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Top Stories

## Army Maximizes Hawaii's Natural Resources to Simulate Corrosive Environments

By Ben Craig

The Hawaiian Islands are known for their natural beauty. Active volcanoes, lush tropical forests, and sun-soaked beaches offer unrivaled appeal to North Americans. In addition to its surfing, snorkeling, helicopter tours, and hiking, Hawaii's beautiful weather attracts millions of visitors every year.

But something else about Hawaii's climate has the Army engaged in a protracted research effort to unlock valuable information to help the military improve readiness and reduce maintenance costs for Pacific-based weapons, equipment and facilities.

Since before World War II, the military has had a major presence in the Pacific. Military forces dedicated to performing Pacific Theatre operations are responsible for a region covering more than half the Earth's surface. The Pacific Rim region spans more than 100 million square miles. The region includes Hawaii, Alaska, Australia, China, Japan, Indonesia, Korea, India, and also encompasses the island nation of Madagascar. In such a vast region, military vehicles and equipment encounter a wide range of climates. Some of these climates are severely corrosive and others have seemingly unpredictable elements.

"Anywhere you have salt water, warm tropical temperatures, and moisture and humidity, maintenance is always going to be a challenge," said Robert Zanowicz, systems engineer with the Army Corrosion Office at the Army Research Development and Engineering Center (ARDEC). In Hawaii, where the Marines, Coast Guard, and other military Services have a noticeable presence, the impact of the climatic conditions on military's assets is quite substantial. "The materiel, the weapons, the armaments, and also the infrastructure take a pretty heavy toll in terms of corrosion." But even for Pacific Rim regions where the climate is not tropical, such as Alaska (a sub-arctic climate), South Korea (a temperate climate), and Japan (mostly a coastal temperate climate), corrosion is a significant problem.

The Army has pursued a major research effort since 2003 to develop correlations between climates and the corrosivity of various materials that are used (or will be used) on military equipment and vehicles. This effort, known as the Pacific Rim Environmental Degradation of Materials Research Program (PREDMRP), is based on a systematic and cost-effective approach to evaluating the corrosion performance of materials in many climates found in the Pacific Theatre. This approach takes advantage of the natural wonders of the Hawaiian Islands, as well as the research facilities at the University of Hawaii.



*The Army's Pacific Rim-based corrosion testing takes place in a tropical marine microclimate. Pictured is a corrosion test yard on Coconut Island, Hawaii. Photo by Ryan Sugamoto, University of Hawaii.*



*An Army test yard at Lyon Arboretum in Hawaii tests for corrosion in the rainforest microclimate. Photo by Ryan Sugamoto, University of Hawaii.*

It is the ideal location for such an effort, contends Zanolowicz, who is the government technical lead for the research program. "All of the climatic conditions in the Pacific Theater are found in the Hawaiian Island chain," he said. Instead of measuring and observing material-environment interactions in all of the distant locations where the military is located within the Pacific Theatre, the program has strategically located test units in the various microclimates of Hawaii, where the data are close by and can be easily retrieved.

### **Taking Advantage of Hawaii's Microclimates**

Hawaii's microclimates include frozen alpine, temperate, rain forest, desert, marine, volcanic (which produces acid rain), industrial, and agricultural. These starkly different microclimates exist within mere miles of each other. The island of Oahu, for example, has an arid microclimate on the slopes of the Diamond Head crater, while a rainforest is only five miles away, in the Manoa Valley.

According to the Pacific Rim program's principal investigator, the island chain's range of climates is due to its geographic eccentricities. "Hawaii has one of the most spatially diverse climates on Earth because of the topography and the winds that come on shore," said Lloyd Hihara, a professor of Mechanical Engineering at the University of Hawaii at Manoa. The spectrum of climates present on Hawaii represents those that might be found on a major continent. "What we do is use the microclimates in Hawaii and the fact that they are all relatively close together to our advantage to test materials under a wide range of conditions," Hihara said.

Under the Army's current and previous Pacific Rim research programs, the University of Hawaii has placed corrosion test racks containing an assortment of materials and material system configurations out in the microclimates to measure how various materials interact with the diverse range of environmental conditions. "Placing these corrosion test yards in these microclimate areas sort of mimic those climates that are found in Korea, Japan, and Alaska, so on and so forth," said Zanolowicz.

There are several other groups performing atmospheric corrosion testing, but this program is fundamentally different, Zanolowicz said. "The part of the Pacific Rim program that stands out comprise the corrosion test yards in Hawaii, in that they expose specimens, not only to the standard marine climate, but to those of rainforest and volcanic conditions, which are also extremely aggressive. I do not think that anyone either in industry or in the military has this unique capacity to atmospherically evaluate corrosion the way the Army and UH are doing it," he said.



*A test yard at Volcanoes National Park in Hawaii tests for corrosion in the volcanic microclimate. Photo by Ryan Sugamoto, University of Hawaii.*

Each test unit has several different sensors that measure all of the climatic conditions that the materials are withstanding during the course of the months while they are in the field. The sensors measure temperature, relative humidity, wind, ultraviolet (UV) rays, chloride content in the air, and time of wetness.

Corrosion data is being collected on materials that are used on current Army systems or will be used for future systems. For example, one of the classes of materials being studied is metal-matrix composites (MMCs). Because the Army is moving toward becoming a lighter, faster, and more deployable force, MMCs will play a critical role in enabling this transformation. However, the corrosion properties of these materials are not well documented, particularly in Pacific Theatre climates.

In addition to field testing, the University of Hawaii is performing electrochemical laboratory studies, as well as accelerated corrosion tests using weathering equipment. Data generated from these studies can be compared to that collected from the field to see how the accelerated laboratory tests correlate with real-world conditions.

"What we want to do in the long-term is take the information we generate under these programs and integrate it into something that we can use to come up with predictive scenarios and predic