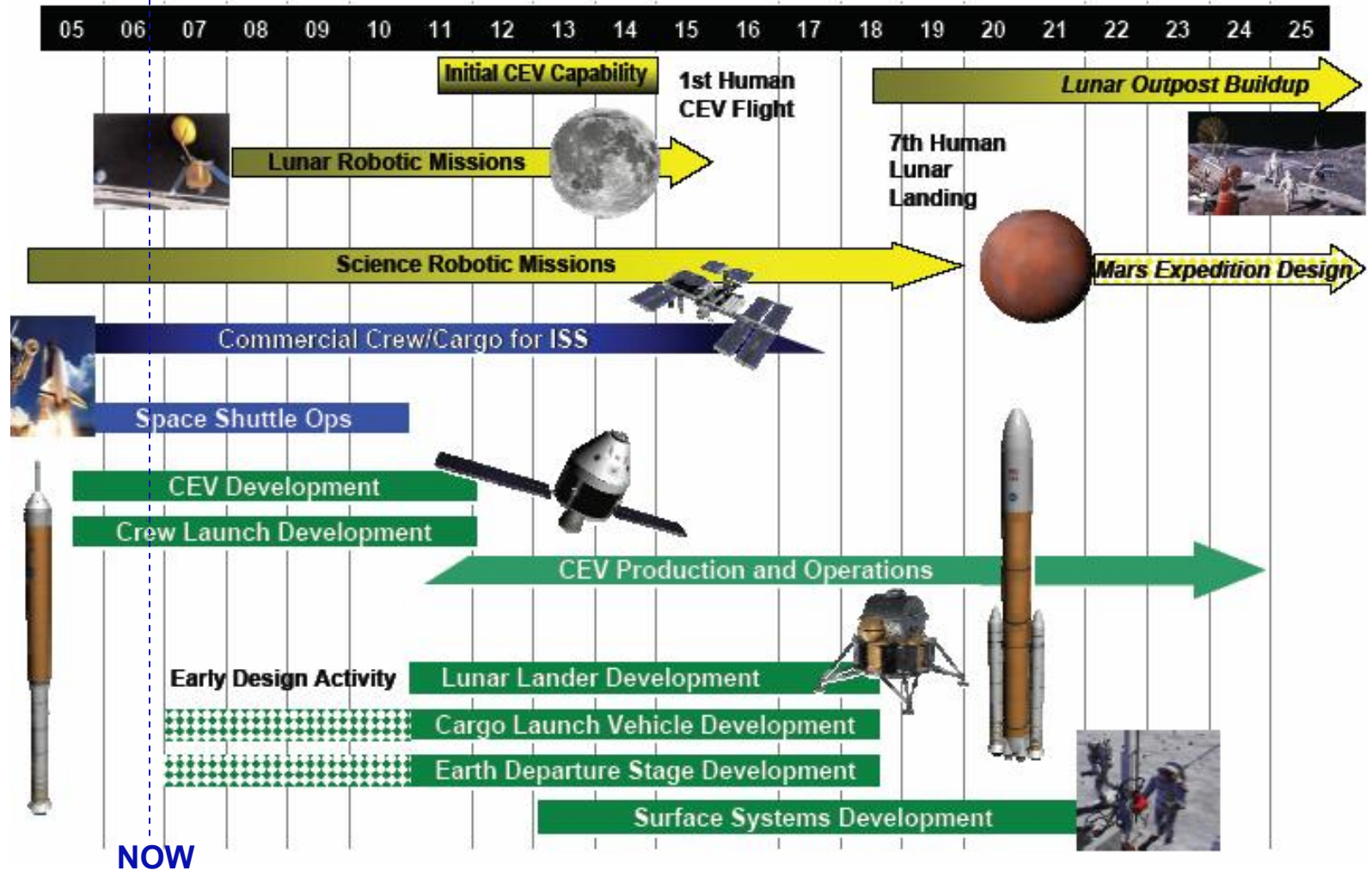


# Plan for Human Space Flight

- **NASA Strategic Goals 2006-2016, NASA 2006 Strategic Plan**
  - Complete International Space Station
  - Safely fly Space Shuttle until 2010
  - Develop and fly Crew Exploration Vehicle before 2014
  - Return to the Moon before 2020
  - Promote international and commercial participation
  - Develop supporting innovative technologies, knowledge, and infrastructures
  - Implement sustained and affordable human and robotic programs



# NASA's Space Vehicle Timeline



# Design for Sustainable Programs

- **NASA plans for the Constellation Program's vehicle designs to have long service lives**
  - Even more important to incorporate sustainable designs to avoid future regulatory issues and operational obsolescence
  - Important to consider:
    - ❖ *Commonality of materials*
    - ❖ *Materials selection to avoid obsolescence*



# Design for Sustainable Programs

- **Commonality of Materials**
  - Encourage the use of common materials and common specifications
  - Such integrated materials and specifications potentially can reduce costs to the program by:
    - ❖ *Reducing hazardous waste streams*
    - ❖ *Allowing the program to buy larger quantities of a single part or material, rather than smaller quantities of numerous essentially identical parts or materials*
    - ❖ *Reducing the number of materials that require qualification testing*



# Design for Sustainable Programs *(continued)*

- **Material Selection Considerations**
  - Design for obsolescence avoidance in long service-life programs:
    - ❖ *Minimizes environmentally high-risk materials*
  - Material replacement efforts require extensive resources (human and financial):
    - ❖ *Affects NASA's program costs and schedules*



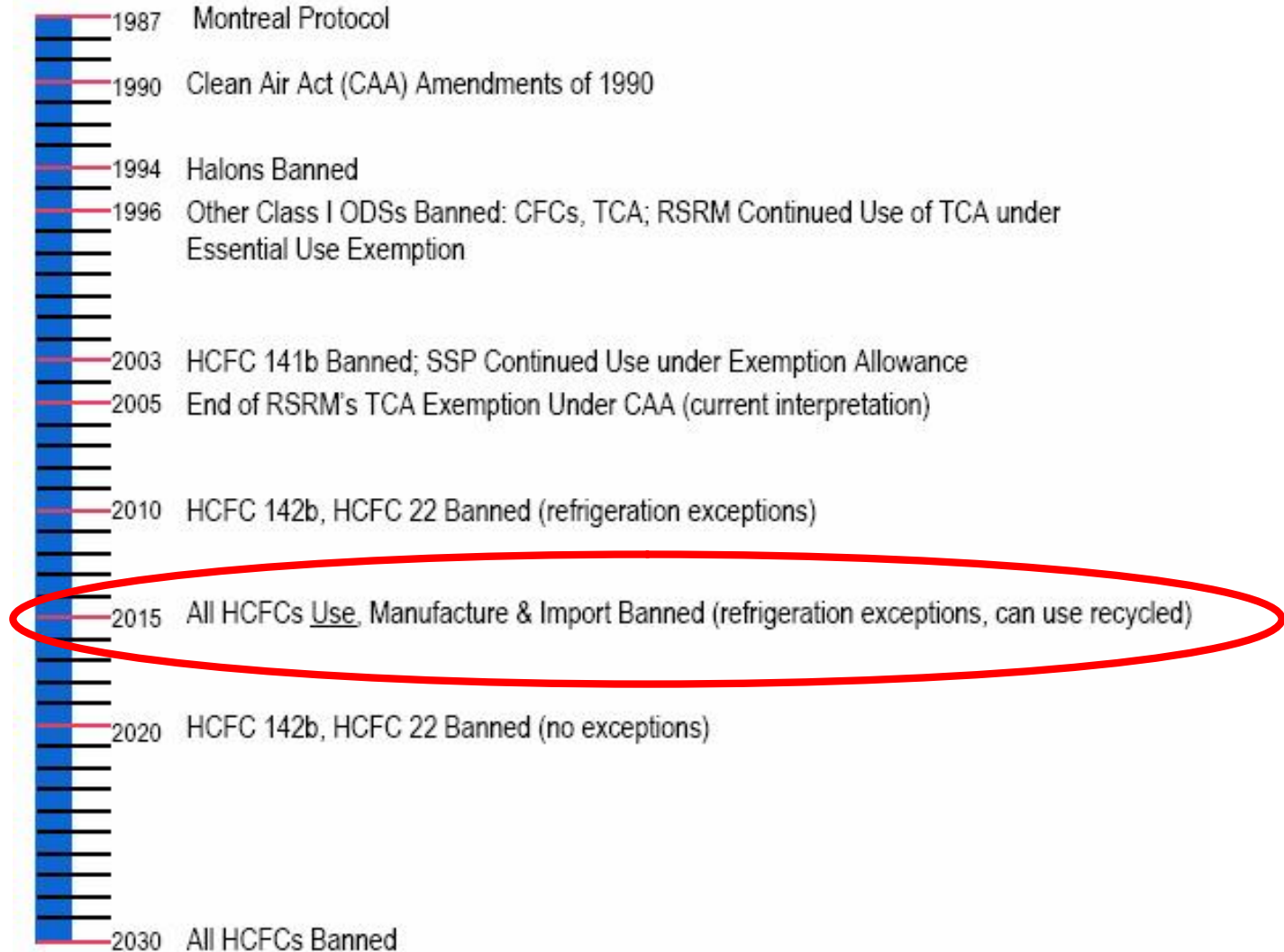


# Impact of Regulatory Changes on Program Sustainability

- **Selected Potential Regulatory Drivers**
  - Ozone-depleting Substances (ODSs):
    - ❖ *Clean Air Act, Montreal Protocol*
  - Volatile Organic Compounds (VOCs) and Hazardous Air Pollutants (HAPs):
    - ❖ *Clean Air Act*
  - Lead-bearing Electronics:
    - ❖ *European Union; China; Korea*
  - Brominated Flame Retardants (BFRs):
    - ❖ *Toxic Substances Control Act; some US States; European Union*
  - Electronics Recycling:
    - ❖ *Some US States; European Union*



# Example: Ozone-depleting Substances (ODSs)



## Example: Ozone-depleting Substances (ODSs) (continued)

- **NASA has reduced ODS usage by more than 96% since 1991**
- **Current critical space vehicle uses include:**
  - Foam-blowing agent
  - Rubber cleaning and activation
  - LOX cleaning
  - Fire suppression
  - On-orbit coolant



# Impact of Emerging Regulatory Actions on Program Sustainability

- **Emerging requirements (here and abroad) may affect program sustainability**
  - Future obsolescence issues:
    - ❖ *May require material replacements*
    - ❖ *Affect NASA program costs and schedules*
- **Selected Emerging Requirements**
  - Clean Air Act (CAA) changes:
    - ❖ *Residual Risk Rules*
    - ❖ *National Emission Standards for Hazardous Air Pollutants*
    - ❖ *Area Source Rules*
  - Persistent Organic Pollutants
  - Electronics Pollution Prevention
  - Biobased Products



# Clean Air Act Rulemakings

- **Emissions Standards**

- Potentially limit the types of materials used in specific applications:

- ❖ *National Emission Standards for Hazardous Air Pollutants (NESHAPs) and associated Residual Risk Rules:*

- Usually apply to larger facilities

- Those that have the potential to emit 10 tons per year (tpy) of any single hazardous air pollutant (HAP) or 25 tpy of any combination of HAPs

- Examples: Surface Coating NESHAPs

- Aerospace NESHAP applies to flight hardware

- Under development:

- Defense Land Systems and Miscellaneous Equipment (DLSME) NESHAP* will apply to ground support equipment



# Clean Air Act Rulemakings

- **Emissions Standards** (*continued*)
  - Potentially limit the types of materials used in specific applications:
    - ❖ *Area Source Rules*
      - Usually apply to smaller facilities
        - Those that do not have the potential to emit 10 tpy of any single HAP or 25 tpy of any combination of HAPs
      - Examples:
        - Plastic and Metal Parts Coating
        - Plastic Materials and Resins Manufacturing



# Clean Air Act Rulemakings

- **Changes to the list of HAPs**

- If EPA makes changes to the HAP list, vendors may react by making advantageous formulation modifications
- Such modifications to qualified materials formulations, even if “minor,” could result in:
  - ❖ *Lack of change awareness by suppliers and end users*
  - ❖ *Change in technical performance characteristics*
  - ❖ *Materials compatibility issues*
  - ❖ *Eventual need for material replacement efforts*



# Clean Air Act Rulemakings

- **Volatile Organic Compounds (VOCs) Rules**
  - Also potentially limit the types of materials used in specific applications
  - Control Technique Guidelines (CTGs):
    - ❖ *Section 182(b) guidance documents*
      - Guidelines for state and local air pollution authorities to control air pollution by establishing a “presumptive norm” for Reasonably Accepted Control Technology (RACT) for a specific VOC source category.
      - Sometimes implemented only in ozone non-attainment areas
    - ❖ *Section 183(e) rules*
      - Guidelines directed toward categories of consumer and commercial products that account for at least 80 percent of the total VOC emissions in areas of the country that fail to meet the national air quality standards set for ozone
      - Examples:
        - Upcoming rule: Aerospace Coatings
        - Planned rule: Miscellaneous Metal Products Coatings





# Clean Air Act Rulemakings

- **Bottom line:**
  - Space vehicle programs must stay abreast of regulatory change and practice proactive supply chain communications:
    - ❖ *These rules potentially can drive manufacturers to change materials' ingredients, which does not always filter up the supply chain.*
  - Future programs must consider best mitigation approaches during the design phase and as early as possible.



# Persistent Organic Pollutants

- **Persistent Organic Pollutants (POPs) Convention**
  - Multilateral environmental agreement designed to protect human health and the environment from POPs.
  - The US has signed the convention, but not yet ratified it.
  - If ratified, the requirements of the Convention probably would be implemented in the US through EPA regulations.
  - The POPs Convention requires the Parties to reduce or eliminate the production and use of POPs used as pesticides or industrial chemicals.
  - Risk of POPs-related chemicals being replaced without warning or notification by manufacturers, especially foreign suppliers.



# Persistent Organic Pollutants

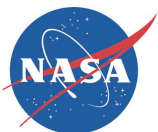
- The first chemicals to be addressed by the POPs Convention were selected in November 2005:

Type	Chemical	Description	Potential Space Vehicle Impacts
Industrial Chemicals	<b>Polybrominated Diphenyl Ethers (PBDE)</b>	Class of brominated flame retardant	May be used as flame retardant constituent in foams, coatings, electronics
	<b>Hexabromobenzene (HBB)</b>	Brominated flame retardant	
	<b>Perfluorooctane Sulfonate (PFOS)</b>	Used in the production of plastics, electronics, textiles, and construction materials	May be used as additive in waterproofing and other surface treatments
Pesticides	Lindane Chlordecone		None



# Electronics P2

- **European Union**  
**ROHS: Effective 1 July 2006**
  - ROHS: Restriction on Hazardous Substances.
  - Bans the following in new electrical and electronic equipment (EEE), with some exemptions:
    - ❖ *Lead*
    - ❖ *Cadmium*
    - ❖ *Mercury*
    - ❖ *Cr+6*
    - ❖ *PBB and PBDE flame retardants*
  - Exemptions reviewed every 4 years.
  - EU currently considering 15 additional exemptions.
  - Potential space vehicle issues:
    - ❖ *Integrity of solder joints can be compromised. A lead-free solder joint is likely to be far more brittle and intolerant of extreme temperature changes.*
    - ❖ *Use of pure tin or tin-rich alloys in electrical systems can result in “tin whiskering,” potentially causing system failure.*



# Electronics P2

- **China**

- **“China ROHS”**

- Announced February 2006; effective date for banning toxics is 1 March 2007.
- Regulates same 6 materials: Pb, Cd, Hg, Cr+6, PBBs, PBDEs.
- Covers all levels of the supply chain; EuroROHS primarily targets OEMs.
- Targets “electronic information” products – scope broader than EuroROHS – products in-scope specifically listed under these categories:

- ❖ *Radar Equipment*
- ❖ *Communication Equipment*
- ❖ *Broadcast Television Equipment Industry*
- ❖ *Computer Industry*
- ❖ *Household Electronics*
- ❖ *Electronic Measuring Instruments*

- ❖ *Electronic Industry Professional Equipment*
- ❖ *Electronic Components*
- ❖ *Electronic Device Industry*
- ❖ *Electronic Applications*
- ❖ *Electronic Professional Use Materials*



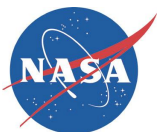
# Electronics P2

- **South Korea**  
**“Korea ROHS”**
  - Announced to World Trade Organization 30 March 2006.
  - Will restrict certain materials, not yet specified.
  - Focus is design for environment – facilitating recycling.
  - Enforcement date: 1 July 2007.
- **Voluntary program already in place to restrict or eliminate the 6 EuroROHS materials:**
  - Approximately 95% of Korean manufacturers currently are participating.



# Electronics P2

- **United States**
  - Numerous states have instituted electronics recycling programs.
  - Federal Universal Waste rules address the recycling of CRTs, thermostats, lead, and mercury.
- **Bottom Line**
  - World-wide electronics P2 initiatives may pose serious safety and supportability risk to space operations.
  - NASA programs must remain vigilant with quality and supply chain management programs.
  - Future programs must consider best mitigation approaches during the design phase:
    - ❖ *Sustainable design where possible*
    - ❖ *Robust quality assurance where non-RoHS electronics are required*



## Federal Biobased Products Preferred Procurement Program (FB4P)

- **Provides for the preferred procurement of biobased products by “procuring agencies”**
  - Both federal agencies and contractors are subject to the biobased procurement preference requirements:
    - ❖ *Requires the purchase of biobased products for designated items where the purchase price of the procurement item exceeds \$10,000 for the federal agency.*



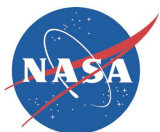


# Federal Biobased Products Preferred Procurement Program (FB4P)

**A Final Rule was issued in the *Federal Register* on 16 March 2006**

- Added 6 items to the USDA FB4P Guidelines for Designating Biobased Products for Federal Procurement.
- Includes minimum biobased contents for each of the items.
- There will be a 1-year transition period to implement these requirements after the final rule is published.
- **Rules provide exemptions for NASA use of these products on space vehicles and launch support equipment for:**
  - ❖ *Mobile equipment hydraulic fluids*
  - ❖ *Diesel fuel additives*
  - ❖ *Penetrating lubricants*

<b>71 FR 13686</b>
Mobile equipment hydraulic fluids
Roof coatings
Water tank coatings
Diesel fuel additives
Penetrating lubricants
Bedding, bed linens, and towels



# Federal Biobased Products Preferred Procurement Program (FB4P)

- **Two proposed rules issued in the *Federal Register* on 17 August 2006:**
  - Add 10 items to the USDA FB4P Guidelines for Designating Biobased Products for Federal Procurement (7 CFR part 2902).
  - Includes minimum biobased contents for each of the items.
  - There will be a 1-year transition period to implement these requirements after the final rule is published.
  - **Rules propose exemptions for NASA use of these products on spacecraft systems and launch support equipment.**
- **Bottom line**
  - **NASA must monitor:**
    - ❖ *Procurement of the items and potential implementation of biobased products for those items*
    - ❖ *Changes to FB4P to identify the potential impact of implementing the use of biobased products to NASA operations*

FR Page 47590	FR Page 47566
2-Cycle engine oils	Adhesive and mastic remover
Lip care products	Insulating foam for wall construction
Biodegradable films	Hand cleaners and sanitizers
Stationary equipment hydraulic fluids	Composite panels
Biodegradable cutlery	Fluid-filled transformers
Glass cleaners	Biodegradable containers
Greases	Fertilizers
Dust suppressants	Metalworking fluids
Carpets	Sorbents
Carpet and upholstery cleaners	Graffiti and grease removers



# Questions?

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