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Army Secretary Approves the Formation of a New Army Corrosion Board

New leadership team and impending regulation is expected to strengthen the Army's corrosion prevention and control program.

By Cynthia Greenwood

On April 7, 2014, Secretary of the Army John McHugh approved the formation of an Army Corrosion Board that will advise and assist the Army Corrosion Executive Wimpy Pybus in the implementation and oversight of the control and prevention of corrosion on Army equipment and infrastructure.

Photo courtesy of Robert Goebel, ArmyAviation.com

Photo courtesy of Robert Goebel, ArmyAviation.com

Pybus, who has served in his post since 2009, will chair the new Army Corrosion Board. As chair, Pybus will cooperate and coordinate with other Army Corrosion Board members in the planning, programming, budgeting, execution, and evaluation of the corrosion program. In granting approval of the new board charter, Secretary McHugh has requested that milestones of success, and metrics by which we will measure those successes, be identified," said Wimpy Pybus, Army Corrosion Executive.

Along with Pybus as leader, the board will consist of one or more members each from the Office of ASA (Installations, Energy, and Environment); the Office of the Deputy Chief of Staff; the Office of the Assistant Chief of Staff for Installation Management; the U.S. Army Forces Command; the U.S. Army Training and Doctrine Command; the U.S. Army Materiel Command; the Army National Guard; the U.S. Army Reserve; and other offices as required. "The presence of high-ranking generals and senior executive service members on the board also indicates that they have committed themselves to address this issue," said Roger Hamerlinck, senior acquisition policy specialist and Pybus's principal point of contact on the Army Corrosion Board.

According to Pybus's team, the establishment of the board’s charter indicates that the Secretary of the Army is committed to recognizing the importance of the Army's corrosion program. “This charter shows that Secretary McHugh believes this program is critical enough to set aside resources in order to work these issues at a very high level," said Hamerlinck.

"By establishing this new board, the Secretary of the Army has also signaled an interest in bringing greater attention to the Army’s corrosion prevention program," Hamerlinck added.

"We commend the Secretary of the Army for taking this action and look forward to seeing what the metrics will be for declaring success and/or failure," said Daniel J. Dunmire, director of the DoD Corrosion Policy and Oversight Office. "We wholeheartedly support the Army's action and look forward to its success."

The New Board's Mission and Strategy


Photo by Sgt. Roberto Di Giovine, U.S. Army

Led by the Army corrosion executive, the Army Corrosion Board must ensure that corrosion prevention and control is addressed appropriately across all Army domains, including doctrine, organization, training, materiel, leadership, and education, as well as personnel, facilities, and policy.

Hamerlinck's office is in the process of drafting a new regulation for the Army Corrosion Prevention and Control Program as it pertains to equipment and facilities. "The basis of this regulation is to be founded upon the signed board charter. Additionally, within a month or so, you will see a draft strategic plan for comment and concurrence," Hamerlinck said.

"Within the published statutory and regulatory [requirements] of the Department of the Army, this new board may change the way we interface and do business with DoD's Corrosion Policy and Oversight Office," said Hamerlinck. "Details of these changes will be included in our new regulation, the strategic plan, and results of the first Army Corrosion Board meeting slated for July."

How the New Board Benefits the Army and Warfighter

The new regulation will establish a program specifying what the Army has to do to establish a CPC program. It will require every Army command, Army service component command, and direct reporting unit to establish a corrosion program within its own command.

"Our goal is not to recreate existing policies,” Hamerlinck said. "It's to put an umbrella policy on top to show what a corrosion program consists of and to require one within each command. Thus, each sub-command should do a SOP (standard operating procedure) or desk book. That’s what we’re doing with this regulation."

"Now that the Secretary of the Army has formally chartered this board, we're going to be able to get its members together and look at higher strategic level issues with corrosion prevention and control," Hamerlinck added. "Along with his approval the Secretary of the Army has given us all some guidance, as well. He wants to see milestones of success and metrics identified by which we will measure those successes."

Implementing the Charter

Photo courtesy of Robert Goebel, ArmyAviation.com

According to the charter, the Army Corrosion Board will advise the Army corrosion executive in fulfilling the many roles and responsibilities as prescribed in Section 903 of the fiscal year 2009 National Defense Authorization Act (NDAA) as he coordinates department-level CPC program activities with the Army and the Office of the Secretary of Defense, program executive officers, and relevant major commands. In addition, the board will support the Army corrosion executive as he implements corrosion prevention and control in all manner of policy and guidance pertaining to research, development, testing and evaluation; system acquisition and production; standardization programs; logistics; and in the design, construction, and maintenance of Army infrastructure.

The Army Corrosion Board will meet formally once a year. "The board will be supported by an Army Corrosion Integrated Product Team (IPT), and that will be made up of representatives of each board member's organizations," said Hamerlinck. "The IPT members will meet as often as necessary, but a minimum of four times a year."

Two years ago, Pybus's office determined that an overarching regulation that united all necessary policies for maintaining and acquiring equipment and facilities. Hamerlinck discussed why the regulation is needed: "We decided that there's equipment maintenance policy, facilities policy, some acquisition policies, but there is no policy that brings it all together as a 'program'. So we decided we needed to publish a regulation as an overarching document making this a formal Army program." While Hamerlinck expects a draft regulation to be ready by fall 2014, the process of approving and editing the document may take two to three years.

The board's charter lasts two years, and is eligible for review and renewal prior to the end of each term. Pybus noted that the charter "served to establish a more formal process for communication and coordination among member organizations. Its intent is to reduce the Army's cost of corrosion overall, through improved accountability, efficiency, and consistency in the addressing of CPC (corrosion prevention and control) issues," he said.

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Whole Building Design Guide Unveils a Compendium on Corrosion Mitigation

By Cynthia Greenwood

Since May 2014, the [Whole Building Design Guide (WBDG) found at WBDG.org](), has unveiled a massive compendium of resources on corrosion mitigation. WBDG.org, sponsored by the National Institute of Building Sciences, is a far-reaching, Web-based reference portal that provides government and industry experts with easy access to building-related guidance, criteria, and technology.

Now, for the first time, building planners, designers, constructors, and maintainers can locate corrosion-related knowledge, codes, guidelines, criteria, best practices, and training material under the WBDG's Corrosion Prevention & Control (CPC) Source page compiled by Joseph Clay Dean, an engineering expert formerly with NAVFAC (Naval Facilities Engineering Command). Dean worked with analysts Paul Chang and Nick Silver to develop the source materials on behalf of the Corrosion Policy and Oversight Office Director Daniel J. Dunmire.

"We hope the consolidation of information into the Corrosion Source page will serve as a useful knowledge source related to design criteria, system design, material selection, production processes, and corrosion prevention strategies, so that building experts at all levels are equipped to make good design decisions that promote long building life and sustainability," said Dunmire.

The Corrosion Prevention & Control Source page includes an introduction featuring a definition and clarification of how building practitioners should define "corrosion", along with a discussion of corrosion's physical and monetary impact on DoD. The Source page introduces DoD's policy and guidance related to the management of facilities and infrastructure, while also defining the importance of identifying the proper corrosion prevention and control requirements in all phases of the construction and maintenance of military facilities and infrastructure. Also included is a section to assist the SRM (Sustainment, Restoration, and Modernization) Engineer with problem solving and sustainability related to corrosion. The section also reviews issues and criteria that experts should consider during the construction and commissioning phases of a project, as well as issues to consider during sustainment planning.

Within the CPC Source - Criteria section of the Corrosion Source page, Dean notes that "corrosion prevention and control is not comprehensively addressed in one specific area of criteria, nor is there a one-stop shop for corrosion-related criteria." Overall, determining the proper CPC guidance can be a complicated process for those who design and construct DoD facilities and infrastructure. In this section, Dean distinguishes among three main criteria categories that are relevant to the corrosion prevention and control of facilities: the Unified Facilities Criteria (UFCs), Unified Facilities Guide Specifications (UFGSs), and Performance Technical Specifications.

The Corrosion Source page links readers to the results of the congressionally mandated Facilities and Infrastructure Corrosion Evaluation Study, released by the DoD Corrosion Office in 2013. Dean explores Best Practices and Lessons Learned from the study so that facilities and infrastructure experts can benefit from the CPC practices of 30 installations involved in the study.

Readers of the Corrosion Source page will also find information about technology research projects funded by the DoD Corrosion Office for the improvement of facilities and infrastructure. These projects include advanced coatings and processes and new approaches to cathodic protection, among many others. A section dedicated to relevant codes, standards, and guidelines is also included in the Corrosion Source material. A page dedicated to CPC Source – Training reviews a variety of training and educational material available to facilities and infrastructure personnel.

The National Institute of Building Science makes the WBDG Web site available to the building community with the support of DoD, the NAVFAC Engineering Innovation and Criteria Office, the Army Corps of Engineers, the Air Force, the General Services Administration, the Department of Veterans Affairs, NASA, the Department of Energy, and the Sustainable Buildings Industry Council.

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Young Researchers Credit their Career Advancement to DoD's Technical Corrosion Collaboration

By Cynthia Greenwood

Christine Sanders is a research chemist at the Naval Research Laboratory in Key West, Florida.

As the Technical Corrosion Collaboration (TCC) enters its seventh academic year under the aegis of the DoD Corrosion Policy and Oversight Office, at least five young scholars and professionals from Ohio State University, University of Akron, and University of Virginia (UVA) credit their academic success and subsequent career advancement to the mentoring and subsidies they received through the TCC.

"When we fund research projects at new universities and institutions who become part of the TCC, we expect them to collaborate to further the technology innovations we need to maintain and sustain DoD aircraft, ground vehicles, and facilities," said Rich Hays, deputy director of the DoD Corrosion Office. Counting this year's winning proposals, 16 TCC-member institutions comprising eight public universities, four military academies, two military graduate schools, and two research institutes have demonstrated a commitment to this goal.

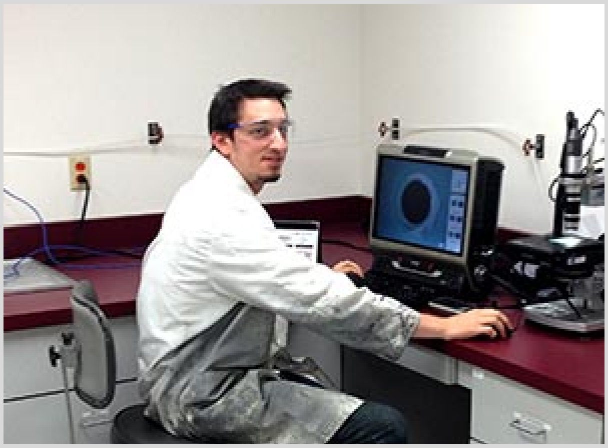
Besides encouraging technology innovation, the TCC is also committed to producing educated and experienced graduates who will join the corrosion control community of experts within DoD and its network of industry and academic supporters. Five creative engineers and scientists have recently landed jobs within DoD laboratories or military contractors. In doing so, they are furthering TCC's mission to ensure that young DoD and industry researchers can make a difference by introducing new products and processes to combat corrosion.

Christine Sanders, who earned a Ph.D. in physical chemistry from Ohio State in 2012, believes her ability to secure her current position as a Research Chemist at the Naval Research Laboratory (NRL) in Key West, Florida, can be traced directly to the five years of graduate study and mentoring she received at Ohio State. "My coming to NRL stems 100 percent from my involvement in the TCC," she said, and added: "Had it not been for the research opportunities I received through the TCC, I would not have worked in corrosion at all."

Among Sanders' many avenues of research, she was the first to elucidate the key role of silver sulfate (Ag_2SO_4) in the corrosion of silver, while correlating the corrosion of metals with multiple environments, Sanders' graduate research also allowed her to collaborate across disciplines with students from other TCC-member institutions, including polymer specialists at the University of Southern Mississippi and materials science students at UVA and the University of Hawaii.

Sarah Galyon Dorman works as a support contractor for the Air Force Academy's Center for Aircraft Structural Life Extension.

One of TCC's strategic goals is to help graduate students who work on TCC projects to land jobs within the Department of Defense. At NRL, Key West, Sanders is allowed to channel her academic zeal for scientific research with NRL's goal of working on naval aircraft technology. "Here at NRL, we're not just doing basic research, we're developing a product that will actually go into the Fleet," Sanders said. Sanders' research, collaboration and success at NRL is the ideal model for the TCC in the eyes of Hays, LMI Senior Consultant Christopher Scurlock, and others who administer the TCC from Washington D.C.



Austin Smith is a Ph.D. student at University of Akron.

Since **Sarah Galyon Dorman** earned her Master of Science degree from the University of Virginia in 2006, she has embarked on a career journey that has connected her to various support contractors who fulfill TCC-funded investigations into the causes of corrosion fatigue and other types of mechanical damage on Air Force aircraft. Over the past three years, she has worked for SAF Engineering (SAFE), a support contractor for the U.S. Air Force Academy's Center for Aircraft Structural Life Extension, or CAStLE.

"On the whole, most of my work now is for the TCC," Dorman said. In one SAFE project, Galyon Dorman is leading an effort to determine the effect of chromate primers on small-scale corrosion fatigue damage in a legacy aircraft aluminum alloy. Because her current work is headquartered at CAStLE at the Air Force Academy's Engineering Mechanics department, Galyon Dorman attends annual meetings where TCC member institutions convene. She also remains involved in TCC through her supervision of cadet research projects.

Last year **Austin Smith** started working on several TCC-supported projects under Professor Homero Castaneda-Lopez in the college of engineering at the University of Akron (UA). Smith used his research into coating damage measurement and evolution to develop a master's thesis topic related to the preservation of aircraft. His research examined zinc and aluminum copper materials, often used in military airplanes, to investigate the impact of pH levels, coating thickness, and coating applications on corrosion rates.

Smith's research under Castaneda-Lopez allowed him to land a summer 2014 internship with Wright Patterson Air Force Base (AFB) in the Materials and Manufacturing Directorate, where he assisted with projects related to military aircraft, corrosion research, and fatigue laboratory experiments. "At Wright Patterson AFB, the part of the electrochemical impedance spectroscopy (EIS) project I was involved in had to do with developing a standard operating procedure and best practices guideline for the use of EIS on coated substrates," Smith said. "The coatings group at the Coatings Technology Integration Office (CTIO) will utilize EIS as a supplemental quality control tool for testing coatings' barrier properties and uniformity to ensure compliance with military standards."

Smith further explained his work on a source code for modeling diffusion alongside the EIS modeling project during his internship at Wright Patterson. "My involvement had to do with developing a standard operating procedure and best practices guideline for the teardown and visual analysis of coated assemblies to simulate C-5 aircraft. Between the CTIO and the Air Force Research Lab, non-destructive investigation techniques will be used to ensure compliance with military standards for future aircraft as well as for cutting costs and increasing time in the air." Smith believes that his ability to leverage his graduate research into a fruitful internship at Wright Patterson will help him with new experiments as a doctoral student at UA, and with future planning in the workforce.

Nicole Tailleart is a research scientist at the Navy Research Laboratory's Center for Corrosion Science and Engineering.

Merrill Tayler's doctoral-level construction of predictive models of coating scribe creep rates, using fractional factorial design and R software, took place in UVA's Center for Electrochemical Science and Engineering in the Materials Science department, with the support of TCC funding. "If it wasn't for the TCC, I don't know where I'd be right now," Tayler said, adding that he is still involved in the TCC program through his collaboration with Professor John Scully, his advisor, as he works to publish his Ph.D.-level research findings in *CORROSION* journal.

Since earning his Ph.D. from UVA, Tayler has landed a position within Northrop Grumman, which will send him out to fulfill three one-year rotations to ensure that he gains experience in areas outside his educational area of expertise. His first assignment will take him to Northrop Grumman's office in

Huntsville, Alabama. Tayler sees a strong working relationship between TCC researchers and his new company.

"My involvement in TCC has afforded me the understanding and knowledge that corrosion engineering is extremely important to the design of qualified products," Tayler said. "This graduate training is definitely something that I take with me in my new job and in the projects I'll be involved in."

In order to earn her Ph.D. in materials science and engineering, **Nicole Tailleart** investigated an innovative, tunable semi-amorphous alloy and its potential for providing a strong barrier, sacrificial anode, and inhibitors to aluminum substrates by way of a thermal spray coating. "The scientific significance of this work is that it considers and elucidates metallurgical, physical, and geometric factors that either govern or do not affect the corrosion performance of such coatings," she explained.

Toward the end of her doctoral research under UVA Professor Scully, Tailleart benefitted from TCC funding provided by the DoD Corrosion Office. Since earning her degree, Nicole has worked as an electrochemical engineer at SAIC (Science Applications International Corporation) in support of the Naval Research Laboratory's (NRL) Center for Corrosion Science and Engineering. She continued working for the Center for Corrosion Science and Engineering as a post-doctoral researcher, where she conducted several types of research, including an investigation into interstitially hardened stainless steels and their use in naval applications. In May 2014 she rejoined NRL's Center for Corrosion Science and Engineering as a government employee and a principal investigator for the Center's interstitial hardening project.

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Kilchenstein Receives Prestigious "Spirit of Service" Award

Maintenance Policy Expert Among 34 Civilians Honored From DoD and Services

Gregory Kilchenstein, a Department of Defense (DoD) maintenance policy expert and a key member of the DoD Corrosion Policy and Oversight Office analyst team, has received the prestigious "Spirit of Service" award for outstanding job performance.


Gregory Kilchenstein

During a ceremony presided over by Deputy Defense Secretary Bob Work in the Pentagon Center Courtyard on May 7, 2014, Kilchenstein was honored alongside seven colleagues from within the DoD, and 26 honorees from the Joint Chiefs of Staff, Army, Navy, Marine Corps, and Air Force.

"I can't imagine another group of 34 folks who represent our DoD workforce better, and have given more to their communities," said Work, who was quoted in an article by Terri Moon Cronk for the American Forces Press Service. "They come from different backgrounds, they have different missions, but are bound together by a common pledge of public service to leave a safer, more prosperous America for future generations."

Kilchenstein serves as the director of Enterprise Maintenance Technology in the Office of the Deputy Assistant Secretary of Defense for Maintenance. In this capacity, he is responsible for developing policy and implementing programs that promote technology enablers in the commercial sector, which are committed to sustaining materiel readiness at optimum cost. As program officer for the Commercial Technology for Maintenance Activities (CTMA), Kilchenstein pinpoints opportunities for DoD to collaborate with industry in order to improve its maintenance processes, which cost an estimated $80 billion each year.

"In Greg's role as director of Enterprise Maintenance Technology, and in his capacity as program officer for CTMA, he has been a dedicated member of our project selection team as we work to lower

DoD's annual $22 billion cost of corrosion," said Daniel J. Dunmire, director of the DoD Corrosion Office. "In helping the DoD Corrosion Prevention Integrated Product Team (CPC IPT) select the best technology demonstration projects submitted by the military departments, Greg brings an invaluable perspective akin to a traffic director who helps us funnel proposals for innovation in corrosion prevention and control to the right government group for consideration."

In order to be chosen for the "Spirit of Service" award, Kilchenstein underwent a competitive nomination process spearheaded by his departmental peers. In being chosen as an "outstanding public servant," he and other honorees were deemed to "display the core qualities of honor, integrity, and excellence in everyday service," according to a memo signed by Christine Fox, who served as acting deputy defense secretary prior to Work’s appointment.

Deputy Defense Secretary Bob Work presides over a Public Service Recognition Week ceremony to honor 34 civilians for their contributions to the Defense Department with the "Spirit of Service" award at the Pentagon, May 7, 2014. DoD photo by Marine Corps Sgt. Aaron Hostutler

"Receiving this award is the highest compliment I can possibly receive from my co-workers," Kilchenstein said. "I was extremely moved to learn that in nominating me for this award, my peers divided up sections of my nomination packet and took time out to defend their selection of me before the assistant secretary of defense."

After completing undergraduate work in aerospace engineering and graduate-level studies in systems engineering at the University of Maryland, Kilchenstein began working for the Naval Sea Systems Command in 1987 as a mine warfare simulation modeler. After joining the Naval Air Systems Command (NAVAIR) in 1989, he was assigned as a propulsion engineer for the V-22, P-3, C-130, and E-2/C-2 aircraft, and had the privilege of witnessing the first flight of the V-22 in his first week with NAVAIR.

Over the next 16 years with NAVAIR, Kilchenstein served as program manager for the T400 engine and Propellers Program; the Basic Design engineer for T58 and T64 engines; the Propulsion and Power Systems engineer for H-53, H-46, H-3, and the Presidential VH-3D; and the Propulsion and Power competency lead for vertical lift propulsion systems.

Besides Kilchenstein, other "Spirit of Service" award recipients from DoD included Justin Beasley, Paul Blackwell Jr., David Canada, Gloria Hazelgreen, Clarence Lewis Jr., Michael Schuman, and Robert Walker.

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TCC Award Recipients Embrace Tangible Innovation

Technical Corrosion Collaboration Adds Five New Members to its Roster of Prestigious Institutions
By Cynthia Greenwood

A few years ago the DoD Corrosion Office started requiring that universities seeking research funding through the Technical Corrosion Collaboration (TCC) align their research and educational goals with those of corrosion scientists and engineers who work in DoD laboratories and in the acquisition and maintenance realms of all military departments. The program's current success lies, in part, to its members' commitment to reducing corrosion's impact on DoD weapons systems and infrastructure.

Ben K. Hoff, then a graduate student at the U.S. Air Force Academy, discusses research related to an aluminum alloy and corrosion fatigue with Office of Naval Research expert Dave Shifler during the 2011 DoD Corrosion Conference poster session contest. The Air Force Academy receives funding from the TCC for cadet research projects. Photo by Diana Zalucky.

"When we fund research projects at new universities and institutions who become part of the TCC, we expect them to collaborate to further technology innovations necessary to maintain and sustain DoD aircraft, ground vehicles, and facilities," said Rich Hays, deputy director of the DoD Corrosion Office. Thus far, the 16 TCC- member institutions comprising seven public universities, four military academies, two military graduate, and three collaborating companies have demonstrated a commitment to this goal.

Three new TCC members came on board in summer 2014, including Arizona State University, Southwest Research Institute, and Scientific Simulations Systems, Inc. In 2013 Pennsylvania State University, North Dakota State University and the U.S. Coast Guard Academy were also welcomed into the program.

As the TCC has evolved into a mature research program seven years after its pilot initiative, it has grown more competitive in nature. In 2014 54 institutions submitted proposals for consideration for funding through the TCC, and 13 were awarded cooperative research agreements. In 2013 the TCC proposal solicitation drew 60 proposals, and 12 were awarded that year. "Applicants must show why their research is useful and that it has a measurable impact on DoD in order to be eligible for funding," said Christopher Scurlock, the TCC executive secretary and senior consultant at LMI.

This year TCC applicants submitted white paper proposals in such technical areas as modeling and simulation efforts of various corrosion mechanisms, as well as coupled corrosion and fatigue; laboratory measurements of corrosion mechanisms; laboratory measurements of coupled corrosion and fatigue; coatings development; coatings improvements derived from understanding failure mechanisms and environmental effects; detailed studies of materials of interest to the DoD; and the development of new materials.

Veteran TCC members include Ohio State University, University of Virginia, University of Akron, University of Southern Mississippi, University of Hawaii, and U.S. Air Force Academy. In 2011 the Naval Postgraduate School, U.S. Naval Academy, and Air Force Institute of Technology received funding for new research proposals. Most recently, the TCC has awarded corrosion-related research funding to the U.S. Coast Guard Academy, U.S. Military Academy at West Point, North Dakota State University, and Pennsylvania State University.

Niteen Jadhay, from North Dakota State University, discusses his graduate research project with DoD Corrosion Conference attendees at the student poster session contest. Since 2013 North Dakota State University students have received TCC funding for graduate research projects. Photo by Diana Zalucky.

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NACE International Launches University Student Design and Applied Solutions Competition

Technical Challenge Event Focuses on Advancing Breakthroughs in Infrastructure and Weapon Systems Sustainability

NACE International has unveiled a new competition to encourage and elicit innovative solutions to combat corrosion. The University Student Design and Applied Solutions Competition has been launched with $1 million in seed funding provided by the Department of Defense (DoD) Corrosion Policy and Oversight Office.

For the inaugural competition event, participating teams will be asked to address a technological challenge related to mitigating the corrosion of defense systems. Specific challenge rules will be announced in the spring of 2015. Student teams from across the globe will be eligible to register during fall 2015, and the first competition will take place in the spring of 2016.
The idea for the competition came during a conversation between Daniel J. Dunmire, director of the DoD Corrosion Policy and Oversight (CPO) Office, and the NACE Chief Executive Officer, Bob Chalker. "I asked Bob what he thought we could do to make a difference in education, outreach, and communication to get the next generation involved in materials sustainment," said Dunmire. "Bob proposed a one-of-a-kind competition unlike anything the corrosion industry has seen before. A vision of something that would be to infrastructure development and sustainability what the xprize is to space travel."

"We are grateful to have the opportunity to build this competition from the ground up," said Chalker. "To pioneer this event and start with such an important challenge corrosion control for U.S. Defense systems is something we're very proud of, and it's a great motivator."

Kim Ray, senior manager of University Programs for NACE International, will lead the program and manage it from the current development phase onward. Ray brings an array of project management skills honed through 16 years of experience in marketing and communications, education, certification, and credentialing. A NACE employee for five years, Ray has been managing the organization's certification team where she played an integral role in launching the NACE International Institute.

Ray is currently developing the Student Design Competition program rules and guidelines. She will work with the DoD corrosion community throughout the development of the competition, and she and her team will recruit schools to participate. In the years following the debut competition, the event scope will evolve to include technical challenges related to corrosion control and prevention on infrastructure and assets outside of the military.

"Hiring Kim Ray to manage this project puts us in an excellent position from the start," said Matt Miller, NACE International chief operating officer. "In her time with NACE, Kim has demonstrated her strength in project management, and she has already hit the ground running with this competition."

"Working at NACE has taught me so much about the needs of society when it comes to corrosion control," said Ray. "To be able to launch a competition that will advance the corrosion industry and impact the lives of so many people around the world is a true privilege."

"We went through due diligence to ensure this competition supports the strategic plan of the Corrosion Office," said Dunmire. "It does that and then some; we've got the right organization, and Kim is the right person to make this happen. The outcome of this competition will support the warriors, the men and women of the U.S. military who deserve equipment that is safe and ready to use when it's needed. Nothing like this has been done before in the field of material degradation; it's an important first."

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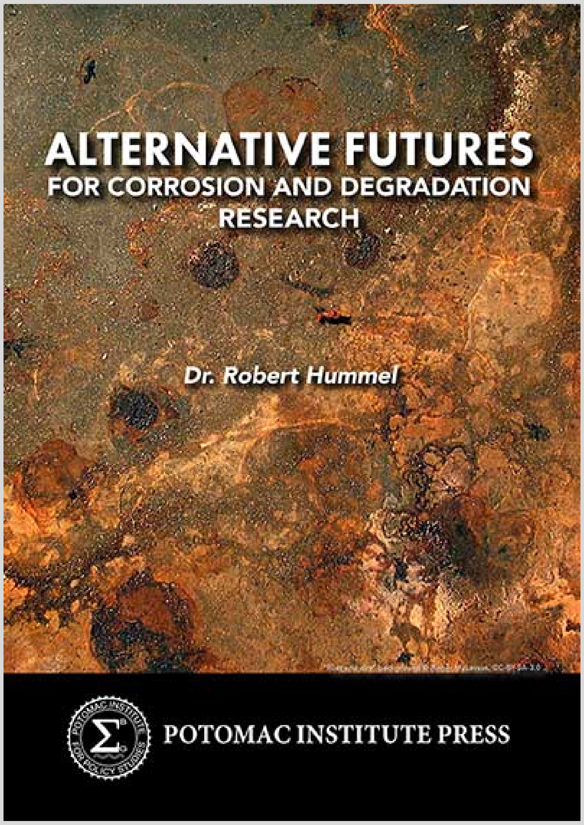
Potomac Institute Releases New Book, Alternative Futures for Corrosion and Degradation Research



Book cover photo © Roger McLassus, CC-BY-SA-3.0

The Potomac Institute for Policy Studies has released a book-length study, *Alternative Futures for Corrosion and Degradation Research*. The new book, written by Dr. Robert Hummel, chief scientist at the Potomac Institute for Policy Studies, arose out of an investigation into research directions that would lead to revolutionary improvements in society's ability to control corrosion processes in materials and systems.

Alternative Futures for Corrosion and Degradation Research offers a road map for novel research directions that could lead to dramatic changes in how the nation views and deals with corrosion and degradation problems. The study outlines new technological and organizational approaches to materials sustainment, which could lead to reduced maintenance requirements and "a future where systems are designed for specific lifetimes."

Hummel envisions a future "where affordable materials and coatings are developed so that systems require minimal maintenance against degradation, and [where] upgrades and end-of-life disassembly and recovery are exceptionally easy."

"This book maps out an innovative approach in battling corrosion and supporting new ideas in materials sustainment," said Daniel J. Dunmire, Director of the DoD Corrosion Policy and Oversight Office and the author of the book's foreword.

Corrosion is a national problem that goes beyond the rusting of metal. Each year, the prevention and maintenance associated with corrosion and degradation cost the United States more than one trillion dollars. *Alternative Futures* "lays out some of the compelling reasons for improving corrosion control," according to Dunmire's foreword. "[The book] surveys the causes and directions in corrosion control, and most importantly, provides a research agenda for new directions that could alter the future of corrosion control," Dunmire states.

Alternative Futures for Corrosion and Degradation Research also sparks discussion about functional advances in corrosion control, including the development of new materials and coatings, as well as novel systems-engineering approaches that could mitigate the effects of corrosion throughout a system's life cycle.

Key chapters in the book address the need for improved corrosion control; the status of the corrosion control enterprise, corrosion research directions, and recommendations focused on research program objectives and the impact of "new directions" research on national needs. Hummel classifies high-priority, corrosion-related problems into such categories as "national defense systems," "national infrastructure," national energy production and distribution systems," "commercial vehicles," and "manufacturing and manufactured products."

While issues surrounding corrosion costs are important, Hummel's study asserts the need to consider issues of safety, the improvement of system reliability, and the importance of increasing system availability and finding ways to avoid replacing systems prematurely.

Hummel conducted the study into *Alternative Futures for Corrosion and Degradation Research* for the DoD Corrosion Policy and Oversight Office. At the Potomac Institute for Policy Studies, Hummel leads studies on science, technology, and innovation. The Potomac Institute for Policy Studies is an independent public policy research institute with a focus on science, technology, and national security issues.

For further information, or to purchase *Alternative Futures for Corrosion and Degradation Research*, visit Potomac Institute for Policy Studies atwww.potomacinstitute.org or contact Kathryn Schiller Wurster, Potomac Institute chief of staff, at kschillerwurster@potomacinstitute.org.

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Allied Countries Collaborate to Combat Corrosion

U.S. Department of Defense and Allied Nation Corrosion Experts to Deepen Partnership at Technical Meeting in 2015

By Cynthia Greenwood

The fight against corrosion and material degradation knows no national borders. The smartest way for DoD to preserve its assets and infrastructure is to seek and exchange solutions with numerous allies overseas. This is why the DoD corrosion community wants to broaden its international program of collaboration with nine strategic allies in Pittsburgh next year at the 2015 DoD Allied Nations Technical Corrosion Conference.

Military corrosion experts from all armed services and at least nine allied nations, guided by the DoD Corrosion Policy and Oversight Office, will gather at the Wyndham Grand Pittsburgh Downtown hotel, in Pittsburgh, Pennsylvania, from August 2 – 6, 2015.

"As we focus on the importance of allied collaboration in combating corrosion, we eagerly seek the participation of military corrosion experts from Australia, Canada, France, Germany, United Kingdom, India, Italy, the Philippines, and New Zealand," said Daniel J. Dunmire, director of the DoD Corrosion Office. Thus far, the Corrosion Office has signed international exchange agreements with five of these nations, including Australia, Canada, France, Germany, and the United Kingdom. Efforts are underway to cement agreements with the other four in the next two years."

Members of the U.S. Navy who are active in the DoD Corrosion Prevention and Control Integrated Product Team will manage the 2015 conference technical program, and NACE International: The Corrosion Society will serve as conference organizer. The technical presenters will accept abstracts for presentations until November 20, 2014.) Click here to view the current Call for Papers.

The 2015 conference will mark the inaugural presence of the department's allied defense ministry partners, whose participation will ensure the expansion of corrosion control efforts worldwide, said Dunmire. "The 2015 DoD – Allied Nations Technical Corrosion Conference will continue where the 2013 NATO Seminar & Workshop left off - to allow a meaningful exchange of corrosion control information between the U.S. DoD and its allied defense ministry partners, industry, academia, and government agencies, so that all entities can collectively seek to reduce the negative impacts of corrosion on global readiness and safety."

The United States Department of Defense (DoD) has developed a comprehensive strategy to combat corrosion throughout the armed forces. As resources directed toward corrosion prevention become increasingly constrained, acquisition-level management decisions, maintenance practices, and sustainment paradigms become critical to prolonging the life cycle of materiel. Corrosion control and prevention throughout the DoD costs the United States $22.5 billion each year. Consequently, DoD actively seeks new corrosion mitigation and prevention technologies, processes, products, and management systems for those who acquire and sustain military weapon systems and infrastructure.

Planning for the DoD-Allied Nations Corrosion Conference is subject to the receipt of official government approval.

CorrDefense
A Retrospective
DoD News about Preserving Military Assets

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Inside DoD

DoD Partners Unveil New Courses for Military Corrosion Specialists

By Cynthia Greenwood

In recent months, the strategic partners of the DoD Corrosion Policy and Oversight Office have stepped up their efforts to meet the training needs of acquisition and maintenance personnel who practice corrosion prevention on military equipment and infrastructure.

SSPC: The Society for Protective Coatings has unveiled a certification program for Aerospace Coating Application Specialists, designed to certify those individual craft workers who have experience in the hands-on surface preparation and coating application of aircraft structure surfaces. In addition, NACE International, The Corrosion Society, has recently premiered a four-hour *Basic Corrosion* course that distills the causes of corrosion and the methods of identifying and controlling it. The mini-course is based upon the weeklong course offered by NACE.

The Corrosion Office is also working with the U.S. Marine Corps Corrosion Program Office and NACE International to develop a five-day course on the identification, repair, and maintenance of ground tactical and support equipment. The new course, slated for release in 2015, will include the basics of corrosion control, corrosion prevention and control procedures for tactical ground equipment, cleaning procedures, corrosion assessment methods, the servicing of materials and parts, surface preparation and touch-up paint procedures, and corrosion-related procedures for deployments.

For the above-mentioned new courses and all others listed below, the Corrosion Office continues to cover the tuition costs incurred by DoD personnel and civilian military contractors. Funding through October 2014 is available to personnel interested in enrolling in DoD-sponsored courses offered by SSPC. Renewed funding for courses taught by NACE will become available later this year.

Descriptions of the most popular courses covered by DoD are listed below, according to subject area. Technicians, inspectors, engineers, consultants, architects, and project managers may take advantage of a diverse array of courses and certification opportunities related to Basic Corrosion, Cathodic Protection, Corrosion Assessment, Coatings, Coatings Inspection, and Water/Wastewater Facilities.

To learn more about course schedules, content, and individual training providers, please click on a course title and link to the appropriate Web site and course description. (To view all 34 DoD-funded courses sponsored by SSPC, please view the following list of courses on the SSPC Web site.)

General Corrosion Education

Basic Corrosion

Basic Corrosion
This course focuses on corrosion and the potential problems caused by corrosion. It provides a basic but thorough review of the causes of corrosion and the methods by which it can be identified, monitored, and controlled. Active participation is encouraged through hands-on experiments and case studies, as well as an open discussion format.

Offshore Corrosion Assessment Training (O-CAT)
The Offshore Corrosion Assessment Training course is a five-day intensive program addressing the elements of in-service inspection and maintenance planning for fixed offshore structures. The course also addresses the Minerals Management Services (MMS) A-B-C facility evaluation grading-system requirements for Level I inspection reporting.

Cathodic Protection

CP-1 Cathodic Protection Tester Course
This is an intensive six-day course that presents CP technology to prepare students for the NACE Cathodic Protection Tester Certification Examination. Course topics include basic electricity, electrochemistry and corrosion concepts, CP theory, CP systems, and CP field measurement techniques. This course provides theoretical knowledge and practical fundamentals for testing on both galvanic and impressed-current CP systems. It also involves lectures and intensive hands-on training with equipment and instruments used in CP testing. Hands-on training at outdoor facilities (weather permitting) is also provided. The course concludes with both a two-hour written and a two-hour practical (hands-on) examination.

CP-2 Cathodic Protection Technician
This is an intensive six-day course that presents CP technology to prepare students for the NACE Cathodic Protection Technician Certification Examination. Course topics include intermediate-level discussions of corrosion theory and CP concepts, types of CP systems, stray alternating-current and direct-current interference, and advanced field-measurement techniques. This course provides both theoretical knowledge and practical techniques for testing and evaluating data to determine the effectiveness of both galvanic and impressed current CP systems and to gather design data. The course involves lectures and hands-on training with equipment and instruments used in CP testing. Hands-on training at outdoor facilities is also included, weather permitting.

CP-2 Cathodic Protection Technician-Marine

Developed for NAVSEA (Naval Sea Systems Command), this six-day course provides theoretical knowledge and practical techniques for testing and evaluating data to determine the effectiveness of both galvanic and impressed current CP systems, as they apply to the marine industry. This is an intermediate CP course.

CP-3 Cathodic Protection Technologist

This is an intensive six-day course that presents CP technology to prepare students for the NACE Cathodic Protection Technologist Certification Examination. The CP 3—Cathodic Protection Technologist Course builds on the technology presented in the CP 2—Cathodic Protection Technician Course covering both theoretical concepts and practical application of CP, with a strong focus on interpretation of CP data, CP troubleshooting, and mitigation of problems that might arise in both galvanic and impressed current systems. The course is presented in a format of lecture, discussion, and hands-on, in-class experiments, and group exercises. There is a written examination at the conclusion of the course.

CP-4 Cathodic Protection Specialist

This is an intensive six-day course that focuses on the principles and procedures for CP design on a variety of structures for both galvanic and impressed current systems. The course discusses the theoretical concepts behind the design and considerations that influence the design (environment, structure type/materials of construction, coatings), design factors, and calculations (including attenuation). The course involves lecture and in-class discussion and practice with design examples on various structures (i.e., pipelines, tanks and well casings, offshore applications, and steel reinforcing in concrete structures). The course concludes with the written NACE CP Specialist examination.

CP Interference

The Cathodic Protection Interference course is a six-day course focusing on AC and DC interference. The course includes in-depth coverage of both the theoretical concepts and the practical application of identifying interference and interference mitigation techniques. Students will learn to identify the causes and effects of interference as well as conduct tests to determine if an interference condition exists and perform calculations required to predict AC interference. The course is presented in a format of lecture, discussion, hands-on, in-class experiments, case studies, and group exercises. There is a written examination at the conclusion of the course.

Coatings and Coatings Inspection

Aerospace Coating Application Certification (ACAS)

The SSPC Aerospace Coating Application Specialist Certification Program is designed to certify those individual craft workers who have experience and training in all aspects of the hands-on surface preparation and coating application of the surfaces of aircraft structures, according to the requirements of the SSPC Aerospace Coating Application Specialist (ACAS) Program.

C-1 Fundamentals of Protective Coatings for Industrial Structures

This course provides a practical and comprehensive overview for those who are new to the protective coatings industry. It is also an ideal refresher for reviewing the fundamentals of corrosion and the use of coatings as a protective mechanism against corrosion and deterioration of industrial structures.

C-1 eCourse Fundamentals of Protective Coatings for Industrial Structures
This online course provides a practical and comprehensive overview for individuals who are new to the protective coatings industry, as well as those needing a review of the fundamentals of corrosion and the use of coatings as a protective mechanism. It begins on the 15th of every month.

C-2 Specifying and Managing Protective Coatings Projects
This course is designed to sharpen your skills in managing the specific requirements of protective coatings projects.

C-2 eCourse Specifying and Managing Protective Coatings Projects
This online management course is designed to sharpen your understanding of overall industry practices, beyond your area of specialization, and put your experience in unison with the most current theories and practices that govern coatings project management. It begins on the 15th of every month in 2009.

C-7 Abrasive Blasting Program
C-7 is designed to certify operators of dry abrasive or portable centrifugal blast cleaning equipment. It covers principles of surface preparation, surface cleanliness, surface profile, dust and debris control, and abrasives. The program's primary focus is the certification of the blasters who demonstrate proper blasting techniques during the hands-on session.

Coating Specification Essentials
This course presents an overview of the logical and systematic development of coating specifications, building upon CSI specification writing knowledge. It reviews a wide range of concerns that can affect project success and presents a checklist for developing coating specifications.

Concrete Coating Inspector (CCI) Program
Students who take this course will be able to determine incompleteness and/or technical errors in a specification and bring these issues to the attention of the specification writer or a supervisor. The course also reviews how to use concrete coating inspection equipment according to the manufacturer's guidelines. The certification portion of this program will certify concrete coating inspectors in the process of correctly observing, assessing, documenting, and reporting all relevant job data as determined by the specification and referenced documents. Students completing the technician-level training (first four days only) would be qualified to work under the guidance of a certified concrete coating inspector.

C-12 Airless Spray Basics
This course is designed to train marine/industrial applicators to operate airless spray equipment, incorporating the use of a paint simulator for hands-on training. You'll learn the proper technique for airless spray painting by using a program that simulates real life situations and equipment used in the field. There are two course options that allow participants to complete training and certification that meet NAVSEA 009-32 requirements. Click on the link above for details about each course offering.

C-14 MPCAC - Marine Plural Component Program
This course is designed to certify craft workers operating plural component spray equipment. It also certifies those applying protective coatings on steel in immersion service by airless spray using plural component spray equipment.

Inspection Planning and Documentation

This two-day course is designed to help coating inspectors learn how to plan inspections effectively before the work starts and accurately document results of tests and inspections conducted after work begins. The training will emphasize: a) Careful review of plans and specifications in order to develop a comprehensive inspection plan; b) Use of forms to accurately and legibly document project-specific inspection and test results, non-conforming work, and rework.

Lead Paint Removal (C3)

C3 includes background information on the hazards of lead and other toxic metals as well as the current legal and regulatory environment. The course contains specific discussions on protecting workers; compliance with environmental regulations; proper management of waste streams and operations that result in potential exposures to lead; and associated control technology. The course also addresses reading specifications and developing programs to effectively control risks to workers, the public, and the environment. It concludes with a discussion of insurance and bonding issues, and an introduction to other safety and health issues that are encountered on painting projects.

Navigating Standard Item 009-32

This one-day course describes the naval ship cleaning and painting requirements found in Standard Item 009-32. It covers the cleanliness, surface preparation, coating application requirements, and system application instructions for various Navy vessels. Requirements of referenced standards are also reviewed.

Quality Control Supervisor (QCS)

This course is designed to provide training in quality management for SSPC - Certified contractor personnel, Technical Quality Managers (TQM), and inspectors employed by SSPC-QP 5 inspection firms. It provides an overview of the quality management aspects of surface preparation, paint, coatings, and inspection operations that a Quality Control Supervisor (QCS) needs to know to ensure delivery of a quality product to customers. It is highly recommended that persons attending the QCS course have recent inspection training (SSPC PCI, NBPI or BCI) or equivalent formal training, and also some quality-control experience.

Quality Control Supervisor (QCS) eCourse

This course is designed to provide training in quality management for SSPC - Certified contractor personnel, Technical Quality Managers (TQM), and inspectors employed by SSPC-QP 5 inspection firms. It provides an overview of the quality management aspects of surface preparation, paint, coatings, and inspection operations that a Quality Control Supervisor (QCS) needs to know to ensure delivery of a quality product to customers.

Basics of Steel Surface Preparation eCourse

This course defines surface preparation for steel through a brief review of the steps involved. It then provides an overview of abrasive blast cleaning, hand-and-power-tool cleaning, and water jetting and the associated standards referenced when these methods are used to prepare steel for the application of protective coatings.

Using PA 2 Effectively

This half-day workshop summarizes and explains the key highlights of SSPC PA 2: Measurement of Dry Coating Thickness with Magnetic Gages. Students will learn to verify the accuracy of a DFT (dry film thickness) magnetic gage; measure the DFT of a coating with a Type 1 or Type 2 gage; and describe and implement the procedure to determine if the film thickness in a given area conforms to the maximum and minimum levels specified.

Coating Inspector Program (CIP) Level 1
This course is an intensive presentation of the basic technology of coating application and inspection over a full 60 hours of personal instruction and practice. This course provides both the technical and practical fundamentals for coating inspection work on structural steel projects.

Coating Inspector Program (CIP) Level 2
This course focuses on advanced inspection techniques and specialized application for both steel and non-steel substrates. The course includes in-depth coverage of surface preparation, coating types, inspection criteria, and failure modes for various coatings, including specialized coatings and linings.

Coating Inspector Program (CIP) Level 2 Marine
CIP Level 2, maritime emphasis, includes topics from CIP Level 1 and CIP Level 2, with a focus on coating inspection in the maritime industry. The course provides in-depth coverage of surface preparation, coating types, inspection criteria, failure modes, and case studies from the maritime industry. CIP Level 2, maritime emphasis, highlights the skills and knowledge required to correctly address the inspection requirements of the International Maritime Organization's (IMO's) Performance Standard for Protective Coatings (PSPC). The course concludes with both written and practical exams.

Coating Inspector Program (CIP) Level 3 Peer Review
This course is a detailed oral examination in front of a three-member review board that lasts approximately two hours and is graded on a pass/fail basis. The Peer Review includes a series of questions to test the candidate's practical and theoretical knowledge of coatings and coating inspection. Candidates are questioned from a random drawing of topics ranging from standards, procedures, ethics, coatings use, inspection instruments, role-playing, and specific case questions. Successful completion of the CIP Peer Review is required to achieve recognition as a NACE Certified Coating Inspector Level 3 individual.

NBPI—NAVSEA Basic Paint Inspector Course
The NBPI course is similar to NACE Level I or SSPC C-1, but it was developed by the Navy. This four-day quality assessment course was developed by NAVSEA (Naval Sea Systems Command) to train coating inspectors to inspect critical coated areas as defined by Navy policy documents. These areas include but are not limited to cofferdams, decks for aviation and underway replenishment, chain lockers, underwater hulls, bilges, tanks, voids, well deck overheads, and others. The content of the course is similar in nature to the NACE CIP Level I, but with a particular focus on ship-painting issues. What makes this course valuable is that it also provides both the technical and practical fundamentals for coating inspection work for any steel structure projects other than ships.

Protective Coatings Inspector Program (PCI)
PCI Level 2 meets ASTM International Standard D3276, "Standard Guide for Painting Inspectors," and has been approved by Lloyd's Register, RINA, and the American Bureau of Shipping (ABS). The objective of this course is to thoroughly train individuals in the proper methods of inspecting surface preparation and installation of industrial and marine protective coatings and lining systems on an array of industrial structures and facilities. There are no prerequisites to attend the PCI Course. However, this course is not an entry-level course.

Shipboard Corrosion Assessment Training (S-CAT)
In this five-day course developed for naval personnel, students learn how to survey and evaluate protective coating systems as part of a maintenance program for marine vessels. This course is intended to provide a foundation in coatings, corrosion, and corrosion control knowledge for assessing the condition of tanks and other structures, and determining the required actions necessary to effectively maintain fully operational status. The course will equip the assessor with practical guidelines for surveying and evaluating the condition of the protective coating system on specific areas of a marine vessel. The desired end result is that assessors use a consistent, orderly, and repeatable process of evaluation that has the confidence of all those involved in the maintenance cycle.

Internal Corrosion Courses

Internal Corrosion (IC) for Pipelines: Basic
This course was designed to provide students with the fundamentals of implementing, monitoring, and maintaining an internal corrosion control program as part of an overall Pipeline Integrity Management program. It is an introductory-level course focusing on the internal corrosion of liquid and natural gas pipelines used for transmissions, storage, and gathering systems. The course combines lecture, hands-on field-testing, and case studies. The course concludes with both a written and practical examination. The practical examination includes OQ (Operator- Quality) Covered Task Assessments for the following tasks: (1) Insert and remove internal corrosion coupons, (2) Measurement of corroded area and pit depth measurement (with pit gauge), (3) Measure wall thickness using handheld ultrasonic meter.

Internal Corrosion (IC) for Pipelines: Advanced
The Advanced Internal Corrosion for Pipelines course focuses on the monitoring techniques and mitigation strategies required to assess internal corrosion and develop and manage internal corrosion control programs. Data interpretation, analysis and integration, as well as criteria for determining corrective action for high-level internal corrosion problems within a pipeline system, will be covered in detail. The course will be five days in length. Students successfully completing the course examination and who also meet the requirements can apply for certification as a Senior Internal Corrosion Technologist.

For more information about the organizations that provide training for DoD employees, please consult the following Web sites:

- NACE International—The Corrosion Society
- SSPC—The Society for Protective Coatings

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Winter 2014

CorrDefense DoD News about Preserving Military Assets

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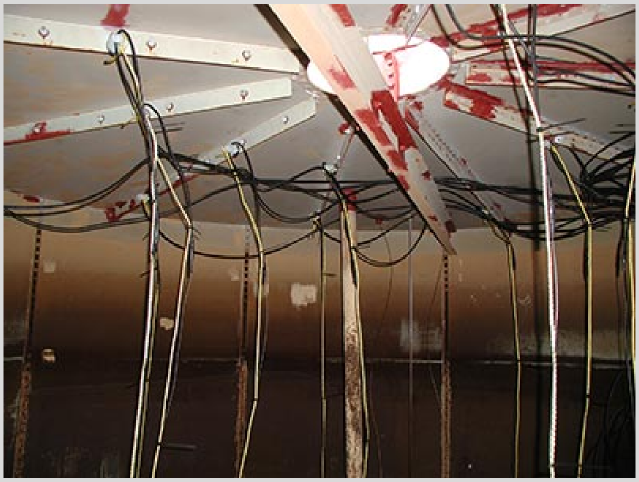
New Technology

Solar-Powered System and Remote Monitoring Protect Water Tanks at Pohakuloa, Hawaii

By David Bailey

The U.S. Army Engineer Research and Development Center (ERDC) has successfully demonstrated an impressed-current cathodic protection (CP) system and remote monitoring unit-both powered by the sun-at a remote military site in Hawaii. Jointly funded by the DoD Corrosion Policy and Oversight Office and the Army Corps of Engineers, the system is operating virtually maintenance-free at Pohakuloa Training Area.



Black cabling for ceramic anodes is hung from the ceiling of the tanks. Yellow nylon ropes secured to the cables have ceramic insulators tied to them at the bottom (providing ballast to the cable). This configuration keeps the anodes suspended vertically in the water to keep them from swaying out of position. Photo by David Bailey, U.S. Army Corps of Engineers, ERDC-CERL.

The new photovoltaic, or solar-based, system offers a variety of benefits. Through the project, Army researchers learned that a photovoltaic-powered, impressed-current CP system can be remotely monitored, and the system can be kept fully operational at all times. These features eliminate the cost and inconvenience of visiting remote sites to make routine inspections.

Another advantage of this system is that it is not vulnerable to interruptions of CP related to power failures on the grid. The third advantage is that once the system is in place, there is no continuing cost for ongoing power consumption. A side benefit is that this system does not compete for power with other applications on the grid in areas where power production capacity is limited. If this type of CP system were to be installed at 50 remote sites, the return on investment is projected to be 11:5:1.

Why Remote Infrastructure is Vulnerable to Corrosion

DoD has many remotely located facilities and training areas across the globe. These sites include critical infrastructure such as water storage tanks, pipelines, and other steel structures that depend on for corrosion prevention and control. Impressed-current CP systems normally require conventional power service and therefore are currently not used in many isolated sites due to the lack of available electric power.

The cost of extending electric utility lines to remote sites has always been high and is steadily increasing. In addition, some remote sites cannot even be served by the grid, so steel structures located there are especially vulnerable to corrosion because their coatings degrade. In these situations, photovoltaic power becomes a logical, cost-effective means for providing CP.

To ensure the performance of these CP systems, remote monitoring units can be installed to detect problems so they can be corrected promptly before corrosion damage is significant. The Army uses remote monitoring units for a variety of infrastructure sustainment applications. The units provide prompt notification to maintenance personnel that a problem in the field needs to be remedied. In locations that are difficult to access and not served by the grid, reliable alternate power sources are critical for continuous corrosion protection and the monitoring of CP system operation.

System Installed in Hawaii

Pohakuloa Training Area, a remote installation located in a highly corrosive environment, partnered with ERDC's Construction Engineering Research Laboratory to demonstrate a photovoltaic-powered CP and remote monitoring system. The structures chosen for the demonstration were three potable water tanks, which are part of the site's water treatment facility. Water is trucked up to Pohakuloa Training Area and stored in three large tanks prior to treatment. After treatment, the water is stored in the three project tanks prior to usage. The vessels measure eight feet high and 15 feet in diameter, and have mostly bare steel interior surfaces and no protective coating.

Pictured are cabinets that house three cathodic protection (CP) control units and the respective banks of batteries below them. This control unit operates the photovoltaic-powered CP system. Photo by David Bailey, ERDC-CERL.

The three tank, photovoltaic-powered CP systems include several components. A solar controller performs continual DC (direct current (DC)-to-DC voltage conversion to precisely regulate power to CP anode beds in the water tanks. The solar controller functions without the use of resistors or potentiometers, which typically dissipate excess power as heat. This elimination of energy dissipation provides improved overall solar power conversion efficiency. The controller board also includes output voltage and current meters for local viewing and adjustments.

A solar charge controller monitors the battery bank charge as well as the solar array output. During sunny days, the photovoltaic array both energizes the CP system and recharges the storage batteries. At nighttime and during periods of too little sunlight, the solar controller senses when power from the photovoltaic array falls below a set threshold, at which time the load transfers to storage batteries. The solar controller also constantly monitors CP system performance by collecting information from the permanent reference electrodes installed in the tank and automatically adjusting the voltage and power to the anode bed.

The control unit also has meters for viewing system parameters and control features for making manual adjustments and maintaining operation. The data extraction modules, located in the bottom of the unit, collect output voltage, output current, and reference electrode current data. Lightning arrestors are provided on both the input and output voltage lines. The arrestors, also referred to as surge protectors, provide a short circuit path to ground in the event of a lightning strike, thereby preventing excessive current spikes that would damage circuitry.

Batteries Essential to Success

For any critical infrastructure application, storage battery life and maintenance requirements are primary considerations in the design of a photovoltaic-powered, impressed-current CP system. The batteries used in the system are designed specifically for renewable energy applications. They are 12-volt batteries rated at 210 amp-hours each, and are valve-regulated with gelled electrolyte, giving them a long cycle life. Three are connected in parallel for a total rating of 630 amp-hours to service each impressed-current CP control system. These batteries provide backup power, and with a full charge, can operate for up to 10 days.

Editor's Note: David Bailey is a research civil engineer at ERDC's Construction Engineering Research Laboratory in Champaign, Illinois. He can be contacted at 217-373-6781 or at david.m.bailey@usace.army.mil.

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New Technology

Zinc-Rich Coatings Can Help Prevent the Corrosion of Military Vehicle Armor Steel

By Sally Johnson

Military vehicles rely on the armor protection of high-strength steel to fend off corrosion, which is an insidious problem that not only affects military vehicle readiness but can also lead to costly inspection and maintenance procedures.

The LAV-25, a light-armored vehicle, and other U.S. Marine Corps ground assets are manufactured with high-strength armor steel to ensure long-term corrosion protection in harsh desert environments. Photo courtesy of U.S. Marine Corps.

Working to find a solution to this corrosion challenge, a team of researchers from the U.S. Naval Academy, Naval Surface Warfare Center, and Elzly Technology Corporation explored the use of zinc-rich primers for high-strength armor steel. They also evaluated the impact of absorbed hydrogen, which is generated as a result of the cathodic protection—sacrificial metal—provided by zinc.

In the April 2014 issue of *CORROSION*, the team describes their findings about zinc- rich coatings and how they are able to use the related quantitative measurements of the material loss of coated armor steel to assess its structural integrity.

Why use embedded zinc particles in primer coatings? Adding zinc particles to primer coatings has been shown to provide "both a barrier to moisture via the epoxy matrix and a cathodic protection mechanism via the sacrificial corrosion of the zinc particles," according to the team. This is deeply significant because isolated zinc particles will only sacrificially corrode after an accidental abrasion of the coating and exposure to the environment.

“Our research was inspired largely because the level of corrosion protection afforded by zinc-rich primers was urgently needed to solve military vehicle readiness issues—but we needed to investigate how it would affect the structural integrity of high-strength armor steel because that was unknown,” explained Michelle G. Koul, the paper’s lead author and an associate professor of mechanical engineering at the U.S. Naval Academy.

The automotive industry has widely embraced a built-in form of corrosion protection for years, which involves a coatings system with a sacrificial metallurgy-bonded zinc layer designed to protect the underlying steel. But a drawback of this technique is that as the sacrificial coating material is consumed over time, the protection it provides also diminishes. Aside from exploring zinc-rich primer coatings as a solution, the team also addressed challenges presented by the cathodic polarization of steel, because it is known to cause the absorption of hydrogen into the metal and can affect the fracture performance of the steel compared to conventionally coated materials.

"While the effect of hydrogen on high-strength steels under cathodic protection has been studied extensively, we focused on cathodic protection provided by the corrosion of zinc particles embedded within a primer. At the outset, we were uncertain whether zinc in this form could provide a continuous source of hydrogen that would promote cracking," Koul said.


This MRAP platform used by the Marine Corps is produced with high-strength armor steel to extend its life cycle. Photo courtesy of the U.S. Marine Corps.

After running scribed panel testing under cyclic salt fog conditions, the researchers concluded that zinc-rich coatings can do a better job of reducing the corrosion damage observed in armor steel than traditional coatings.

In marine environments, however, the research team found that the presence of a zinc-rich coating moderately degraded the resistance to crack initiation compared to uncoated steel during immersion in artificial seawater. Crack propagation rates also doubled compared to uncoated steel in seawater immersion. But the researchers say these rates improve if they add a chemical agent-resistant coating topcoat to the zinc-rich coating.

Koul believes their experiments can be emulated to evaluate other similar systems, which may help ease decision-making for others when it comes to choosing an appropriate primer material.

What’s next for the team? Koul and colleagues hope to further explore the morphology of the zinc primer and its role in crack initiation and growth.

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DoD News about Preserving Military Assets

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New Technology

Innovative, High-Performance Concrete Floor Sealants Prove Successful

By Clint Wilson

The Army Corps of Engineers Engineer Research and Development Center (ERDC) and Hunter Army Air Field, Georgia, recently demonstrated and validated a high-performance concrete floor sealer under a project for the Office of the Secretary of Defense Corrosion Prevention and Control Program. The floor sealer is unique in that it uses nano-lithium technology to both seal the concrete and densify the surface.

Photo courtesy of Army Corps of Engineers, ERDC-CERL.

Photo courtesy of Army Corps of Engineers, ERDC-CERL.

Army vehicle and aircraft maintenance facilities often coat their floors to protect them, improve lighting, and to make them easier to clean and more aesthetically pleasing. Almost universally, the coatings used for these purposes are epoxy paint floor coatings that eventually chip and peel, and become damaged and very slippery when wet unless an anti-skid abrasive is added. These floor coatings typically have a five- to 10-year life span based on manufacturer warranties. Replacing these floor coatings is both costly and repetitive, since the Army's facilities have life expectancies of more than 50 years.

The floor sealer used in this project is a waterborne product that is applied with a mop and absorbs into the concrete. The sealer reacts chemically with concrete to provide a permanent hydrophobic surface. It hardens and densifies the surface, making it resistant to damage and abrasion. This sealer also forms a chloride ion screen that provides protection against salt penetration, which, in turn, prevents corrosion.

For this project, personnel removed an existing epoxy floor coating in six heavy vehicle maintenance bays and support areas, including tool rooms, which were deteriorated and scheduled to be replaced.

In the offices and hallways, vinyl tile was removed from the floors. Once existing flooring was removed, the concrete floors were ground to a high polish and the sealer was applied. This process resulted in highly polished floors that were very hard, chemically resistant, and water-resistant.

During one year of use and observation, the unit personnel were pleased with the performance of the floors. Concerns that the glossy floors would be slippery were not realized because the floors, when wet, have nearly the same slip coefficient as unfinished concrete and pose a much lower slip hazard than epoxy-coated floors. The floors were cleaned routinely using pressure washers, and their regular maintenance amounted to significantly less than a painted floor.

For more detailed information about the Army's high-performance concrete floor sealant, please contact Clint Wilson at 217-373-6742 orClint.Wilson@usace.army.mil.

Editor's Note: Clint Wilson is a senior research civil engineer at ERDC's Construction Engineering Research Laboratory in Champaign, Illinois.

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DoD News about Preserving Military Assets

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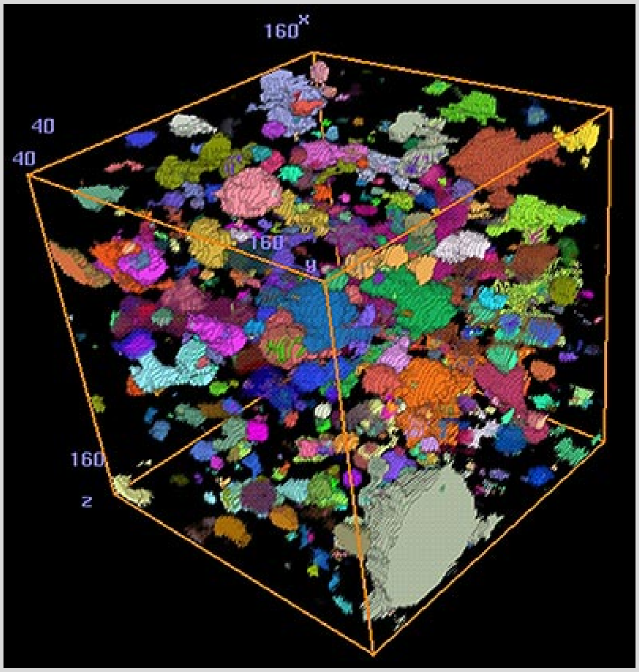
New Technology

On a Fast Track: DARPA Plans to Speed Process for Developing New Materials

By David Bailey

Military platforms-such as ships, aircraft, and ground vehicles-rely on advanced materials to make them lighter, stronger, and more resistant to stress, heat, and other harsh environmental conditions. Currently, the process for developing new materials to field in platforms frequently takes more than a decade. This lengthy process often means that developers of new military platforms are forced to rely on decades-old, mature materials because potentially more advanced materials are still being tested, and aren't ready to be implemented into platform designs.



DARPA'S Materials Development for Platforms (MDP) program seeks to develop a methodology and toolset to compress the applied material development process by at least 75 percent: from an average of 10 years or longer to just two and a half years. Image courtesy of DARPA.

The Defense Advanced Research Projects Agency, or DARPA, has a plan to put advanced materials development on a fast track. DARPA's Materials Development for Platforms (MDP) program seeks to address the problem by developing a methodology and toolset to compress the applied materials development process by at least 75 percent: from an average of 10 years or longer to just two and a half years. To achieve this goal, the program intends to establish a cross-disciplinary model that incorporates materials science and engineering, Integrated Computational Materials Engineering (ICME) principles, and the platform development disciplines of engineering, design, analysis, and manufacturing. The program plans to focus on the rapid development of materials with specific platform capabilities and intended mission in view, rather than supporting long-term, generalized materials development acceleration followed by an assessment of potential applications for the resulting materials.

“In this program, we want to move from the current mindset of sporadic ‘pushes’ in materials technology development to a mindset that 'pulls' materials technology forward driven by platform design intent and mission need,” said Mick Maher, DARPA program manager. "Ideally, we could envision materials development happening on time scales more in line with modern commercial automobile development."

As a test case for this new development concept, the program intends to focus its initial efforts on a hypersonic platform design—a bold and pressing challenge, since hypersonic vehicles operate under extreme conditions that push state-of-the-art materials to their thermal, chemical, and structural limits. Specifically, the initial MDP materials development effort would be applied to the design of an outer aerodynamic shell for a hypersonic vehicle that would glide through the atmosphere. Hypersonic air vehicles travel at more than five times the speed of sound, resulting in shell temperatures of several thousand degrees Fahrenheit-hot enough to melt steel. The goal is to prove the MDP concept by developing, manufacturing, and independently testing various new material structural elements of an outer shell within two and a half years.

"A key to the program's success will be integrating expertise from a wide range of relevant technical disciplines," Maher said. "We want to reach out to potential performers in all of the relevant scientific and engineering communities-and from both large companies and small businesses-so they can team together to create the most effective solutions possible."

For anyone interested in the opportunity to participate in the MDP materials development program, DARPA has released a Broad Agency Announcement solicitation on the FedBizOpps Web site at www.fbo.gov.

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Cost of Corrosion

Corrosion Office Updates its 2009 Report on the Cost of Corrosion Within DoD

New Report Updates Data through Fiscal Year 2013
By Eric Herzberg

Congress, concerned with the high cost of corrosion, enacted legislation in December 2002 that assigned the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (USD[AT&L]) with the policy and oversight responsibilities for preventing and mitigating the effects of corrosion on military equipment and infrastructure[1]. To perform its mission of preventing and mitigating corrosion, fulfilling congressional requirements, and responding to Government Accountability Office (GAO) recommendations, the USD(AT&L) established the Corrosion Prevention and Control Integrated Product Team (CPC IPT), a cross-functional team of personnel from all the military services as well as representatives from private industry.

In response to a GAO recommendation to "develop standardized methodologies for collecting and analyzing corrosion cost, readiness, and safety data,"[2] the CPC IPT created standard methods to measure both the cost[3] and availability[4] impact of corrosion for DoD's military equipment and infrastructure.

In April 2006, the CPC IPT published the results of the first corrosion-related cost study[5], con-ducted by LMI, which used the standard corrosion-related cost estimation method. In July of 2009[6], the CPC IPT published the first report to assess the total cost of corrosion for DoD, including study segments that previously had not been measured. The amalgamation of those unmeasured segments (such as small arms, ammunition, communications equipment, and various watercraft) were called "DoD-other equipment."

This report is an update to that first report of the total cost of corrosion for DoD. LMI presents the results of the cost studies for all years in Table 1.

Table 1. DoD Cost-of-Corrosion Studies to Date and Future Efforts

Study year[a]	Data baseline	Study segment	Annual cost of corrosion
2005–06	FY2004	Army ground vehicles	$1.5 billion
	FY2004	Navy ships	$3.4 billion
2006–07	FY2005	DoD facilities and infrastructure	$1.4 billion
	FY2005	Army aviation and missiles	$1.7 billion
	FY2005	Marine Corps ground vehicles	$0.5 billion
2007–08	FY2005–06	Navy and Marine Corps aviation	$4.5 billion
	FY2005–06	Coast Guard aviation and vessels	$0.3 billion
2008–09	FY2006–07	Air Force	$4.9 billion
	FY2006–07	Army ground vehicles	$2.6 billion
	FY2006–07	Navy ships	$2.6 billion
	FY2006	DoD—other equipment	$5.1 billion
2009-10	FY2007-08	Marine Corps ground vehicles	$0.4 billion
	FY2007–08	DoD facilities and infrastructure	$1.9 billion
	FY2007–08	Army aviation and missiles	$1.6 billion
2010–11	FY2008–09	Air Force	$5.7 billion
	FY2008–09	Navy and Marine Corps aviation	$3.9 billion
2011–12	FY2008–10	Navy ships	$3.9 billion
	FY2008–10	Army ground vehicles	$1.9 billion
2012-13	FY2009–11	Marine Corps ground vehicles	$0.4 billion
	FY2009–11	DoD facilities and infrastructure	$3.0 billion
	FY2009–11	Army aviation and missiles	$2.0 billion
	FY2009	DoD—other equipment	$3.6 billion
2013-14	FY2010–12	Navy and Marine Corps aviation	Pending
	FY2010–13	Air Force	Pending

[a] Study period is 1 calendar year.

Table 2 highlights the costs for FY2009, the most current year for which all studies had data. Using FY2009 as a common baseline, LMI estimates the total cost of corrosion for DoD to be $23.1 billion, which includes costs outside normal reporting. This cost equates to 20.5 percent of the total maintenance funds expended by the DoD for weapon systems, infrastructure, and facilities.

Table 2. DoD Cost-of-Corrosion Studies for FY2009

Study year[a]	Data baseline	Study segment	Annual cost of corrosion
2010–11	FY2009	Air Force	$5.7 billion
	FY2009	Navy and Marine Corps aviation	$3.9 billion
2011–12	FY2009	Navy ships	$3.6 billion
	FY2009	Army ground vehicles	$1.9 billion
2012-13	FY2009	Marine Corps ground vehicles	$0.4 billion
	FY2009	DoD facilities and infrastructure	$2.7 billion
	FY2009	Army aviation and missiles	$1.4 billion
	FY2009	DoD—other equipment	$3.6 billion

The method used to measure corrosion-related cost focuses on direct material and labor costs as well as indirect costs, like research and development and capital expenditures for corrosion-related facilities (e.g., paint booths). The corrosion cost estimation is based on a combined top-down and bottom-up approach. The top-down portion uses summary-level cost and budget documentation to establish maintenance spending ceilings for depot and field-level maintenance for both organic and commercial activities. This establishes a maximum cost of corrosion for each area. The bottom-up portion uses detailed work order records to aggregate actual occurrences of corrosion maintenance and activity to define a minimum level of corrosion costs in each maintenance area. Statistical methods are then employed to bridge any significant gaps between the top-down and bottom-up figures to derive a final estimate for the cost of corrosion.

The CPC IPT–approved cost estimation method also segregates costs by their source and nature, using the following three schemas:

1
- *Depot maintenance* (DM)—corrosion costs incurred while performing depot maintenance
- *Field-level maintenance* (FLM)—corrosion costs incurred while performing organizational or intermediate maintenance
- *Outside normal reporting* (ONR)—corrosion-related costs not identified in traditional maintenance reporting systems[7]

2
- *Corrective*—costs incurred while addressing an existing corrosion problem
- *Preventive*—costs incurred while addressing a potential future corrosion issue

3
- *Structure*—direct corrosion costs incurred by the body frame of a system or end item
- *Parts*—direct corrosion costs incurred by a removable part of a system or end item

Corrosion Cost Trends

LMI compared the corrosion cost information from the previous DoD total cost studies, which used FY2006 data, and compared the totals to the more recent studies that used data from FY2009. LMI shows the results in Table 3. These figures exclude the ONR costs[8].

The total corrosion cost for DoD (excluding ONR) was $19.3 billion in FY2006. In FY2009, the DoD corrosion cost estimate was $21.6 billion. While this was more than a $2.0 billion increase, the entire change can be explained by looking at the increase in maintenance spending overall. Maintenance expenditures rose by nearly $17 billion. A more useful figure to examine is the corrosion cost as a percentage of maintenance cost, which actually decreased from 21.8 percent to 20.5 percent. This is a significant improvement.

Table 3. DoD Corrosion Cost Estimated by Study Segment—FY2006 and FY2009 ($ in millions)

	FY2006			FY2009		
Study segment	**Maintenance cost**	**Corrosion cost estimate (DM & FLM)**	**Corrosion as a percentage of maintenance**	**Maintenance cost**	**Corrosion cost estimate (DM & FLM)**	**Corrosion as a percentage of maintenance**
Navy and Marine Corps aviation	$10,512	$4,447	42.3%	$12,035	$3,781	31.4%
Air Force aviation/missiles	$18,270	$4,376	24.0%	$21,316	$5,689	26.7%
Navy ships/vessels	$12,443	$2,365	19.0%	$13,335	$2,994	22.5%
Army ground vehicles	$11,680	$1,860	15.9%	$12,544	$1,692	13.5%
Army aviation/missiles	$6,507	$1,583	24.3%	$7,777	$1,322	17.0%
Marine Corps ground vehicles	$2,237	$352	15.7%	$2,233	$297	13.3%
DoD facilities and infrastructure	$10,216	$1,167	11.4%	$16,225	$2,224	13.7%
DoD other equipment	$16,508	$3,118	18.9%	$19,864	$3,561	17.9%
Total	$88,373	$19,268	21.8%	$105,329	$21,560	20.5%

LMI can also see another interesting trend after examining the results by commodity grouping. This trend is shown in Table 4.

Table 4. DoD Corrosion Cost Estimated by Commodity Grouping— FY2006 and FY2009 ($ in millions)

	FY2006			FY2009		
Commodity grouping	**Maintenance cost**	**Corrosion cost estimate (DM & FLM)**	**Corrosion as a percentage of maintenance**	**Maintenance cost**	**Corrosion cost estimate (DM & FLM)**	**Corrosion as a percentage of maintenance**
Aviation/missiles (all services)	$35,289	$10,406	29.5%	$41,128	$10,792	26.2%
Army and Marine Corps ground vehicles	$13,917	$2,212	15.9%	$14,777	$1,989	13.4%
Navy ships/ vessels	$12,443	$2,365	19.0%	$13,335	$2,994	22.5%
DoD facilities and infrastructure	$10,216	$1,167	11.4%	$16,225	$2,224	13.7%
DoD other equipment	$16,508	$3,118	18.9%	$19,864	$3,561	17.9%
Total	$88,373	$19,268	21.8%	$105,329	$21,393	20.3%

Significant progress is being made in the aviation/missile and ground vehicle communities, where corrosion costs have either held steady or dropped in the three (3) years between FY2006 and FY2009, and where corrosion costs as a percentage of maintenance costs have improved significantly. For the ships/vessels and facilities/infrastructure groups, however, both corrosion costs and corrosion as a percentage of maintenance have increased.

Most alarming is that corrosion costs have nearly doubled for facilities and infrastructure. This is of concern because the amount of deferred maintenance for infrastructure and facilities (maintenance that is not completed because of budget concerns or other priorities) has been steadily rising. This means corrosion costs for facilities and infrastructure could rise even further.

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[1]*The Bob Stump National Defense Authorization Act for Fiscal Year 2003, Public Law 107-314, 2 December 2002, p. 201; Public Law 107-314 was enhanced by Public Law 110-181, The National Defense Authorization Act for Fiscal Year 2008, Section 371, 28 January 2008.*

[2]*GAO, Opportunities to Reduce Corrosion Costs and Increase Readiness, GAO-03-753, July 2003, p. 39.*

[3]*LMI, Proposed Method and Structure for Determining the Cost of Corrosion for the Department of Defense, Report SKT40T1, Eric F. Herzberg, August 2004.*

[4]*DoD CPC IPT, The Impact of Corrosion on the Availability of DoD Weapon Systems and Infrastructure, October 2009.*

[5]*LMI, The Annual Cost of Corrosion for Army Ground Vehicles and Navy Ships, Report SKT50T1, Eric F. Herzberg et al., April 2006.*

[6]*OSD, DoD Annual Cost of Corrosion, Prepared by the Under Secretary of Defense (Acquisition, Technology and Logistics), July 2009.*

[7]*These costs are not distributed within the other two schema.*

[8]*LMI excludes the ONR costs because some of these costs are not maintenance costs such as research and development and capital expenditures. In order to properly estimate the corrosion cost as a percent of maintenance cost, only maintenance costs can be included*

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Cost of Corrosion

DoD Releases New Report on the Effect of Corrosion on the Cost and Availability of Army Aviation and Missile Systems

By Eric Herzberg

LMI was asked by the Department of Defense (DoD) Corrosion Prevention and Control Integrated Product Team (CPC IPT) in August 2012 to measure the effect of corrosion on the availability and cost of Army aviation and missile systems. Using data from fiscal year (FY) 2012[1], LMI estimated the annual corrosion-related cost to be $1,963 million, or 21.9 percent of the total maintenance costs for all Army aviation and missile systems. We also estimated that corrosion was a contributing factor in 2,026,102 non-availability hours for Army aviation assets. This figure represents 18.1 percent of the total non-availability hours reported by the Army for its aircraft and equates to an average of 472 hours, or 19.7 days, of corrosion-related non-availability per year for Army aircraft or missile systems.

This review, which is funded by DoD, is part of a multiple-year plan to measure the effect of corrosion on DoD weapon systems. It is the third study to assess the effect of corrosion on maintenance costs and the second study to analyze the effect of corrosion on Army aviation and missile system availability. Table 1 lists previous Army aviation and missile system studies on the cost of corrosion, while Table 2 lists all DoD studies on the effect of corrosion on availability.

Table 1. Army Aviation and Missiles Cost-of-Corrosion Studies

Study year[a]	Data baseline	Estimated annual cost of corrosion	Corrosion as a percentage of total maintenance
2006–2007	FY2005	$1,654 million	18.6%
2009–2010	FY2007	$1,277 million	17.3%
	FY2008	$1,486 million	21.0%
2012–2013	FY2009	$1,261 million	16.8%
	FY2010	$1,704 million	20.1%
	FY2011	$1,929 million	20.6%
	FY2012	$1,963 million	21.9%

[a] Study period is 1 calendar year.

Maintenance expenditures fluctuate and supplemental maintenance funding is variable; so, too, are corrosion-related cost totals. Therefore, corrosion cost as a percentage of maintenance is a better indicator of any overall trends when looking at the effect of corrosion on the cost of weapon systems. The corrosion-related average of 21.9 percent of total annual Army aviation and missile system maintenance costs is roughly midrange for the DoD weapon systems LMI has studied. This percentage has been increasing steadily over the last four (4) fiscal years (FY2009–12).

The scope of LMI's study included all Army aviation and missile end items and major sub-components in inventory during FY2009–12. In that period, 69 types of aircraft and 12 missile systems existed at the type, model, and series level of detail, which equates to more than 4,500 aircraft and missiles[2]. Also included were 50,000 major aircraft and missile subcomponents.

To assess corrosion's effect, we segregated the Army's corrosion-related costs into three separate schemas: depot versus field-level maintenance, corrective versus preventive costs, and costs associated with structure versus parts. Table 3 shows both the costs and percentages within each schema for FY2012.

Table 2. DoD Studies on the Effect of Corrosion on Availability

Study year[a]	Data baseline	Study segment	Annual non-available time attributable to corrosion: Total	Annual non-available time attributable to corrosion: Avg. per end item
2010–2011	FY2008–09	Army aviation and missiles	1,717,898 hours	17.4 days
		Navy and Marine Corps aviation	95,237 days	26.5 days
		Air Force	2,102,476 hours	15.9 days
2011–2012	FY2008–10	Army ground vehicles	662,649 days	1.7 days
2012–2013	FY2009–11	Marine Corps ground vehicles	209,115 days	3.3 days
	FY2009–12	Army aviation and missiles	2,026,102 hours	19.7 days

[a] Study period is 1 calendar year. Availability results are based on the last year of the data baseline.

FLM accounted for 58.0 percent ($1,139 million) of the combined corrosion-related cost for Army aviation and missile systems within schema 1 ($1,963 million). However, in terms of percentage of overall maintenance, corrosion-related DM costs exceeded corrosion-related FLM costs. The corrosion-related DM cost as a percentage of total Army aviation and missile system DM was 29.3 percent; the same FLM measure was only 18.7 percent (see Table 4).

Table 3. Nature of Corrosion-Related Costs for Army Aviation and Missile Systems (FY2012)

	Schema for corrosion-related costs	Corrosion-related cost (in millions)	Percentage (within schema)
1	Depot maintenance (DM)	$771	39.2%
	Field-level maintenance (FLM)	$1,139	58.0%
	Maintenance outside normal reporting	$53	2.8%
	Total	$1,963	100.0%
2	Corrective maintenance	$272	14.2%
	Preventive maintenance	$1,634	85.6%
	Unable to classify	$4	0.2%
	Total	$1,910	100.0%
3	Structure	$538	28.2%
	Parts	$1,330	69.6%
	Unable to classify	$42	2.2%
	Total	$1,910	100.0%

The remaining $53 million for corrosion-related maintenance that is outside normal reporting reflects the maintenance performed by operators with a non-maintenance occupation specialty, which typically is not recorded in standard maintenance systems.

Costs incurred to prevent corrosion (e.g., inspecting, treating, coating, washing) were far higher ($1,634 million versus $272 million) than those for corrosion-related corrective actions (e.g., fixing, replacing, and blasting). This 6-to-1 ratio is likely exaggerated by the lack of detail in Army maintenance records. The lack of descriptive text shifts the ratio of corrosion costs in favor of preventive classifications. Parts-related costs ($1,330 million) were also significantly higher than structure-related costs ($538 million).

LMI also stratified the corrosion-related costs of Army aviation and missile systems by type, model, and series; total cost; and cost per item, ranking systems by their total and average corrosion-related costs. Aircraft and missile systems with both a high total cost of corrosion and a high average cost of corrosion per item merit the most attention. LMI identified five aircraft that were among the top 10 contributors for both (see shaded entries in Table 5). Each of these five aircraft presents a specific opportunity for the Army to focus resources to mitigate the negative effect of corrosion.

Table 4. Comparison of DM and FLM Corrosion-Related Cost for FY2012

Type of maintenance	Total maintenance cost (in millions)	Corrosion-related cost (in millions)	Percentage of corrosion-related maintenance cost
Depot	$2,627	$771	29.3
Field-level	$6,081	$1,139	18.7

Corrosion-related non-availability hours (2,026,102 hours) accounted for 18.1 percent of the total non-availability reported[3]. LMI shows in Table 6 the highest 10 contributors to corrosion-related non-availability hours. Two utility helicopters, the UH-60L and UH-60A, had the highest corrosion-related non-availability hours. The OH-58D observation helicopter accounts for both the highest percentage of corrosion-related non-availability hours to total non-availability hours, and the highest average corrosion-related non-availability hours per aircraft.

Table 5. Highest Combined Ranking for Average and Total Corrosion Cost (FY2012)

Type, model, & series	Description	Total corrosion cost (in millions)	Corrosion cost rank	Corrosion cost per item (in millions)	Per-item corrosion cost rank	Combined rank score
UH-60L	Utility helicopter	$267.9	1	$0.3	6	7
MH-47G	Special operations helicopter	$58.8	9	$0.9	2	11
OH-58D	Observation helicopter	$112.8	4	$0.3	8	12
UH-60M	Utility helicopter	$90.6	6	$0.3	9	15
CH-47D	Cargo helicopter	$95.7	5	$0.3	10	15
AH-64D	Attack helicopter	$195.2	2	$0.3	13	15
UH-60A	Utility helicopter	$195.1	3	$0.3	14	17
MH-60M	Special operations helicopter	$32.4	16	$0.7	3	19
MH-60L	Special operations helicopter	$20.9	19	$0.6	4	23
EH-60A	Electronics helicopter	$29.8	18	$0.6	5	23

With the exception of the OH-58D, the range of percentages for corrosion-related non-availability hours in Table 6 is fairly narrow. This indicates common causes of corrosion likely affect these aircraft in a common way.

Table 6. Comparison of Corrosion-Related Non-Availability Hours to Total Non-Availability Hours (FY2012)

TMS	Description	Avg. number of aircraft	Total NAHs	Related to corrosion		
				NAHs	Percentage of total NAHs	Avg. NAHs per aircraft
UH-60L	Utility helicopter	832	2,288,779	442,624	19.3%	532
UH-60A	Utility helicopter	672	2,017,296	340,215	16.9%	506
AH-64D	Attack helicopter	663	1,602,959	286,451	17.9%	432
OH-58D	Observation helicopter	347	926,229	236,426	25.5%	681
CH-47D	Cargo helicopter	260	825,457	154,298	18.7%	593
TH-67A	Training helicopter	224	563,078	117,593	20.9%	609
OH-58A	Observation helicopter	211	559,831	104,962	18.7%	590
UH-60M	Utility helicopter	193	443,838	73,624	16.6%	329
CH-47F	Cargo helicopter	178	312,344	57,038	18.3%	383
C-12V	Passenger and light cargo helicopter	149	214,504	33,811	15.8%	372

The relationship between corrosion cost and corrosion-related non-availability is strong for Army aviation and missile systems. The systems that experience the highest corrosion-related cost also suffer high corrosion-related non-availability (see Table 7).

Table 7. Total Corrosion-Related Cost and Non-Availability Hours by Type, Model, & Series (FY2012)

	Corrosion-related cost			Corrosion-related non-availability		
TMS	Rank	Total corrosion cost (in millions)	Corrosion as a percentage of total maintenance	Rank	Total corrosion NAH	Corrosion NAHs as a percentage of total NAH
UH-60L	1	$268	19.9%	1	442,624	19.3%
AH-64D	2	$195	20.1%	3	286,451	17.9%
UH-60A	3	$195	20.5%	2	340,215	16.9%
OH-58D	4	$113	21.7%	4	236,426	25.5%
CH-47D	5	$96	19.7%	5	154,298	18.7%
UH-60M	6	$91	21.6%	8	73,624	16.6%
UH-60A (E21985)	7	$87	34.7%	—	—	—
ENGT-701D	8	$75	28.8%	—	—	—
MH-47G	9	$59	27.5%	—	—	—
ENGT-700	10	$58	41.3%	—	—	—

Four of the 10 aircraft and missile systems with the highest total corrosion cost had no reported non-availability (depicted in the last four rows of Table 7). However, the six aircraft with the highest total corrosion cost were among the top eight aircraft for high, total, corrosion-related non-availability hours[4].

This is actually good news. Efforts to mitigate the cost of corrosion on these aircraft should also increase availability.

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[1]*Data was collected for FY2009–12, but LMI based the corrosion-related cost and availability of Army aviation and missile systems on FY2012 data.*

[2]*To our knowledge, this includes all types of Army aviation and missile systems.*

[3]*LMI measured the total corrosion-related non-available hours in a manner consistent with how the Army reports its results that are not mission capable.*

[4]*This correlation was statistically strong. To calculate the correlation, LMI used a statistical formula based on an R-squared value. An R-squared value of 100 percent shows a perfect correlation; whereas 0 percent indi-cates no correlation at all. For the FY2012 study period, the R-squared value of the relationship between the corrosion-related cost and corrosion-related non-availability hour rankings by type, model, and series was 89 percent.*