



# Corrosion Prevention and Control for DoD Facilities

*“A facilities optimization challenge”*

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\*Contract support to: OSD Corrosion Policy and Oversight

# Today's Discussion

## Corrosion Prevention and Control

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- Background of the Corrosion Prevention and Control (CPC) effort for Facilities
- Impact of Corrosion to DoD
- Partnerships and Resources
- Focus Areas
  - Identify Areas for Improvements
  - Strategies for Optimization
  - Progress

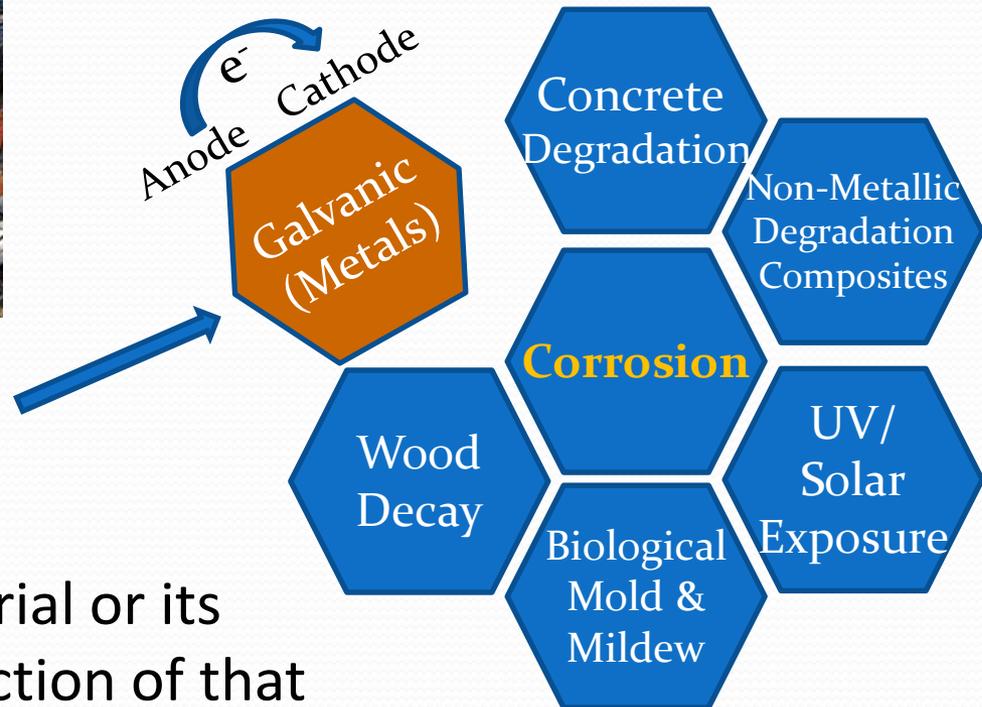
# Defining Corrosion



## *More than just "Rust"*

- **10 USC Sec. 2228**

The deterioration of a material or its properties because of a reaction of that material with its chemical environment.





# The Corrosion Challenge

## DoD Facilities

(9/30/2017)

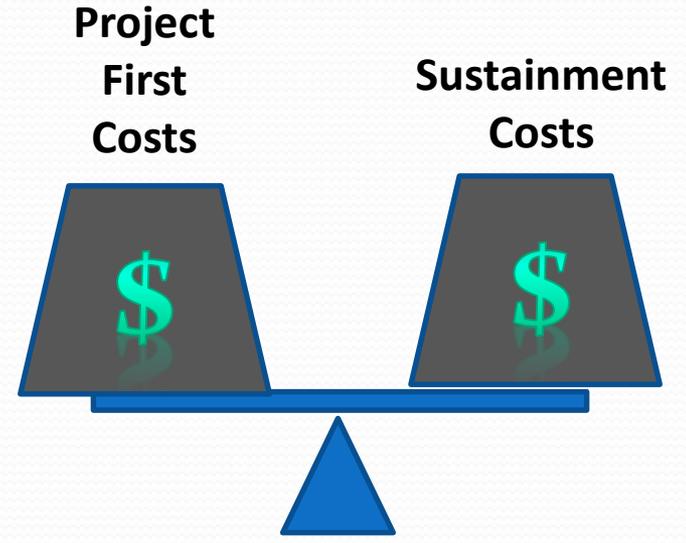
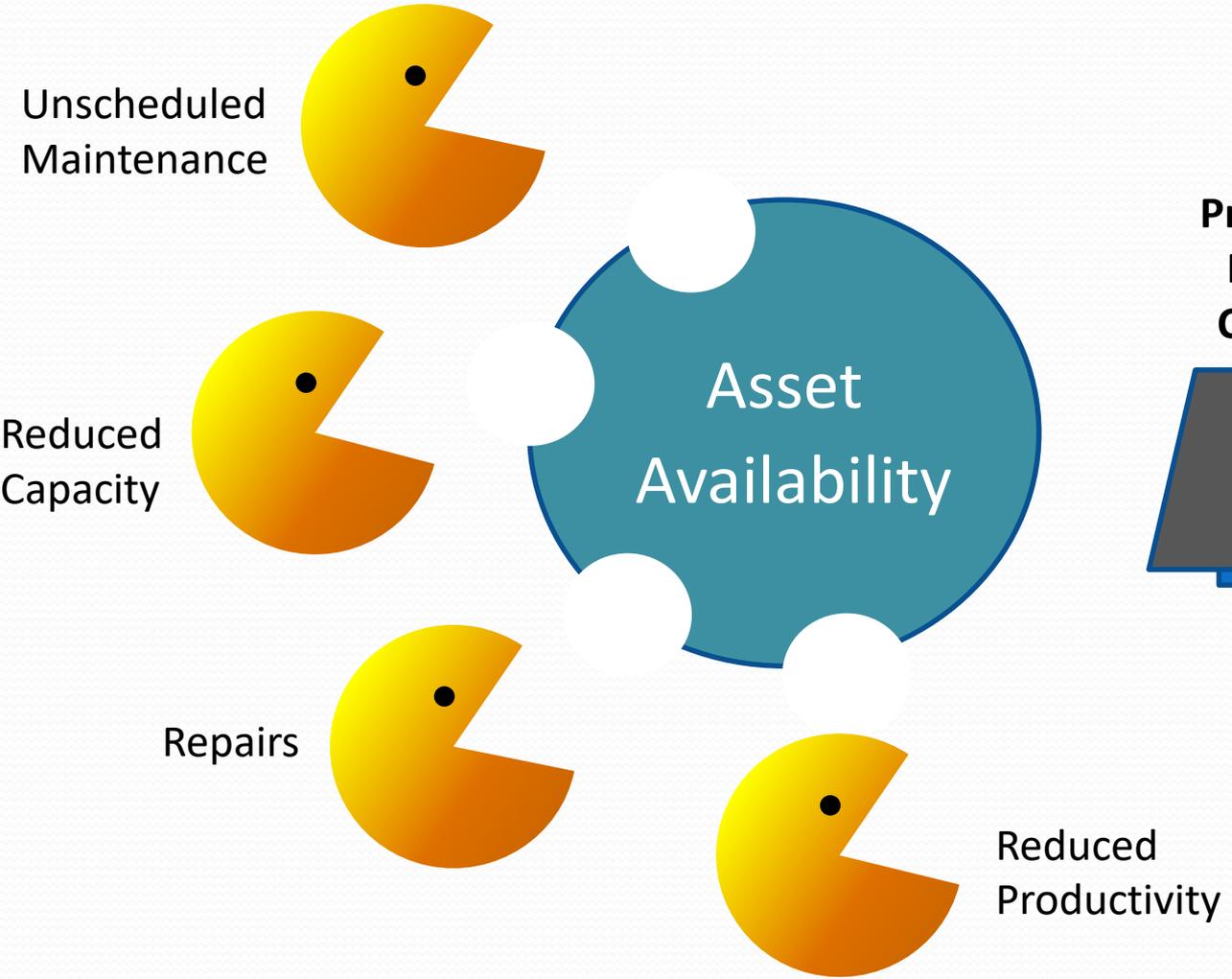
**585, 816 Facilities (Buildings and structures)  
+ Utilities, pipelines, roads, and ports  
at 4,775 Sites on 26.9 million acres of real property**

### Corrosion :

- Adds **\$2B** to annual facility sustainment costs
- Affects **mission and asset readiness** (availability/capacity/productivity)
- Affects safety, health, quality of life, and the environment



# The Optimization Challenge





# How we got here

## Law & Policy

- 10 USC Sec. 2228
- DoDI 5000.67

## Oversight

- Office of the Secretary Defense Corrosion Policy and Oversight (CPO) – *Management and Risk Assessment*

## Analysis & Data

- Facilities and Infrastructure Corrosion Evaluation Study
- DoD Facilities Maintenance Data

## Focus Areas

- Training, Education & Knowledge Development
- Technology Transition
- Criteria and Policy– Unified Facilities Criteria



# Partnerships and Resources

## Focus Areas

Training, Education & Knowledge Development

Technology Transition

Criteria & Policy

## Partners

- Military Corrosion Prevention and Control Executives
- Unified Facilities Criteria Program (ESEP/CP/DWG)
- DoD Subject Matter Experts NAVFAC/USACE/AFCEC
- Defense Acquisition University
- NIBS - WBDG
- Industry experts (NACE/SSPC/MPI)
- Private Architect and Engineering Consultants





# Steve Geusic

Leidos

Contract Support for OSD Corrosion Policy and Oversight

## Analysis and Strategy



# Partnerships and Resources

## Focus Areas

Training, Education & Knowledge Development

Technology Transition

Criteria & Policy

## WBDG – *A Good Fit*

- **Facilities Knowledge Center**
  - Resources – Training - Criteria
- **Unified Facilities Criteria**
  - DoD Subject Matter Experts
- **WBDG Reach**
  - Government
  - Industry
  - Private Architects and Engineers
  - Standards Orgs

# Focus Area

## Training, Education & Knowledge Development



Training, Education & Knowledge Development

### Areas of Improvement

- Access to **CPC knowledge across Facilities Life Cycle**
- Develop **Training opportunities and Competencies**

Corrosion Prevention and Control (CPC) Source

The screenshot displays the WBDG (Whole Building Design Guide) website, a program of the National Institute of Building Sciences. The page is titled "CORROSION PREVENTION & CONTROL (CPC) SOURCE". It features a navigation bar with links for "ABOUT", "SITE MAP", "CONTACT", "CREATE ACCOUNT", and "LOG IN", along with a search bar. The main content area includes a "RELATED LINKS" section with bullet points for "Non-Government Standards (Limited Access)", "Military Standards: ASSIST database", "Corrosion Prevention & Control (CPC) Source", and "Tri-Service Building Technology Vendor Portal". Below this is a section for "EPC RESOURCES" listing various articles and reports such as "Corrosion Prevention & Control (CPC) Source Overview", "CPC Source—Training", "CPC Source—Best Practices Identified During the Facilities and Infrastructure Corrosion Evaluation Study", "CPC Source—Environmental Severity Classification (ESC)", "CPC Source—The Importance of Including Corrosion in the Planning Process", "CPC Source—Acquisition Issues", "CPC Source—Criteria", "CPC Source—Design and Construction Issues", "CPC Source—Sustenance, Restoration, Modernization (SRM), Operations and Maintenance (O&M)", and "CPC Source—Competencies". A "KNOWLEDGE AREAS" section lists topics like "Cathodic Protection", "Corrosion Science", "Diagnoses", "Finishing", "Paint and Coatings", and "Pavements". Logos for the Department of Defense, US Army Corps of Engineers, and NAVFAC are also visible.



# CPC Source Page

## Corrosion Prevention and Control Source

### CPC Resources

CPC Overview

Training

Best Practices

Environmental Severity Classification (ESC)

Planning

Design and Construction

Sustainment (SRM)

Competencies

Corrosion Costs

Knowledge Areas (8)



**Corrosion Toolbox**

**ICCET (Metals)**

Wood Decay Hazard

Pollution



# CPC Knowledge Areas

## Knowledge Areas (Current)

**Cathodic Protection**  
**Corrosion Science**  
**Doors**  
**Fencing**  
**Paints and Coatings**  
**Pavements**  
**Utilities and Buried Structures**  
**Waterfront and Coastal Structures**

## Planned Knowledge Areas

**Drydocks, Marine Railways**  
**HVAC Systems**  
**Exterior Structures**  
**Concrete**  
**Mold, Mildew, Moisture**  
**Plants (Boiler, Water, Wastewater)**  
**Weapons Systems Support**  
**Integrated Logistics Support**  
**Tropical Engineering Content**



# CPC Training Modules

Length - (1 hour)  
 Voice over/transitions/test  
 Qualifies for Professional Development Hours (PDH)  
 Leveraging WBDG training courses with DAU

## WBDG Available

- ❖ Corrosion Fundamentals
- ❖ Cathodic Protection Basics
- ❖ CPC for Utilities and Buried Structures
- ❖ Waterfront and Coastal Structures

## On Deck

- ❖ Coatings Fundamentals (3 Modules)
- ❖ CPC Facilities Lifecycle (Design/Construction/Sustainment)
- ❖ Fuel Utilities and Storage Tanks
- ❖ HVAC Systems/Building Envelope



# Focus Area

## Technology Transfer

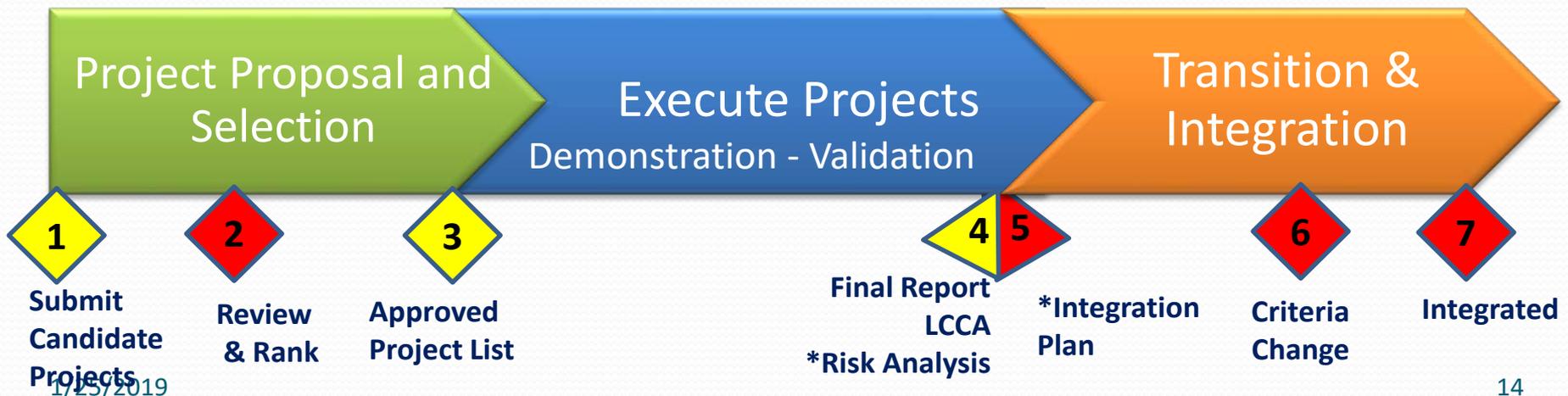


Technology Projects - Demonstration and Validation Phase (6.4)

### Areas of Improvement

- Greater focus on CPC technologies
- Better transition of technologies to criteria and DoD projects

**Outcomes:** Improved process (better communication, risk analysis at validation, and development of an integration plan)



# Technology Transfer

## Case Study



### Polysulfide Modified Novolac Epoxy Low VOC Coating for Interior Welded Steel POL Tanks

- **Goal** - Develop / evaluate Low VOC, easily repaired / maintained alternative for interior welded steel tanks for POL
- **Demonstration/Application**
  - Tested at 5 sites
  - 100% solids –no VOC concerns
  - 2 coats applied - Compared to traditional 3 coat epoxy systems



# Technology Transfer

## Results and Validation



### ● Results

- Durability - Greater abrasion and impact resistance
- Adhesion - 2x greater (+2000 psi vs 800 to 1000 psi) helps reduce under film corrosion
- Polysulfide acts as “ball bearings”
  - Elongation 5x greater than typical epoxy
  - Flexibility much greater than typical epoxy
- Lower porosity reduced moisture vapor transmission
- Bridges Cracks and pinholes
- Higher water contact angle therefor easier to clean (greater slickness)



# Technology Transfer Benefits and Integration



## • Benefits

- Better chemical and fuel resistance
- Longer Service Life – 50 years vs. 20 years
- Easier to maintain and clean
- Costs
  - Higher material costs
  - Reduced application cost – 2 vs. 3 coats
  - Lower life cycle costs



## • Integration and Impact

- UFGS 09 97 13.15 “Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks”
- 1540 Welded Steel tanks DoD wide
- Can be applied to concrete tanks with an additional primer sealer

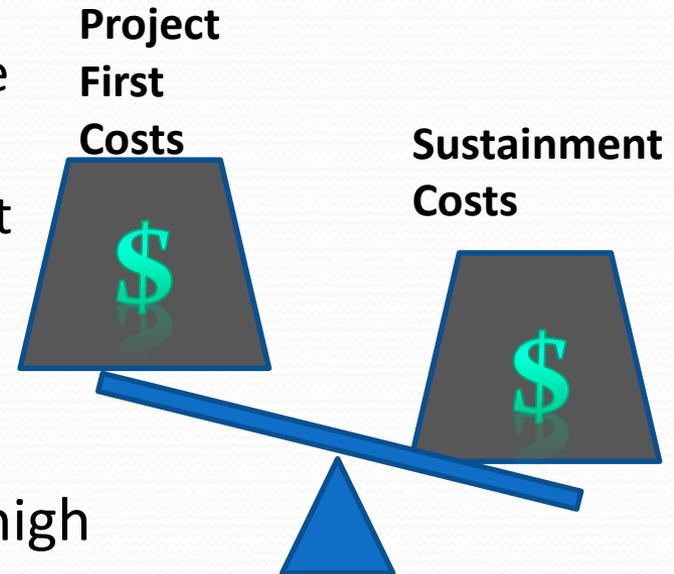
# Focus Area Criteria



**Extreme Option:** Require the use of the most corrosion resistant materials and coatings for all components and systems at all DoD locations.

## Areas of Analysis and Optimization

- Systems and components that have high sustainment requirements
- Environmental severity effects (installation location)
- CPC awareness and enforceability in design and construction





# Criteria CPC Gaps

## Areas of Analysis and Optimization

- **High Sustainment Components and Systems**

- DoD Maintenance Data - Corrosion related sustainment costs
- By system (Doors, Windows, HVAC, etc.)
- By location (installation)

- **Environmental Severity effects**

- There are increase costs associated with severe environments
- Need better integration of environmental severity in UFC and UFGS

- **CPC awareness and enforceability**

- How is CPC communicated to designers and contractors
- Project acquisition strategy – Design-Build
- Guide Specifications (UFGS) – How is enhanced CPC requirements triggered

# Corrosion Toolbox – ICCET

## Environmental Severity Development

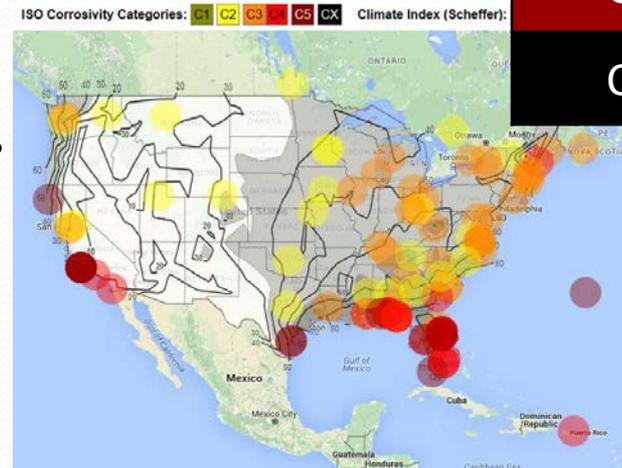


**Estimates ISO 9223 corrosion categories** *\*For metals*

### Algorithm

- *Mass loss data of metal coupons at DoD installations*
- *NOAA ISD-Lite database (Hourly Temperature, Relative Humidity/Dew Point)*
- *Three equations based on distance to salt water*
  - *Less than 1 mile*
  - *1 mile to 6 mile*
  - *Greater than 6 miles*

Category	Corrosivity
C1	Very Low
C2	Low
C3	Medium
C4	High
C5	Very High
CX	Extreme



# Corrosion Toolbox – ICCET Environmental Severity Classification



**User Inputs**

Site  
Coordinates: 40.0218, -74.2207  
Start year / month: 2010 / 1  
Range: 5 years  
Site is within 6 miles of saltwater: yes  
If yes, provide distance to saltwater: 4.4 miles  
measure distance in map  
Data Completeness 90 %

**Optional**

OK, find station and get values  
Weather Station  
Station: MONMOUTH EXECUTIVE AIRPORT  
Quality: 92.2%  
distance: 19.4 km

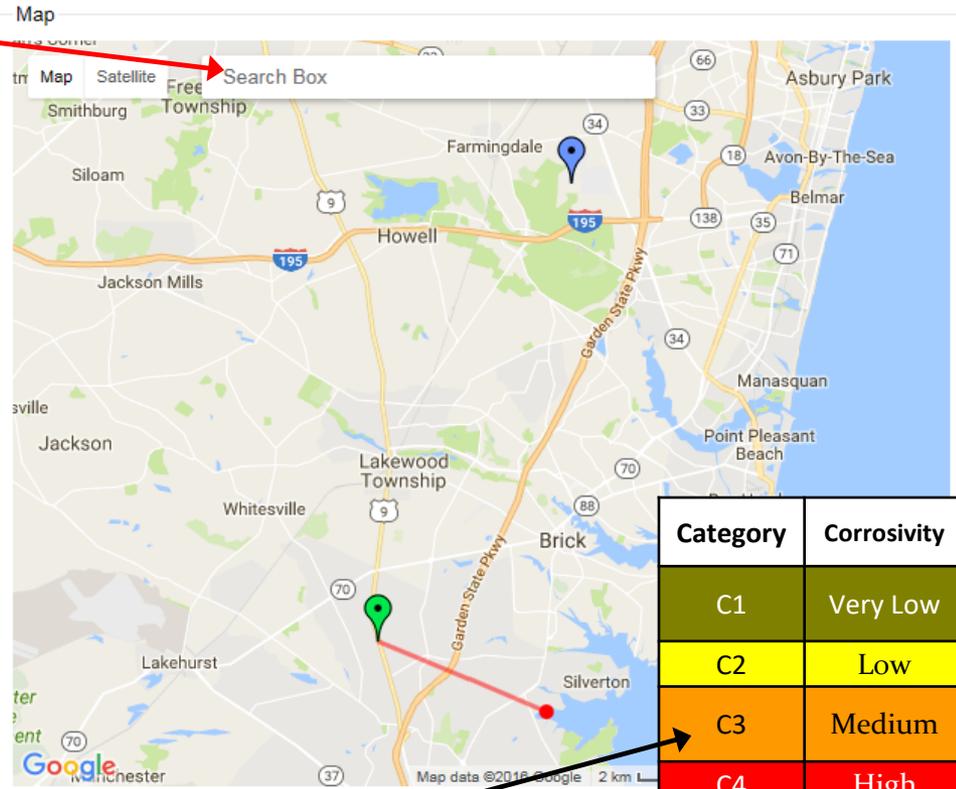
**Review**

Result  
Initial Model No 2  
Final Model No 2  
Estimated Steel Mass Loss: 29696  $\mu\text{g}/\text{cm}^2/\text{a}$   
Estimated ISO Corrosivity Category: C3

Log  
data parsed parsing data...  
542 kB of data downloaded downloading 2014 Weather Data...  
data parsed parsing data...  
542 kB of data downloaded downloading 2013 Weather Data...  
data parsed parsing data...  
473 kB of data downloaded downloading 2012 Weather Data...  
data parsed parsing data...  
501 kB of data downloaded downloading 2011 Weather Data...  
data parsed parsing data...  
496 kB of data downloaded downloading 2010 Weather Data...  
distance: 19.4 km  
Station: MONMOUTH EXECUTIVE AIRPORT  
finding nearest station...  
12827 stations found  
Bad Weather Data data (70%)  
data parsed parsing data...

**Estimated Mass Loss**

**ISO Category**



Category	Corrosivity
C1	Very Low
C2	Low
C3	Medium
C4	High
C5	Very High
CX	Extreme

# Environmental Severity Classification



UFC 1-200-01

20 June 2016

Change 2, 01 Nov 2018

Table B-1 ESC for US, Its Territories and Possessions

UNITED STATES, ITS TERRITORIES AND POSSESSIONS		
State/Territories/Possessions	Installation Master Name	ESC*
Alabama	Anniston AR Depot	C3 <sup>1</sup>
	Fort McClellan	C3 <sup>1</sup>
	Fort Rucker	C3 <sup>1</sup>
	Maxwell AF Base	C3 <sup>1</sup>
	Redstone Arsenal	C3 <sup>1</sup>
	Alabama National Guard	C3 <sup>1</sup>
	Alabama Reserves	C3 <sup>1</sup>
Alaska	Clear AF Station	C2 <sup>1</sup>
	Eielson AF Base	C2 <sup>1</sup>
	Fort Greely	C2 <sup>1</sup>
	Fort Wainwright	C2 <sup>1</sup>
	Alaska National Guard	C4 <sup>3</sup>
	Alaska Reserves	C4 <sup>3</sup>
	Joint Base Elmendorf-Richardson	C3 <sup>3</sup>
Naf Adak Ak	C5 <sup>3</sup>	

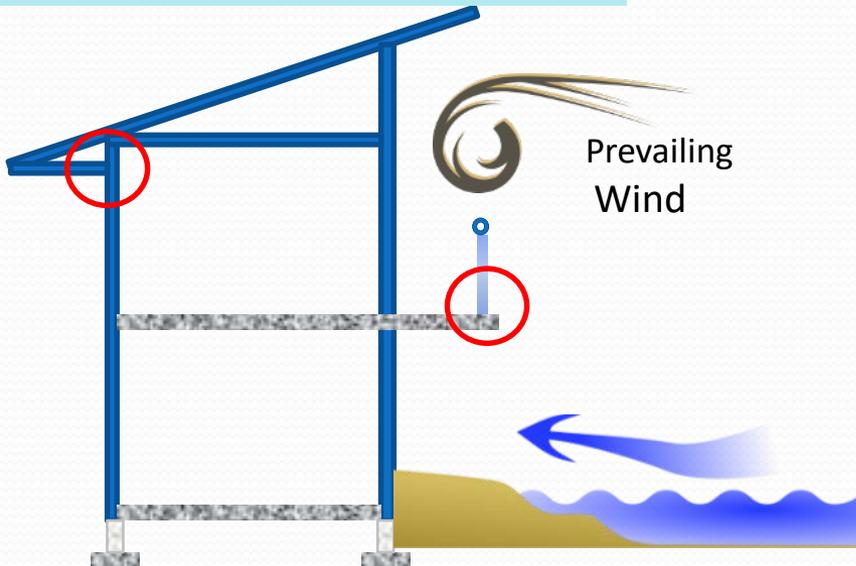


# ESC - “Just the Beginning”

**ESC alone cannot always correctly define the final corrosive condition:**

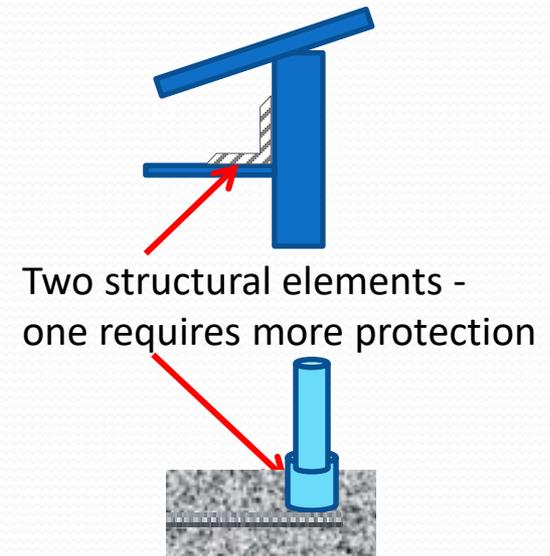
## Micro Climate & Exposure

- Structure Location
- Orientation
- Local Contaminants (Pollution)



## Element Conditions

- Location on structure
- Detailing
- Adjacent materials & connections





# Sherri McMillion

Naval Facilities Engineering Command, Atlantic

Application:

Design and Construction Criteria



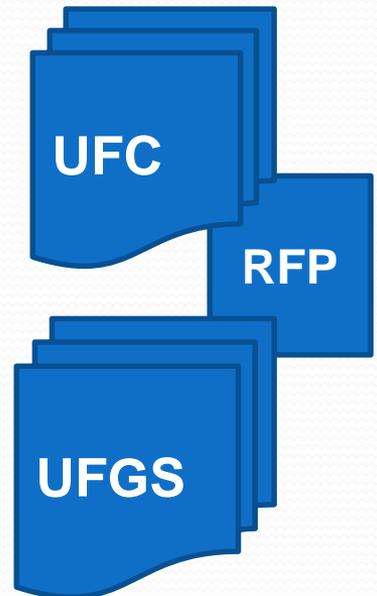
# Criteria Strategy

## Gaps and Data

- Corrosion Cost Data
- Environmental Severity (ESC)
- CPC Criteria
  - Awareness
  - Requirements
  - Triggers

Integration

Impact





# Facility Corrosion Cost Drivers

## Building Envelope

- Doors/frames/hardware - #1
- Windows/frames and storefronts
- Roofing
- Gutters and downspouts
- Metal Building systems

## Mechanical

- HVAC systems
- Plumbing (piping and fixtures)
- Water heaters
- Boilers

## Miscellaneous

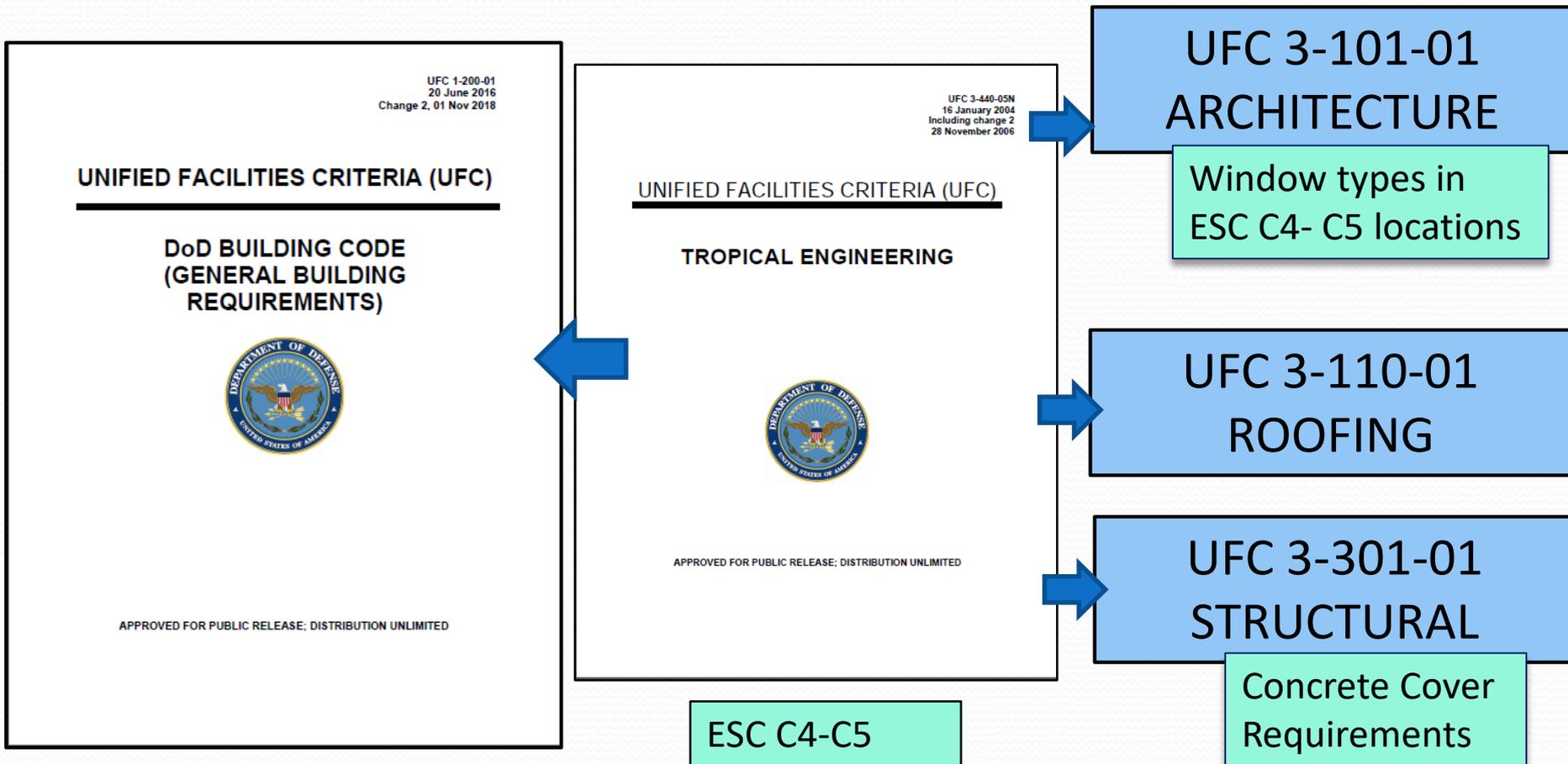
- Stairways
- Fencing
- Exterior railing
- Wastewater plants

## Electrical

- Panels and breakers
- Transformers
- Lighting fixtures



# Transition into Design





# Discipline Design UFCs

- **Defines Corrosion**
- **Design for ESC at the project location:**
  - UFC 1-200-01 Appendix B with ESC for each DoD Installation
  - ESC C3 -C5 require higher level of CPC in UFGS
- **Applies ESC factors to Interior locations:**
  - Bathrooms and locker rooms
  - Interior locations exposed to exterior or unconditioned
- **Defines humid locations as ASHRAE 90.1 01A, 1A, 2A, 3A, 3C, 4C, and 5C**



# UFC 1-200-01 Appendix B: ESC

UFC 1-200-01  
20 June 2016  
Change 2, 01 Nov 2018

UNITED STATES, ITS TERRITORIES AND POSSESSIONS		
State/Territories/Possessions	Installation Master Name	ESC*
<b>Colorado</b>	Pueblo Chemical Depot	C2 <sup>1</sup>
	Rocky Mountain Arsenal	C2 <sup>1</sup>
	Schriever AF Base	C2 <sup>1</sup>
	USAF Academy	C2 <sup>1</sup>
<b>Connecticut</b>	Connecticut National Guard	C3 <sup>1</sup>
	Connecticut Reserves	C3 <sup>1</sup>
	Nwirp Bloomfield Ct	C3 <sup>1</sup>
	Stratford AR Engine Plant	C3 <sup>2</sup>
	Subbase New London Ct	C4 <sup>3</sup>
<b>Delaware</b>	Delaware National Guard	C3 <sup>1</sup>
	Delaware Reserves	C3 <sup>2</sup>
	Dover AF Base	C3 <sup>2</sup>
<b>District of Columbia</b>	Naval Station Washington Navy Yard	C3 <sup>3</sup>
	Joint Base Anacostia-Bolling	C3 <sup>1</sup>
	Marbks Washington Dc	C3 <sup>1</sup>
	District Of Columbia National Guard	C3 <sup>1</sup>
	Washington DC Reserves	C3 <sup>1</sup>
<b>Florida</b>	Florida National Guard	C5 <sup>3</sup>



# UFC 1-200-01: Overall Design

- **Drawing Details:**

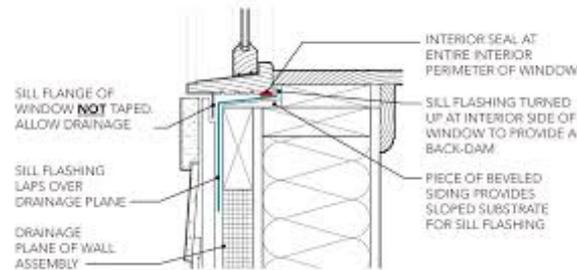
- Geometries preventing collection of debris and allowing water to drain
- Dissimilar metal isolation

- **Material Requirements:**

- **Coatings:**

- Galvanized steel with an industrial coating.
- Aluminum with an industrial protective coating or heavy duty anodized coating.
- Type 316L stainless steel or duplex stainless steels.

WINDOW FLASHING AT SILL





# Transition into UFGS

Applied ESC and other factors:

- Updated 35 UFGS sections – NOV 2018
- Selection of systems, components, materials

**Example: UFGS 08 71 00 DOOR HARDWARE**

## **2.5 FINISHES**

**NOTE:** Use stainless steel in bathroom and toilet locations and in project locations with Environmental Severity Classifications (ESC) of C3 through C5. See UFC 1-200-01 for determination of ESC for project locations.

# CPC Criteria Process

## Case Study



### Parking Structure – Washington Navy Yard Cast-in-Place Concrete

UFC 1-200-01  
20 June 2016  
Change 1, 01 Feb 2018

#### UNIFIED FACILITIES CRITERIA (UFC)

DoD BUILDING CODE  
(GENERAL BUILDING  
REQUIREMENTS)



APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

**Chapter 3**  
CPC General Requirements  
**Use ESC (App B)**  
**Evaluate Local Factors**

**Washington Navy Yard:**  
**ESC – C3 (Medium Corrosivity)**

Designer  
consider C4?

**Soil Corrosivity** → **Pile Foundation**  
**Pollution** → **Not Severe**  
**Exposure** → **Salinity at Waterfront**  
**Transfer of Road Salts**

# CPC Criteria Process

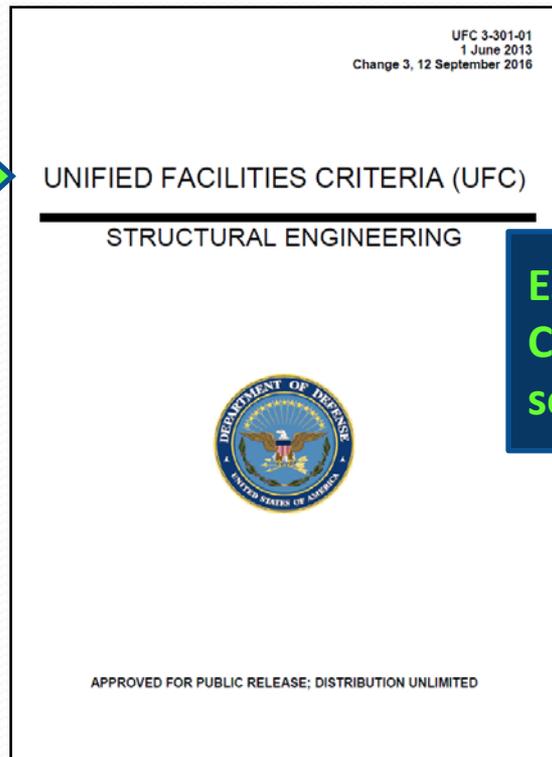
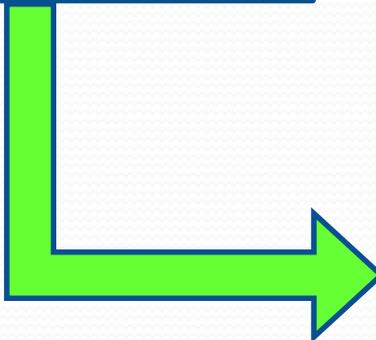
## Case Study



**ESC – C4 (High Corrosivity)**



**UFGS 03 31 29 Marine Concrete**  
**- Mix Requirements**  
**- Reinforcement coatings**



**ESC C3-C5:**  
**Concrete cover**  
**selection criteria**



# Next Steps:

- Transition Mechanical and Electrical Tropical Engineering UFC Requirements
- Prioritize UFCs and UFGSs to fully incorporate CPC requirements:
  - Doors and Windows
  - Concrete
  - Metal Buildings
- Perform Life-Cycle-Cost and cost impact analysis
- Incorporate feedback through Criteria Change Request (CCR) process



# Criteria Feedback - CCR

## UNIFIED FACILITIES GUIDE SPECIFICATIONS (UFGS)

UFGS Master Updated August 17, 2018; Posted August 23, 2018

Unified Facilities Guide Specifications (UFGS) are a joint effort of the U.S. Army Corps of Engineers (USACE), the Naval Facilities Engineering Command (NAVFAC), the Air Force Civil Engineer Center (HQ AFCEC) and the National Aeronautics and Space Administration (NASA). UFGS are for use in specifying construction for the military services. [Read More](#)



<b>DIVISION 03 - CONCRETE</b>	08-01-2018	 ZIP	
UFGS 03 01 00 Rehabilitation of Concrete	02-01-2018	 PDF    ZIP	
UFGS 03 11 13.00 10 Structural Cast-In-Place Concrete Forming	05-01-2014	 PDF    ZIP	
UFGS 03 11 19.00 10 Insulating Concrete Forming	05-01-2014	 PDF    ZIP	
UFGS 03 15 00.00 10 Concrete Accessories	05-01-2014	 PDF    ZIP	
UFGS 03 20 00.00 10 Concrete Reinforcing	05-01-2014	 PDF    ZIP	
UFGS 03 23 00 Stressed Tendon Reinforcing	05-01-2016	 PDF    ZIP	
UFGS 03 30 00 Cast-In-Place Concrete	05-01-2014	 PDF    ZIP	
UFGS 03 30 00.00 10 Cast-In-Place Concrete	05-01-2014	 PDF    ZIP	



# Criteria - Lessons Learned

## ESC's

- General Location
- Atmospheric
- Applies mostly to Metals

## Designer Responsibilities

- Micro Climate
- Exposure
- Element Conditions and Detailing

## Other Environmental Factors and Materials

- Better quantify and classify corrosive environmental factors such as UV, soil contaminants, insects, and pollution
- Application to non-metals – Timber, composites, concrete, etc.



# Way Forward

- Corrosion significantly impacts costs, availability, and safety of DoD facilities
- DoD is taking a comprehensive approach to reduce these impacts:
  - Policy and guidance
  - Training and knowledge deployment
  - Technology and tools
  - Criteria and specifications
- Goal is to achieve required availability and safety with optimal first cost and sustainment investments



# Questions?

# Thoughts?

