



The Vital Role of the Kennedy Space Center Beachside Atmospheric Corrosion Test Site in Selecting Corrosion Protection Coatings for Increased Sustainability

Jerome P. Curran

**NASA Corrosion Technology Laboratory,
Kennedy Space Center**

2014 INTERNATIONAL WORKSHOP ON ENVIRONMENT AND ALTERNATIVE ENERGY

"Increasing Space Mission Resiliency through Sustainability"

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Overview

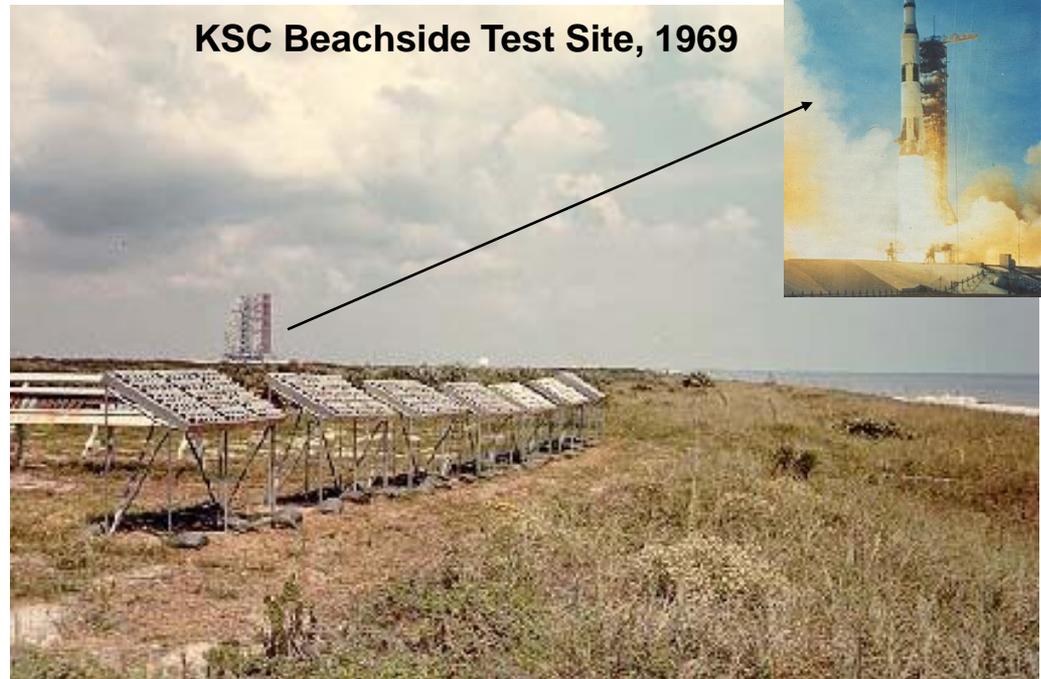
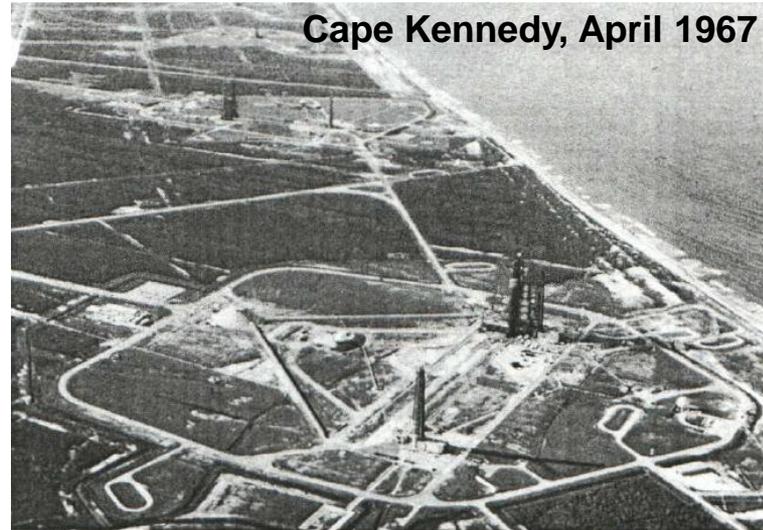


- **History of the Exposure Site**
- **Environmental Conditions**
- **Projects and Partnerships**
- **People**



History – Site Establishment

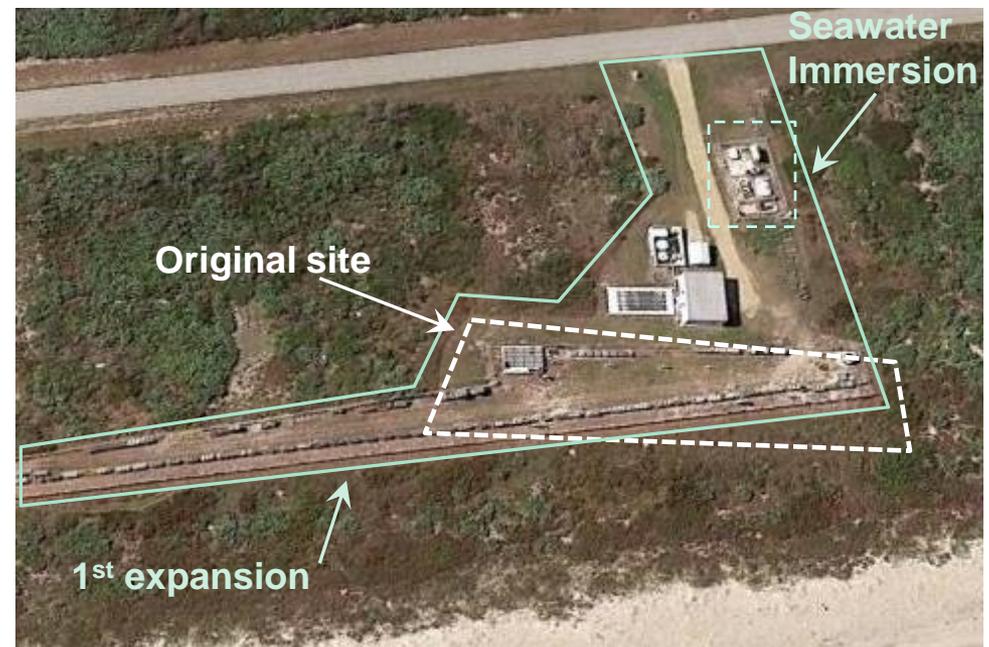
- **1966:** First coatings testing located at the Cape Kennedy launch pads during the Gemini/Apollo Programs for long-term protective coatings for atmospheric protection of carbon steel.
- **1969:** The NASA Beachside Corrosion Test Site established more controlled and cost effective ways to conduct testing on coatings for carbon steel in a seacoast launch environment.



History – 1st Expansion



- **1990's:** Numerous studies at the site required an expansion to 600 feet parallel to the Atlantic Ocean
- Environmentally friendlier coatings, zinc-rich primers and inorganic topcoats, silicone ablative coatings
- Identified materials, coatings, and maintenance procedures for launch hardware and equipment exposed to the highly corrosive environment at the launch pad
- Results have helped KSC find new materials and processes that increase the safety and reliability of launch structures and ground support equipment



History: Upgrades

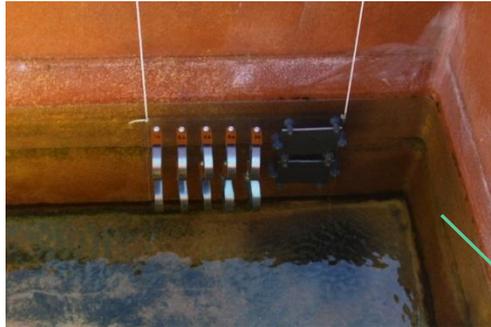


Upgrades:

- Weather station
- New permanent building with laboratory and machine shop
- Remote camera system
- Remote field monitoring

Seawater immersion:

- Simulates natural tidal conditions
- Water Quality (pH, dissolved oxygen, chlorides, temperature)
Oxygen concentration monitored



Alternating Seawater Spray Test:

- Sprays seawater pumped from the ocean
- Frequency programmable



Concrete:

- Test rebar in concrete
- Electrically connected



History: 2nd Expansion



- **Site expansion as a result of current demand for additional corrosion testing from NASA, the Department of Defense and other external customers**
- **900 total feet of coastal atmospheric exposure space parallel to the Atlantic Ocean**
- **200 feet from the mean high tide line**
- **Accommodates specialty components**



2nd Expansion: Environmental Considerations



Tortoise Protection:

- Successfully relocated

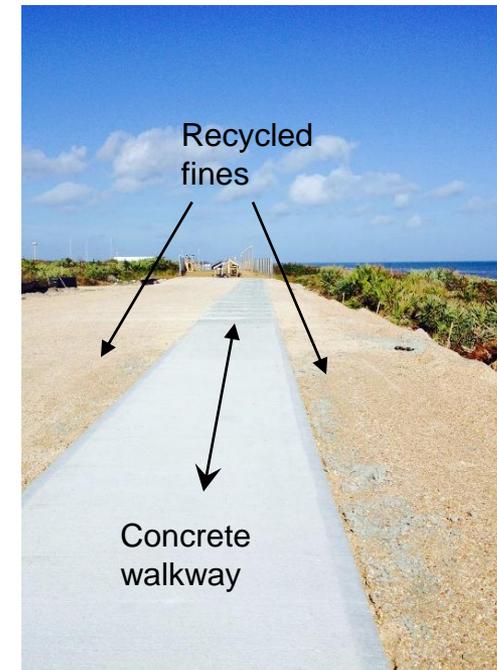


Reuse Materials:

- Reused recycled fines from the Crawler way rock for the fill and surface of the new section and new driveways

Safety:

- Installed a 6-foot wide sidewalk that spans the entire 900 feet to better secure the racks and stands
- Created a more secure environment for worker safety and stability



KSC Corrosive Environment



- **Natural Environment**
 - Ocean salt spray
 - Heat
 - Humidity
 - Sunlight
- **Atmospheric exposure can be time consuming, but the gold standard in lifetime prediction.**
- **Atmospheric exposure requires less labor as compared to most accelerated methods.**
- **Thus far, no accelerated test method can satisfactorily correlate to atmospheric exposure.**

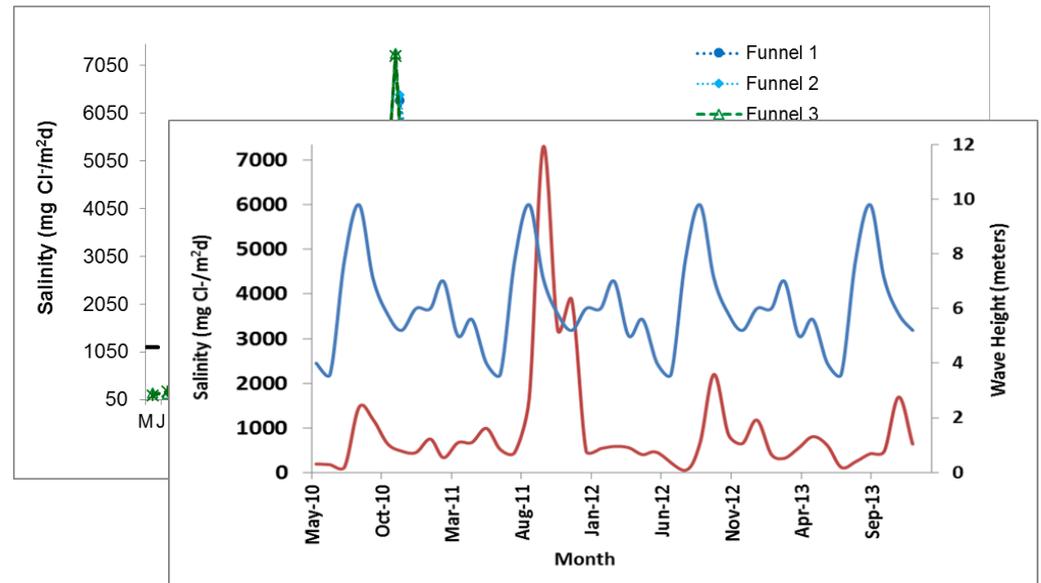
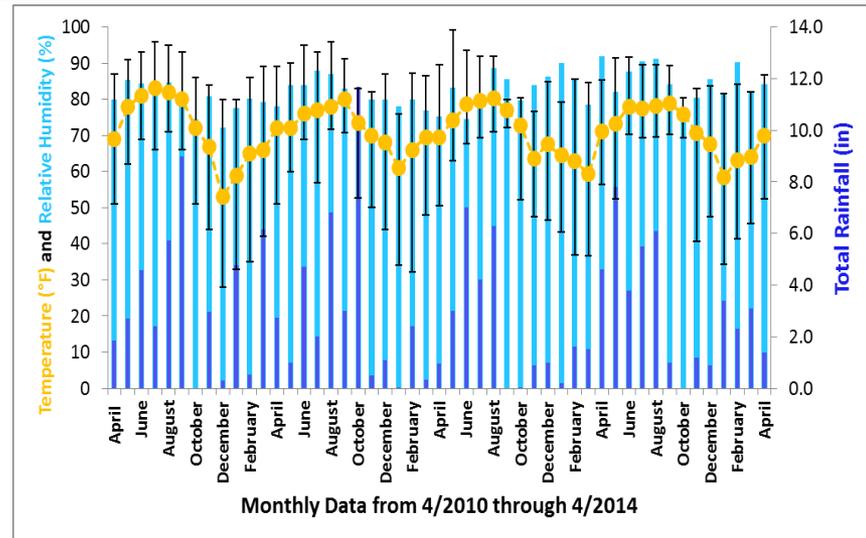


Monitoring of Natural Conditions



- **Temperature**
 - Ambient
 - Panel-specific
- **Relative humidity**
- **Precipitation**
- **UV exposure**
- **Wind (direction and speed)**

- **Chloride deposition**
- **Sulfur deposition**
 - NADP FL99
 - 1-2 mg/m²-d (very low)
- **Wave height**
 - NOAA buoy #41009
 - Average over 10 years

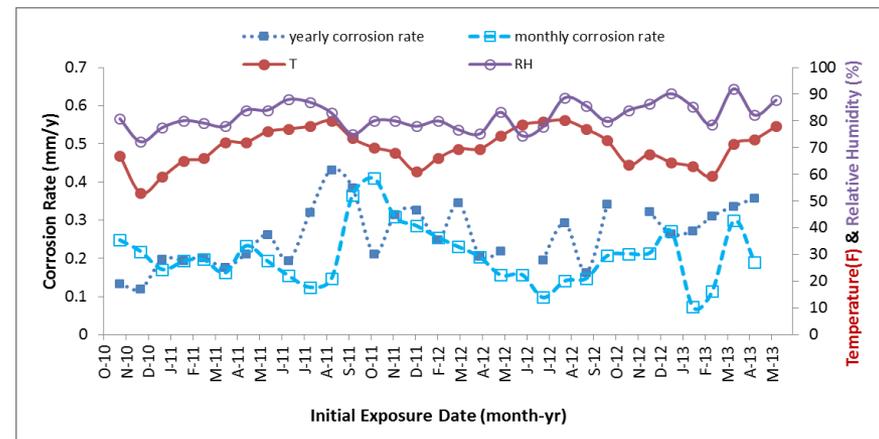
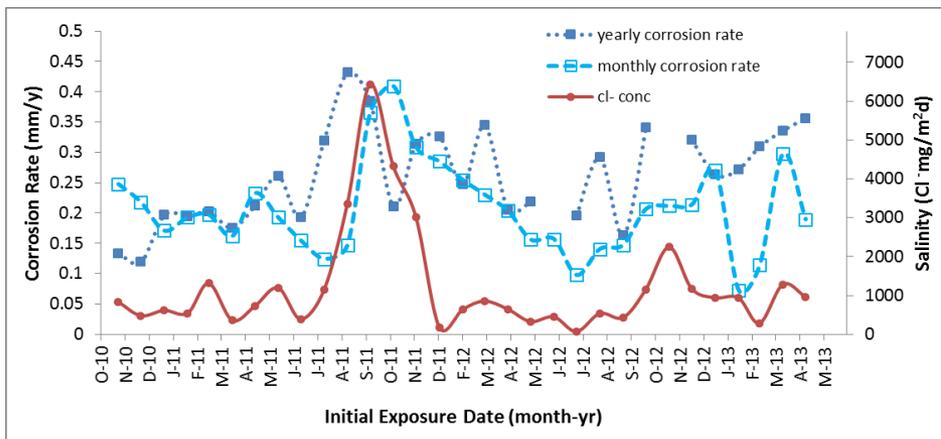
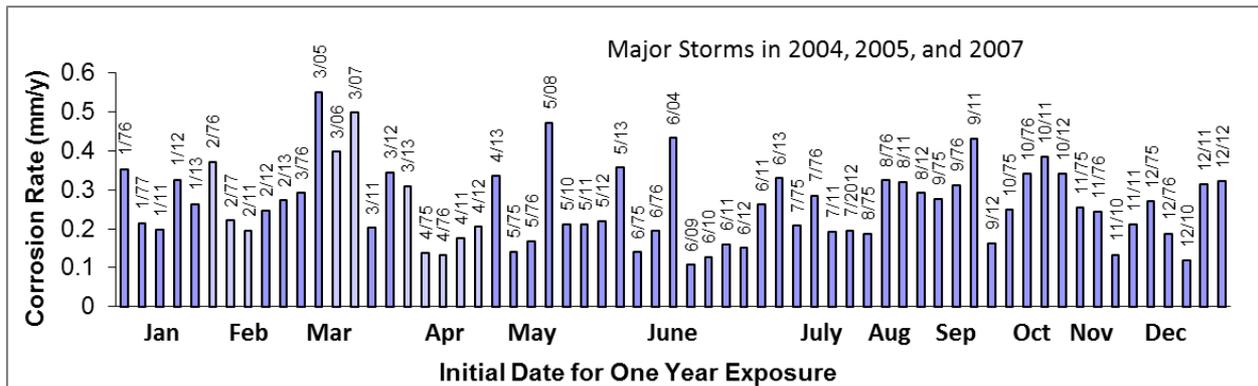


Monitoring Natural Conditions



- **Corrosion Rate**

- Weight loss with carbon steel coupons
- Ranges from 0.127 – 0.51mm/y
- Rates vary seasonally and as a function of chloride/precipitation



Collaborations and Partnerships



- **Wide range of organizations**
 - **Government**
 - **Military**
 - **International**
 - **Industry**
 - **University**
 - **Consortium**
- **Wide range of focus**
 - **Environmental**
 - **Aerospace**
 - **Aviation**
 - **Energy**
 - **Coatings**
 - **Metals**
 - **Ceramics**
 - **Polymers**
 - **Composites**
 - **Transportation**

Collaborations and Partnerships



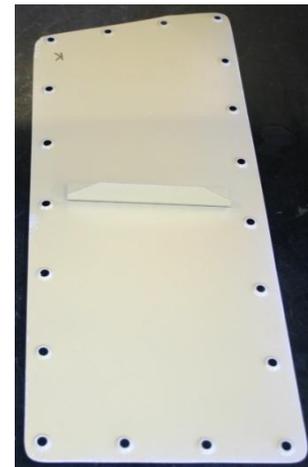
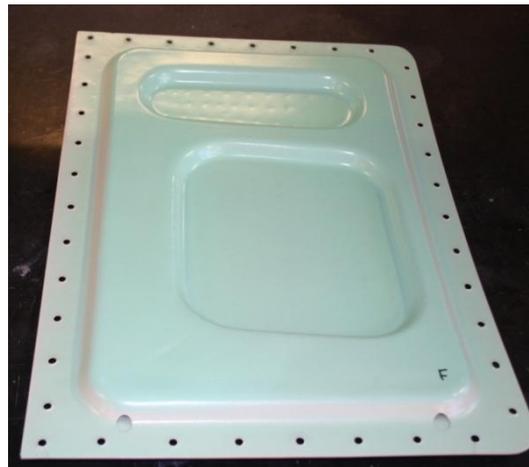
- **US Government**
 - DoD
 - Army
 - NAVAIR
 - NAVY
 - Marines
 - AFSC
 - Air Force
 - DOT
 - NIST
 - NOAA
- **Industry**
 - Automobile manufacturers
 - Industrial coatings manufacturers
 - AEROSPACE
 - Commercial
 - OEM
 - Business
 - Metal manufacturers
 - Solar panel manufacturers
- **International**
 - ESA
 - Canadian Govt
 - University (US and International)
 - Coatings manufacturers
 - REACH
- **Path Forward**
 - Support the 21st Century Launch Complex program and Commercial Orbital Transport Services
 - Continue to support material obsolescent projects that stem from REACH regulations

Collaboration Highlights



Collaborative project between NAVAIR, KSC Corrosion Lab, NASA TEERM and NASA WFF to evaluate hexavalent chrome free coatings in a real world environment

NASA's P-3 Orion Aircraft – Stationed at WFF



Collaboration Highlights



Collaborative projects with NASA, DoD, ESA,
Aerospace OEM, and Industry

- Hexavalent Chrome-free for Electronics
- Hexavalent Chrome-free Coating System Alternatives
- BR127 Chromated Bond Primer Replacement
- Citric Acid Passivation
- Environmentally Preferable Protective Coatings

All test programs include beachside atmospheric
exposure testing

Projects: 2000's - Present

NASA-only Projects



- All exterior coatings used at NASA's Kennedy Space Center are tested at the site
 - In addition to corrosion protective coatings, items such as metal test panels, launch vehicle components, heat shields, radar support structures, and window frames are tested at the site for corrosion resistance and material compatibility.
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- Corrosion Resistant Tubing for Space Shuttle Launch Sites
 - Chloride Rinse Additive Study
 - Electrochemical Evaluation of Alloys for Spaceport Design
 - Multi-sensor for Corrosion Prediction
 - Nano-scale Admixtures to Prevent the Corrosion of Rebar in Concrete
 - Corrosion Testing of Airplane Wing Structures
 - Liquid Applied Coatings for Imbedded Rebar
 - NASA (UB) - Two Hour Salt Spray Exposure of Strike Plate (Internal Angular) Part No. 1110ND051
 - VAB Roof Remediation Support
 - Hex Chrome Alternative Coating Testing
 - VAB Siding Coatings Testing
 - LC-39 Cryogenic Storage Tank Corrosion Control and Mitigation
 - Coatings Support for Exploration and Spaceport Design
 - Laser Depainting Study
 - Launch Coating Operations Support (NASA and CCAFS)
 - Self Cleaning Coatings
 - AR7 Coating Replacement
 - Polyimide Based Powder Coatings
 - In-Situ Phosphatization for KSC Coatings and Corrosion Preventative Compounds
 - TEERM and AFSPC Program Support
 - **Smart Coating Project**
 - Sintering Methods for Building a Lunar Launch Pad
 - Environmentally Friendly Coating Technologies
 - Low Volatile Organic Low Volatile Organic Compound (VOC) Topcoats for Thermal Spray Coatings
 - AR-7 Replacement
 - Refractory Materials Development, Test and Analysis Support
 - Continuous Flow Sintering System for Lunar Surface Stabilization
 - New Organic Zinc Rich Primer for Launch Structures
 - **Hexavalent Chrome Alternatives for Aerospace**
 - **Demonstration/Validation of Environmentally-preferable Coatings for Launch Facilities**
 - **GSDO Program Hexavalent Chrome Alternatives**
 - **Hexavalent Chrome Free Alternatives for BR127 Bond Primer**
 - **Environmentally Friendly Corrosion Preventative Compounds**
 - **New Accelerated Test Method for Corrosion Protective Coatings**
 - **Implementation of environmentally friendly corrosion preventative compounds into KSC ground processing use**
 - **Environmentally friendly post treatment/coating extender for improved asset sustainability for CPCs**

Projects: late 2000's - Present

Partnerships or Outside Customers:



- **Projects are part of collaborations or directly-contracted work**

- Naval Research Laboratory Support
- Army Research Lab/CTC Coupon Project
- Electrochemical Evaluation of Coatings (Private company)
- Effects of Chlorine Dioxide on Metals (Private company)
- Corrosion Resistance of Friction Stirred Welded Stainless Steel (Naval Research and Lehigh University)
- Powder Coating Evaluation (Private company)
- DoD Cost of Corrosion Study
- Naval Facility Support
- Rebar Corrosion (Private company)
- Fluorescing Coating Study (Private company)
- Weapons Group Coating Study (Private company)
- Chromate Coating Replacement for Aircraft Alloys (NAVAIR)
- Boeing (UB) – Evaluation of Corrosion Mitigation Techniques for Flight and other Critical Hardware using Citric Acid Passivation and fluorinated Polyether Grease
- Depainting Technology for Structural Steel (AFSPC and NASA)
- Polyurethane Replacement Coatings (AFSPC and NASA)
- NASA AP2 Program Support (NASA and US Air Force)
- Evaluation of USMC Hatch Covers
- US Army Vehicle Coating Study
- NAVAIR Support for Non-Chrome Coatings
- NAVAIR / China Lake
- Army Research Laboratory Coatings and Corrosion Research
- Validation of Citric Acid as an Alternative to Nitric Acid for Passivation of Stainless Steel (NASA and DoD)
- **U.S. Army Research Laboratory Coastal Atmospheric Exposure of Army Research Laboratory (ARL) Coated Panels**
- **U.S. Army Research Laboratory Transparent Armor**
- Gulfstream Jet Corrosion Study
- NTPEP Panel Exposure
- Solar Panel Evaluation
- Launch Coatings, Phase 2 for AFSPC
- Lockheed Martin Aeronautics Coating Study
- **Paint Manufacturer - Based Non-Chrome Coating Study**
- AFSPC Launch Coating Support- Eastern Range Coatings
- Magnesium Coating Study

NASA's Corrosion Technology Laboratory Team



CORROSION TECHNOLOGY LABORATORY

NASA KENNEDY SPACE CENTER



B.P. Pearman, M.R. Kolody, M.N. Johnsey, J.W. Buhrow, L. Fitzpatrick, J.X. Zhang, L.M. Calle, T.A. Back, S.T. Jolley, E.L. Montgomery, J.P. Curran, and W. Li

Summary

- **NASA Beachside Atmospheric Exposure Test Site has evolved into a world-class test facility**
- **Dynamic capabilities and personnel to accommodate the changing needs of a multitude of users**



<http://corrosion.ksc.nasa.gov/>