



**SPACE SHUTTLE PROGRAM**  
Shuttle Propulsion Office (MSFC)  
NASA Marshall Space Flight Center, Huntsville, Alabama



# SHUTTLE ENVIRONMENTAL ASSURANCE INITIATIVE



**Matt Segars**

United Space Alliance: [matt.g.segars@nasa.gov](mailto:matt.g.segars@nasa.gov)

Propulsion Systems Engineering and Integration Office (PSE&I)/MSFC

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# Overview

- **Shuttle Environmental Assurance Initiative (SEA)**
  - Need and Objectives
  - Team
  - Approach
  - Issues/Risk
  - Issues Across Shuttle Elements
  - Issues (HCFC-141b; PFOA; BFR; Lead-Free Electronics)
  - Lessons Learned
  - SEA Future
- **Shuttle Transition Environmental Support Team**
- **Contact Information**



# SEA: Need and Objectives

- **Need**

- Environmental requirements increasingly focus on reduction of hazardous materials use, some critical materials banned
- Material availability continues to be impacted by domestic and international regulations, industrial pollution prevention goals and related vendor economics

- **SEA Objectives**

- Integrated team that works to identify and address environmental health and safety driven materials obsolescence issues and pollution prevention opportunities
- Systems focus on issues driven by current or future environmental drivers
- Proactively identify potential problems, make efficient use of resources and expertise in mitigation



## SEA: Team

- Propulsion Systems Engineering & Integration (PSE&I) Group, SEA Lead
- NASA and contractor representatives from SSP elements, ground support equipment, logistics and flight crew equipment, materials and processes
- Center Environmental Offices
- HQ Environmental Office
- NASA Principal Center for Regulatory Risk Analysis and Communication (RRAC)
- NASA Technology Evaluation for Environmental Risk Mitigation Principal Center (TEERM)
- MSFC, JSC Materials Engineering
- HQ Air Force Space Command
- Army Engineering Environmental & Logistics Oversight Office, Redstone Arsenal
- Interfaces with Constellation

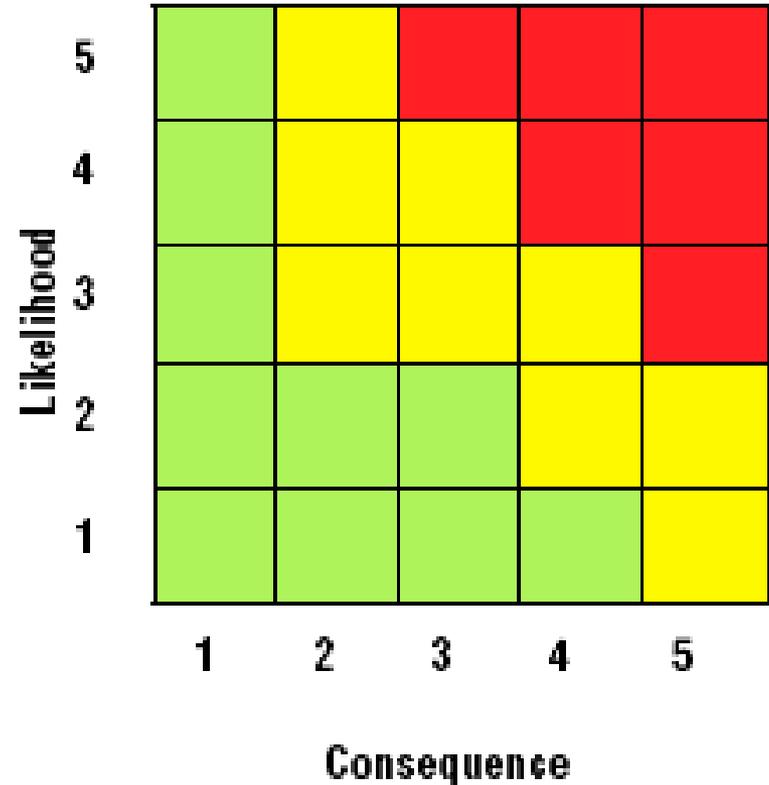




# SEA: Approach

**Risk Management Approach:**  
evaluate program risk, mitigate,  
track, and control identified issues

- Technical and Systems Focus
- Multi-disciplinary Team
- Regulatory Assessments and Reporting
- Communication, Interfaces and Collaboration
- Program and Project Management



SSP risk matrix.



# SEA: Issues/Risk

	SSP SEA Current Risks
HCFC 141b Blowing Agent	YELLOW
1,1,1 Trichloroethane Elimination (Orbiter use; RSRM use)	YELLOW
Hexavalent Chromium Replacement in Conversion Coatings and Primers	YELLOW
High Volatile Organic Compound Coatings	YELLOW
Lead-Free Electronics	YELLOW
Perfluoroalkyl Sulfonates	YELLOW
Brominated Flame Retardants	YELLOW
Perfluorooctanoic acid (PFOA)	YELLOW
Hexavalent Chromium in Alkaline Cleaners	GREEN
Chemical Paint Stripper Alternatives (Methylene chloride)	GREEN
Alternate Dry-Film Lubricant	GREEN
Cadmium Replacement in Plating Applications	GREEN
Hypalon Paint	GREEN
Hazardous Air Pollutant Inks	GREEN
Cleaning and Verification Solvents	CLOSED
Methyl Ethyl Ketone Replacement	CLOSED

# SEA: Issues Across Shuttle Elements

## External Tank

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

## Orbiter

- HCFC 141b
- Trichloroethane
- Cadmium
- Hexavalent Chromium
- Methylene Chloride
- High VOC coatings
- Lead free electronics
- Hazardous Air Pollutant Inks
- Cleaning and verification solvents
- Methyl ethyl ketone
- PFAS
- BFRs
- PFOA

## Space Shuttle Main Engines

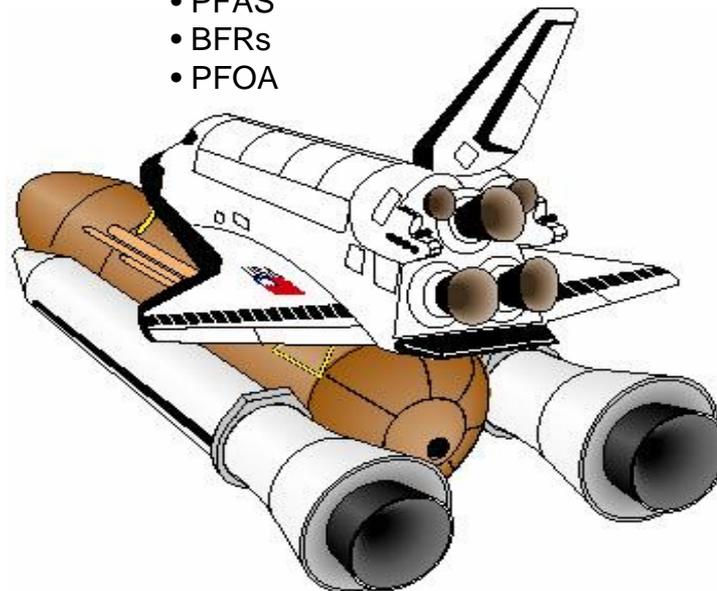
- Hexavalent Chromium
- Cadmium
- Lead-free electronics
- Cleaning/verification solvents
- PFOA

## Solid Rocket Boosters

- HCFC 141b blowing agent
- Hexavalent Chromium
- Lube-Lok
- High VOC Coatings
- Hypalon paint
- Lead-free electronics
- BFRs
- PFOA

## Flight Crew Equipment

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



## Reusable Solid Rocket Motors

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

## Ground Support

- Cadmium
- Hexavalent Chromium
- PFOA



# **SEA: Issues**

## **HCFC-141b**

- HCFC-141b is a class II ozone depleting substance (ODS) used as a TPS foam blowing agent
- Risk is the potential for HCFC–141b to become unavailable affecting ET, Orbiter, SRB, and RSRM processing
- EPA granted NASA and the SSP an exemption allowance for mission critical uses
- The exemption must be officially conferred from NASA to the Prime Contractors and from contractor to manufacturer
- 2 biannual usage reports are required / potential repetition
- Exemption stipulates annual/ongoing replacement efforts
- Material may only be used for exempted SSP applications and is subject to strict disposal guidelines



## **SEA: Issues**

### **PFOA (perfluorooctanoic acid)**

- Evidence that PFOAs can bioaccumulate; potential toxic effects
- Major producers of PFOA have agreed to a significant reduction in PFOA and related chemicals
- PFOA (perfluorooctanoic acid) is used in the production of fluoropolymers and fluoroelastomers (includes Teflon, Viton)
- Risk is potential performance impacts associated with identified and unidentified material changes
- Obsolescence impacts have been identified by Orbiter/Logistics (Beta cloth), EMU (Beta Cloth), ISS (Teflon T30), ET (Dupont coatings), SSME (Dupont Coatings), RSRM (Dupont Coatings)
- SEA has established a sub-team that is working to identify materials subject to reformulation, evaluate risk and suggest mitigation
- SEA is also participating in a team lead by ISS/JSC
- Provided a MSFC NASA Advisory (NA-MSFC-2007-01)



## **SEA: Issues**

### **Brominated Flame Retardants (BFRs)**

- The European Union has banned the use of some brominated flame retardants because there is evidence that they can bioaccumulate
- Manufacturers are beginning to replace BFRs with other flame retardants
- BFRs are used as additives to plastics, rubber, foam and in electronics manufacturing
- Risk is the potential performance impacts associated with identified and unidentified material changes
- Targeted BFRs are used in small quantities and specific applications are difficult to identify
- SEA has established a sub-team that is working to identify uses of targeted BFRs in SSP applications, help define the risk to the SSP, and recommend a mitigation strategy



# SEA: Issues

## Lead-free Electronics

- The European Union is banning the use of lead and lead solder in electronics
- Manufacturers are moving toward production of lead free electronics
- High reliability applications (NASA; DoD) require lead
- Risk is potential receipt of lead free components even when leaded parts are specified, and potential impacts/failures
- SEA has a lead free sub-team evaluating potential risks and developing suggestions for mitigation
- White paper available
- Mitigation strategies include:
  - Notification to parts manufacturers and suppliers
  - Identification of suppliers of critical hardware at greatest risk of supplying lead free parts
  - Receiving inspection
  - One time buy



## **SEA: Lessons Learned**

- SEA identified materials to avoid or address
  - HCFC 141b Blowing Agent
  - 1,1,1 Trichloroethane
  - Cadmium in Plating Applications
  - Hexavalent Chromium Replacement in Conversion Coatings/ Primers
  - Lead-Free Electronics
  - Perfluoroalkyl Sulfonates/Perfluorooctanic acid
  - Brominated Flame Retardant
- SEA Lessons Learned communication
  - Input to HQ Infrastructure risk list and supporting white papers
  - Data in historical uses of Ozone Depleting Substances to HQ
  - SEA briefed Constellation
  - Also briefings have been provided by the Principal Center for Clean Air Act Regulations and MSFC Engineering
  - Invited Constellation participation and appropriate information sharing at SEA meetings



## SEA: FUTURE

- SEA has been identified as a capability for Transitioning to new human space flight programs
- Some SEA issues overlap identified concerns for Constellation
- SEA will produce a Transition Plan
- Constellation participation increasing



## **Shuttle Transition Environmental Support Team**

- A separate effort managed by Propulsion Systems Engineering & Integration is the Transition and Retirement Environmental Support Team
- Team includes SSP transition managers as well as Center environmental representatives
- Environmental Transition Plan and Site Summaries finalized
- Team is working on National Environmental Policy Act requirement for a Shuttle Programmatic Environmental Assessment
- Team provides support to Shuttle Program elements in addressing environmental risks and issues associated with transition and retirement



## CONTACTS

- For SEA information, contact Steve Glover or Cathy Clayton
- For EST information, contact Steve Glover or Anne Meinhold

**Cathy Clayton [USA/MSFC] 256-544-0488**

**[Cathy.P.Clayton@nasa.gov](mailto:Cathy.P.Clayton@nasa.gov)**

**Steve Glover [NASA/MSFC] 256-544-5016**

**[Steve.E.Glover@nasa.gov](mailto:Steve.E.Glover@nasa.gov)**

**Anne Meinhold [ITB/MSFC] 256-544-6494**

**[Anne.F.Meinhold@nasa.gov](mailto:Anne.F.Meinhold@nasa.gov)**

**Matt Segars [USA/MSFC] 256-544-0535**

**[Matt.G.Segars@nasa.gov](mailto:Matt.G.Segars@nasa.gov)**