

National Aeronautics and Space Administration



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

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Overview



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



History – Site Establishment



- **1966:** First coatings testing located at the cape side launch pads during the Gemini/Apollo Programs for long-term protective coatings for atmospheric protection of carbon steel.
- **1969:** Beach Corrosion Test Site established with more controlled and cost effective ways to conduct testing on coatings for carbon steel in seacoast launch environment.
- **1981 – 1986:** Coatings resistant to hydrochloric acid from SRB's for the Space Shuttle Launch Program.

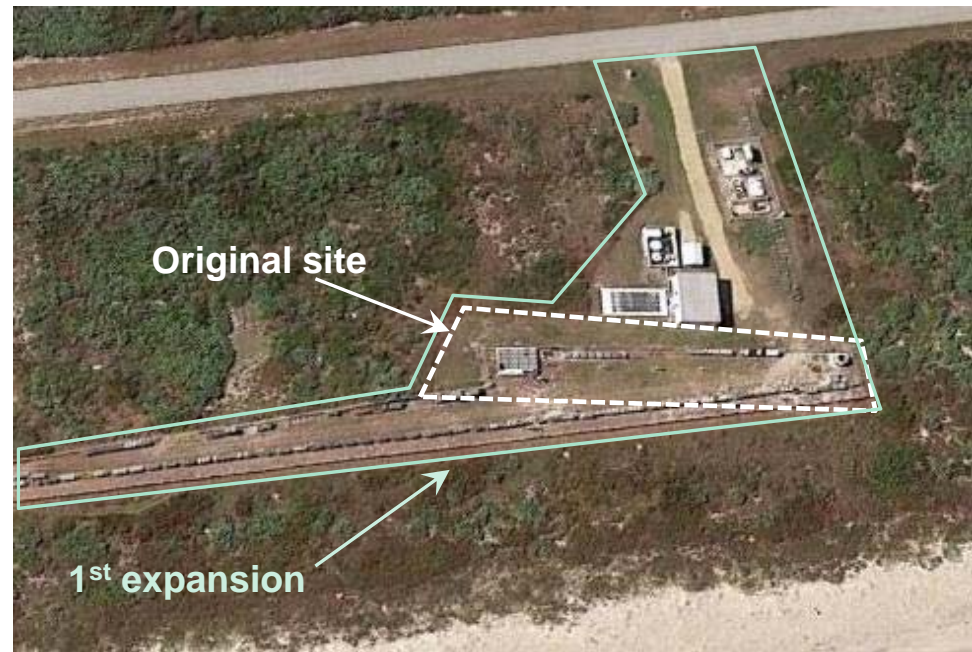
I am putting the original picture of the site here



History – 1st Expansion



- **1990's:** Environmentally friendlier coatings, zinc-rich primers and inorganic topcoats, silicone ablative coatings
- **1992:** Numerous studies at the site required an expansion to 600 feet parallel to the Atlantic Ocean
- 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
- New testing capabilities

Seawater submersion:

- Simulates natural tidal conditions
- 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 and external customers
- 900 total feet of exposure space parallel to the Atlantic Ocean
- 200 feet from the mean high tide line
- Accommodates specialty components



2nd Expansion: Environmental Considerations



Tortoise Protection:

- One successfully relocated

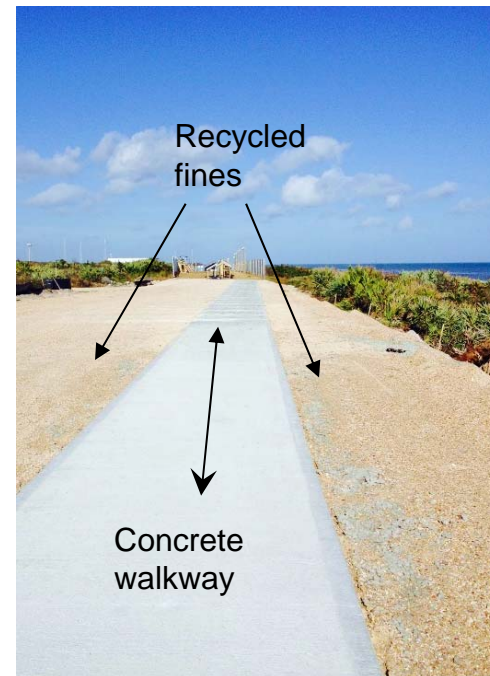


Reuse Materials:

- Reused recycled fines from the Crawlerway 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



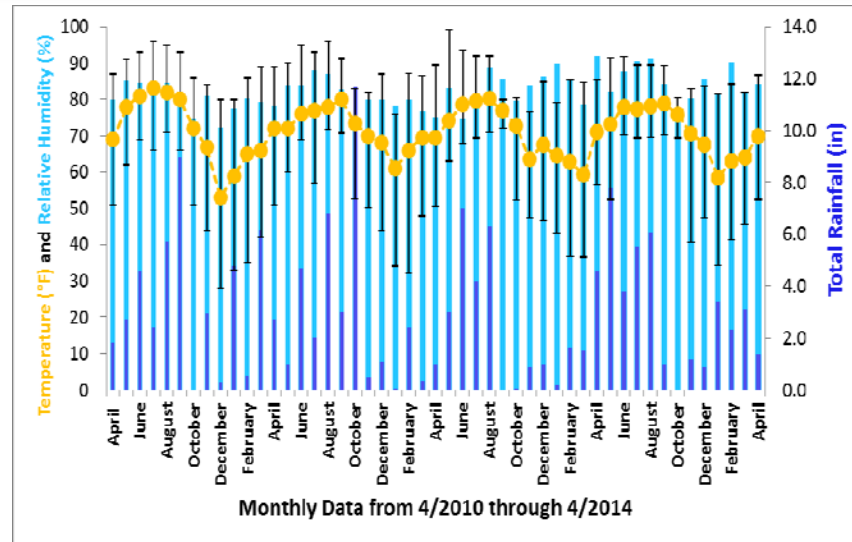
- **Natural Environment**
 - Ocean salt spray
 - Heat
 - Humidity
 - Sunlight
- **In addition, when launching:**
 - Acidic exhaust from Solid Rocket Boosters
 - Creates a 70 ton 0.1M HCl vapor cloud during heavy lift vehicle launch
- Atmospheric exposure is time consuming, but the gold standard in lifetime prediction.
- Thus far, no accelerated test method can satisfactorily correlate to atmospheric exposure.



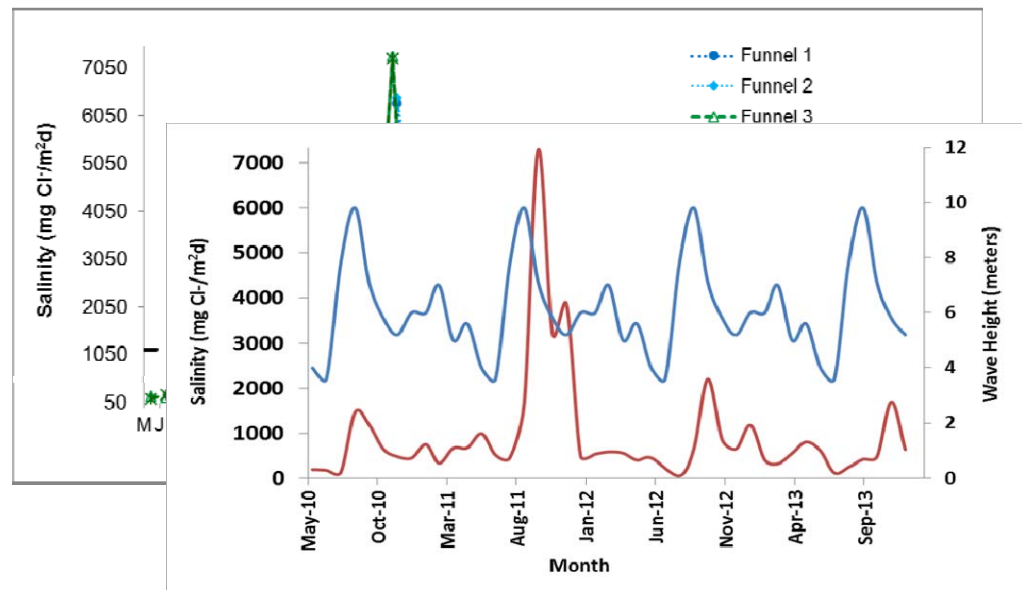
Monitoring Natural Conditions



- **Temperature**
 - Ambient
 - Panel-specific
- **Relative humidity**
- **Precipitation**



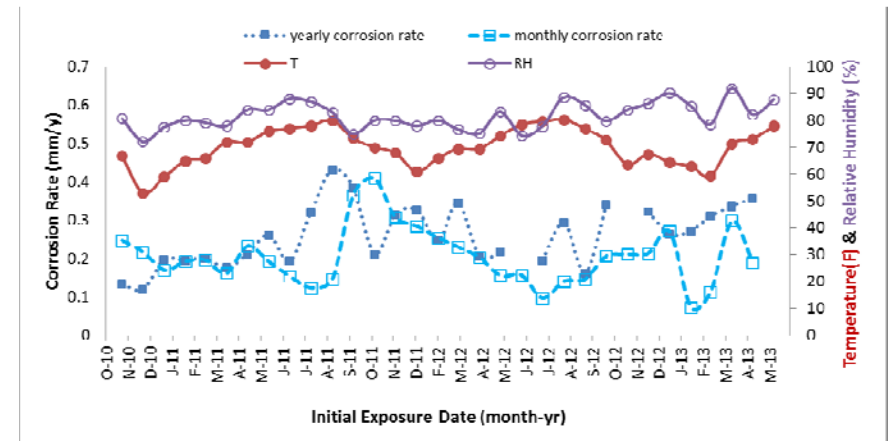
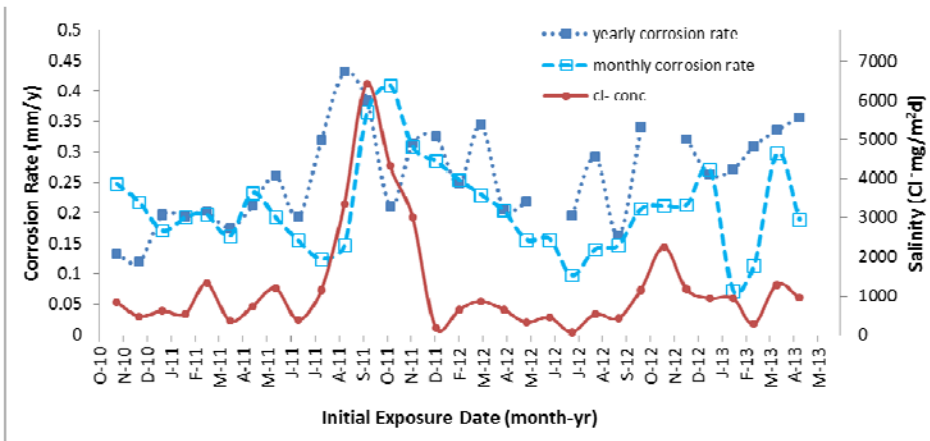
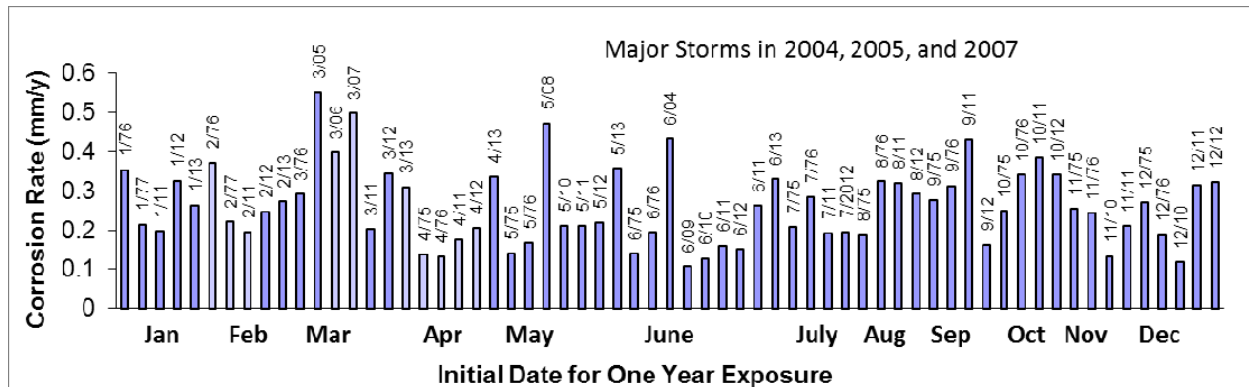
- **Chloride deposition**
- **Sulfur deposition**
 - NADP FL99
 - 1-2 mg/m²-d (very low)
- **Wave height**
 - NOAA buoy #41009
 - Average over 10 years



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
 - Aeospace
 - 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 efforts of REACH

Projects: late 90'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
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- Corrosion Resistant Tubing for Space Shuttle Launch Sites
 - Chloride Rinse Additive Study
 - Electrochemical Evaluation of Alloys for Spaceport Design
 - Multisensor for Corrosion Prediction
 - Nanoscale 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**
 - **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 90'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 Perfluorinated 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

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**



Acknowledgements