

Task 2.2, Task 1:

Title: *Measurements of Surface Environments Developed in Natural Atmospheres*

Objective: The overarching objective of this task is to better characterize the surface chemical environments that develop on materials exposed to natural atmospheres.

Approach: We will make measurements of a full range of chemical conditions will be made on inert surfaces (LexanTM), metal surfaces (steel, an Al alloy, Ag), and organic coating surfaces exposed at different microclimates. The inert surfaces will allow a characterization of the surface environment without the influence of the material surface reactions; essentially they will represent the environmental input to the corrosion process. Measurements of the surface environment on the reactive material surfaces will allow a determination of how chemical and electrochemical reactions due to the material surface influence the chemical environment and the subsequent corrosion. Measurement of surface pH will also be made using a flat surface pH probe. The final selection of locations for the surface environment exposures will involve input from all participants and will be part of the Research Plan to be delivered within 1 month after Contract Award. However, it is likely that three locations will be selected that span a range of corrosivity. Candidates include: the Battelle Daytona Beach site, site(s) accessible by Prof. Hihara of of the University of Hawai'i, the Atmosphere-Ocean Chemistry Experiment Tower at Tudor Hill, Bermuda, a rooftop at UVa, Appledore Island, Maine. The latter three sites have the advantage of the existence of extensive and comprehensive data on atmospheric chemistry, including the analyses of reactive trace gases and aerosols. Specific milestones are as follows:

- *Develop a method for the characterization of the chemistry of the surface environment.* A protocol for the capturing of surface environments from samples exposed to natural environments will be developed and validated. Collection methods will be validated by experiments in the laboratory and the field of calibration standards.
- *Measure surface pH and surface environment chemical composition on inert surfaces.* LexanTM will be the inert surface used for determining the input surface environment in the absence of interactions with the substrate at three locations selected. Species of interest include HCOO⁻, CH₃COO⁻, CH₃COO₃⁻, SO₄²⁻, Cl⁻, Br⁻, NO₃⁻, NH₄⁺, Na⁺, Mg²⁺, K⁺, Ca²⁺, and total organic C. These will be determined using either ion chromatography or capillary electrophoresis.
- *Measure surface pH and surface environment chemical composition on reactive surfaces.* Steel, an aluminum alloy, silver and an organically coated steel surfaces will be exposed at the three locations selected to determine the effects of environment/substrate interactions on the steady state environment. The same species will be of interest as for the inert surface.

Student Development Approach: A combination of graduate research assistants, post-doc and undergraduate assistants will be work on this project. Either an M.S. or Ph.D. degree will be obtained. Student participation at the Tri-service Conference and other forums will be expected.

Suggested Collaborator Role: Collaboration will be sought with Prof. Hihara at the University of Hawaii by which the effects of common mitigation strategies for atmospheric corrosion (*i.e.*, washing and clear water rinsing, sheltering) on the surface environments will be studied by providing sheltering for a subset of samples. USM will be involved in the selection of the painted surfaces to be exposed. USM would analyze the surface solutions from the polymers and would lead the interpretation of those results in terms of polymer degradation.

DOD Payoff: This proposed OUSD program will leverage and capitalize on the foundation established at UVa in surface and atmospheric environment characterization relevant to corrosion. Characterization of natural atmospheres remains in its infancy, and a lack of proper protocols that focus on capturing the relevant environments is a major roadblock to improvement. This work will result in the establishment of specific protocols for the collection and analysis of surface environments that can be used by OUSD and other in both failure analysis and corrosion modeling. The OUSD-enabled partnership among UVa, UH, and USM will also allow the enhancement of corrosion studies at USM in the polymers area while providing the means for linking the outdoor exposure experience and facilities at UH with the chemical characterization abilities at UVa.