Field-level Assessment of Mg-rich Primer

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Presentation Overview

- Project Team
- Objective and Purpose
- Technical Approach
- Results of Laboratory Testing
- Results of Field Testing
- Conclusions
- Planned Future Activities
- Questions

Project Team

- COTR – Thomas J. Lorman, 77AESW (ASC/ENVV)
- Primary Project Stakeholders
  - Mike Spicer, AFRL/CTIO
  - Joel Johnson, AFRL
  - MSgt. Mike Ramsey, Florida Air National Guard
- Additional Stakeholders
  - AFRL/CTIO, F-22 SPO, F-35 SPO, FANG, Boeing, Akzo-Nobel Aerospace Coatings (ANAC), NAVAIR Pax River, Hill AFB, NASA - Kennedy Space Center
  - Battelle's Florida Materials Research Facility

Objective and Purpose

Objective

- Validate an environmentally friendly coating system through laboratory coupon tests and outdoor exposure tests on select non-chromate coating system stack-ups for use on legacy, as well as the F-22 and F-35 aircraft

Purpose

- Testing will serve to validate the chemical and physical performance requirements specified in T.O. 1-1-8 and other applicable T.Os referenced for approved Air Force coating systems
- Data gathered from this project will be provided to F-22 and F-35 SPO for possible application of the non-chromate stack-up to metallic and composite structures

Technical Approach

- Scope
  - Conduct controlled “round-robin” laboratory tests to assess performance of Prekote pretreatment, Mg-rich primer, and Aerodur 5000
- Deliverables

  Demonstration Test Plan
  - Integrate testing and analysis protocols with Boeing-Long Beach, AFRL/CTIO, Akzo-Nobel Aerospace Coatings, NAVAIR Pax River, Hill AFB, NASA Kennedy Space Center
  - Test Plan included testing protocols, articles, substrate matrices, surface treatments, primers, and topcoats
  - Test Plan complements Round Robin Test Plan drafted by UDRI and provided to Battelle May 2008

  Technical Data Package
  - Literature survey, technical review and reporting on components contained in non-chromate coating systems being investigated for project

Mg-rich Coating Formulations

- Prototype university formulation (2004)
  - Utilized 100+ mm Mg particles and five component resin system
  - Performance in B-117 and cyclic salt spray very good
- Akzo-Nobel Aerospace Coatings (ANAC) licenses technology (2004)
  - Worked to resolve surface roughness, compliance, and “usability” issues
- PD374-165 (2005)
  - First formulation with viable smaller Mg particle; utilization of a two component resin system
  - Performance in B-117 marginally good
- PD406-35 (2005)
  - Modification of resin system; VOC compliant using exempt solvents; performance in B-117 good
- XP405-110 (2006)
  - Optimized Mg pigment volume concentration (PVC)
  - Performance excellent over bare and PreKote panels, some adhesion loss over fresh Alodine 1200
  - Some samples prepared with an “active” lot of Mg powder; excess of fines created blistering
- XP417-183 (2007)
  - Resin system modified to improve flexibility and performance over Alodine 1200
  - Improved overall performance as reported by ANAC
- XP455-30 aka “Aerodur 2100” (2007-2008)
  - Inclusion of green pigment for contrast ratio; reported to have no adverse effect on performance

XP417-183
Most Reported Results Good

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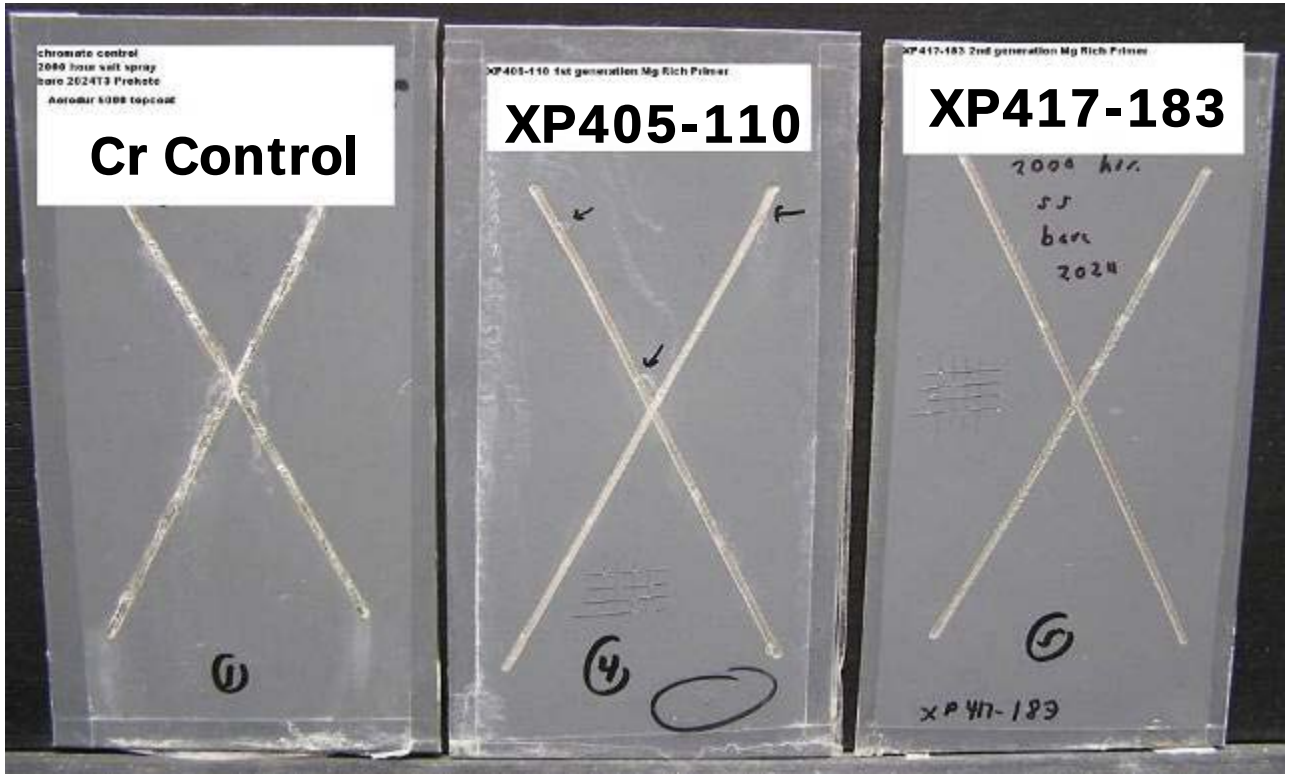
ANAC (2,000 hrs. B117)



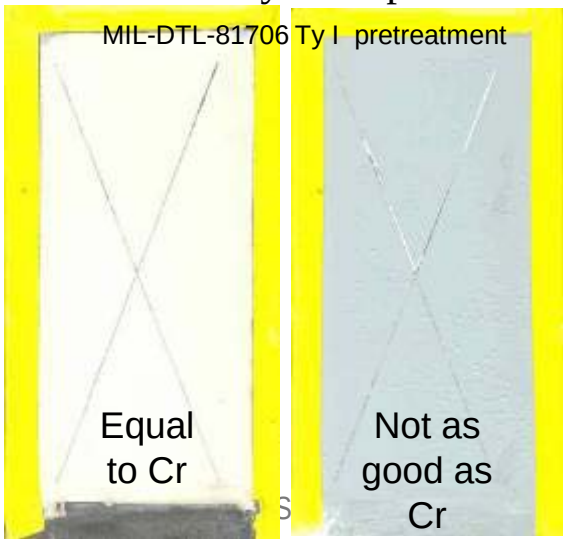
AFRL (HH-60)

NAVAIR

5,000 hrs B117 AA2024-T3

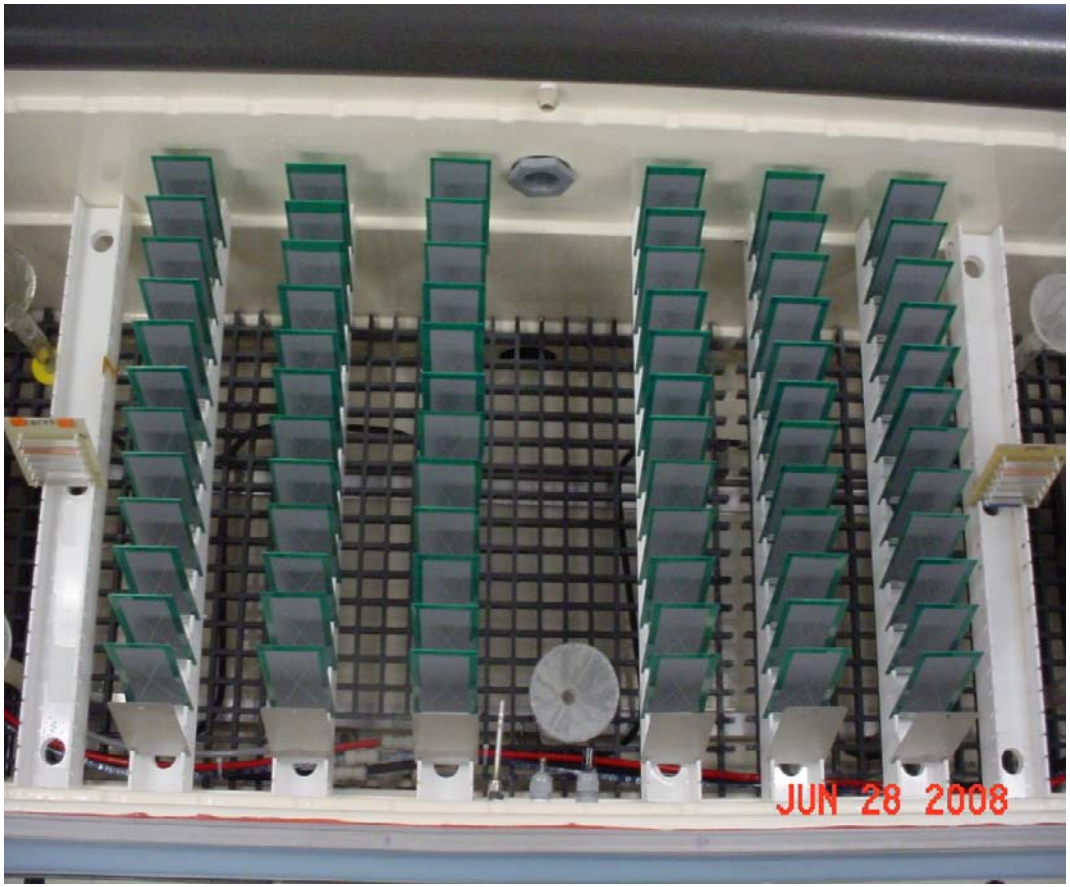
Primer Only Topcoated

MIL-DTL-81706 Ty I pretreatment



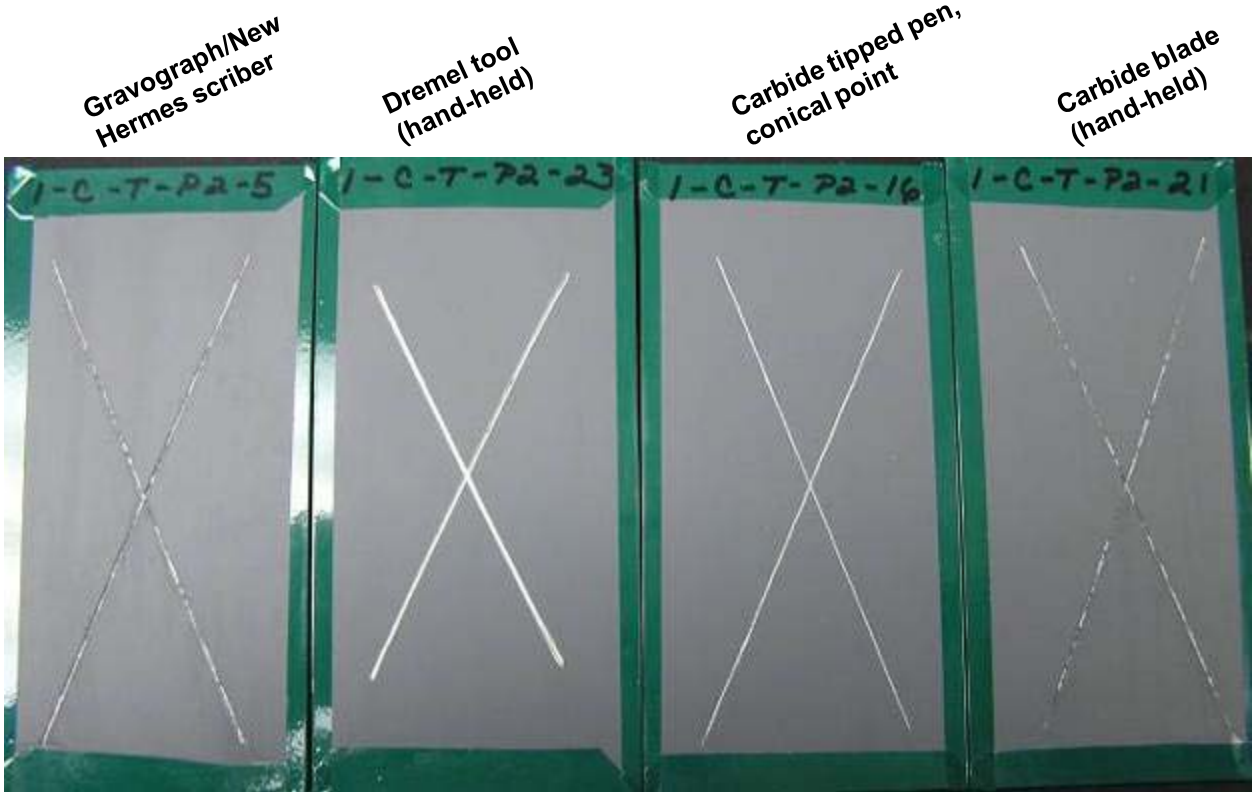
Technical Approach Phase I – Laboratory Assessment - Status

- ASTM B-117 Exposure Testing of Coated Test Panels
  - Required 3,000 hour or 125 day exposure period with visual assessments every 504 hours
  - ANAC and AFRL coated panels (Aerodur 2100)
  - First exposure test terminated after ~650 hours by AFRL/CTIO because of test protocol issues (i.e., X-scribe morphology and test environment)



Technical Approach Phase I – Laboratory Assessment - Status

- Must seriously address the issue of scribe morphology on potential performance in B-117 test environment
  - Growing body of evidence showing that “rough” scribes can have a serious impact on performance, even for Cr controls



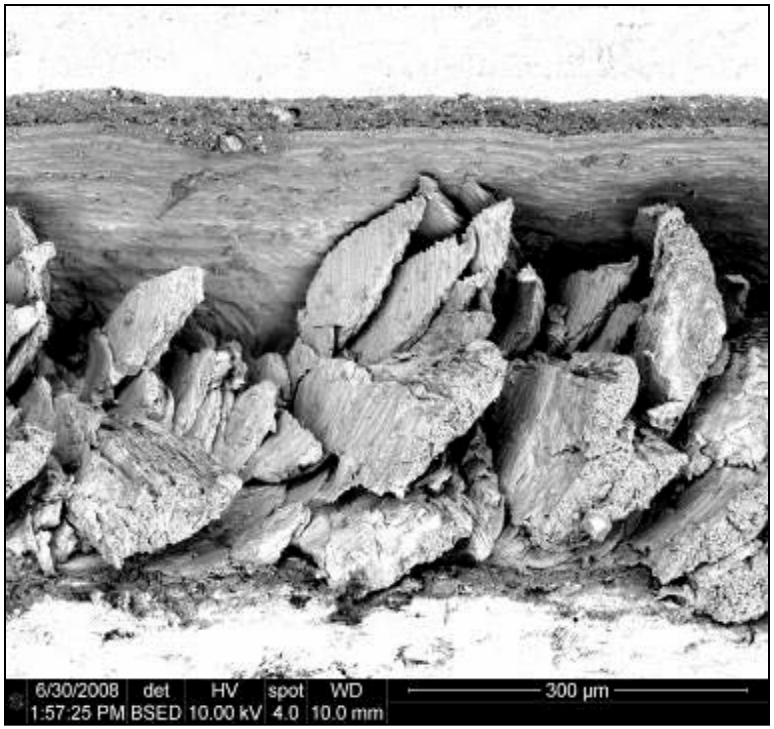
ANAC generated scribe variability on Cr controls; same topcoated, Cr-primer system, four different scribe methods after 650 hours of B-117

Scribe Morphology (cont.)

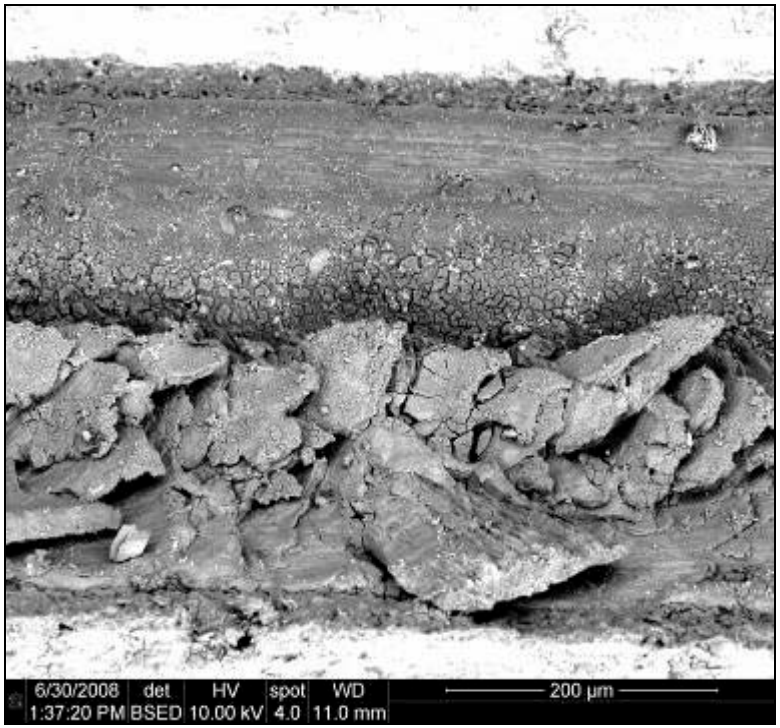
- In nearly all cases, significant amounts of corrosion product is seen on the rough "conventional cut" side of the scribe and very little on the smooth "climb cut" side
- Reduced Chromate Control
  - PreKote / Deft 02-Y-40 / Deft 99-GY-001 (color 36173)

"Climb Cut" Side

"Conventional Cut" Side



Sample 799-A1D-016
2024-T3 Bare



Sample 799-D1D-016
7075-T6 Bare

Round Robin Results – 650 hours Chromated Controls

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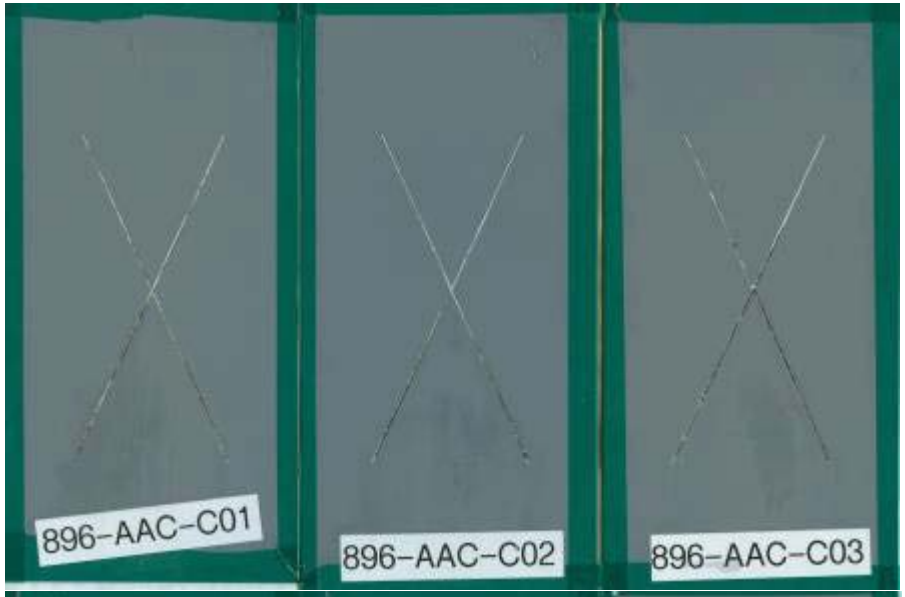
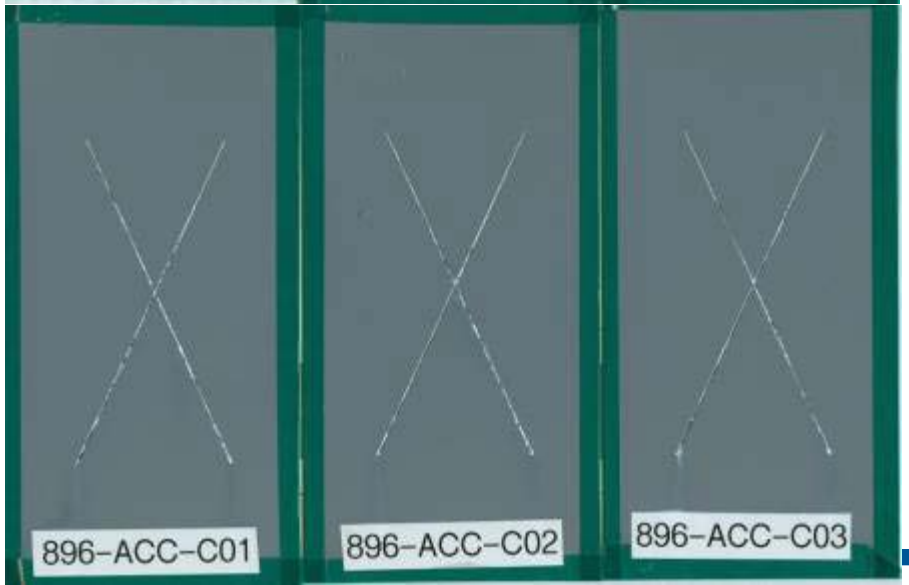
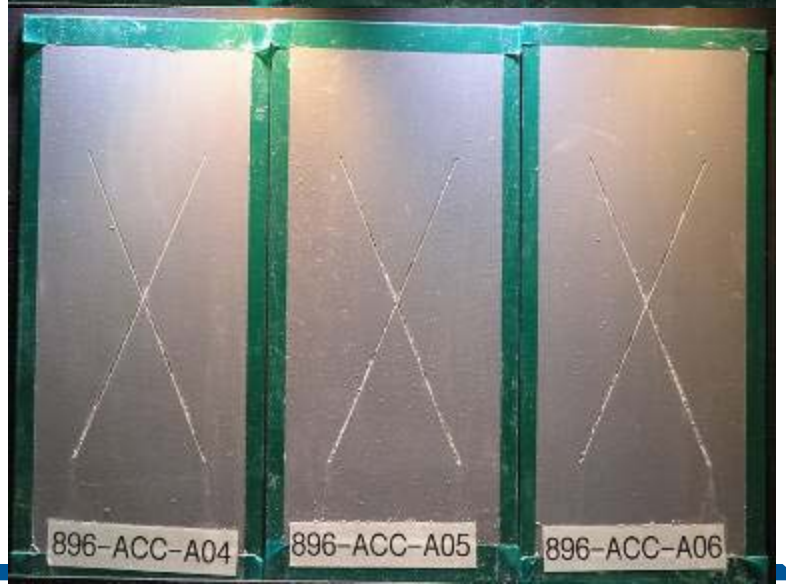
AFRL





ANAC



Round Robin Results – 650 hours Mg-rich Primer (Aerodur 2100)

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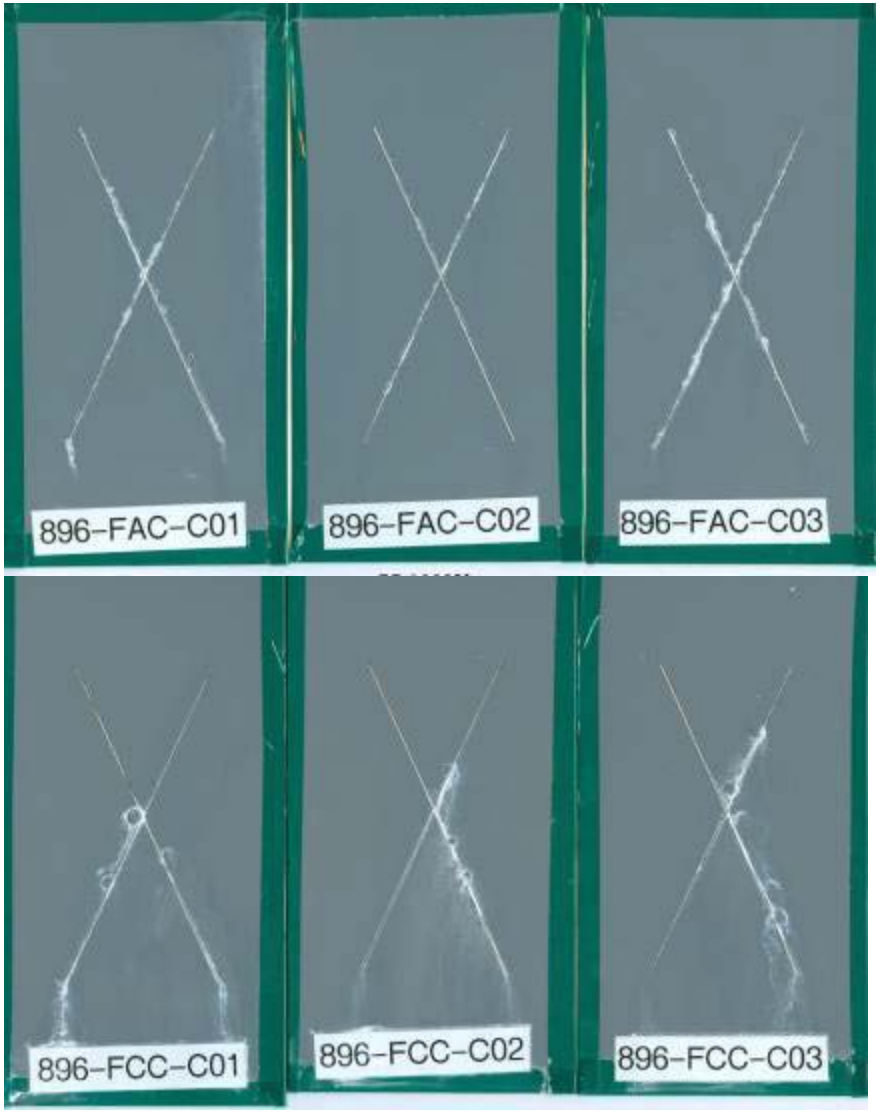
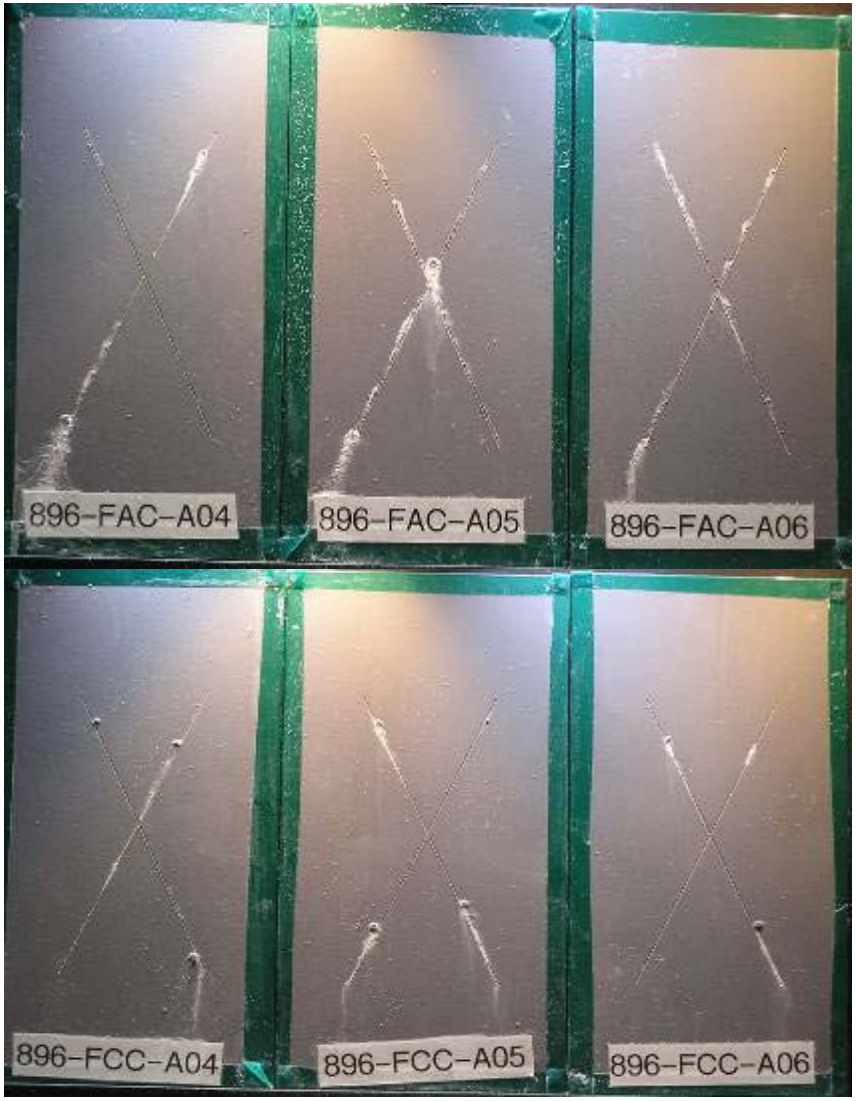
AFRL

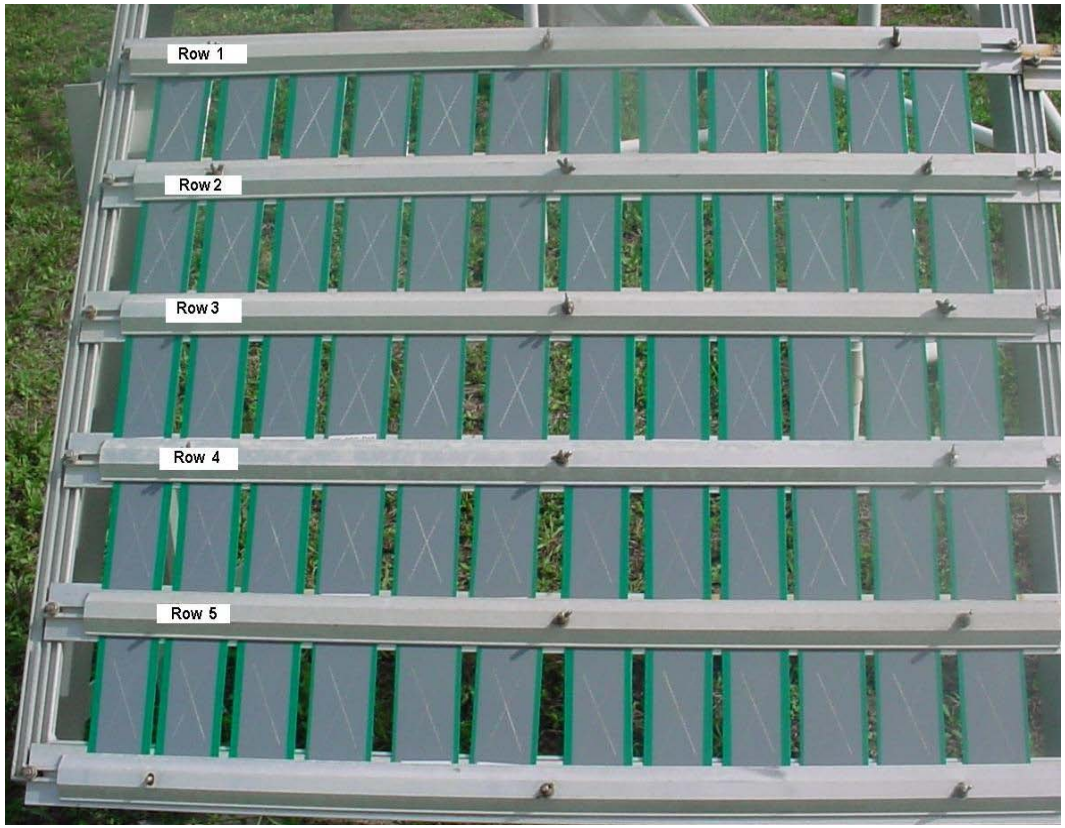


ANAC



Technical Approach Phase I – Field Assessment - Status

- Exposure Testing of Coated Test Panels
  - 12-month Exposure Tests
    - Commenced June 25, 2008 at FMRF
    - Commenced October 9, 2008 at FANG
  - Nine month FMRF exposure conducted on March 18, 2009
    - No significant change in scribe rating
    - Undercutting detected on select panel sets
    - Blistering on “blank” test panels (no primer)
    - No major chalking, gloss or color changes (ΔE<1)



Technical Approach Phase I – Field Assessment - Status

9-month Exposure Results
- no visual changes noted
(typical)

Technical Approach Phase I – Field Assessment (9-months)

Set ID	Panel ID	Surface Treatment	Primer	Topcoat	Scribe Corrosion	Undercutting	Blistering
A	ACU/ACC	MEK/Brulin GD815/Phos. Acid/1200 S	Deft 02-Y-04	Aerodur 5000	1/1	0/0	0/0
A	AAU/AAC	ANAC Std/1200 S	Deft 02-Y04	Aerodur 5000	1/1	1/1	0/0
B	BCU/BCC	Prekote	PRC 7233	PRC 9311	0/0	0/0	0/0
B	BAU/BAC	Prekote	PRC 7233	PRC 9311	0/0	0/0	0/0
C	CCU/CCC	Prekote	Blank	Aerodur 5000	2/2	4/4	1/0
C	CAU/CAC	Prekote	Blank	Aerodur 5000	2/2	4/4	0/1
D	DCU/DCC	Prekote	ANAC Mg 1	Aerodur 5000	2/1	1/0	1/0
D	DAU/DAC	Prekote	ANAC Mg 1	Aerodur 5000	2/2	2/3	1/0
E	ECU/ECC	Prekote	ANAC Mg 2	Aerodur 5000	2/2	3/2	0/0
E	EAU/EAC	Prekote	ANAC Mg 2	Aerodur 5000	2/2	1/0	0/0
F	FCU/FCC	Prekote	ANAC 2100	Aerodur 5000	2/2	0/1	0/0
F	FAU/FAC	Prekote	ANAC 2100	Aerodur 5000	2/1	1/0	0/0

Technical Approach
Phase II – Field Assessment

- Test two non-chromate stack-ups on static A/C at Florida ANG (125th Fighter Wing), Jacksonville, FL

F-102

F-106

T-33

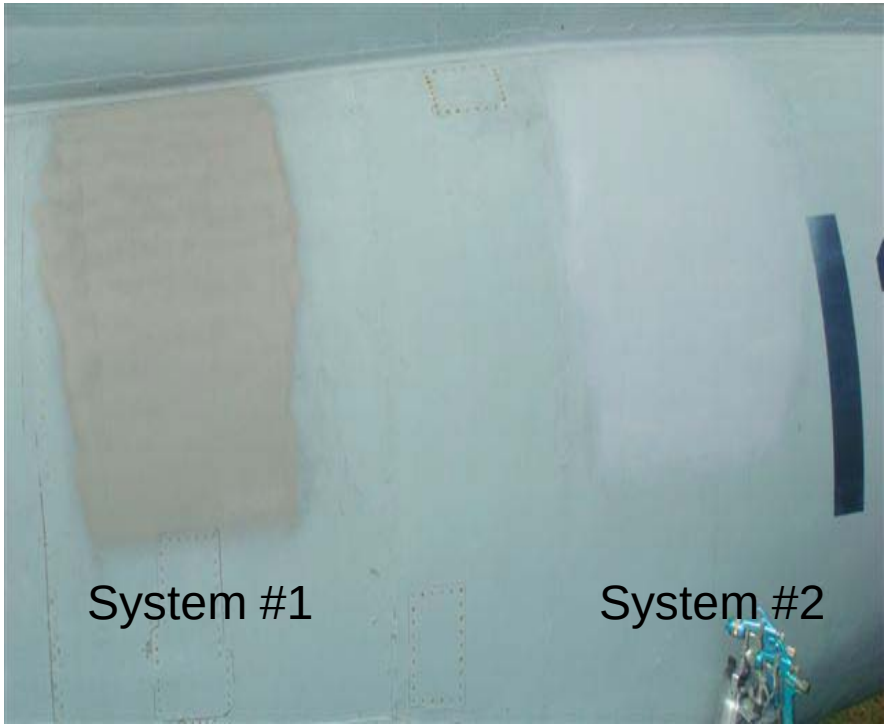

F-15

- Additional exposure testing of coated panels and sensors at FANG and FMRF for data correlation purposes
- Sections of a/c painted include: upper/lower wing, lower fuselage
- Coordination between ANG and AFRL/CTIO

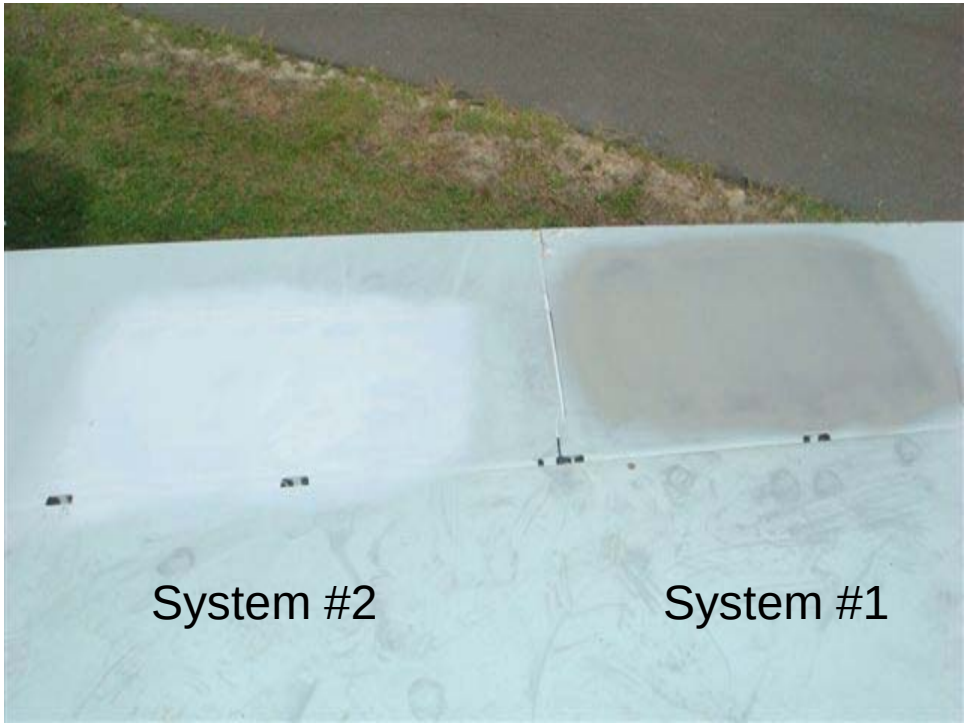
Technical Approach
Phase II – Field Assessment

- Stack-ups included:
  - PreKote/Aerodur 2100 primer/Aerodur 5000 topcoat
  - Alodine 5200/ANAC 577-630 primer/Aerodur 5000 topcoat
- Initial scuff-sand operations conducted during July 2008
- Weather-related delays (i.e., temperatures and rainfall) in completing application of primer and topcoat materials to test sections of all aircraft
- Decision was made by Battelle and FANG to postpone painting of aircraft until fall
- Final strip & painting of test sections and all surfaces of static aircraft completed October 10, 2008

F-102 Test Sections (2 of 4)

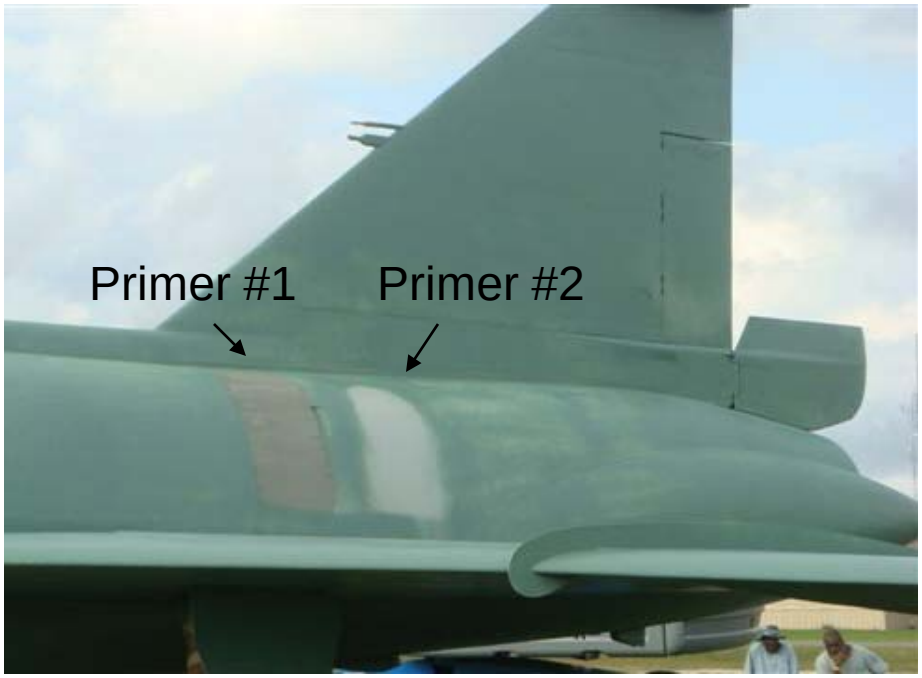


RH-side Fuselage

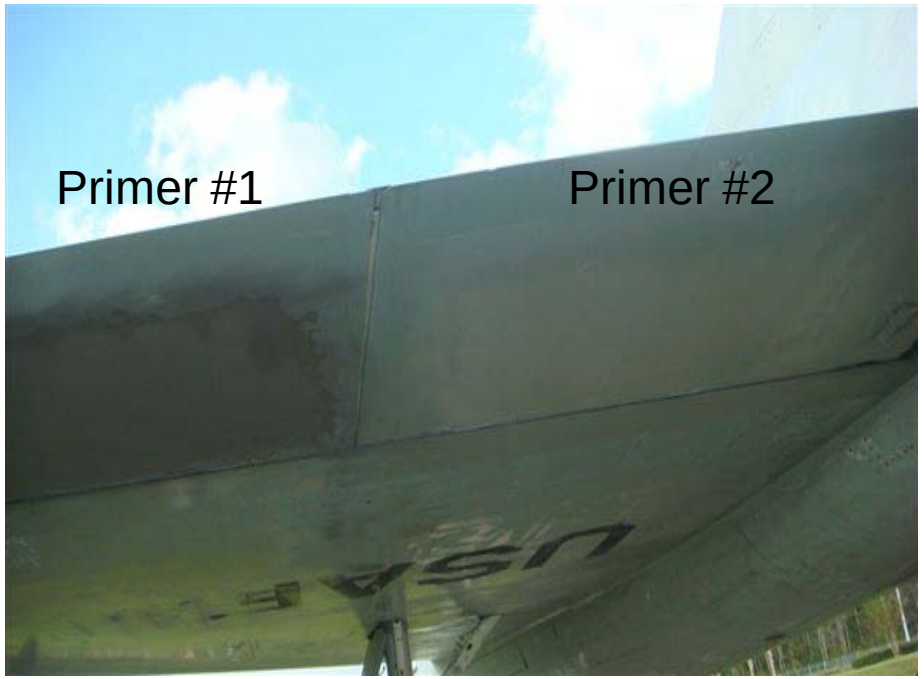


LH-side Upper Wing

F-106 Test Sections (2 of 4)

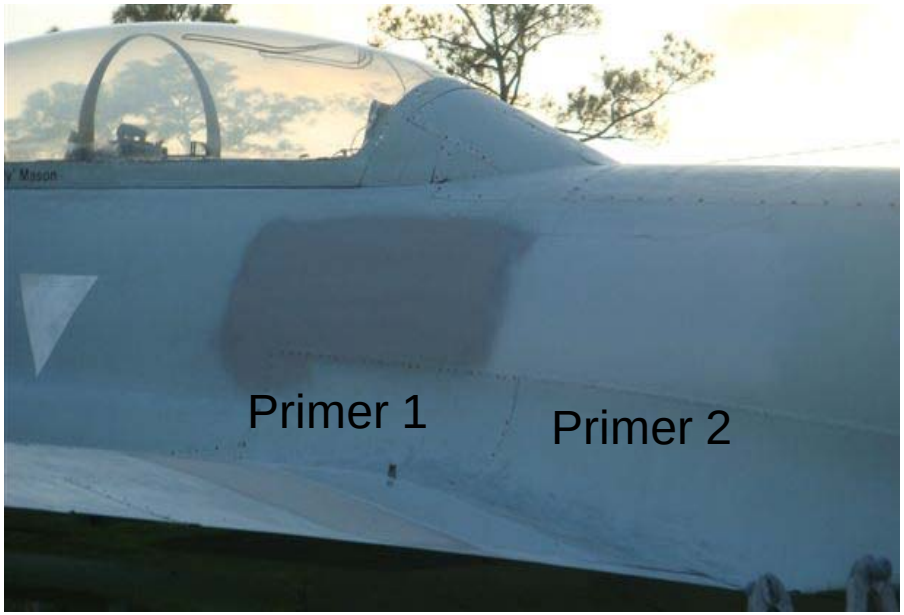


LH-side Fuselage

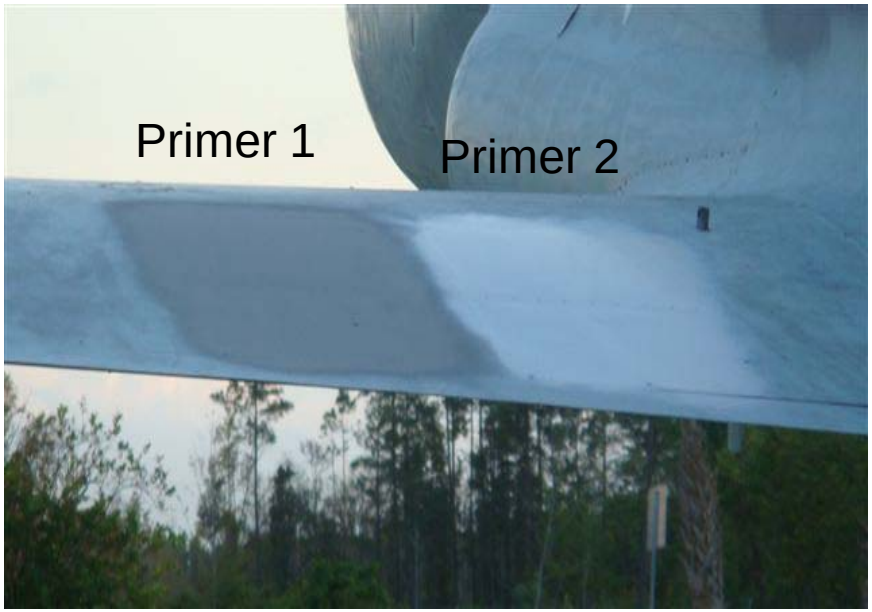


RH-side Lower Wing

T-33 Test Sections (2 of 4)



RH-side Fuselage



RH-side Upper Wing

F-15 Primed and Topcoated

Primer Coated

Topcoat Completed

The “Crew”

Conclusions

- Initial laboratory testing of Mg-rich primer systems delayed as a result of scribing morphology and test environment compatibility with “novel” coating system
- ASTM B117 is not appropriate test method for Mg-rich primer
- 9-month outdoor exposure data confirms excellent performance of Prekote/PRC 7233/PRC 9311 and control systems. Aerodur 2100 primer performing well
- AFRL to determine next iteration of laboratory testing
- 2-year field exposure panel test results (Abbott), 6-18 month flight testing (H-60, P-3 and AH64A) of coated sensors (Abbott) and 9-month panels from subject project yield good results for Mg-rich primer stack-up
- NAVAIR results with Mg-rich primer are very encouraging
- Next generation of Mg-rich primer coating performance better than all previous generations
- Future need to address alternative polymeric backbone chemistries (i.e., flexible primers and multiple stack-up combinations)

Planned Future Activities

- Continued quarterly monitoring of field exposure test panels (FMRF and FANG)
- Preparation for next 3,000-hour laboratory test exposure
- Obtain color/gloss/chalk and corrosion assessments from four static aircraft