National Aeronautics and Space Administration

QuEST

Qualifying Environmentally Sustainable Technologies

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Message from the Principal Center Manager

The idea of international collaboration is not new, but the drive to better utilize and preserve Earth's resources has never been greater. TEERM is working with an ever-expanding list of international partners including the European Union, the European Space Agency and the nation of Portugal. The collaboration that is at the heart of TEERM's international partnerships will help to accomplish current missions and foster a more sustainable future that reduces risks to missions that lie ahead.

Working with international partners provides NASA with opportunities to explore ways to protect our natural resources, conserve energy, reduce the use of hazardous materials and reduce greenhouse gases that potentially affect all of Earth's inhabitants. NASA and its partners are also seeking new sources of renewable energy to meet the needs of future generations.

Our common goal is to foster a sustainable future in which we continue to explore the universe while preserving our home planet's resources for future generations. We look forward to continuing work with all our partners to better prepare NASA to meet present and future challenges.

Chuck Griffin

TEERM Principal Center Manager
NASA KSC/NE-T

Risk Identification and Mitigation

The materials and processes historically used by NASA are continually impacted by environmental legislation. Domestic regulation and international agreements have banned certain materials from future use or production, making it necessary to find replacements that comply with environmental regulations and provide equivalent performance. NASA is also compelled to meet the requirements of directives on improved energy efficiency and the use of renewable and alternative energy.

The NASA Technology Evaluation for Environmental Risk Mitigation Principal Center (TEERM) identifies and validates environmental and energy technologies through joint activities that enhance NASA's mission readiness and reduce risk while minimizing duplication of effort and associated costs. In order to do that, however, we must first understand what the risks are. TEERM works with several partners who identify potential risks and communicate that information to us.

An important TEERM partner is the Shuttle Environmental Assurance Initiative (SEA). The SEA is comprised of government and contractor representatives from each of the Space Shuttle Program (SSP) Elements. The SEA provides an integrated approach to promoting environmental excellence, proactively managing materials obsolescence, and optimizing resources. The SEA team works to identify environmental regulations that may restrict or eliminate the use of certain materials on the SSP.

One example of collaboration between TEERM and SEA is on the matter of the toxic chemical hexavalent chromium. In the late 1990s and early 2000s, NASA and TEERM were involved in several Department of Defense (DoD) projects to examine the viability of pretreatments or primers for aluminum substrates that contained no hexavalent chromium. The SEA group and SSP contractors had also identified where hexavalent chromium was used on the SSP and were working to identify potential replacements.

When the Occupational Health and Safety Administration lowered the Permissible Exposure Limit for hexavalent chromium, this presented a true risk to NASA that chrome-containing products might become obsolete. In response, TEERM initiated a joint NASA-DoD project to examine non-chrome coating systems for aircraft and aerospace applications. SEA members have been invaluable stakeholders in the project.

Another partner that works with TEERM and SEA is the NASA Principal Center for Regulatory Risk Analysis and Communication (RRAC PC). The RRAC PC identifies, analyzes, and communicates potential risks to the NASA mission from domestic and international regulations. The RRAC PC also supports NASA Programs, Centers, and related stakeholders by representing their interests to environmental regulators during rulemaking activities. Their research is invaluable in recognizing which processes or materials could be restricted in the future. TEERM uses that information to determine the best course of action for mitigating those risks.

TEERM also works with environmental employees and contractors at the various NASA Centers and facilities to identify opportunities for investigation. Personnel on the front lines provide invaluable information on what is of the most concern in their local

area. For example, TEERM gathered input from Center environmental managers, shop owners, and procurement personnel to create a "Consumer's Guide" to alternative parts washers. The guide provides critical information to assist personnel in deciding which environmentally preferable parts washer would work best for their shop.

TEERM is developing partnerships with international entities in order to access the knowledge of the global engineering community. Aerospace agencies and industries around the world face many mutual challenges, and collaboration between NASA and international partners benefits all involved by sharing resources and bringing the experts of the world together to meet common goals.

TEERM relies on all its partners to identify processes or materials whose continued use places the NASA mission at risk. It is then our goal to find and qualify acceptable alternatives that meet environmental, financial, and performance requirements. It is only by working together that we can make the best use of limited resources and ensure our continued commitment to exploring our home planet and the universe beyond.

Material Management and Substitution Efforts

Hexavalent Chrome-free Coatings

Although an excellent corrosion preventative, hexavalent chromium is a toxic and carcinogenic substance that has become increasingly regulated. The benefits of replacing hexavalent chromium materials include avoidance of obsolescence risks, reduction in occupational exposure and risk, and a reduction in hazardous waste and associated costs.

Aerospace Applications

The TERRM Non-Chrome Coating Systems for Aircraft and Aerospace Applications project aims to qualify complete coating systems that are free of hexavalent chromium for outer mold lines of aircraft and space vehicles. Substrates include typical aluminum alloys as well as NASA-specific lithium-aluminum alloys used on legacy and future space flight hardware. Testing is complete and a draft final report is currently being prepared.

Electronics Applications

Due to regulations pertaining to hexavalent chromium, electronics manufacturers are evaluating the use of chrome-free coatings. It is not known, however, whether commercial chrome-free coatings will provide adequate protection in harsh military/aerospace environments. TEERM is working with multiple NASA and DoD representatives to begin testing coatings that do not contain hexavalent chromium. A joint test plan has been developed.

Low VOC Coatings

NASA and U.S. Air Force space launch facilities and support equipment are coated with materials to protect them from the harsh effects of corrosion and thermal ablation. The most commonly used coatings contain zinc, volatile organic compounds (VOCs) and isocyanates. These materials, however, are subject to increasing environmental and safety regulations and concerns. In order to address these compliance needs, more environmentally friendly coatings are being developed by industry.

Test coatings applied to launch complex at Vandenberg Air Force Base

Over the years, TEERM has brought together technical representatives from NASA and the Air Force to participate in efforts to evaluate alternative coatings for ground support equipment and launch support facilities. Coatings must be able to withstand the effects of severe temperatures and corrosive exhaust gases from rocket launches to adequately protect the underlying structural steel or concrete. Coatings must also be

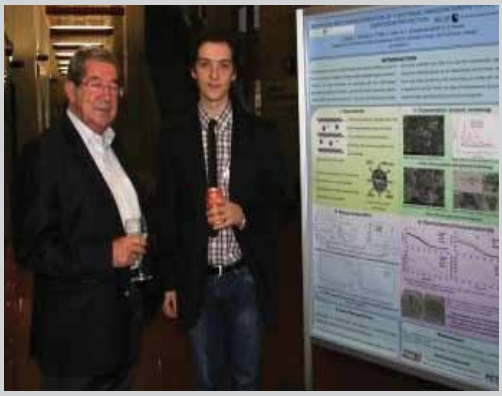
2010 International Workshop Was a Big Success

The 2010 C3P/NASA International Workshop on Environment and Alternative Energy was held November 2-4, 2010, at the University of California San Diego (UCSD) campus. Subject matter experts from around the world presented on environmental and energy related topics ranging from renewable and alternative energy to climate change response to site remediation.

The workshop provided an excellent forum to showcase innovative and emerging technologies, share lessons learned, and identify new joint opportunities. Individuals from seven countries attended the three-day event, which included a panel discussion on the issue of measuring sustainability, as well as a session devoted to oral and poster presentations by research students at universities in the U.S., Portugal, and Germany.

Plans are underway for the 2011 International Workshop to be held November 15-18, 2011, at The European Space Research and Technology Centre in Noordwijk, The Netherlands. For more information, visit the TEERM website at http://www.teerm.nasa.gov/workshop.html.

Participants listening attentively to a technical presentation



Joao Tedim, student from the University of Aveiro, Portugal, discusses his work with General Castelo Branco of C3P

able to protect against the deleterious effects of ambient conditions such as temperatures, ultraviolet exposure, and salt spray typical of tropical launch sites.

One coating technology for which TEERM is assisting in the demonstration and evaluation is gas dynamic spray. Also commonly called cold spray, the technology can apply any number of coating materials to a variety of substrates. Use of the technology can reduce the amount of maintenance and hazardous materials/wastes generated as compared to current processes. In the demonstration project, test panels showed few signs of corrosion after 18 months of exposure at the Kennedy Space Center Corrosion Beach Test Site.

In addition to testing in Florida, alternative coatings have also been applied to launch pads at Vandenberg Air Force Base in California. Interim evaluations show some of the coatings performing well. Final evaluations were conducted in early 2011.

Lead-Free Electronics

Major commercial suppliers of electronics have begun replacing tin-lead solder in their products with materials that are entirely free of lead. Compared to traditional tin-lead components, the reliability of lead-free components is not well understood. To reduce the risk that lead-free solder presents, TEERM is now completing the second of two projects to understand how lead-free electronics perform in high-reliability applications.

Subsequent to TEERM's first lead-free electronics project, Marshall Space Flight Center leveraged the TEERM test vehicle design and project findings to design a small active package containing lead-free test boards. The boards, along with a data acquisition system, are now on the exterior of the International Space Station. The experiment uses components and materials similar to those found on test vehicles used in TEERM lead-free electronics projects. The resistance of each circuit and temperature in the box is being recorded at periodic intervals and will be evaluated once returned to Earth.

Project Highlight

Corn-Based Depainting Media

Corn hybrid polymer media has several performance and environmental benefits over plastic media for abrasive blasting. Corn hybrid polymer media is effective at removing coatings from delicate substrates without causing loss of substrate or other physical damage while generating less waste. Corn hybrid polymer media is made of a polycrystalline cornstarch material that is 100% organic, non-toxic and biodegradable.

The technology was added to a military specification for corrosion control after the Departments of Defense and Homeland Security conducted tests and subsequently approved eStrip™ GPX Type VII media (a corn hybrid polymer based product) as a satisfactory alternative to certain plastic blast media types for specific applications.

TEERM arranged for technical demonstrations to introduce the technology to potential users at both Kennedy Space Center and Johnson Space Center. A demonstration of the Type VII media occurred at Johnson Space Center's Forward Operating Location in El Paso, TX. Based on the demonstration, facility technicians and Johnson Space Center's Engineering Team has approved Type VII as an alternative blast media for use on specific components of NASA's T-38 aircraft.

Equipment upgrades and technician training is currently underway. The exclusive use of the corn hybrid polymer media for specific de-coating processes will commence in 2011. This will be the first known NASA process to use this bio-based technology. Other applications are being explored.

Demonstration of corn hybrid polymer blast media at JSC Forward Operating Location

Alternative Energy Efforts

Hydrogen Sensors

Hydrogen is an invaluable alternative for energy sustainability and efficiency. Hydrogen fuel cells operate more cleanly, are more efficient, and have better reliability than do their petroleum-based counterparts. The development of efficient hydrogen production, storage, and utilization technologies brings with it the need to proactively detect and pinpoint hydrogen leaks for the protection of personnel and equipment.

In order to accelerate the deployment of stationary fuel cell installations at NASA facilities while mitigating associated safety risks, TEERM is collaborating with subject matter experts within NASA and other federal agencies to identify promising commercial hydrogen sensor technologies. TEERM's future goal is to validate one or more sensor technologies through testing.

Solar Air Conditioning

Reliable access to affordable, stable energy supplies is a challenge for NASA and the DoD, and disruption or curtailing of critical power supplies affects mission readiness. One means of mitigating this risk is the use of renewable energy. Studies have concluded that air conditioning accounts for 30-60% of total energy use at DoD facilities, so TEERM organized a collaborative technology demonstration project with the DoD and Environmental Security Technology Certification Program (ESTCP) to gather performance data on using solar energy to cool buildings.

The project will demonstrate that concentrated solar collectors can be integrated with absorption chillers to provide a renewable energy based source of air conditioning. The goal is to provide reliable access to affordable, stable energy supplies at NASA and DoD facilities while increasing energy efficiency. The project will help facilities meet federal mandates to reduce energy intensity while increasing renewable energy usage. Performance objectives have been developed, the demonstration site has been selected, and a demonstration plan has been approved by the ESTCP Program Office. Construction of the solar collectors and installation of the absorption chiller is anticipated in mid-2011.

Demonstration site for Solar AC project

Other TEERM Efforts

Energy and Water Management

TEERM expanded its support of NASA Headquarters Environmental Management Division (HQ EMD) in 2010. Activities now include energy/water reporting to the Department of Energy and Office of Management and Budget and maintaining "Dashboards" that show at a glance key metrics such as a Center's energy intensity, water intensity, renewable energy usage, and funding needs. TEERM engineers also support HQ EMD in conducting on-site Environmental and Energy Functional Reviews, which provide functional oversight of NASA Center energy/water management implementation activities.

TEERM engineers also drafted a NASA presentation to a delegation of Bavarian diplomats on NASA's contribution to Clean Technology and Energy Policy in the U.S. Other TEERM activities in support of NASA energy management included analyzing NASA energy/water data, and redesigning NASA's Hydrogen Web Page at http://www.nasa.gov/topics/technology/hydrogen/index.html.

Redesigned Hydrogen web page highlights NASA's use of hydrogen and fuel cells, both in the air and on the ground

Remediation Technology Collaboration

TEERM is working with remediation liaisons at NASA HQ EMD and remedial program managers at NASA Centers and Component Facilities to identify technologies for remediation of contaminated sites. TEERM engineers have formed a baseline of deployed site remediation processes/conditions and continue to research innovative site-applicable technologies. Technologies of prime interest include cleanup technologies, renewable energy systems (green remediation), and long-term monitoring.

International Efforts

As more countries gain experience and knowledge with renewable energy and high efficiency technologies, opportunities exist for collaboration. As one example, NASA TEERM and the Centro Para Prevenção da Poluição (C3P) are working together to document technologies and best practices for increasing the environmental sustainability of buildings while optimizing economic viability and the comfort and safety of occupants.

The result of this collaboration will help advance the causes of ecological and economic efficiency in the U.S. and Portugal. Both NASA and C3P will benefit from sharing technical information on new technologies and designs for individual buildings and groups of facilities. Perfecting the design of sustainable buildings on Earth can also help engineers develop sustainable habitats for use in other locations across the solar system.

TEERM is also working with the European Space Agency (ESA) to identify and evaluate less hazardous materials for use in space hardware and operations. Presently, TEERM and ESA are collaborating on a plan for testing hexavalent chromium free coatings. To facilitate further collaboration and development of environmental projects, ESA's European Space Research and Technology Center in the Netherlands will be the host site for the 2011 NASA-C3P International Workshop.

TEERM Support

Technical, engineering, business, and management support for TEERM provided by staff from ITB, Inc., headquartered in Dayton, Ohio. ITB has been part of TEERM since the program's inception in 1998. ITB TEERM engineers identify opportunities for collaboration and develop them into joint projects, which ITB then manages or otherwise supports. ITB provides support to NASA Headquarters on environmental, remediation, energy, and water matters. ITB is also a valuable resource in NASA's partnership with C3P in Portugal.

QuEST is a publication of the NASA Technology Evaluation for Environmental Risk Mitigation Principal Center (TEERM) located at Kennedy Space Center, FL.

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http://teerm.nasa.gov

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