F-35 Pollution Prevention Activities

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Agenda

• What is F-35
• Pollution Prevention (P2) Background
• P2 Implemented System Solutions
• P2 Solutions in Work
• P2 Solutions Offering More Opportunities for Near Term F-35/ESTCP Partnerships
What is Joint Strike Fighter?

F-35A
Conventional Take Off Landing (USAF)

F-35B
Short Take Off Vertical Landing (USMC and UK)

F-35C
Carrier Variant (USN)

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F-35 ESH Requirements

- Contract Data Deliverable List CDRL-001
  Air System Lifecycle Plan
    - Hazardous Materials Reduction/Elimination Initiatives
      - Identified and Controlled in Detailed Plan 2YZA00049 Hazardous Materials Management Plan
    - Demilitarization/Disposal Plans
      - Demilitarization/Disposal Plan 2YZA00102
The Continuing Sustainability Challenge and Interaction with Design for Environment (DfE)

• LMAero Solved the Easy-To-Do Material/Process Substitutions on Previous Programs
  – Low Hanging Fruit
  – Typically Focused on Employee Exposure During Manufacturing
• Now the Challenge is to Find Material Substitutions That Reduce Life-Cycle Expense, i.e. Sustainability
  – Focus on Customer Maintainers Exposure During Operation, Maintenance, Depot Overhaul, Deactivation, Demilitarization, Disposal
  – Awareness of Hazmat Liability to Sub-tier Suppliers due to Current and Future Regulations
  – Reduce Life Cycle Cost Impact through Hazmat Minimization
  – This Results in the Design for Environment (DfE) Approach

Identify the Goal and Force the Solution
Hazardous Materials Control Approach – Controlled by HMMP and M&P

Support Equipment Design

- Airframe/Subcontractor Design
- NEPA/Conformity Planning
- Partner Country Regulation Research

Control Materials on Program

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System Changes and Improvements Implemented on F-35 With Demonstrable Pollution Prevention Benefits
Key DfE Technology – No Cadmium Fasteners

- Traditional Aircraft Use Thousands of Steel Fasteners with Cadmium Plating
  - Cadmium provides corrosion protection and lubricity
  - Exposes Maintenance Workers to Cadmium During Depainting Because They Grind the Old Coatings Off
  - Several Thousand Dollars per Year for PPE and Longer Grinding Time Due to Occupational Limits

- JSF Uses Titanium or Stainless Steel Fasteners
  - No Cadmium
    - Except for Three Locations with no Drop-in Replacement (QAD, SFD, Gun)
  - More Expensive Up-front But Less Life Cycle Cost

Reduces Up/Down Stream ESH Impact
• Traditional Military Aircraft Used Halon 1301 (ODC) to Provide Fire Protection to Fuel Tanks
  • Empty Fuel Tank Volume Must be Filled with Inert Gas to Prevent Fire/Explosion from Bullets/Shrapnel

• On-Board Inert Gas Generating System (OBIGGS) Replaced Halon 1301
  • Filters out Oxygen from Ambient Air to Create Nitrogen Enriched Air Suitable for Fuel Tanks
  • Military No Longer Required to Maintain Halon Stockpile for Wartime Fuel Tank Inerting

No More Halon Stockpiles
Key DfE Technology - OBOGS

• Traditional Aircraft Carried the Pilots Oxygen Supply in Liquid Oxygen Tanks
  • Liquid Oxygen will Trigger Rapid Combustion of Any Dirt or Contaminates in the Supply System
  • Supply System Must Be Perfectly Clean
  • Best Cleaning Solutions Freon CFC-113 and HCFC-141b

• On-Board Oxygen Generating System Replaced Liquid Oxygen
  • Produces Oxygen-Rich Breathing Gas From Engine Bleed Air Using Molecular Sieve Technology
  • No Exotic Cleaning Solutions
  • Military No Longer Required to Stockpile Freon for Oxygen System Cleaning

No More Freon Stockpiles
Key DfE Technology - IPP

• Traditional Military Aircraft Contain An Emergency Power Generation System to Restart Failed Engine at Altitude
  • Some Systems Like F-16s Used Hydrazine
  • Unstable, Toxic, Dangerous Fluid Produces Gas to Turn a Turbine and Generate Enough Power to Restart Engine

• Integrated Power Package (IPP) Replaces Hydrazine System
  • Small Turbine Engine Integrated with Other Vehicle Cooling/Heating Systems
  • Basically a Small Jet Engine
  • Easy to Start/Stop, No Hydrazine, No Leaks

No More Hydrazine Hazards
• Traditional Aircraft Landing Gear and Other High Wear Surfaces were Chrome Plated
  • Chrome Plating Bath Environmental Liability
  • High Life Cycle Cost:
    • Requires Stripping/Replating every 3-5 Years
    • Military Services Must Have Plating Facilities
    • Replating Takes 2-3 Months
    • Requires Large Quantities of Spares
• High Velocity Oxygenated Fuel (HVOF) Technology
  • High Velocity High Temperature Stream of Powder Shot Onto Part Surface Forming Hard Impervious Wear-Resistant Coating
  • Long Life – Minimal Maintenance
  • Ultra-Smooth Superfinish Extends Life From Seals That Rub Against HVOF Coating
  • Standard Coating for All JSF Actuators, Wear Surfaces, Landing Gear

No More Chrome Plating
Key DfE Technology – ODC Free Manufacturing

• Traditional Aircraft Fabrication Aids, Sealants, and Cleaning Solutions Often ODC-Based
  • Good Cleanliness and Efficient Product Delivery

• LM Replaced All ODC-Containing Products in 1995
• No Class I/II ODCs Allowed on F-35 to Date

No More Ozone Depletion
Key DfE Technology Non-Chrome Primer

- Approved Deft 44GN098 as F-35 Structural Primer
  - *BF-1 Effectivity (First STOVL)*
  - *Fully Implemented on Airframe by BF-4*
    - Implementation on System Suppliers Voluntary to Avoid Costs
- LM Aero and Northrop Grumman Performed Four Batch Verification
- Additional Compatibility with Exterior Finishes and Materials
- Qualified to LMA-MR003 Primer Specification
  - *Equivalent to Mil-PRF-85582*
- NAVAIR Completed Qualification to Mil-PRF-85582
Key DfE Technology - Copper-Beryllium Bushing Replacement

• Copper-Beryllium (Cu-Be) Bushings Added to LMAero Restricted Materials List February 2004
  – F-35 Technical Mgmt Concurred with Action Plan to Identify Locations and Develop Alternative Material Where Feasible
• Typically Used for Flight Control Actuators and Other High Load Environments
  – 350+ Specific Locations
  – Switched to Other Materials for Many Applications

Rapidly Qualify/Implement New Materials
Bushing Replacement Lab Testing

- **F-35 Evaluation of Alternative Materials**
  - *ToughMet, Nitronic 50/60, 304/HBN, SBIR Developed, etc.*
  - *Phase 1 Completed Tensile, Compression, Bearing, and Shear*
  - *Phase 2 Completed Wear and Galling*
  - *Phase 3 Completed Elevated Temp Tensile*
  - *Phase 4 Completed SCC and Salt Fog exposure*
  - *All F-35 Bushings <2.5”Ø Switched to Cold Worked Nitronic 60*
  - *Phase 5 test plan Evaluating Installation Issues*

- **ASC PP3010 FY05-06 Funding**
  - *Subscale Testing and Implementation*

- **Materials Affordability Initiative (MAI)**
  - *25/75 Contractor/Government Cost Share with LM/Boeing/BrushWellman*
  - *Phase III Advanced Screening and Toughmet “S” Basis Generation*
  - *Phase IV Toughmet “A/B” Basis Generation, Fatigue and Fracture, Installation*
  - *Phase V Implementation Studies*
Key DfE Technology - Material Disposal

- CDRL A001 Requires Disposal Plan
- No Available Methods for Composites/Low Observable Materials
- Need Recycling Alternative with Beneficial Reuse to Avoid RCRA HazWaste Designation for Disposal
- Phase II Air Force SBIR LO Coating Destruction
  - Phase I Fluidized Bed Reactor Concept Demonstrated Complete Breakdown of Materials and Conversion to Calcium Carbonate
- F-35 Participating in Phase II
  - Provide Materials, Lab Verification of Destruction
- ESTCP Scale Up Assistance?

Eliminate Composite Disposal Uncertainty

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Key DfE Technology - Corrosion Detection

- F-35 Needs Low Budget Device to Solve Several Issues
  - Corrosion Detection, Locate OML Panel Edges and Fasteners, Detect Fluid Leaks, Inspect Composite Material Beneath Several Coating Layers, Verify Coating Thickness
- Existing Phase II SBIR Developed Microwave Corrosion Detection Device
- F-35 JPO ESH Sponsored Phase II Extension and Phase III Commercialization
  - LMAero F-35 Generating Reqmts
- P2 Benefit – Reduce Scheduled (non-necessary strip/repaint cycles) Coating Maintenance, Minimize Coating Damage During Event Maintenance

Avoid ESH Impact of Needless Coating Rework
Future ESTCP Cooperation

How F-35 and ESTCP Can Continue to Work Together and Expand Work to Enhance Value
Key DfE Technology - Cadmium Plating

• Traditional Aircraft Steel Parts Protected From Corrosion by Cadmium Plating

• Alternative Technologies Under Development

• ESTCP Funded S-53 High Strength Stainless Steel Dem/Val Program on F-35 RGAs
  • Risk Reduction Phase Underway by Fabricating One RGA ‘Set’ and Fatigue Testing
  • LMAero/BAES Studying Corrosion Performance Enhancements
  • Full Demonstration Starts 2007
Key DfE Technology - Gap Fillers

- LO Aircraft Require Gap Fillers Between Exterior Panels
- Maintainer Exposure Issue During Panel R&R Due to Sanding/Grinding Filler
- F-35 Studying Alternative Materials
  - Northrop Grumman Awarded AFMC P2 R&D Program
    - Non-nickel Alternatives
      - Other Internal R&D Projects
- If Successful Alternative Found, Can ESTCP Assist with Cross-Program Qualification/Implementation?
  - Unique Program Qualification Requirements will Drive Cost

Improved Performance Less ESH Impact
Summary

• F-35 Largest DoD Weapon System Acquisition Program
• Replaces Several Legacy Aircraft Worldwide
• Operates Under Comprehensive ESH Management and Hazmat Control
• Conducts Aggressive Pollution Prevention and Material Substitution Activities Focusing On Life Cycle Cost Reductions
• Integrates Partner Country Requirements into Program