Air Force Research Laboratory
Support for Sustainment
A Briefing to the 2011 Corrosion Conference

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Integrity ★ Service ★ Excellence

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Outline

• AFRL & its Sustainment Activity Context
• Rapid Response System Support
• Current Fleet Support
• Evolving Corrosion S&T Strategy
• Summary
AFRL Sustainment Portfolio

Embedding robust reliability and predictable readiness into current and future fleets to assure maximum mission capability and maintainability while minimizing costs

- AFRL considers Sustainment an integral part of Life-Cycle Management
  - AFRL’s effort Covers the Entire Product Life Cycle
- AFRL investments aimed at meeting MAJCOM needs/strategies
- Goals of AFRL Sustainment Investments
  - Support Sustainment of Current AF Fleet
  - Improve Fleet Health Management
  - Enable Robust Design of New Systems

Technology to increase readiness and reduce life cycle costs of current and future systems
## Extending System Life

### USAF Fleet Timeline

<table>
<thead>
<tr>
<th>Decade</th>
<th>Aircraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>50’s</td>
<td>B-52, C-130, C-5, U-2, T-38</td>
</tr>
<tr>
<td>60’s</td>
<td>KC-135, F-15, F-16, A-10</td>
</tr>
<tr>
<td>70’s</td>
<td>F-15, B-1B, T-1A, F-117</td>
</tr>
<tr>
<td>80’s</td>
<td>B-1B, C-17, T-6, R/MQ-1</td>
</tr>
<tr>
<td>90’s</td>
<td>F-22, B-2, ABL CV-22</td>
</tr>
<tr>
<td>00’s</td>
<td>RQ-4, CV-22</td>
</tr>
<tr>
<td>10’s</td>
<td>F-35</td>
</tr>
</tbody>
</table>

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AFRL Sustainment Investment

- Develop Strategic Collaborations
- Leverage External Resources

Prioritization and Program Development

- Fleet Safety
- Fleet Availability
- Fleet Affordability

- AFRL Expertise
- AFRL Resources Available
- Tech Transition Probability & Partners

AFRL Sustainment Portfolio
Support Sustainment of Current AF Fleet
Improve Fleet Health Management
Enable Robust Design of New Systems
Rapid Response Systems Support
AFRL Sustainment

AFRL / RX SYSTEMS SUPPORT MISSION

Merge systems engineering application expertise with AFRL technology expertise to provide timely, effective solutions to user needs

VISION

Now/Near Term Focus
Event Driven Rapid Response
Customer Connected
Implementation Oriented

Keep AF Systems Safe, Available, and Affordable
Merge systems engineering application expertise with materials and processes (M&P) technology expertise to provide timely, effective solutions to user needs

- MATERIALS INTEGRITY BRANCH (RXSA)
- ACQUISITION SYSTEMS SUPPORT BRANCH (RXSC)
- LOGISTICS SYSTEMS SUPPORT BRANCH (RXSS)
  - Advanced Composites Office (Hill AFB)
  - Coatings Technology Integration Office (WPAFB)
  - Corrosion Prevention & Control Office (Robins AFB)
  - Metals Technology Office (Robins AFB)
  - Nondestructive Inspection Office (Tinker AFB)

Keep AF Systems Safe, Available, and Affordable

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## Field and O&M Support
### Current Fleet Sustainment Issues

<table>
<thead>
<tr>
<th>Mission</th>
<th>Impact/Benefit to the User</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide technical leadership in pervasive AF structural MX areas to ensure flight safety, reduce cost, improve availability, &amp; reliability</td>
<td>• Improves fleet availability by sharing MX best practices</td>
</tr>
<tr>
<td><strong>Technology/Solution</strong></td>
<td>• Optimized C-130 wash schedules to balance mission &amp; corrosion control</td>
</tr>
<tr>
<td>• 5 Offices Collocated at ALCs</td>
<td>• Command Corrosion &amp; NDI MX Surveys</td>
</tr>
<tr>
<td>• Engr &amp; Tech Assistance for MX &amp; Sustainment</td>
<td>• 1st AF plan to mitigate latrine corrosion on 11 MDS</td>
</tr>
<tr>
<td>• Maintenance of T.O.s &amp; Reference Mat’l</td>
<td>• Speeds technology transfer form R&amp;D to MX Ops</td>
</tr>
<tr>
<td>• Field Surveys/SAVs</td>
<td>• 90% reduction in paint-to-fly time for aircraft</td>
</tr>
<tr>
<td></td>
<td>• 75% reduction in install time on C-17 antennas</td>
</tr>
<tr>
<td></td>
<td>• Develops rapid technical solutions to Ops challenges</td>
</tr>
<tr>
<td></td>
<td>• Solved 3 C-130 SATCOM antenna problems</td>
</tr>
</tbody>
</table>

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AFRL Sustainment Offices

Mission Scope: Structural Maintenance Support for Fielded Aircraft Operations
“The Technical Home Office for 5 AF Maintenance Career Fields”

Advanced Composites Office (Hill AFB)
- Technical support / consultation
  - Evaluate, prototype, field test, & transition
- Repair process development
- Facilities and M&P evaluations
- Manage AF Composite Repair, CDDAR TOs
- Composite training support

Nondestructive Inspection Office (Tinker AFB)
- Technical support / consultation
  - Evaluate, prototype, field test, & transition
- Eng. Authority for centrally procured NDI equipment
- Conduct Worldwide NDI Lab Assessments
- Manage AF NDI TOs
- NDI training support

Corrosion Prevention & Control Office (Robins AFB)
- Technical support / consultation
  - Evaluate, prototype, field test, and transition
- Conduct Worldwide AF Corrosion Surveys
- Manage AF Corrosion TOs
- Support Weapon System CPABs

Coating Technology Integration Office (WPAFB)
- Technical support / consultation
  - Evaluate, prototype, field test, & transition
  - Repair process development
- Environmental aging test facility

Metals Technology Office (Robins AFB)
- Technical support/ consultation
- Standardize equipment, training, processes

Mission directed by AF/A4M; Programmed and funded by AFMC/A4M; Executed by AFRL/RXSS
USAF Aircraft Latrine Study
Conducted by the AF Corrosion Prevention & Control Office

- Directed by AFMC/CC
- Visited 11 heavies’ PDM facilities and SPO engineers

RECOMMENDED:
- Creation of Equipment Specialist position in each SPO responsible for lavatory
- Immediate action on issues facing C-5, KC-10 & B-52
  - Replace existing C-5 lav with COTS system
  - Perform engineering study on KC-10 system to fix or replace
  - Select & execute B-52 SPO’s pick for urinal replacement or install B-1 / B-2 improved toilet
- AFMC direct SPOs incorporate all AFCPCO suggestions
  - Most AFCPCO suggested material changes, coating stack-ups and use of damming agents are relatively inexpensive and can be implemented immediately
- Encourage SPOs to actively engage w/ field units & hold annual CPABs
  - CPABs are SPO’s best way to gain field insight/collectively solve action items
- Encourage MAJCOMs to support CPABs by funding MAJCOM Functional/SME TDYs
  - MAJCOM/Wing/SPO Corrosion Mgr involvement paramount for prgm success
- Ensure lavatory refurbishment is mandated in all PDM work packages
- SPOs working implementation plans and reporting status to AFMC/CC/A4
AFRL System Support Process

Customer Needs
Operational
• Mat’ls Failure

Maintenance
• Repair Issues

Acquisition
• Mat’ls Selection
• Component Design

Tech Development
• Transition Issues
• Improve Sustainability

System Support
• Adhesives / Comp / Elast
• Failure Analysis
• Testing/Evaluation
• Non-Destructive Insp.
• Collocates
• RX R&D Exp.
• RB and RZ R&D Exp.
• AF Structural MX O&M
• Other AFRL TDs

Products
Solutions
• Root Cause
• Repair Technology

Information
• Adv Mat’ls Req’ts
• Unbiased Data

Lessons Learned
• Failure Avoidance
• Adv Tech Transition

Prototype Systems
• Field/Depot Processes

Wide Range of Customers
Broad Expertise Base
Credible, Capable – Trusted 3rd Party
Full Spectrum of Products

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• Rain/Particle Erosion
• Nondestructive Inspection
• Electronic & Structural Failure Analysis
• Electrostatic Discharge Control
• Composite Supportability
• Adhesive Bonding
• Aircraft Wiring
• Elastomers & Seals
• Materials, Structures & Engine Test & Evaluation capabilities
• Coatings (integration/transition/support)
• Manufacturing Processes
• Air vehicle/Engine Integration and Design
Systems Support Time Line
Customer Focused S&T Solutions

Deliver Rapid Response Engineering

Provide Mishap & Tech Consultation
1-30 Days

F-16 Throttle Cable

Technology Solutions
- Fleet Management Options
- NDI Tools & Procedures
- Production Modifications
- Materials Selection/Sub
- Repair Procedures
- New S&T- Processes/Mfg
- Commercial Tech Insertion
- Training and Field TOs

Develop & Apply Tech Solutions

F-15 Arc Fault CB

Days

F-16 341 Bulkhead Bonded Repair

Months

Partner for Long term S&T Solutions

F-16 341 Bulkhead Bonded Repair

Cracked B-2 Aft Deck

Weld Repair Program

ARAMIS Strain Survey

Tech Transition

System Modifications

systems Support Time Line
Customer Focused S&T Solutions

Deliver Rapid Response Engineering

Provide Mishap & Tech Consultation
1-30 Days

F-16 Throttle Cable

Technology Solutions
- Fleet Management Options
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Develop & Apply Tech Solutions

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F-16 341 Bulkhead Bonded Repair

Cracked B-2 Aft Deck

Weld Repair Program

ARAMIS Strain Survey

Tech Transition

System Modifications

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AFRL Customers and Collaborators

Over 170 Projects
More than 70 Customers
2009 Data

AFMC
AMC
ACC
AETC
AFSPC
WR-ALC
OC-ALC
OO-ALC
AF Safety Center
ASC
46th TW
NASIC
AFRL
OSI
MAJCOMs
ALCs

ASC/EN
USAFA (CASstLE)
WR-ALC
ALCs
OC-ALC
OO-ALC
AFIA

AFRL Customers and Collaborators

Time Critical AF Mission Support for Acquisition, Operational, and Sustainment Needs

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Current Fleet Support
PROBLEM:
• Fuel leaks a significant maintenance driver

FINDINGS:
• Determining which bladder is leaking is difficult on multi-bladder platforms
• Leak check methods for bladders are primitive, time consuming and inaccurate
• AFRL and ALC team proposed solutions
  • Implement advanced detection techniques
  • Structurally isolate the bladder cavities
  • Develop sensors and tapes to aid in leak path analysis
  • Develop self-healing bladders

STATUS:
• Solutions identified
• Funding being sought for TCTOs and development programs
APPROACH: Collaboration with AFMC/A7 Environmental Program to demonstrate improved processes using high temperature plastics, such as Ultem® and PEEK, or composites, such as epoxy graphite, develop a durable non-metal blade that retains a sharp cutting edge. Combine these blades with heat and power tools for easy removal of materials.

DELIVERABLE:
- Performance data for SPOs to demonstrate worker-friendly handle and durable blade systems and processes for removal of materials on- and off-aircraft.
- Modify power assisted tools that can be adapted to the blades.
- Develop a heated removal process that softens materials prior to removal.

PAYOFF: Rapid removal of materials for corrosion inspection without worker injury resulting in lower maintenance costs and aircraft downtime.

PROBLEM: Environmentally friendly coating and sealant removal for corrosion inspection difficult with current low cost plastic scrapers.

Technology Availability: FY12
POC: AFRL/RXSA DSN 986-9214
PROBLEM:
- Fuel probes for the C-130 are degrading and giving inaccurate fuel level indications in the tanks
- AFRL/RX found corrosion products from fuel residue/build-up on electrical connections are the cause of premature probe failures

DELIVERABLE:
- RX evaluating new probe design with accelerated test methods to validate extended life for probes.
- Test results on redesigned components will provide SPO design data for inserting new probes as preferred spares

IMPACT/PAYOFF:
- Significantly reduced field/depot maintenance costs (increased Mean Time Between Failure - MTBF).
- Increased Aircraft Availability by reducing number of repair actions
- Next generation materials can be transitioned to other platforms/systems.

Technology Availability: FY13
POC: AFRL/RXSA  DSN 986-9214
**PROBLEM:**
- Silver plated copper wiring susceptible to corrosion (Red Plague)
- Fluoropolymer wire insulations can off gas corrosive material and damage wiring, connectors and fiber optic systems

**OBJECTIVES:**
- Characterize corrosion mechanisms
- Develop novel test methods that quantify wire corrosion susceptibility
- Develop improved silver plating systems to mitigate corrosion
- Develop new Fluoropolymer insulation systems that don’t off gas corrosive materials

**DELIVERABLES:**
- Improved corrosion resistant wiring
- New wiring plating/insulation
- Insulation specification and industry sources

**IMPACT/PAYOFF:**
- Impacts systems such as the JSF, F-22 and many USAF missiles and satellites
- Significantly reduces field/depot maintenance costs (increased Mean Time Between Failure – MTBF)

**Technology Availability:** FY15

POC AFRL/RXSA DSN 986-9214
Improving Maintainability
Surgical NDI/E Methods Development

**DELIVERABLE:**
- Portable, field level multi-axis segmented sensor placement tool to effectively inspect critical areas inside aircraft structure without disassembly

**IMPACT/PAYOFF:**
- Increase inspection reliability by minimizing awkward inspector access to constrained areas
- Minimize costly and time consuming disassembly of aircraft for inspection
- Enable pre-induction inspections for realizing HVM objectives

**PROBLEM:**
- Critical NDI inspections are required in limited access locations
- Disassembly is costly and time-consuming
- Disassembly introduces potential for additional damage

**Technology Availability:** FY14/15

**POC:** AFRL/RXLP DSN 785-9803
## Objective
Reduce or eliminate chromium, cadmium, nickel, hazardous air pollutants (HAPS), and volatile organic compounds (VOCs) from coatings and related processes.

## RX Technology Areas
<table>
<thead>
<tr>
<th>Organic &amp; Inorganic Coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Treatment</td>
</tr>
<tr>
<td>NDI</td>
</tr>
<tr>
<td>Coating Removal</td>
</tr>
</tbody>
</table>

## Benefits
- Increased operations capability
- Less hazardous waste
- Less toxic exposure
- Less hazardous air emissions
- Reduced cost
- Improved performance

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**Hazardous Cr and Cd Replacements**

**UV Cured Paint**

**Laser Paint Stripping**

Drivers: EO 13423; CAA, CWA, RCRA, OSHA; Cr6+ minimization/elimination in acquisition policy memorandum from DUSD J.J. Young, Jr; OSD Emerging Contaminants Watch List; foreign environmental regulations.

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Air Force UV-Curable Program Approach

Funded by AFMC/A7-Pollution Prevention

Step-wise approach utilized to validate and advance UV-curable coatings

- Eliminates all hazardous materials
- Improves maintainability/reduces process flow time

Phase I
Stencils/markings and repairs
In-Process

Phase II
Off-aircraft small components
In-Process

Phase III
Large area off-aircraft UV-curable coating cure
In-Process

Phase IV
Full Aircraft Painting

Optimization and test phase
 Planned systems delivery – FY 14

In-Flight tests
F-16/C-130
2007-2011

POC: AFRL/RXSC DSN 986-5709

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AFRL and HQ AFMC identified laser technology as a viable alternative and initiated the AF Laser Program

**Program Goal:** Establish and expand the use of laser technology as a viable alternative technology for depot maintenance operations

**Phase I**
- Handheld laser coatings removal applications
  - COMPLETED

**Phase II**
- Large area, off-aircraft laser coatings removal applications
  - COMPLETED

**Phase III**
- Automated full aircraft laser coating removal applications
  - IN-PROCESS

**System Delivered**
- Tinker – 2007
- Hill - 2009

**Scheduled Delivery**
- Hill - 2012

POC: AFRL/RXSC
- DSN 986-5709

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S&T Corrosion Study
AFRL Corrosion Activities

AF S&T Strategy, Technology Horizons

Product and Logistic Center Needs

AF and MAJCOM Needs

Rapid Reaction Urgent Warfighter Needs

Science & Knowledge ~20%

Technologies ~50%

Capability Concepts ~20%

Service Core Function Capabilities

Transitions to - Laboratories
- Industry
- Ideas

Transitions to - Product Ctrs
- Logistic Ctrs
- Industry
- Experiments

Transitions to - Product Ctrs
- Logistic Ctrs
- MAJCOMs
- Demos
- Prototypes

Transitions to - Warfighter
- Fielded System

Provides Subject Matter Experts

AFI 20-114

Operations and Mx Structural Sustainment Mission

AFCPCO Office Career Field Support & Technology Implementation

Current Program Funding Sources

RDT&E (S&T) 3600

O&M 3400

Customer Funding

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Corrosion S&T Study Strategy

- A targeted study on the potential of S&T to meaningfully impact corrosion problems facing the AF
- Assess existing and required corrosion expertise to impact AF enterprise
- Identify major cost / mission availability drivers
- Identify AFMC priorities with special attention to AF Fleet Viability Board systems projections
- Set S&T investment options to deliver immediate/sustained technology to AF corrosion enterprise
  - Establish options for rapid response technology demonstration and transition of projects to impact AF fleet
  - The corrosion plan strategy also focuses on longer term investments creating science & technologies to enable future capabilities
AFRL is delivering S&T Expertise & Solutions to the Current AF Fleet

Keeping AF Systems Safe, Available, and Affordable
  • Now/Near Term Focus
  • Event Driven Rapid Response
  • Customer Connected
  • Implementation Oriented

Identifying Opportunities for Longer Term S&T Investment
  » Improve Fleet Health Management
  » Enable Robust Design of New Systems
    • Accelerate insertion of new materials in legacy
Back up slides
AFRL is delivering S&T Expertise & Solutions to the Current AF Fleet

Keeping AF Systems Safe, Available, and Affordable
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Identifying Opportunities for Longer Term S&T Investment
- Improve Fleet Health Management
  - Fleet management tools for safety and Life extension
- Enable Robust Design of New Systems
  - Accelerate insertion of modern materials in legacy AC
Desired AF Corrosion Enterprise Characteristics

- **Head Quarters AF & CCPE** - AF Corrosion governance process stability & leadership visibility
  - Policies refined, AF Corrosion Prevention Advisory Board (CPAB) active and staffed
  - Mechanism in place for Integrated Life Cycle Management (ILCM) reporting of Gaps—expertise and resources
  - AF corporate decision/resources allocated to improve AF corrosion enterprise
  - Active/binding processes for functional Acq program AF SME input/lessons learned
  - Development, implementation, sustainment of strategic plan for corrosion

- **AFMC - Operations & Maintenance** – AFI 20-114
  - AFRL Corrosion Prevention & Control Office resourced to match mission requirements
  - Sufficient Staffing/Resources for SMEs presence in Field, Depot and Acquisition Pgms
  - SME Support and governance/standards for weapon systems (CPABs, TOs and Surveys)

- **AFRL - S&T AFRL Programs** (delivering solutions while rebuilding competencies)
  - Funding Initial S&T targeted to high TRL projects - rapid technology impact
  - Labs available for development of AF corrosion expertise and AF SMEs
  - AF Commitment to align long term S&T resources with AF strategic plan objectives
  - Continue to Leverage DoD & other Services S&T investments

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Material and Design Compliance
Environmental Compliance

- Reduction of Hazardous Substance (RoHS) and Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) requiring change in traditional materials where aging and performance characteristics are largely unknown
- Impact spans production, manufacturing, quality control, design, test, and maintenance processes

<table>
<thead>
<tr>
<th>Substance</th>
<th>Use (non-inclusive)</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead (Pb)</td>
<td>Aircraft electronics</td>
<td>Significant</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>Circuit breakers, relays, connectors, wire</td>
<td>Significant</td>
</tr>
<tr>
<td>Hexavalent Chrome</td>
<td>Anti-corrosion primer on airframe structures</td>
<td>Significant</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>Stainless and magnetic metal alloys</td>
<td>Significant</td>
</tr>
<tr>
<td>Beryllium (Be)</td>
<td>Airframe structures, aircraft wiring, nuclear applications</td>
<td>Significant</td>
</tr>
</tbody>
</table>

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• Some primers have been implemented on some aircraft
  – Majority of aircraft are still using chromated primers
  – Various primers have been field tested but have not been approved
  – Approval must come from the authorizing engineer for individual weapon systems for implementation to occur
• Performance of the primer can depend heavily on pretreatment/conversion coating selection
  – Focus is shifting to the qualification of complete Cr-free systems, rather than qualifying each component individually
• Additional field testing and qualification required to continue Cr-free primer implementation efforts
  – Magnesium-based primer has shown great promise in initial testing