



# **Overview of AFSPC Corrosion Solutions**

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# CTIO Focus and Capabilities

## Primary Focus and TRLs



- **Primary focus is integration of Commercial Off-the-Shelf (COTS) technology**
  - **CTIO provides a range of support for Air Force organizations**
    - **Mechanical, chemical, and environmental testing**
      - **ISO 17025 Certified**
      - **SAE AS 5505 Accredited**
    - **Coatings Test Method Development**
    - **Technical Consultation**



# CTIO Focus and Capabilities

## Primary Focus and TRLs



- **Technology Development**
- **Technology Transfer to Field Organizations**
- **System Development and Demonstration**
- **Engineer (Integrate) New Capabilities**
  - **Improved or Superior Coatings Systems**
  - **Refined Coatings Processes and Equipment**
  - **Enhanced Corrosion Control Capability**



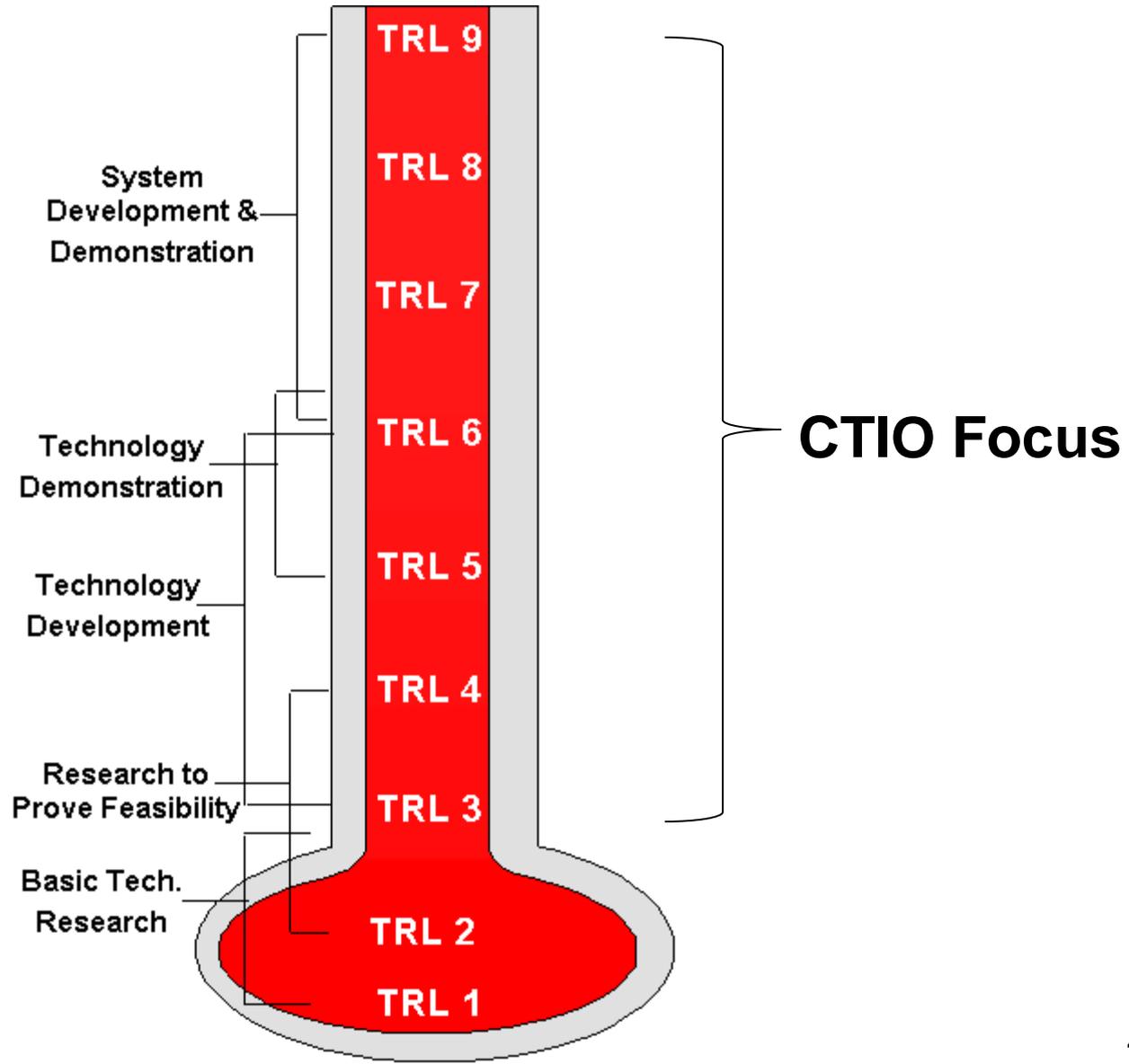
# CTIO Focus and Capabilities

## Primary Focus and TRLs



**Technology  
Readiness  
Level (TRL)**

**(Definitions  
taken from  
DoD 5002-R,  
5 Apr 2002)**





# CTIO Focus and Capabilities

## Primary Focus and TRLs



**TRL 9**

- **Best material formulation, application processes, and equipment proven through successful mission operations**

**TRL 8**

- **Best material formulation, application processes, and equipment qualified through test and demonstration**

**TRL 7**

- **Best material formulation, application processes, and equipment demonstrated in an operational environment**

**TRL 6**

- **Best material formulation, application processes, and equipment demonstrated in a relevant environment**

**TRL 5**

- **Top material formulations validated in a relevant environment**

**TRL 4**

- **Candidate material formulations tested against full spectrum of tests in laboratory. Material specification is frozen**

**TRL 3**

- **Screening test weed out poor material formulations. Detailed material specification is developed**

**TRL 2**

- **Material formulations vary wildly. Key requirements are documented**

**TRL 1**

- **Basic principles of materials observed and reported. Requirements are non-specific and incomplete**



# CTIO Programs – AFSPC



- **AFSPC**
  - **Space Launch P2 Programs**
  - **Weapon System Pollution Prevention (WSP2) Efforts**



# CTIO Programs – AFSPC

## Targeted Areas – Space Launch P2



- **Three programs are the focus of Space Launch Pollution Prevention efforts**
  - **WSP2 Eastern Range Coatings Support (WSP2 Eastern Range)**
  - **WSP2 Dem/Val of Coatings Alternatives at Vandenberg AFB (WSP2 Vandenberg Coatings)**
  - **WSP2 Opportunity Assessment: Western Range, Vandenberg AFB (WRP2OA)**





# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Eastern Range



- **Eastern Range Coatings Support Program**
  - Collaborative effort between AFSPC and NASA to field test alternative coating systems for Eastern Range operations
  - Identify only technologies that reduce the environmental impact of coatings operations
  - Potentially seeks to reduce the release of zinc coating by-products to the environment by either
    - Encapsulation of zinc with more robust barrier coating systems OR
    - Replacement of zinc coatings with effective treatments for steel which do not require zinc



# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Eastern Range



### Coatings Applied in Eastern Range Coatings Support Dem/Val

Surface	Coating Material	Previously Lab Tested	Previously Field Tested
Bare steel and Over Zinc Metallize	Carboline Carbozinc 11WB	Yes (NASA/TEERM)	Yes (NASA/TEERM)
	Carboline Carboxane 2000		
Bare steel and Over Zinc Metallize	Carboline Carbozinc 18WB	Yes (NASA/TEERM)	Yes (NASA/TEERM, ITB/ASRC and AFRL)
	Carboline Carbothane 133MC		
Bare steel and Over Zinc Metallize	Deft 02W052	No	Yes (NASA/TERRM, ITB/ASRC and AFRL)
	Deft 55W002	Yes (AFRL)	
Zinc metallize	Carboline Carbozinc 11WB	Yes (NASA/TEERM)	Yes (NASA/TEERM)
	Carboline Carboxane 2000		
Zinc metallize	Carboline Carbozinc 18WB	Yes (NASA/TEERM)	Yes (NASA/TEERM, ITB/ASRC and AFRL)
	Carboline Carbothane 133MC		
Zinc metallize	Deft 02W052	No	Yes (NASA/TERRM, ITB/ASRC and AFRL)
	Deft 55W002	Yes (AFRL)	
Zinc metallize	Sherwin-Williams Macropoxy 646-100 (B58)	Yes (NASA/KSC)	Yes (NASA/KSC, current)
	Sherwin-Williams Polyurethane 100 (B65)		
Zinc metallize	Carboline Carbothane 134MC	Yes (NASA/KSC)	Yes (NASA/KSC, current)
Zinc metallize	Ameron Amerlock Sealer	Yes (NASA/KSC)	Yes (NASA/KSC, current)
	Ameron PSX 700		



# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Eastern Range



- **Surface Preparation and Metallize Application**



- **Black Beauty Blast Media and Zinc Metallize Demo**



# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Eastern Range

TRL  
8



- **Coating Application Over Bare Steel or Zinc Metallize**





# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Eastern Range



- **MBX Bristle Blaster - Wire Wheel with Shroud Demo**





# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Eastern Range



- **Coating Application Dem/Val and Final Location at KSC Corrosion Beach Test Site (18 mos exposure)**



Coatings were not yet applied at time of photo



Topcoats were applied and overspray was removed before placement at the Beach Test Site



# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
8



- **Vandenberg Coatings Dem/Val**
  - **Collaborative effort between AFSPC, NASA, and ULA to field test alternative coating systems for launch facilities**
  - **Goal of the program is to identify, demonstrate, and validate coatings materials that reduce the environmental impact of coatings operations in a variety of locations at active launch sites**
  - **Identified technologies can either be immediately utilized by corrosion control personnel in space launch organizations or be evaluated further in additional targeted studies designed to develop more tailored solutions for specific missions**



# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
8



- **Dem/Val Areas at SLC-2W and SLC-6**
  - **Areas identified and selected by RPI/COR-RAY and ULA as having the highest probability for use in the DEM/VAL**
    - **MST (Zone 4) landing of SLC-2**
    - **Buildings in Zone 2/3 of SLC-2**
    - **Deluge pit of SLC-2**
    - **Deluge pit of SLC-6**



# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
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- **Zone 4, MST at SLC-2W**



**Test area was enclosed to prevent flash-rusting and moisture build-up because of high fog and high humidity**



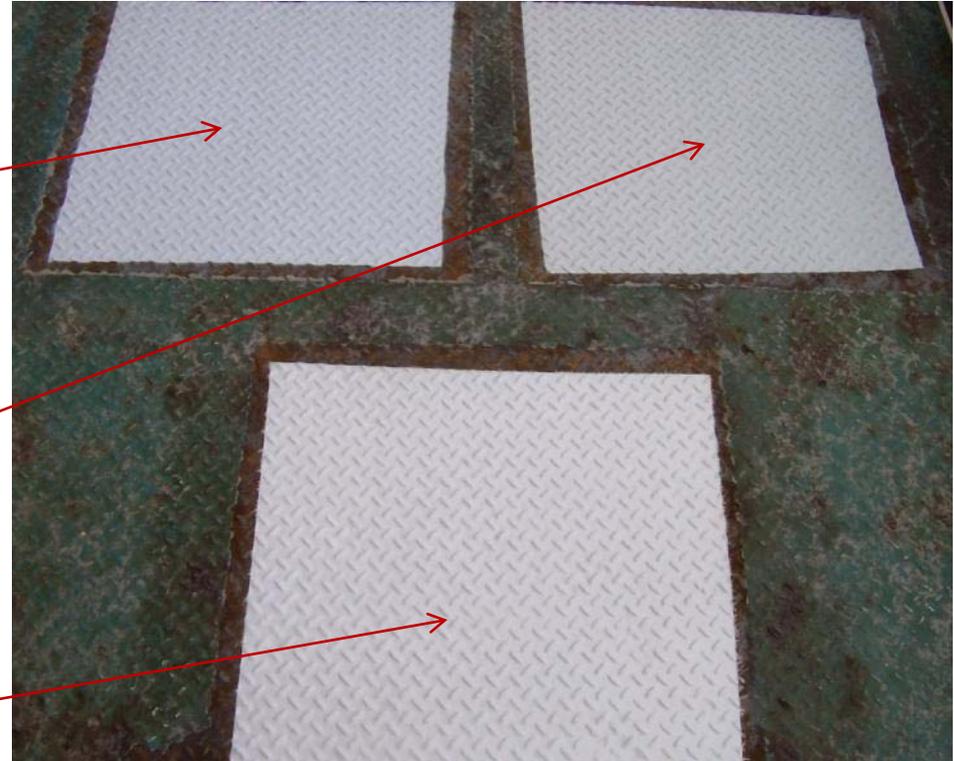
# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
8



- **Coatings Applied to Zone 4, MST, SLC-2W**
  - **Carboline Carbozinc 18WB and Carbothane 133MC**
  - **Carboline Carbozinc 11WB and Carboxane 2000**
  - **Deft Epoxy 02W052 and Polyurethane 55W002**





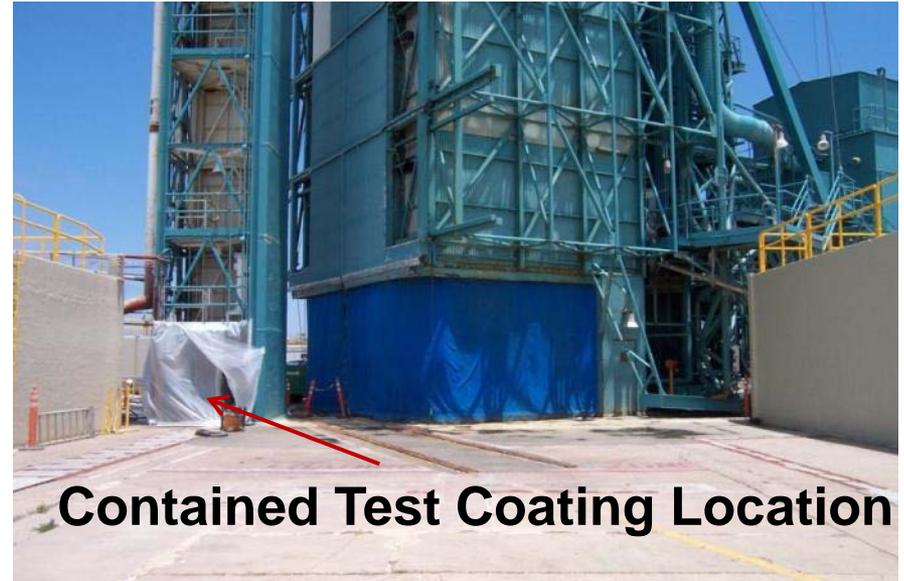
# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
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- Zone 2/3, Buildings and FUT at SLC-2W





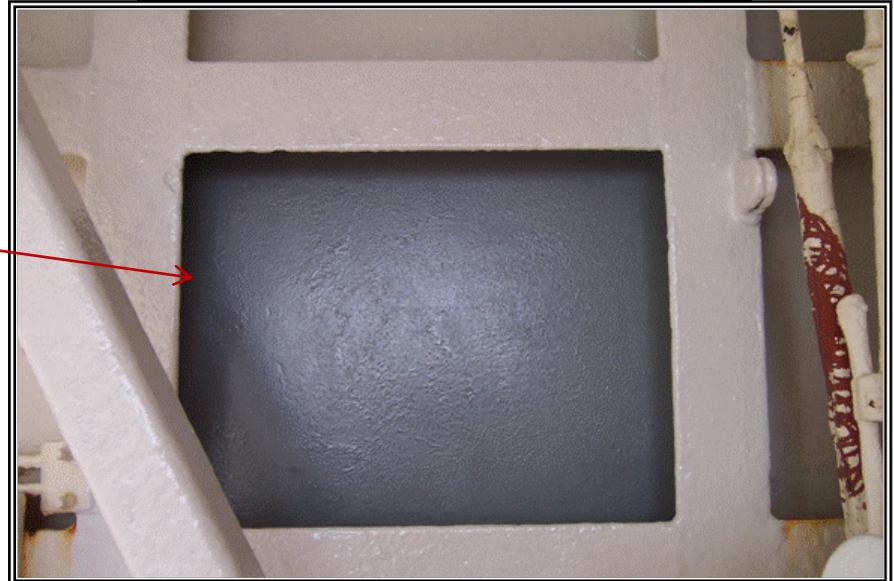
# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
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- **Coatings Applied to Zone 2/3, Buildings and FUT**
  - **Applied on the Building**
    - **Carboline Thermaline 451 Flake-Filled Novolac Epoxy Coating**
  - **Applied on the FUT**
    - **Carboline Thermaline 450 Novolac Coating**





# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
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- **Zone 1, Deluge Pit at SLC-2W**



- **Test Coating Location**
  - **Inside the Right Wall of the Deluge Pit just beyond the water deluge system**



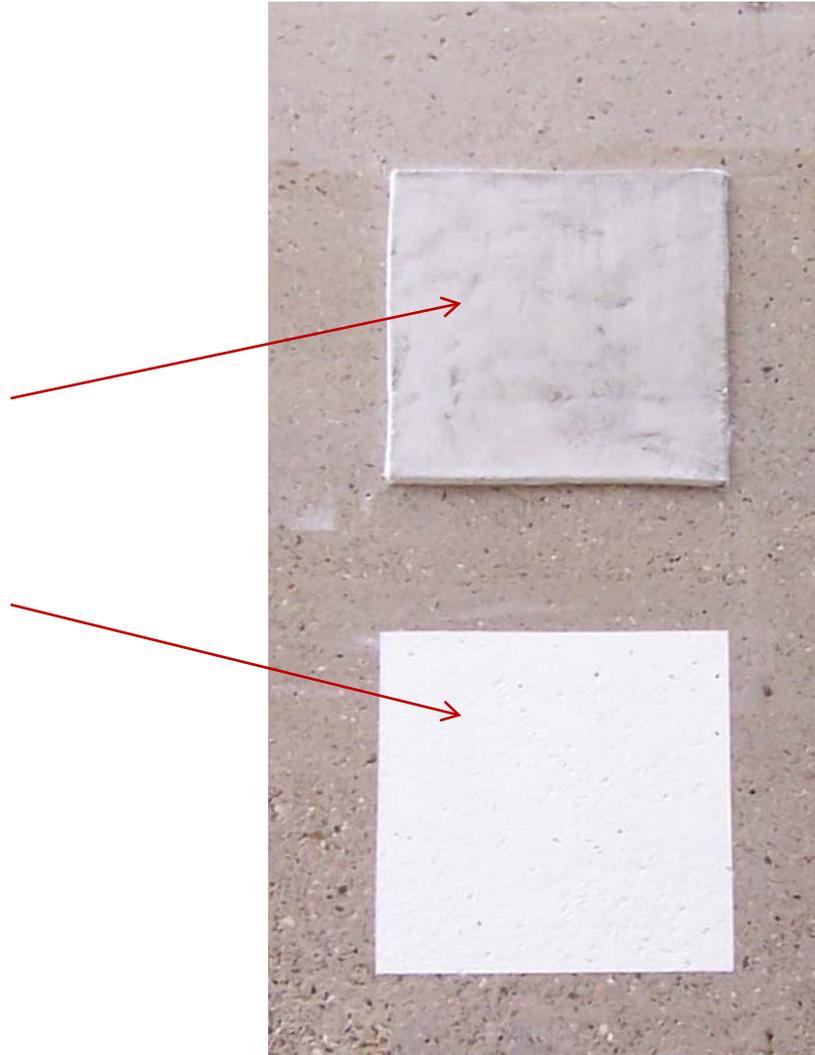
# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
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- **Coatings Applied to Wall in Deluge Pit**
  - **Foam Safe Cementitious Material**
  - **KBS Ablative Coating**





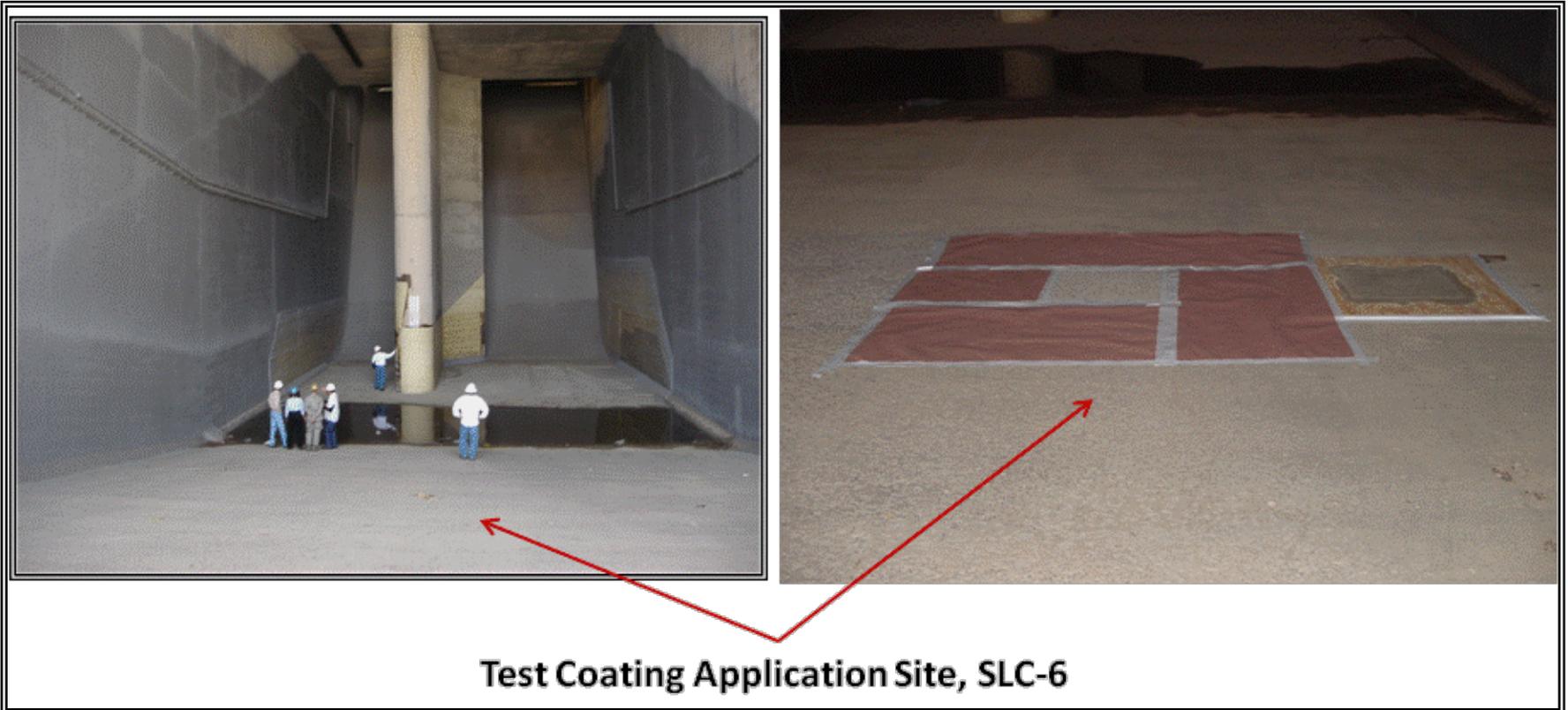
# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
8



- Zone 1, Deluge Pit at SLC-6





# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
8



- **Coatings Applied to Floor in Deluge Pit at SLC-6**
  - **KBS Ablative Coating**
  - **Foam Safe Cementitious Material**





# CTIO Programs – AFSPC

## Targeted Areas – WSP2 Vandenberg Coatings

TRL  
8



- **Data on coating application will be provided per subcontract with RPI/Cor-Ray Coatings and will be certified by the NACE coating inspector at SLC-2 and SLC-6**
- **Coatings will be checked after 6 months or after launch, whichever occurs first**
- **At present, the launch from SLC-2 is scheduled for the end of October 2010 and the launch from SLC-6 is scheduled for January 2011**



# CTIO Programs – AFSPC

## Targeted Areas – WRP20A



- **Western Range P20A**
  - **Identifies alternative, environmentally preferable solvents, coatings, and de-paint equipment for corrosion control operations at the Western Range**
  - **Alternatives were selected on the basis of their projected ability to mitigate the environmental risk of current processes**
  - **Alternatives are drop-in replacements which**
    - **Provide no materials performance reduction or improvement OR**
    - **Provide materials performance improvements but will require some training to implement**



# CTIO Programs – AFSPC

## Targeted Areas – WRP20A



- Site Survey was performed in March 2010



**AN-TPQ-18**



**CT-5**



**915 Profiler**



**CT-3**



# CTIO Programs – AFSPC

## Targeted Areas – WRP20A



- **Site Survey Results for Western Range P20A**



**Stress Corrosion  
Cracking on OSS Radar  
Tower at Lion's Head**



**AN/TPQ-18, Minor Corrosion  
on Pedestal and Trunion**



**Current Status, CT-5 Trailer**



# CTIO Programs – AFSPC

## Targeted Areas – WRP20A



Operational Impact	5	Green	Yellow	Red	Red	Red
	4	Green	Yellow	Yellow	Red	Red
	3	Green	Green	Yellow	Yellow	Red
	2	(A)	Green	Green	Yellow	Yellow
	1	(B),(D), (E)	(C)	Green	Green	Yellow
			1	2	3	4
		Environmental Compliance				

- Results for increased environmental compliance
  - High probability of success
  - Low probability of operational impact



# CTIO Programs – AFSPC

## Targeted Areas – WRP20A

TRL  
1



<b>Situation</b>	<b>Description</b>
(A)	Replacement of damaged steel towers with composite towers (only impact would be down-time for replacement)
(B)	Replacement of antiquated corrosion control equipment (minimal time needed to acquire, demonstrate, and train personnel on new equipment)
(C)	Replacement of non-standard coatings with a standardized coating system protocol (minimal impact once current materials are replaced with high-performance standardized materials wherever possible)
(D)	Recycling of MWAS wire (zero impact and generates an environmental benefit as well as a potential monetary benefit)
(E)	Replacement of high-VOC coatings with low-VOC alternatives (minimal impact on operations with high environmental payback)



# CTIO Programs – AFGSC



- **AFGSC**
  - **Weapon System  
Pollution  
Prevention Efforts**



# CTIO Programs – AFGSC

## Targeted Areas – WSP2 Efforts



- **Three programs to support weapon system pollution prevention initiatives**
  - **Missile Suspension System Minuteman III Coatings Dem/Val (MSS)**
  - **Transporter Erector Coatings Support (TE)**
  - **Rocket Motor Semitrailer Coatings Dem/Val (RMS)**



# CTIO Programs – AFGSC

## Targeted Areas – MSS



- **Missile Suspension System Metallization Program**
  - **MSS Project demonstrates and validates thermal metallization coating technology for MMIII weapons system support equipment (missile suspension system) for the 581st MMXS depot refurbishment squadron at Vandenberg AFB**
  - **Deliverables**
    - **Supply 581<sup>st</sup> MMXS with a suitable metallizer, materials and training (Completed)**
    - **Supply AFGSC documentation suitable for incorporation of metallization into Technical orders (Completed)**



# CTIO Programs – AFGSC

## Targeted Areas – MSS



- **Review/oversee the application of appropriate metallize coating on a frustum (Completed)**
- **Inspect/analyze the performance of metallize on the frustum after one launch (Pending)**
- **Inspect/analyze the performance of metallize on the frustum after 4 launches (Pending)**
- **Provide support data/information to AFGSC and AFRL concerning the adhesion and corrosion characteristics of metallize for the ICBM launch environment**
  - **Pending, separate funding from AFRL/RX**

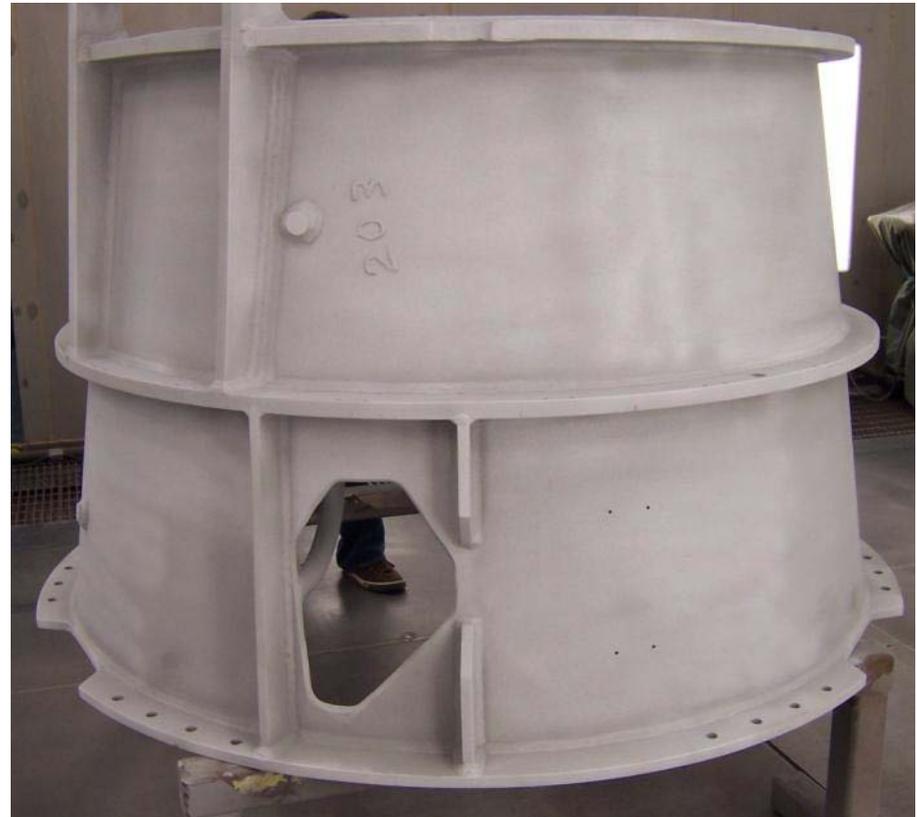


# CTIO Programs – AFGSC

## Targeted Areas – MSS



### Frustum Coated with Aluminum Metallize



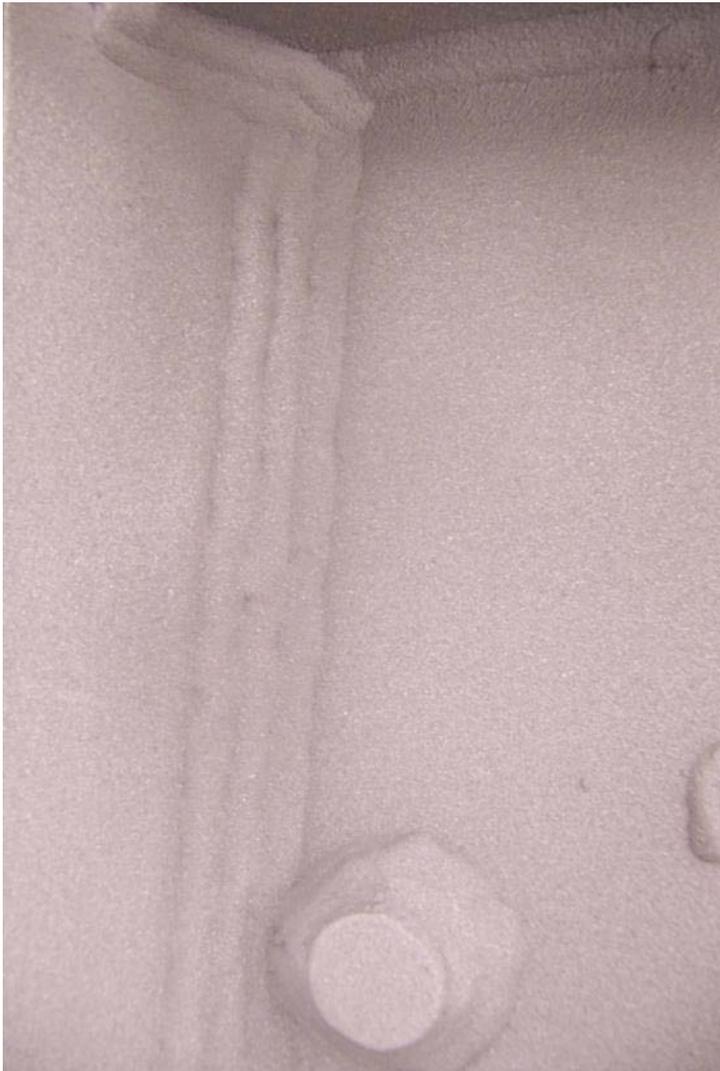


# CTIO Programs – AFGSC

## Targeted Areas – MSS



### Frustum Coated with Aluminum Metallize





# CTIO Programs – AFGSC

## Targeted Areas – TE



- **ICBM Transporter Erector (TE) Dem/Val**
  - TE program goal to Dem/Val drop-in replacements for current organic coating systems
  - Test coatings are environmentally-friendly and use current application equipment / technology
  - Field test activities were carried out by corrosion maintenance personnel at Malmstrom AFB summer 2009
  - Coatings were checked at 10 months to monitor chipping resistance, adhesion, and corrosion resistance



# CTIO Programs – AFGSC

## Targeted Areas – TE



- **Surface Preparation of the TE for Test Coating Application**





# CTIO Programs – AFGSC

## Targeted Areas – TE



- **TE Actuator Arm Dem/Val Coating Process**





# CTIO Programs – AFGSC

## Targeted Areas – TE



- **Field Test Results on TE after 10 months**

<b>TE Location</b>	<b>Coating System</b>	<b>ASTM D 714 Rating</b>	<b>ASTM D 610 Rating</b>	<b>ASTM D 1654 Rating</b>	<b>ASTM D 3170 Rating</b>	<b>Color/Gloss Rating</b>
Right Side, Under Container	System 1	10	10	10	no chipping	N/A
Left Side, Under Container	System 2	10	10	10	no chipping	N/A
ECS Air Inlet Box, Top	System 4	10	10	10	no chipping	N/A
ECS Air Inlet Box, Bottom	System 5	10	10	10	no chipping	N/A
Forward Landing Gear, Right	System 3 (Bare Metal)	10	10	10	no chipping	N/A
Forward Landing Gear, Left	System 3 (Scuff/Shoot)	10	10	10	no chipping	N/A
Rear Actuator, Right	System 3 (Bare Metal)	10	10	10	no chipping	N/A
Rear Actuator, Left	System 3 (Bare Metal)	10	10	10	no chipping	N/A



# CTIO Programs – AFGSC

## Targeted Areas – TE

TRL  
8



- Overall behavior of the coating systems suggests that the test coating systems have demonstrated satisfactory performance and are suitable for use elsewhere in field demonstration activities in the ICBM community
- Field testing needs another year (unfunded CTIO support)





# CTIO Programs – AFGSC

## Targeted Areas – RMS



- **ICBM Rocket Motor Semitrailer (RMS) Coatings Dem/Val**
  - Project performed field testing of environmentally friendly coating systems at Hill AFB
  - Low-VOC coating systems with nonchromated pretreatments were tested against existing systems on support equipment in September 2008
  - Test coatings were exposed to outdoor conditions on the RMS for a period of 2 years
  - Results provided several coating systems for recommendation to the ICBM community



# CTIO Programs – AFGSC

## Targeted Areas – RMS



RMS Door

2-Years Field Testing



RMS Rear Bumper



Metallized Landing Gear



# CTIO Programs – AFGSC

## Targeted Areas – RMS

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8



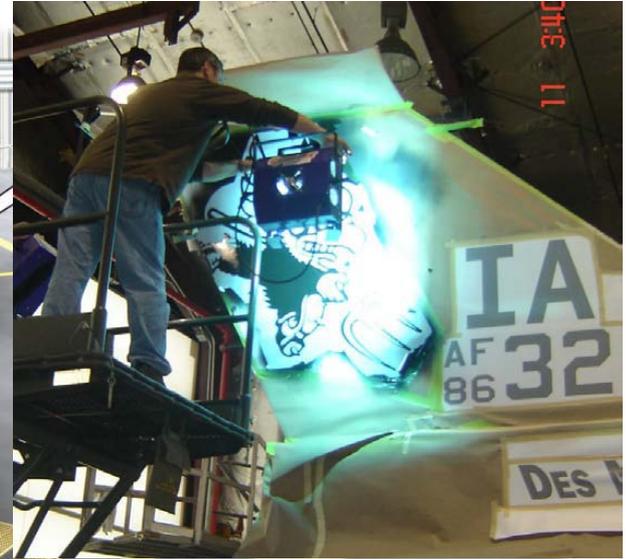
Coating System Identifier	Pretreatment	Primer	Topcoat	Recommendation
1	None	Deft 65-Y-001A	Deft 55-W-002	Potential Drop-In Replacement for Scuff-and-Shoot
2	None	Deft 65-Y-001A	Deft 36-W-005	Drop-In Replacement for Scuff-and-Shoot
3	PreKote	Deft 65-Y-001A	Deft 55-W-002	Potential Drop-In Replacement for Full Recoat or Acquisition
4	PreKote	Deft 65-Y-001A	Deft 36-W-005	Drop-In Replacement for Full Recoat or Acquisition
5	None	Hentzen 00812FEP-ZVOC	Hentzen 04605BUX-ZVOC	Drop-In Replacement for Acquisition
6	None	Deft 65-Y-001A	Deft 55-BL-007	Potential Drop-In Replacement



# CTIO Programs



- Targeted Coatings Areas elsewhere in DoD





# CTIO Programs

## Targeted DoD Areas



- **Current and Recent DoD Programs Supported by CTIO**
  - **Hot Dip Galvanize for AGE**
  - **Deployable UV Cure Kit**
  - **UV Curable Stencils**
  - **Chromate-Free Coating Systems**
    - **Magnesium-Rich Primers**
    - **Electroactive Polymers**
    - **Organometallic Zinc Corrosion Inhibitors (OZI)**



# CTIO Programs

## Targeted DoD Areas – Hot Dip Galvanize



- **Hot Dip Galvanize for AGE**
  - CTIO initiated a project in Sep 07 at the request of PACAF to investigate HDG for air ground equipment (AGE) in highly corrosive environments





# CTIO Programs

## Targeted DoD Areas – Deployable UV Cure Kit

TRL  
4



- **Depolyable UV Cure Kit (DUCK)**
  - **UV cure is a method of rapidly curing a coating fabricated from UV curable materials**
  - **These materials are coatings that cure in minutes under UV light rather than 3+ days via standard coating chemistry reactions**
    - **(Example: polyurethane topcoats under MIL-PRF-85285)**
  - **UV coatings typically have very low to zero VOC's**
  - **UV coatings are typically temperature independent, and will cure in cold/freezing temperatures**



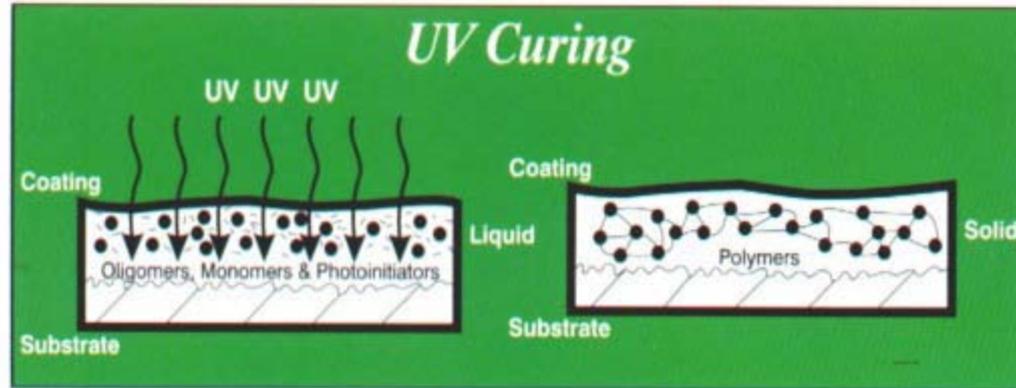
# CTIO Programs

## Targeted DoD Areas – Deployable UV Cure Kit

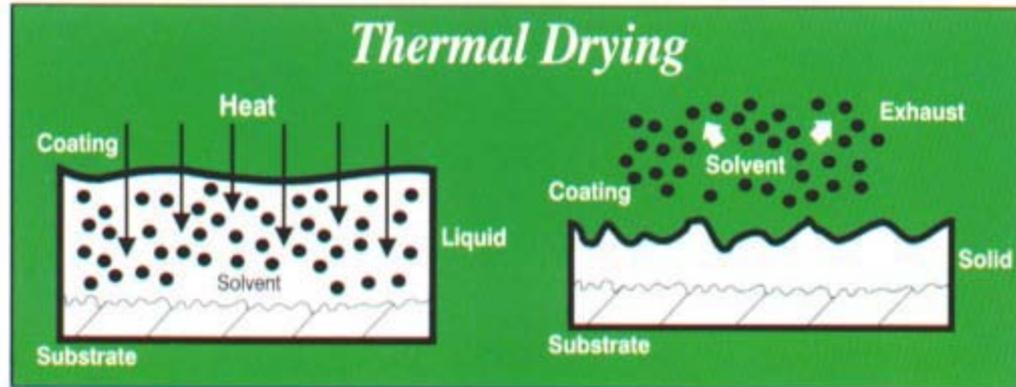
TRL  
4



*Compare for Yourself*



*Vs.*



*Since solvent-based thermal drying evaporates solvents, the initial laydown is typically reduced by more than 50%. UV curing uses no solvents, so chemicals in the coating cure instantly with no loss of film thickness.*



# CTIO Programs

## Targeted DoD Areas – Deployable UV Cure Kit

TRL  
4



- **Program Goals**

- **Deliver UV Technology to Field Units**

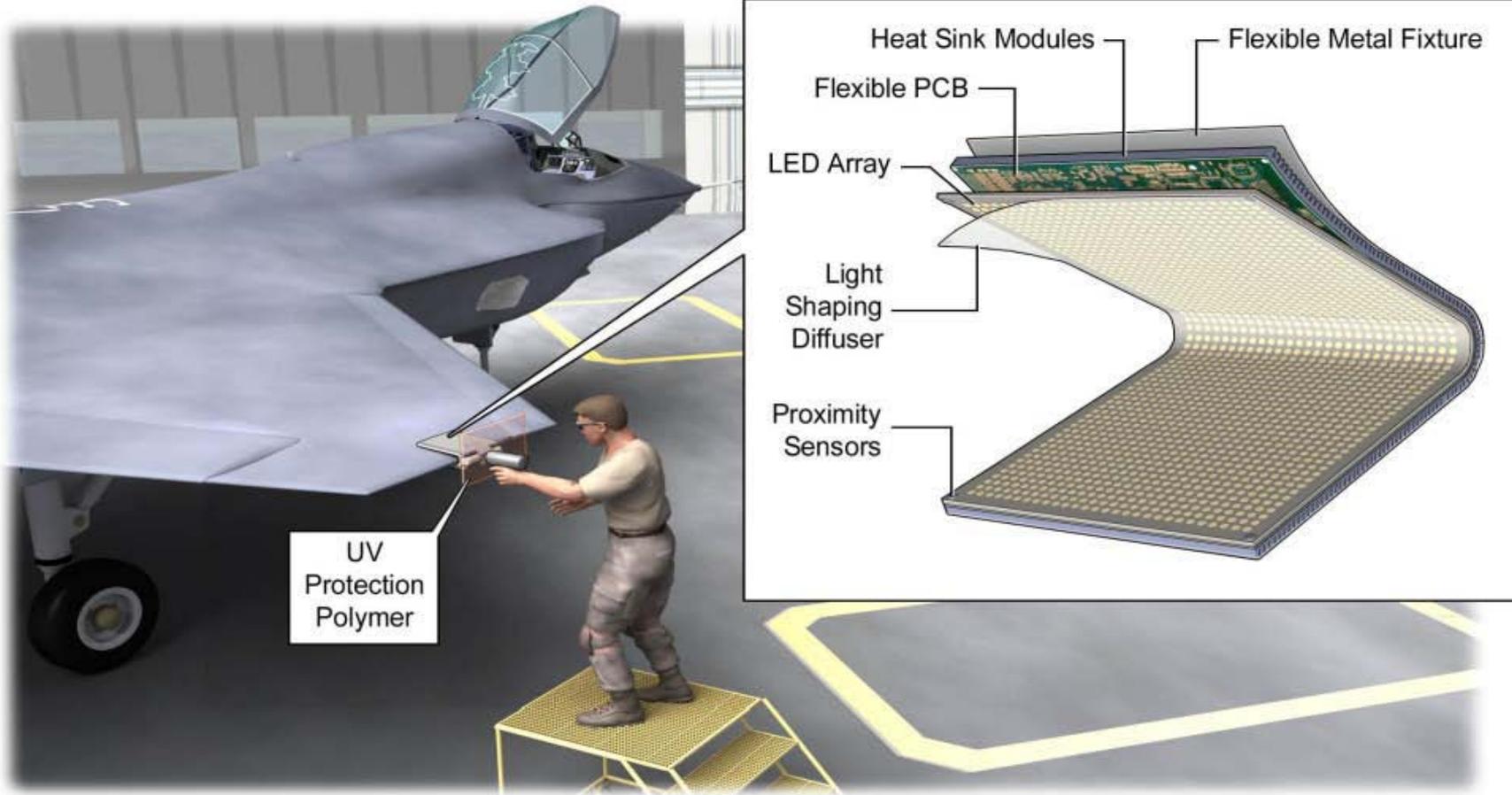
- **Repair Kit will cure a 9 sq ft area in less than 4 hours**
- **Provides field-level repair in environmentally restrictive areas**
- **Kit Components**
  - **UV Lamp System**
  - **UV Curable Coatings**
  - **Training Video**
  - **Restocking Info**
  - **MSDS and PPE Info**
  - **UV Curable Coatings**
  - **Telescoping Stand**
  - **Carrying Case**



# CTIO Programs

## Targeted DoD Areas – Deployable UV Cure Kit

TRL  
4





# CTIO Programs

## Targeted DoD Areas – UV Curable Stencils

TRL  
5



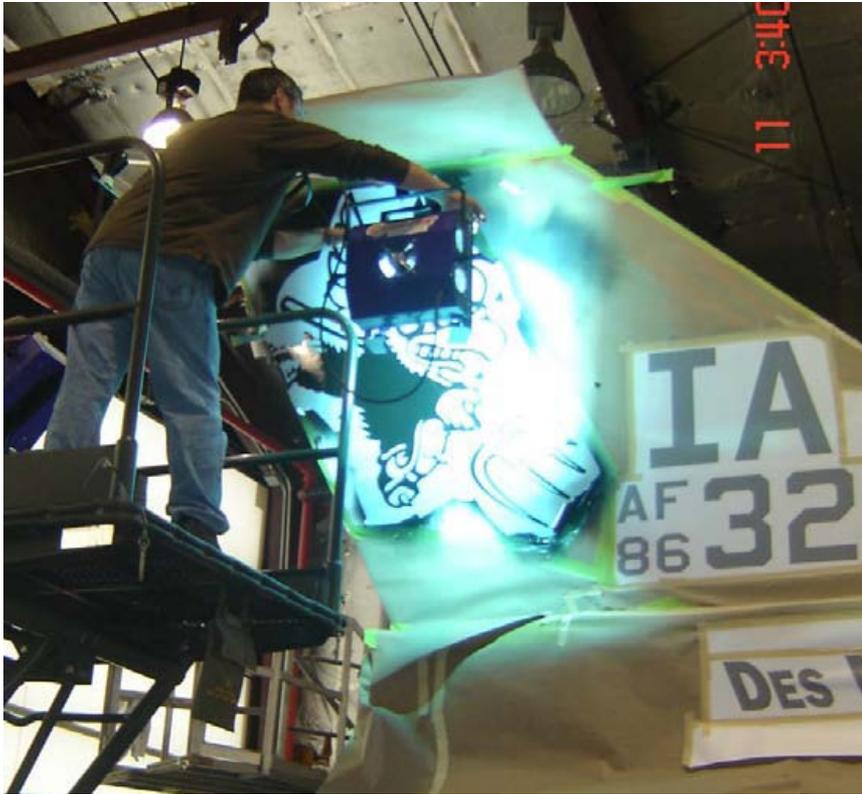
- **UV Curable Stencil Project**
  - **UV Curable Stencils cure only when exposed to the correct dose/intensity of UV light at the correct wavelength**
  - **System is single-component; there is no mixing and no unused waste**
  - **Required cure time is measured in minutes instead of days**
  - **It is environmentally friendly and low/zero VOC**
  - **Enables rapid touch-ups and re-painting**



# CTIO Programs

## Targeted DoD Areas – UV Curable Stencils

TRL  
5



F-16 Tail, Iowa ANG, Dec 2007



C-130, 911th Air Wing, Apr 2008

**After 7 months and 340+ flying hours there was no adhesion loss; 1/2 of the color degradation as compared to conventional markings on the aircraft**



# CTIO Programs

## Targeted DoD Areas – Mg Rich Primer



- **Magnesium (Mg) Rich Primer Development**
  - **Mg Rich Primer is a developmental non-chromated primer as part of a fully non-chromated system**
  - **Concept was developed by NDSU and was licensed to an aerospace coating company for commercial development**
  - **Provides cathodic corrosion protection to aluminum**
  - **Analogous to zinc primers on steel substrates**
  - **Designed as a Drop-In for MIL-PRF-23377 coatings**



# CTIO Programs

## Targeted DoD Areas – Mg Rich Primer



- **Mg Rich Primer Schematic**



**NOTE: System does not use a chromated conversion coating; the use of chromates interferes with the protection to the aluminum alloy that is provided by the Mg Rich Primer**



# CTIO Programs

## Targeted DoD Areas – Electroactive Polymers

TRL  
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- **Electroactive Poymer Coatings Field Demonstration**





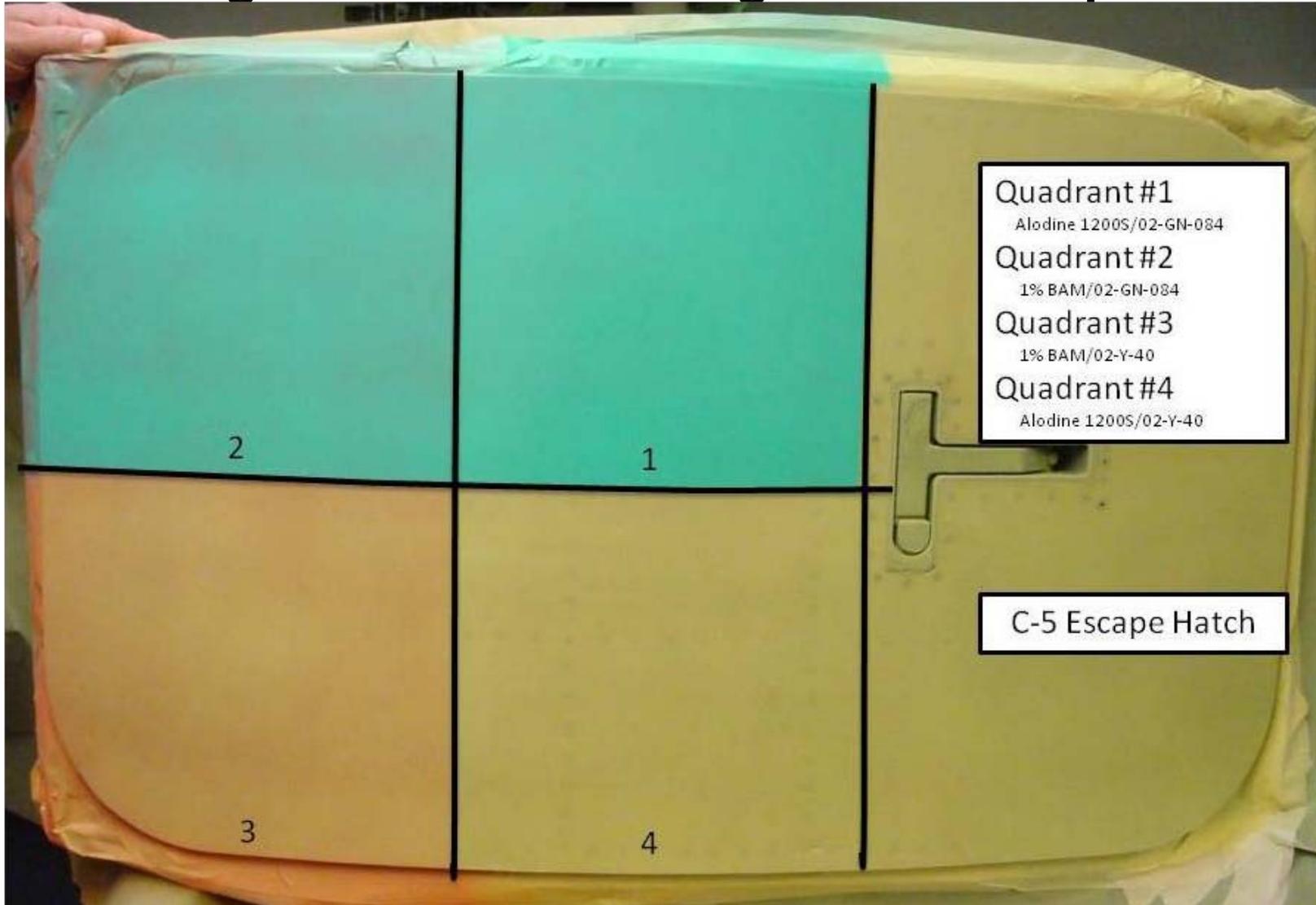
# CTIO Programs

## Targeted DoD Areas – Electroactive Polymers

TRL  
4



- Coatings From Field Testing on C-5 Escape Hatch





# CTIO Programs

## Targeted DoD Areas – Electroactive Polymers

TRL  
4



- **Escape hatch has been flown on a C-5 operational aircraft for 299.7 flight hours and has had at least one confirmed overseas duty assignment during that time.**
- **Color data shows that there was no color change in the test coatings beyond the color change noted for the standard coating (quadrant 4)**
- **Thickness data shows that there is some dirt build-up and some scuffing to the surface but that there is no loss of adhesion to the system**
- **Program has completed 4-years under ESTCP**



# CTIO Programs

## Targeted DoD Areas – OZI Primer



- **Organometallic Zinc Corrosion Inhibitor (OZI) Primer Development**
  - Work developed under ESTCP
  - New primer for aluminum alloys and steel substrates which requires no chromates or cadmium
  - Collaborative effort between NAVY (NAWCWD), Army (Army Research Lab), Air Force (AFRL/WPAFB), and Industry Partner (Crosslink USA)
  - Completed one year in a 4-year effort



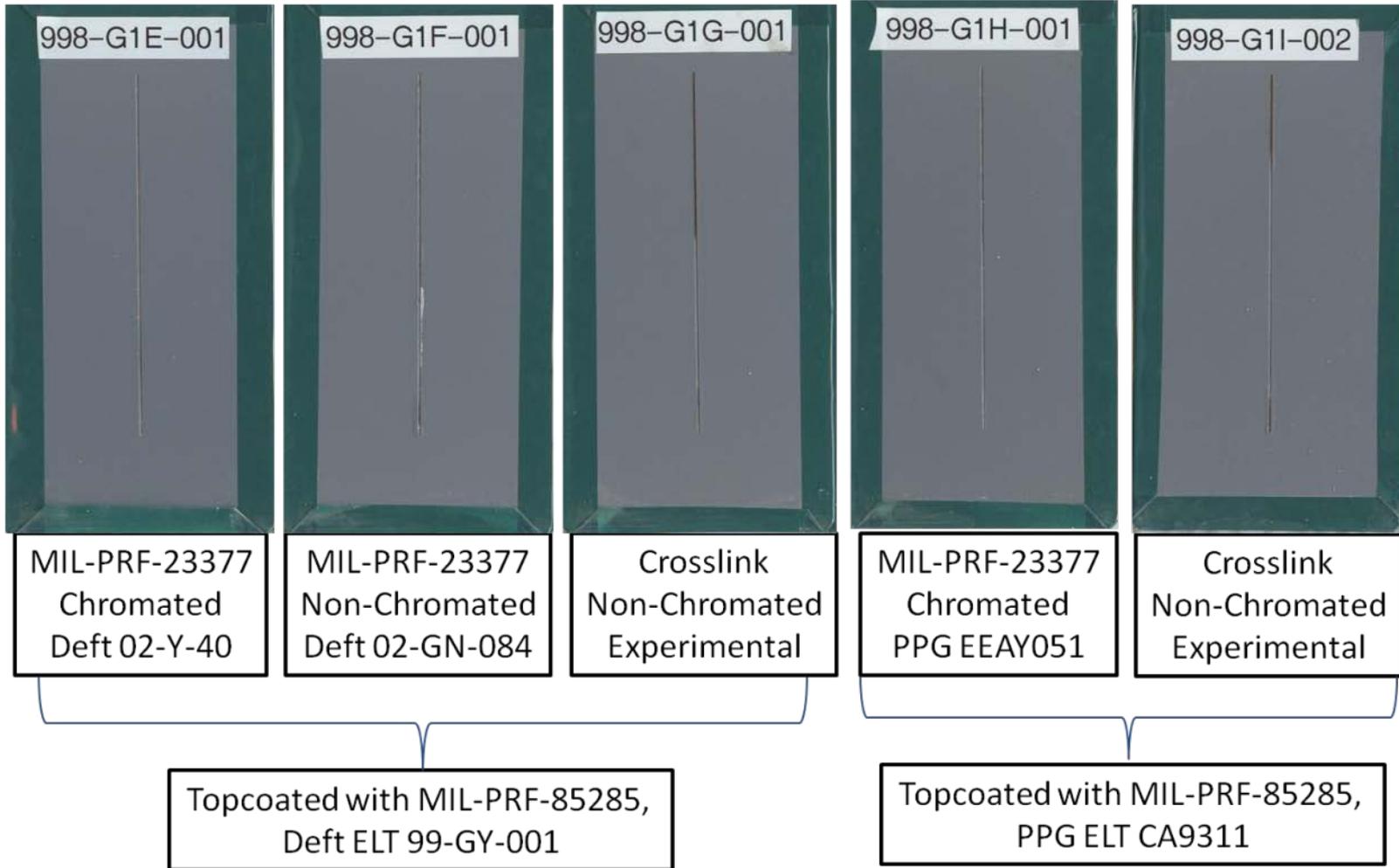
# CTIO Programs

## Targeted DoD Areas – OZI Primer

TRL  
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Topcoated samples after 40 cycles of GM9540P exposure  
Substrate = 1010 steel  
Pretreatment = Cadmium plate (QQ-P-416)



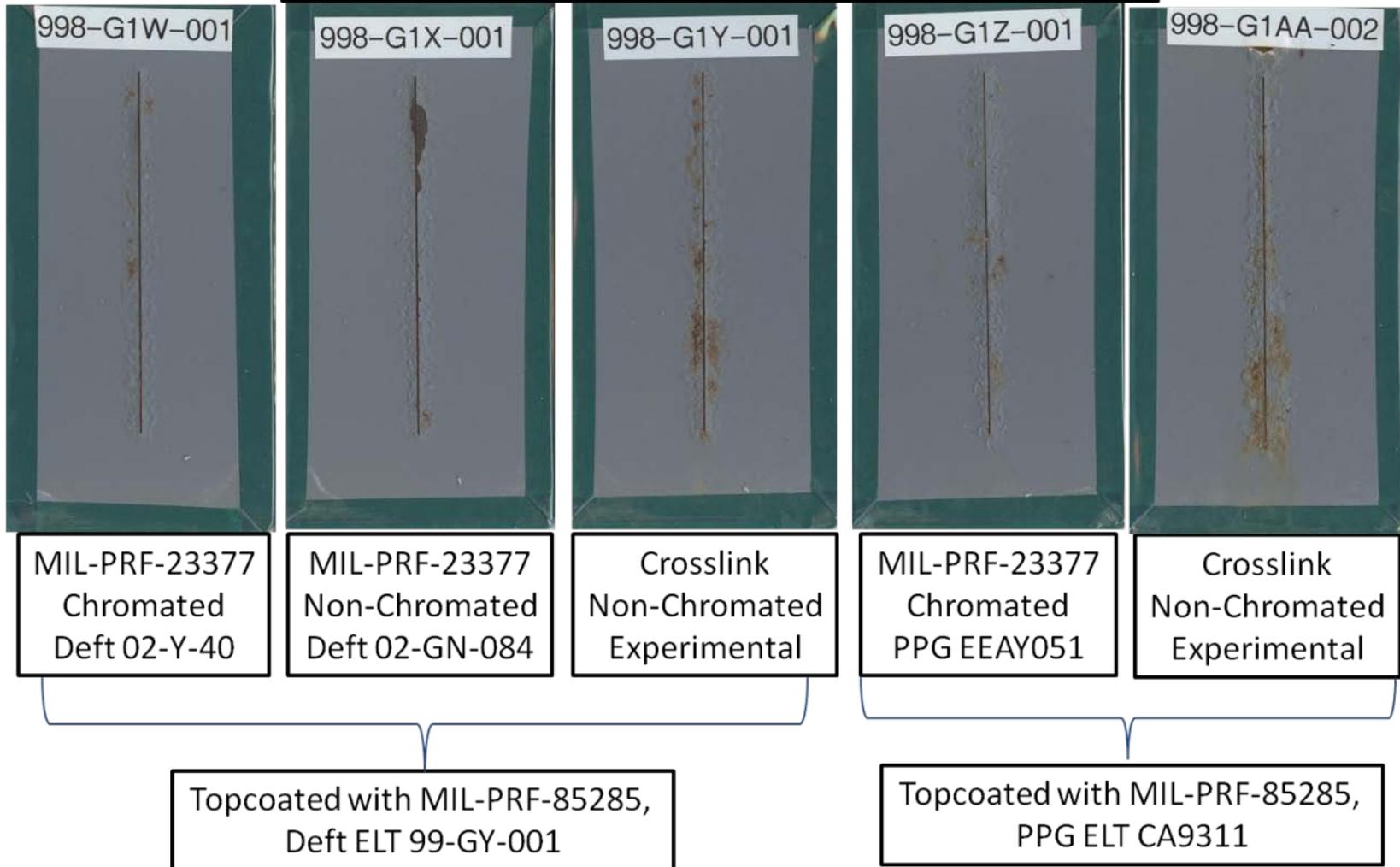


# CTIO Programs

## Targeted DoD Areas – OZI Primer



Topcoated samples after 40 cycles of GM9540P exposure  
Substrate = 1010 steel  
Pretreatment = Non-Chromated Coating, BAM-PPV





# CTIO Programs

## Targeted DoD Areas – OZI Primer



- **OZI Primer performs comparable to other nonchromated materials for adhesion but performed slightly worse than other nonchromated materials in GM9540P Accelerated Corrosion testing**
- **Year 2 will focus on improved corrosion resistance in GM9540P and improved application techniques**