USAF Corrosion Prevention and Control Enterprise – Sustainability Links

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BLUF

- **Introduction to the DoD and AF Corrosion Prevention and Control (CPC) enterprise**
  - **Corrosion is a significant sustainment issue: $6.0B – 24.9% of total maintenance costs**
  - **Congressional topic of interest – legislation, reports, inspections, and plus-ups**
- **Continued collaboration and crossfeed essential between CPC program and DoD sustainability efforts**
  - **Overlapping surface engineering efforts**
    - **Potential for smart resource allocation and synergy**
    - **Can't afford improvements in one aspect (e.g. sustainability) that result in unacceptable trade-offs in another (e.g. corrosion)**
  - **Lessons learned – e.g. approaches beyond "material substitution"**

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Topics

- CPC Background
- OSD-funded CPC research & technology
- Impact of Corrosion on Operations & Sustainment
- Perspectives on "Sustainability"
- Summary

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Background - Congressional Interest

- Corrosion-related Congressional direction to DoD almost every year since the FY2003 NDAA
- Subsequent public laws specified Congressional reporting and additional lines of authority (codified in 10 USC Sec 2228)
  - Annual budget report to Congress
  - Required a DoD Director, Corrosion Policy and Oversight
- Substantial funding increases to the OSD corrosion line above the President’s budget
- FY2009 NDAA required the Military Departments to each have a Corrosion Control and Prevention Executive with an annual reporting requirement (10 USC Sec 2228)

AF CPC Breadth of Activities

- Implementation of improved materials and processes
  - Assessment and assistance for field implementation of new materials (AFCPC Office, AFRL)
  - Military standard for CPC of aerospace systems (AFRL, other MilDeps, AQR, OSD, AFLCMC)
  - Electronics CPC standard with SAE (OSD, other MilDeps, AFRL, AQR)
  - Integration of corrosion with the Aircraft Structural Integrity Program (AFLCMC, AQR)
  - MAJCOM corrosion surveys (AFCPC Office, MAJCOMs)
- Communication and collaboration
  - AF CPC Working Group telecons (HAF, MAJCOMs, AFMC Centers)
  - DoD CPC IPT and supporting WIPTs (OSD, other MilDeps, AQR, AFRL, AFCPC Office)
  - Technical Corrosion Collaboration program (OSD, other MilDeps, AFRL, AQR, various universities, USAFA, USMA, USNA, NPS, AFIT)
- Information and training
  - Technical Order updates for improved materials and processes (AFCPC Office)
  - Information clearinghouse for maintainers and engineers (AFCPC Office)
  - Training development and implementation (AFCPC Office)
- Research
  - Technologies that track aircraft exposure, enabling CBM and improved depot workload planning (AFRL, AFLCMC)
  - Coatings development, testing, and integration (AFLCMC, AFRL, AFCPC Office)
  - Corrosion-conscious engineering design tools (AFRL)
  - Structural integrity effects of corrosion (AFRL, USAFA, AFIT)
  - Realistic accelerated corrosion testing (AFRL)

Improvement Across the AF CPC Enterprise

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Enterprise changes

- CPC Strat Plan: awareness, goals and metrics
- Annual report: each organization provides input

MAJCOM/Weapon system emphasis

- CPC Plans: 60% of major acft pgms updated within last 2 yr
- CPABs

Process Improvements; examples:

- Aircraft washing
- Antenna gasket
- Improved coatings
- Controlled humidification

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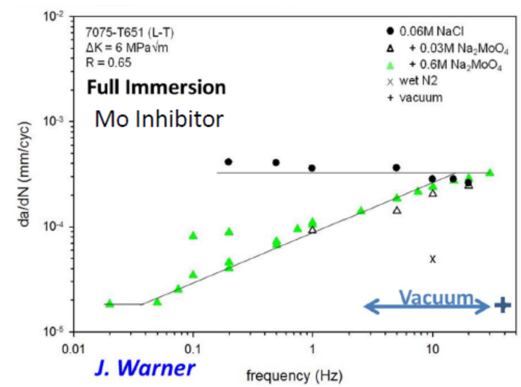
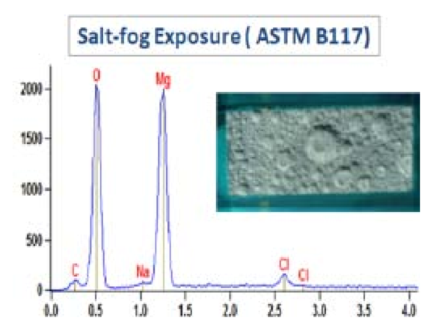
OSD Corrosion Program Technology Projects

- OSD has been the primary source of funding over the past 9 years to transition technology to address corrosion
  - 250 projects and $84M
  - <u>Example of potential synergy</u>: From FY05-14, the DoD Corrosion Program funded 21 projects on hexavalent chromium reduction
- OSD also funds a research and education program with multiple universities - Technical Corrosion Collaboration
  - Research covers corrosion mechanisms, coatings, effects on structural integrity, environmental effects, etc
  - Some topics of interest
    - Inhibitor mechanisms for mg-rich primer (non-chrome)
    - Corrosion and inhibitor effect on crack-growth





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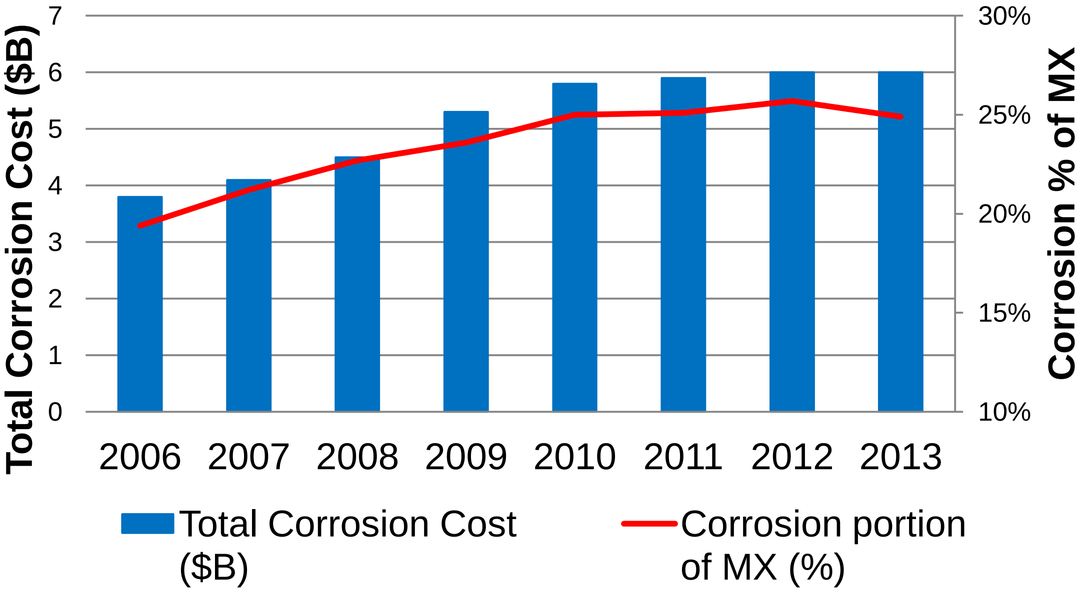
Corrosion Cost Trends

- OSD-sponsored study: ***The Estimated Effect of Corrosion on the Cost and Availability of Air Force Aircraft And Missiles***
- **Detailed, platform-specific maintenance data**
- **Scopes the magnitude of the CPC challenge**
- **Can be used to help identify targets of opportunity**
- **Data indicate the corrosion cost curve may be "bending"**
- **Corrosion portion of maintenance is decreasing**



Note: the 10-30% scale on the "Corrosion % of MX" axis was chosen because it is likely that the corrosion fraction of maintenance will remain in this range.

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Perspectives on Sustainability

- **The AF CPC enterprise recognizes that coating – decoating activities are among the biggest drivers of ESOH risk and cost**
  - **Increases corrosion costs, increases time-in-maintenance, decreases availability and flexibility**
  - **Sustainability, therefore, a consideration in CPC initiatives**
- **CPC enterprise utilizes a balanced, risk-based approach**
  - **Financial and engineering resources are limited**
  - **Potential costs of corrosion are significant**
- **Supporting replacements for hexavalent chromium (CrVI) and cadmium with biggest sustainability impacts and low corrosion risk**
- **Equally important: improvements beyond material substitution that**
  - **Decrease time-in-maintenance**
  - **Reduce infrastructure, material, water, labor, energy usage**
  - **Reduce waste**

Example of AF CPC Risk-Based Prioritization Framework

(Hexavalent Chromium Replacement)

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		Corrosion and Mishap Risk Posed by this Application Area *(Green indicates application area will tolerate less capable alternatives)*		Risk Assessment of the Use of CrVI in this Application Area *(Green indicates application poses lower ESOH risks to AF personnel and installation environment)*		Risk Assessment of the Use of Alternatives in this Application Area *(Green indicates adoption of alternatives would not increase risk in these areas)*		
	CrVI Applications	**Life Cycle Corrosion**	**Life Cycle Mishap**	**DoD Worker Exposure Risk if CrVI Used**	**ESOH Life Cycle Cost**	**Corrosion Prevention Performance**	**Technical Maturity Risk**	**Life Cycle Cost**
Near-term Focus Areas for Implementation	Primer on support equipment and infrastructure	Visible and repairable		Larger source of worker CrVI exposure	Larger source of installation ESOH costs			
	Aircraft Outer Mold Line (OML) Primer	Sometimes						Some alternatives require more frequent inspection and application;
	Bare metal surface treatments/Conversion Coatings/"Sealers"	necessary to <u>improve performance of outer mold line replacement</u>						alternatives still require exposure controls
	Sealants							
Longer-term Focus Areas	Adhesive bonding primers							
	Internal Structural primer	Hidden, difficult to inspect or access Frequent corrosion;	Known life cycle structural integrity risk	Limited or no expected worker exposure	Limited or no installation ESOH costs			Higher life cycle probability of loss of aircraft or of availability
	Fuel tank primers, coatings, and sealants		Known life cycle mishap risk					

CrVI Replacement

- Examples of OSD-funded AF CPC projects
  - C-130 Non-Chrome Field Test
  - Universal Primer on Ground Support Equipment
  - F-16 Reduced Chrome Study
  - Evaluation of Non-Chrome Paint Systems in Field Environments
- AF CPC enterprise partnering with lab, ESOH, product support, life cycle management communities to target elimination of CrVI in AF aircraft outer mold line (OML) coating systems (conversion coating, primer, top coat)
  - MIL-PRF-32239A, *Coating System, Advanced Performance, for Aerospace Applications* (1 Oct 2014)
  - Supported by data from outdoor exposure testing

Process Improvements

- Replacing hazardous constituents, like CrVI, not the only approach
- Example: Non-HAZMAT topcoat improvements
  - Improved AF topcoat, implemented in 2005, driving a 20% drop in average annual per-aircraft touchup costs
    - Reduces occupational exposure risk, emissions, waste
  - Need further improvements, e.g. the appearance durability of coatings to reduce field-level scuff-sand & overcoat operations
  - Long-term objective: reduce number of field-level whole-aircraft corrosion control facilities (currently more than 100)
    - Limit whole-aircraft painting to depots and regional facilities
    - Reduce exposure risk, emissions, waste, infrastructure

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Process Improvements

- **Coating/De-coating automation – AF Sustainment Center initiative**
  - **Robotic laser depaint, automated plating lines, etc**
  - **Can virtually eliminate exposure risk; reduce emissions & waste**
  - **Decrease time-in-maintenance**
  - **Can allow the "sustainable" use of hazardous coatings in those applications with highest corrosion risk/cost**

Summary

- **Continue collaboration and crossfeed between CPC program and DoD sustainability efforts**
  - **Expand communication, information and training – *i.e. spread successful approaches***
  - **Support smart resource allocation and synergy**
  - **Avoid unacceptable trade-offs and unexpected adverse impacts**
- **Develop and implement improved processes: Looking at solution sets beyond material substitution**
- **Utilize measurements and analyses of corrosion effects and the results of CPC enterprise actions**