Design Modules for Corrosion Protection

F. J. Martin
Naval Research Laboratory
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Naval Research Laboratory, 4555 Overlook Ave., SW, Washington, DC, 20375

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As required by OSD AT&L Office of Corrosion Policy and Oversight, the Duncan-Hunter Act, and DoD Instruction 5000.2, each Service is now required to develop and employ a corrosion control strategy and materials development/implementation program to reduce the effects and costs of corrosion on DoD assets.

Corrosion is the Navy’s No. 1 Maintenance Problem.

![Corrosion Costs Pie Chart]

- Ships: $2.44B*
- Aircraft: $3.0B
- Ground Vehicles: $0.7B

$6.14B/Yr
Development Objectives

Design Modules for Corrosion Prevention (DMCP)

A new product development effort to allow platform designers and acquisition professionals to incorporate the corrosion knowledge base as inherent element of component and system design analysis

Scope:
• This effort addresses cross-platform corrosion cost drivers.
• This effort targets new solutions for platform specific corrosion challenges.
• This effort will enable corrosion informed materials selection and design to reduce total ownership cost (TOC) and to enhance operational readiness.
Design Modules for Corrosion Prevention

Technical Description:

- Develop an analytical tool that incorporates algorithms, architecture and automation to enable selection of materials, simulation of corrosion responses and rapid feedback cycle for initial design revisions
  - Provide working, integrated component corrosion analyses for Naval design communities
  - Achieve 80+% successful prediction of corrosion locations and severities (service life) on selected test case components
  - Demonstrate corrosion prevention recommendations on selected test case components
  - Demonstrate potential to reduce corrective action maintenance costs caused by poor design practices through improved design review

- The deliverable will be DMCP Software
  - Corrosion prevention and control (CPC) analyses software accessible to the design engineer
  - Transparency of CPC Score for improved technical oversight, design and mitigation
  - Risk analysis and mitigation through alternative material selection
**Design Modules for Corrosion Prevention (DMCP)**

**Problem Description:**
OSD mandate regarding corrosion protection input for all ACAT 1 programs (DOD Instruction 5000.2)

- Navy systems are constructed from a complex system of materials with widely varying corrosion properties
- Component and system designers do not have a sophisticated level of corrosion prevention knowledge
- Present design process relies on a dwindling number of corrosion subject matter experts reviewing details of relatively mature designs –inefficient and costly
- Corrosion costs the Navy $6.6B/yr
- Decades of knowledge exist without an efficient mechanism for delivery into the front of the design pipeline
- A robust and flexible conduit is needed to deliver known and developing corrosion knowledge into the design process for future Naval platforms
Design Modules for Corrosion Prevention

Rationale for Selection:

- Navy-wide corrosion issues share a common problem
  - Insufficient consideration for corrosion prevention in the acquisition cycle prior to Milestone B and C
- No technical solutions presently exist to address this challenge
- This EC product will move corrosion prevention inputs forward in the design process, increasing the efficiency and effectiveness of the corrosion review process for new components and systems
- The developed product will provide a future transition path for current S&T in corrosion mechanistic studies and related computational modeling being developed by ONR Code 333
Design Modules for Corrosion Prevention

Underlying Technology:

- **Existing technologies**
  - Historical knowledgebase
  - Design rules and best practices per Naval Ship’s Technical Manual (NSTM)
  - Cathodic protection models
- **Emerging technologies**
  - Navy Materials Database (NMATDB)
  - New materials and coatings
  - Active corrosion countermeasures
  - ONR-developed corrosion behavior models
Design Modules for Corrosion Prevention

Interaction with DMCP Module:
- System/Component Drawing
  - Geometry
  - Materials & Coatings
  - Component Connectivity
- Component Usage
  - Environment
  - Function
  - Maintainability

Corrosion Analysis Results
- Corrosion Risks
- Life Prediction
- Design Revisions

Act as a tool native to the CAD system environment
Assimilate results into overall corrosion risk score
Design Modules for Corrosion Prevention: Analytical Algorithm

Analysis Inputs:
- Parse CAD Model
  - Listing of all bulk materials, coatings, surface preparations, lubricants, and inhibitors applied to designed component
- Service Environment
  - Corrosion failure modes are down-selected based on service environment, list of materials, and known phenomena associated with these combinations.
- Corrosion Model Selection
  - Specific corrosion behavior models are invoked by the decision matrix. These behavior models dictate which properties of state must be tracked and modeled in component analysis.
- Build Geometric Models
  - Assembling the corrosion model based on properties of state that must be modeled. Automatic finite element meshing either for surface or for 3-D field distributions.
- Initial Condition Model
  - Corrosion risk analysis is conducted on a “time zero” corrosion damage model.
- Initial Results Plots
  - Results of time-zero analyses are plotted on drawn component surfaces. Output is presented to designer.
- Life Prediction Analysis
  - Progression of corrosion damage is followed through a time-stepping sequence in the corrosion model codes.
- Design Revisions
  - Results of corrosion risk analysis “what-if” scenarios are compared as alternate materials, coatings, or service environment conditions are considered.

DMCP
Design Modules for Corrosion Prevention

Technology Development Plan:

- Identify and resolve known and well established corrosion design flaws during design – prior to delivery in new a Naval operational platform
Developmental Considerations:

- Algorithms need to be properly validated by real-world component validation tests, under purview of subject matter experts
- Incorporating multiple mechanism stressors and properties (stress, temperature, etc.) in addition to corrosion
- Continued investment in basic scientific models with specific emphasis on robustness
- Model selection matrix needs to be based on service environments – not on esoteric materials science parameters