Naval Aviation Enterprise
Corrosion Prevention Team

Army Corrosion Summit

3-5 February 2009
Report Documentation Page

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18
## Reduce the Cost of Corrosion: Today and Tomorrow

### Phase 1  
**New Aircraft**
- Establish Corrosion Contract Language and Define Corrosion Performance Criteria
- Develop Standard Verification and Validation Criteria for Environmental Performance
- Promulgate Corrosion Prevention and Control Guidance and Policy
- Establish and Support Corrosion Prevention Action Teams
- Revitalize Corrosion S&T
- Incorporate Lessons Learned

### Phase 2  
**Early Mature Stage**
- Optimize Corrosion Prevention and Control Strategies to Minimize Fleet Maintenance Actions
- Demonstrate, Validate and Implement New Technologies
- Conduct Validation and Verification Inspections for Unproved Materials
- Establish Improved Data Collection Methods
- Standardize Data Assessment Methods
- Feed Lessons Back to New Aircraft

### Phase 3  
**Late Mature Stage**
- Service Life Assessment and Service Life Extension
- Optimize Corrosion Prevention and Control Strategies to Minimize Fleet Maintenance Actions
- Implement New Repair Technologies
- Feed Lessons Back to Early Mature and New Aircraft

### Phase 4  
**Final Life Stage**
- Apply Advanced Inspection Techniques to Minimize Airframe and Component Disassembly
- Reduce Component Scrap Rate Through Emergent Remanufacturing Technologies
- Capture Lessons Learned and Fleet Data and Feed Back to Other Stages of Life

---

### Corrosion Stages of Life

**Lust**

- Optimize Corrosion Prevention and Control Strategies to Minimize Fleet Maintenance Actions
- Demonstrate, Validate and Implement New Technologies
- Conduct Validation and Verification Inspections for Unproved Materials
- Establish Improved Data Collection Methods
- Standardize Data Assessment Methods
- Feed Lessons Back to New Aircraft

**Dust**

- Service Life Assessment and Service Life Extension
- Optimize Corrosion Prevention and Control Strategies to Minimize Fleet Maintenance Actions
- Implement New Repair Technologies
- Feed Lessons Back to Early Mature and New Aircraft
## Cost of Corrosion Schedule and Cost Estimates
(from LMI Cost of Corrosion Report MEC70T3, May 2008)

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<th>Year</th>
<th>Study area</th>
<th>Costs</th>
<th>Cum.</th>
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<td>2005/06</td>
<td>Navy ships (FY2004 data)</td>
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<td>Air Force aviation and repeat Navy ships and Army ground vehicles</td>
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<tr>
<td>2009/10</td>
<td>Repeat FY2006/FY2007</td>
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**Total Navy Annual Cost of Corrosion:** ~$6.1B  
**~46% of DoD/CG Total**
Impact of Corrosion on Navy/NAE

Total Navy Cost

Corrosion Maintenance Costs, $B

- Aircraft: $2.44
- Ships: $0.70
- Ground Vehicles: $0.70
- Total: $3.00

NAE Cost

$3B Corrosion Maintenance Cost

- Airframe: 86%
- Ships: 14%
- Other: 0%

“death by a thousand cuts”
# Maintenance and Corrosion Costs

**NAE**

(from LMI Cost of Corrosion Report MEC70T3, May 2008)

## Estimated annual depot costs

<table>
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<tr>
<th>Node or sub-node</th>
<th>Description of corrosion cost node</th>
<th>Total aviation and engine maintenance cost (in millions)</th>
<th>Corrosion cost (in millions)</th>
<th>Corrosion cost as a percentage of total aviation and engine maintenance cost</th>
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## Estimated annual field costs

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<th>Corrosion cost (in millions)</th>
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<td><strong>Field-level total</strong></td>
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## TMS Cost Rank/Combined

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Nov 2005 to Feb 2007 – AIR 4.3.4 (Materials Engineering Division) advocated for improved coordination, planning, and execution of corrosion efforts across the NAE

Feb 2007 – AIR 4.0 stakeholder meeting regarding assessment corrosion is costing Navy $1B/1M MMHRS annually

- source: Air 4.2 Dr Stoll and Air 6.0 Conroy cost assessments
- the “should” cost has never been assessed and is a key topic for the new Corrosion Cost Working Group

Jun 2007 NAE BOD briefed corrosion significantly impacting RFT gap across multiple T/M/S

- source: CAPT Trainer, OPNAV N42

Jul 2007 NAE BOD sponsors Corrosion Prevention Team (CPT)

- Corrosion lead- RDML Mike Hardee (AIR-6.0)
- NAE CPT is a multi-competency, multi-disciplinary team (CNAF, CNATT, Air 1.0/4.0/6.0, COMFRC, etc.)

Sept 2007 NAE CPT Aligned Within M&SCM Goal 1, RFT Gap Closure

- first formal link to BOD
## Governance

### Board of Directors (BOD)

| *Commander, Naval Air Forces (CNAF), CEO | US Marine Corps Aviation (USMC AVN) |
| *Commander, Naval Air Systems Cmd. (NAVAIR), COO | Naval Strike Air Warfare Center (NSAWC) |
| *Commander, Naval Air Forces Atlantic (CNAL) | Naval Supply Systems Command (NAVSUP) |
| *TFR Officer (AIR 1.0, NAVAIR) | Operational Test & Evaluation Force (OPTEVFOR) |
| *Chief Financial Officer (AIR 6.8, NAVAIR) | Commander, US Fleet Forces Command (CFFC, N4/7) |
| N43, N82, *N88 | Chief of Naval Air Training (CNATRA) |

**Deputy Assistant Secretary of the Navy, Air***

**Deputy Assistant Secretary of the Navy, Logistics***

### Governance

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<td>Air Launched Weapons</td>
<td>Total Force Shaping</td>
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**NAVRIIP Cross-Functional Team (CFT)**

**Total Force Readiness CFT**

**Cost Management CFT**

**Corrosion Prevention Team Link to BOD**
Alignment under M&SCM Goal 1:

- Achieve Optimal Aircraft Readiness
- Reduce RFT Gap to less than 5%
- Reduce RFT Gap of each TMS by 20.0%

Goal 1: Cost-wise Aircraft RFT Entitlement

- Goal Team 1A: CWRIIP
- Goal Team 1B: Component Reliability
- Goal Team 1C: Corrosion Control

M&SCM Goal 1C – Corrosion Control

"Improve Airframe Material Condition Through Systematic Corrosion Abatement Strategies As Assessed At Scheduled Corrosion Inspections Throughout The Maintenance System.”
M&SCM Goal 1C Corrosion

FY09 Goals/Deliverables

- Develop & Apply Corrosion Focus Area List for:
  - E-2/C-2
  - H-60
  - H-53
- Complete H-60 RCA Study; ID & Implement Improvement Opportunities
- Complete Training Gap Analysis
- Draft Air Vehicle Circular (AVC)
- Establish Cost of Corrosion Baseline for F/A-18

Progress

- TMS Deployment Plan Implementation Underway
- E-2/C-2 FAL delivered & applied on MCI Events
- H-60 RCM/FAL - Working with FST/PMA to develop completion strategy
- H-53 FAL Developed, RFU at pilot start
- H-60 RCA study site visits complete. Results analysis underway
- Training GAP Analysis in-work ECD Jul
- AVC in-work, completed draft ECD Jan
- Working w/RESET to Calculate CoC Baseline ECD TBD

Barriers (B) and Mitigation (M)

- (B) Inconsistent Data & Analysis across TMS
- (M) FRC Southwest modifying ADCS to improve data capture accuracy. Deploy to FRC East & Southeast.
- (M) AIR-4.0 RCM Lead will Standardize Data & Analysis processes across all TMS FST’s
- (M) Working to rollout ADCS to Type Wings
- (B) H-60 RCM Analysis unfunded
- (M) Fund RCM Analysis

Future Plans/Timelines

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<td>15</td>
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<td>F/A-18 Pilot Program</td>
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<td>16</td>
<td>2:1:1</td>
<td>ID Corrosion Areas &amp; Produce FAL</td>
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<td>21</td>
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<td>TMS MCI Instruction Incorporating FAL</td>
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<td>27</td>
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<td>Monitor FAL Grading Results</td>
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<td>E-2 Pilot Program</td>
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<td>92</td>
<td>2:3</td>
<td>H-53 Implementation</td>
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<td>H-48 Implementation</td>
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<td>156</td>
<td>3:1</td>
<td>FRC Aircraft Completion Delivery Letter Coordination</td>
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<td>162</td>
<td>4:1</td>
<td>Value Stream Corrosion Prevention/General Life Cycle Process Mapping</td>
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<td>169</td>
<td>5:1</td>
<td>Perform F/A-18 HPC Study</td>
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<td>178</td>
<td>6:1</td>
<td>Perform H-48 RCA Study</td>
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<td>183</td>
<td>7:1</td>
<td>Perform Training GAP Study</td>
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<td>169</td>
<td>8:1</td>
<td>Deploy MCI ADCS</td>
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What Is Needed

- **Establish Expectations**
  - Baseline Airframe Material Condition
  - Reduce Maintenance System Variation
  - Determine Should Be and Actual Costs
  - Reduce Corrosion Impact By Improving Corrosion Resistance in Design

- **Establish Communication And Feedback**
  - FRC E&E, FST, Wing MCI, Squadron, AIR-1.0/4.0/6.0, CNAF

- **Integrate With/Be Supportive Of Existing Related Processes**
  - USMC Reset, AIR 4.0 Future Readiness, IMC/RCM, WLS Process, Distance Support, Enterprise Airspeed

- **Rectify Fragmented Activity – Design Holistic System Approach For Standardization Of Corrosion Prevention/ Treatment**
  - Understanding Of System Interactions, Ownership
  - Common Assessment/ Reporting Process/ Metrics
  - All Stakeholders Part Of Solution – Integrated Team With Regular Mtgs, Joint Products And Coordinated Objectives
  - Affect Entire Life Cycle

Basis For Components Of Strategy
• Expectation Management
• Communication, Integration, Standardization
• Feedback To Future Readiness
• Link To Cost
• System Design Map
• Establish Metrics, Requirements, Funding
## Tactical Components of Strategy

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>ACTIVITY</th>
<th>EXPECTED OUTCOME</th>
</tr>
</thead>
</table>
| **Baseline Material Condition Expectation Process**  
(Team I.D.’d and Launched) | • Develop foundational standardized process guidance for BMCE development by FSTs  
• FSTs develop TMS specific BMCE | • Set expectations for mat’l condition  
• Quantify effectiveness of maint system  
• Establish “norms” and triggers  
• Provide corr data that will enable stakeholders to make informed decisions |
| **Implement Mat’tl Condition Assessment @ FRCs/Wings**  
(Team I.D.’d and Launched) | • Utilize ‘depot’ E&E artisans to inject FST developed mat’tl condition expectations during planned Type Wing MCI inspections | • Early injection of knowledge to Fleet  
• Immediate identification and prevention/mitigation of corr  
• Minimize variation  
• Communication/feedback regarding maint system effectiveness |
| **Value Stream Map Corrosion Prevention/Control Life Cycle Process**  
(Team I.D.’d and Launched) | • Capture and convert data to CPI activity and mitigation strategies  
• Corrosion response, assessment and mitigation HICVS | • Identify, link and align all on-going activity  
• Targeted efforts  
• Data source tracking  
• Identification of policy owners |
| **Future Readiness**  
(Team I.D.’d and Launched) | • Identify design opportunities/shortfalls and create feedback loop to Future Readiness Team  
• Develop improved corr contract language | • More reliable future weapons systems  
• Increased acquisition awareness of areas req’ing design chgs/improvements/mods  
• Improved SOWs |
| **Cost Development**  
(Team I.D.’d and Launched) | • Link corr effects on a/c to expended costs (LMI Study???)  
• Identify “should costs”  
• Work to mitigate delta | • Targeted efforts  
• Biggest “bang for the buck”  
• Increased awareness for focused decision making |
NAE Corrosion Root Cause Assessment

**Genesis:** effort derived from a root cause analysis for wiring failures at fleet level

**Status:** multi-year plan to assess root cause factors for corrosion issues with Navy and Marine Corps aircraft

**Support:** CNAF and NPRE funding

**Impact:** F/A-18s and H-60s make up 38% of NAE aircraft in FY09

<table>
<thead>
<tr>
<th>Year</th>
<th>Key Points</th>
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<tbody>
<tr>
<td>2007</td>
<td>CNATT/HPC Human Performance Assessment on EA-6Bs and F/A-18’s (Completed)</td>
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<td>Solutions include changes to Policy, Training, Technologies and processes and practices.</td>
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<tr>
<td>2008</td>
<td>Impact of corrosion on the NAE Assessed (Current Readiness <em>(minimal)</em>, Future Readiness <em>(major)</em>, Safety <em>(minor)</em>, Cost <em>(major)</em>)</td>
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<tr>
<td>2009</td>
<td>Goal to Link efforts across platforms and from legacy to new</td>
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<tr>
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<td>Provides fleet driven needs back to logistics and engineering</td>
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</table>

**Highlights**

**Key Outcome:** Balanced approach to reduce impact of corrosion on NAE
Future Readiness Team is Focused on Solutions in Acquisition so that Current Problems are Minimized 20 Years from Now

New to fleet: EA-18G, V-22, H-60R/S, UH-1Y/AH-1Z
2 Decades: FA-XX, EP-X
Future Readiness Thrusts

- **Corrosion Resistant Design**
  - Influence requirements documentation to include corrosion prevention guidance
  - Influence future contract language to include corrosion prevention activities
  - Influence technical guidance documentation (SETR / Risk Management)
  - Require life-cycle corrosion cost documentation at design review
  - Maximize effectiveness and implementation of corrosion prevention and control plans and corrosion action teams

- **Standardized Technical Criteria & Data**
  - Establish standard corrosion validation & verification criteria for NAE
    - Airframe, Avionics, Components (Engineering Circular//4.1.9/4.5/4.3)
    - Improve prototyping, make better use of test squadron a/c, rotary wing COE
  - Use established or develop new feedback loops for in-service corrosion information
  - Support RDT&E
    - Guide FSTs/programs in common corrosion issues and solutions for new design and upgrades
    - Assess actual corrosion performance compared to design expectations (supports BCAs)

- **RDT&E**
  - Develop multi-year RDT&E plan for NAE corrosion prevention
  - Re-establish aircraft-related S&T corrosion support at ONR and other sponsors
  - Build coalition in NAE to support RDT&E needs in corrosion- CTO

- **Funding**
  - CorrCIP/POM10
FY08 Future Readiness Progress

- Established Corrosion CIP funding for FY10
  - Program element and FY10 funding in budget ($309K)
  - Execution process drafted

- Completed S&T Corrosion point paper advocating re-establishment of corrosion S&T funding

- Outlined Corrosion Engineering Circular

- Identified FA-XX & EP-X as target platforms for improved contract language

- Completed revision of MIL-STD-7179A “DoD Standard Practice for Finishes, Coatings and Sealants”
  - Used as acquisition corrosion documentation to defines the primary corrosion prevention and control materials used on the system
FY09 Future Readiness Plans

- Complete Corrosion Engineering Circular
- Submit Proposals for Corrosion S&T Funding
- Execute CorCIP Project Selection Process for FY10 starts
- Enhance/stand up Corrosion Action Teams
  - F/A-18 A-D/E/F/G
  - H-60 B/F/R/S
- Execute pilot efforts with FA-XX & EP-X including improved corrosion contact language, trade studies, technology R&D
- Revise and Upgrade Specs:
  - Revise MIL-S-5002: Surface Treatment and Inorganic Coatings
  - Upgrade MIL-HDBK-1250 to STD: Corrosion Prevention and Control for Electronics and Assemblies
Corrosion Engineering Circular

• Content
  – Acquisition
    • Program CPC Guidance
    • System Design CPC Contract Language
    • CPC Trade Study Information
    • Corrosion Verification and Validation Criteria
    • CPC Program Assessment
  – Sustainment
    • CPC Lessons Learned
    • Impact of Corrosion on NAE
  – Appendix
    • Corrosion Airworthiness Requirements
Corrosion S&T

• Re-vitalizing working relationship with NRL
  - Work together on key S&T areas
    • Galvanic modeling, verification and validation testing
    • Low temperature carburization
    • Alloy development

• Growing links with universities
  - Projects
  - People

• Working to Establish ONR Corrosion S&T Funding
  - Corrosion Innovative Naval Prototype Proposal for “Durable Aircraft”
  - Cold spray
Innovative Technologies for a Maintenance Free Aircraft

November 2008

VISION: Develop galvanic management technologies and engineered systems that eliminate fleet maintenance and reduce life-cycle corrosion cost of aircraft

Major Focus Areas

• Surface Potential Modeling and Simulation
• Tests for Prototyping Corrosion
• Engineered Interfaces

Navy Science & Technology Guidance

• Seapower 21
• Naval Aviation Enterprise S&T Strategy
• 2009 NAVAL S&T Plan ONR
Surface Potential Modeling and Simulation

Technology solutions will focus on F/A-18, H-60, E-2, and H-53 a/c and future platforms, N-UCAS, F/A-XX.
- highest cost drivers by platform and need
- build upon initial work done by NRL for ships

Description: Innovative technologies that enable the modeling, simulation and validation of galvanic stress

Proposed Investment: $20M for 5 yrs
Investment Technologies (TRL 2):
- computer model of galvanic stress
- validation process for model
- simulator for new design

Tests for Prototyping Corrosion

Technology solutions will focus on F/A-18, H-60, E-2, and H-53 a/c and future platforms, N-UCAS, F/A-XX.
- highest cost drivers by platform and need
- build upon work underway funded by SERDP

Description: Innovative test technologies that enable prototyping and risk reduction for airframe corrosion performance at sea

Proposed Investment: $15M for 5 yrs
Investment Technologies (TRL 2):
- test and validation process
- prototyping standard
- advanced trade study method

Engineered Interfaces

Technology solutions will focus on F/A-18, H-60, E-2, and H-53 and future platforms, N-UCAS, F/A-XX
- highest cost drivers by platform and need
- multiple possible solutions

Description: Develop new technologies that reduce galvanic potential between materials used on airframe

Proposed Investment: $15M for 5 yrs
Investment Technologies (TRL 2):
- Carbon fiber composites with reduced cathode area and less noble open circuit potential
- Multi-compatible fasteners and conductive coatings/sealants
- Galvanically tuned protective coatings

Vision of Galvanic Modeling Tool:
Mapping Galvanic Stress Areas

\[ \Delta V = \Delta V^0 - \frac{RT}{nF} \ln \left( \frac{[M_i^+]}{[M_j^+]} \right) \]
NAVY Corrosion Prevention & Control (CPC)

OSD CPC Office

ASN RDA DepCHSENG

CFT Lead

“designate…the corrosion control and prevention executive within 90 days.”

NAVY Corrosion Prevention & Control Executive

Membership

Cross Functional Team (CFT)

NAVAIR  NAVSEA  MARCOR  ONR

NAVFAC  SPAWAR*  NAVSUP*

* currently not participating in DOD CPC Forums

Sec. 903, signed 14 Oct 2008, & 10 USC 2228
Summary

• Corrosion is a significant cost to the Navy
  – NAVAIR’s total annual budget is ~$40B; annual corrosion cost is estimated at $3.0B

• The Naval Aviation Enterprise Corrosion Prevention Team is attacking corrosion problem in all phases of aircraft life cycle

• Solutions lie in the areas of leadership, training, policy, basing, materials, design, and documentation