



QUEST

Qualifying Environmentally Sustainable Technologies

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Message from the Principal Center Manager

The past year was an exciting one for NASA TEERM. In addition to continuing support for NASA in the areas of material substitution, pollution control, remediation and energy and water support, we also became involved in the Ground Systems Development and Operations Program to help NASA and Kennedy Space Center meet the goal of becoming a sustainable multi-use spaceport.

We are also much energized about the partnerships we have developed. Domestically, we are working with Sandia National Laboratories from the Department of Energy and continuing to work with the Department of Defense. Internationally, we are maintaining our relationship with Portugal's Centro Para Prevenção da Poluição (Center for Pollution Prevention or C3P). We also now have a formal agreement with the European Space Agency (ESA) that allows us to exchange information and work together on projects.

This is a new era for space exploration, and NASA TEERM looks forward to the exciting opportunities that await us all.

Thank You,

Chuck Griffin

TEERM Principal Center Manager
NASA KSC/NE-T

Foundation of TEERM Technology Evaluation is Testing and Qualification

A fundamental activity of the NASA Technology Evaluation for Environmental Risk Mitigation Principal Center (TEERM) is the testing and validation of technologies that can reduce environmentally driven risks to NASA's mission. Testing of such materials or processes is necessary to obtain data on their performance prior to implementation at NASA Centers.

Materials and processes approved for use in NASA applications have been "qualified," meaning they have been deemed acceptable based on testing to stringent performance requirements. When evaluating any new material or process for which little data is available, engineers are reluctant to consider it a viable replacement without seeing representative test data.

TEERM works with NASA and other stakeholders throughout the entire project to ensure its successful completion. TEERM staff identifies and screens promising technologies, helps develop the test plan, oversees the testing, prepares the test report and supports implementation. This continuity element is essential to the acceptance of suitable alternative materials and technologies.

A key element in successful projects is the development of a technically sound test program. TEERM engineers have extensive knowledge and experience in demonstrating materials or processes for coatings, coating removal, cleaning, pollution control, recycling, remediation, renewable energy and sustainable development, among others. This understanding enables TEERM to guide project participants to design a test program that ensures all their critical performance requirements are included and the appropriate test methods are used.

After the test plan is complete, TEERM helps project stakeholders identify and obtain the services of reputable testing facilities. One of our frequent testing collaborators is the NASA Corrosion Technology Laboratory (CTL) located at NASA Kennedy Space Center (KSC). The CTL evaluates and determines materials performance and degradation in different environments in support of NASA, other government organizations, industry and educational institutions. The CTL includes a Coatings Application Laboratory, Accelerated Corrosion Laboratory and the Beachside Atmospheric Test Facility. The Beachside Atmospheric Test Facility, located approximately 150 feet from the Atlantic Ocean and one of the harshest environments in the world, has provided data on the long-term performance of materials since the 1960s.

Numerous other facilities have performed testing services for TEERM projects also. For example, in a lead-free electronics project that TEERM initiated and managed for NASA and the U.S. Department of Defense (DoD), TEERM obtained the testing and analysis services of multiple agencies and industry partners, including Sandia National Laboratories, COM DEV International (Canada), Naval Surface Warfare Center-Crane

Division, Celestica (Canada), Boeing, Nihon Superior (Japan), Raytheon, Lockheed Martin and Rockwell Collins.

TEERM's knowledge of promising new technologies and test plan development helps guide project members in knowing what kind of testing to perform. Generally, testing can comprise laboratory testing, simulated environment testing, or field-testing. Laboratory testing is useful and cost-effective for new or developing technologies, while field testing is ideal for mature, commercial products that have already undergone laboratory or simulated environment testing. Over the years, TEERM has frequently collaborated with the U.S. Air Force Space Command (AFSPC) to test protective coatings at active Air Force and NASA launch sites. As a result of these field demonstrations, several environmentally preferable coatings have been approved by one or both of the agencies.

Years of experience and data are available for legacy materials and processes. In order to qualify other materials and technologies, TEERM works with project stakeholders and laboratories to test alternatives in an objective, unbiased manner. Our work allows engineers to use environmentally preferable alternatives with the same confidence as previously used materials and processes. That is what truly makes TEERM so beneficial not only to NASA, but to all of our partners.

Materials Management and Substitution Efforts

Hexavalent Chrome-free Coatings

Coatings containing hexavalent chromium provide excellent corrosion resistance, especially in harsh environments. However, hexavalent chromium is a toxic substance and heavily regulated. Continued use of these coatings presents an environmental and safety risk as well as an obsolescence risk. As such, engineers are considering the use of hexavalent chromium-free coatings in everything from avionics boxes to exteriors of aerospace vehicles. Switching to hexavalent chromium-free coatings is complicated by the fact that historical testing shows they do not perform as well as coatings containing hexavalent chromium.

Aerospace Applications

In 2011, TEERM completed its study and report of non-chrome coating systems for aircraft and aerospace applications. This project tested promising non-chromated coating systems (pretreatment, primer and topcoat) to the performance requirements designated in the NASA-DoD approved test plan.

TEERM and ESA are working together to screen new hexavalent chromium-free coatings and further evaluate previously tested materials that showed promise for use in space applications. The project's test plan calls for testing coatings both in a systems lay-up (pretreatment, primer, topcoat) and as individual components. Procurement of test materials is currently underway and testing will begin in 2012.

Electronics Applications

TEERM is working with over 40 public and private organizations, including NASA and DoD, to test chromium-free coatings for electronics enclosures. Testing has begun in accordance with a team-approved test plan.

Lead-Free Electronics

Electronics suppliers are moving away from lead in their standard products due to regulations and overall "greening" of the electronics industry. Inclusion of lead-free materials, whether by design or inadvertently, into electronic assemblies used by NASA is growing. There is great risk to high-reliability applications due to a lack of performance data, poorly understood failure mechanisms and unknown long-term functionality for lead-free materials. In order to mitigate the risk, TEERM worked with the DoD and defense and space contractors to assess the reliability of solder interconnects assembled and reworked with lead-free alloys and mixed (lead/lead-free) alloys. The project's draft test report is available on the TEERM website.

Low VOC Coatings

Environmentally Preferable Coatings for Launch Facilities

Launch pads are exposed to extremely corrosive ambient and operational conditions. Over the years, TEERM has managed or supported various NASA efforts to test and qualify effective, environmentally friendly coatings for launch structures.

In a new project under the NASA Ground Systems Development and Operations Program, TEERM is facilitating the identification and testing of environmentally preferable coatings for considered use at KSC launch facilities.

European Space Agency Supports NASA-C3P Workshop



Workshop attendees during tour of the ESTEC and Space Expo (visitor's center)

NASA and C3P held an international technical workshop on November 15–18, 2011, at the European Space Agency Research and Technology Center (ESTEC) in Noordwijk, The Netherlands. NASA TEERM provided primary coordination for the event, for which more than 100 individuals from 11 countries attended. The workshop provided an excellent forum to showcase innovative and emerging technologies in pollution prevention, remediation, green buildings and renewable energy.

In order to promote the study of science, technology, engineering and mathematics, a full day of the workshop was dedicated to a student session. Fifteen students from around the globe gave oral presentations along with poster displays relating to the latest technological developments in environmental and alternative energy strategies. Judges from NASA, C3P and the ESA awarded plaques for the top three student presentations.

The 2012 International Workshop will be December 4–7, at NASA's Goddard Space Flight Center in Maryland. For more information, visit the TEERM website at <http://teerm.nasa.gov/workshop.htm>.

Several coating systems have been identified. Testing is scheduled to begin in 2012 with coated test panels being placed at the KSC Beachside Atmospheric Test Facility.

Citric Acid Passivation

Stainless steel alloys undergo a process called passivation to increase corrosion resistance. The material most commonly used for passivation is nitric acid, which has a number of environmental, safety and operational issues. Citric acid is employed in some industries as a safer substitute for nitric acid; it is naturally occurring, biodegradable, does not create toxic fumes and is not a hazardous waste. TEERM is working with representatives from NASA and the DoD to qualify citric acid as a replacement to nitric acid for their applications.

Precision Cleaning & Contamination Control Group

Many precision cleaning agents used by NASA are categorized as Class 1 or Class 2 Ozone Depleting Substances and have been banned from production and/or use, while others will be phased out in the future. In response to this obsolescence risk, NASA has formed a Precision Cleaning & Contamination Control Group led by NASA White Sands Test Facility and co-chaired by TEERM. The group's objective is to maintain a peer-driven network of individuals, engaged in precision cleaning and contamination control issues, who come together to share their collective knowledge and learn from one another. Members work together to identify common problems and explore solutions, to develop and implement best practices and seek to advance precision cleaning technology.

The group has been actively participating in the DoD's Joint Service Solvent Substitution Working Group. The collaboration has resulted in NASA Marshall Space Flight Center performing a lab scale study funded by the U.S. Army to look for replacements to n-Propyl Bromide for vapor degreasing applications.

Recycling and Pollution Control Efforts

Recycling Spent Blast Media into Concrete

Spent media from abrasive media blasting contributes measurably to NASA's landfilled waste. TEERM began looking into novel ways to either recycle or reuse this waste. A solution currently under review is incorporating non-hazardous spent blast media as an alternative aggregate into concrete. TEERM is currently

NASA TEERM Program Highlight

Partnership Agreements

In executing technology evaluation projects, TEERM often collaborates with other agencies, both domestic and international. One of the biggest benefits of collaboration is the leveraging of knowledge and resources of all the team members. Partnering can result in a significant cost savings to team members who might otherwise have paid for the entire project themselves.

To enable such collaboration, NASA may enter into formal agreements with its partners. In recent years, TEERM has facilitated the signing of agreements, notably:

- a Space Act Agreement between NASA KSC, the U.S. Navy and U.S. Air Force for the Concentrated Solar Air Conditioning for Buildings Project;
- an agreement between NASA KSC and Sandia National Laboratories for the Hydrogen Fuel Cell Mobile Lighting Tower project; and
- an agreement with ESA to collaborate on testing alternatives to coatings containing hexavalent chromium.

TEERM has also facilitated numerous Military Interdepartmental Purchase Requests between NASA and the DoD for a variety of efforts, including coatings for launch facilities, lead-free electronics, and hydrazine waste minimization.

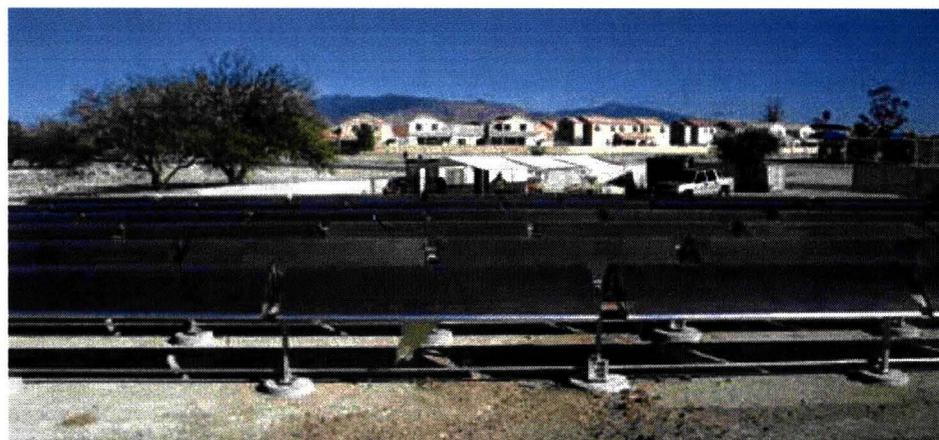
These agreements help NASA to better position itself to respond to new global regulatory and business paradigms. Collaborating provides opportunities within the global science community to maximize scientific value while minimizing costs and risks for all involved.

identifying test locations to test the concept. Success of the project can decrease the costs of construction and waste disposal for NASA.

Energy Efforts

Concentrated Solar Air Conditioning for Buildings

TEERM is supporting a collaborative technology demonstration project between NASA, the U.S. Air Force and the U.S. Navy to gather performance data on using solar energy to help offset the energy demand to cool buildings. The project is demonstrating a new type of concentrated solar collector integrated with absorption chillers to provide a renewable energy based source of air conditioning. Background data being collected will be used with system models to aid design and the decision process and evaluate potential installations at NASA Centers. Construction of the solar collectors and installation of the absorption chiller at the Davis-Monthan Air Force Base, Arizona, is currently underway.



Solar parabolic trough collectors for the Solar Air Conditioning for Buildings project at Davis-Monthan Air Force Base

Hydrogen Fuel Cell Mobile Lighting Tower

TEERM is supporting NASA KSC and Sandia National Laboratories in evaluating the performance of a mobile tower lighting system that uses a hydrogen fuel cell as a replacement for the common diesel-powered generator systems. The tower was demonstrated at the KSC Press Site during the final launch of the Space Shuttle Program, STS-135. KSC was chosen as



Hydrogen Fuel Cell Mobile Lighting Tower at the launch of the Space Shuttle Atlantis (July 2011)

a deployment site to evaluate the technology's performance in a hot, humid and corrosive environment. Advantages of the new technology over conventional diesel include reduced noise, elimination of diesel particulate emissions and increased energy efficiency. The technology can also be used both indoors and outdoors and the high color-rendering index of the plasma lighting aids human visual acuity and can improve employee safety.

Bio-fuel for Aviation

Bio-fuels offer the advantage of decreased dependence on petroleum and reduced carbon footprint, among other things. NASA researchers have been exploring methods to cost-effectively grow and cultivate native plants and algae for bio-fuel. Native plants are an ideal bio-fuel because they do not compete with existing crops for land and water resources. TEERM is working with KSC and Glenn Research Center to locate a site at KSC to grow and cultivate native plants in order to test growth and lipid production in a real-world environment.

Energy Efficiency and Sustainable Construction

As more countries gain experience and knowledge with renewable energy and high efficiency technologies, more opportunities exist for international collaboration. Under

an agreement between NASA and Portugal, TEERM and C3P began working together in 2011 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.

One project is located in the center of the city of Beja; a new municipal services building is being renovated and equipped with photovoltaic technology. The effort is using innovative construction techniques and solutions for space rehabilitation to create an energetically sustainable and zero carbon footprint building. The work will reduce energy costs, contribute to increasing awareness in local communities of energy efficiency and create an improved workspace.

Remediation Efforts

Remediation Technology Collaboration

TEERM is working to identify technologies for reducing the total liability associated with contaminated NASA sites. TEERM engineers have formed a baseline of deployed site remediation processes/conditions and continue to research innovative site-applicable technologies. Technology areas of interest include cleanup technologies, renewable energy systems (green remediation) and long-term monitoring.

In 2011, TEERM worked with the Oak Ridge National Laboratory to test a compact real-time, in-situ groundwater monitor. A field demonstration conducted at NASA Stennis Space Center (SSC) proved that the technology could identify contaminants such as trichloroethylene (TCE) in groundwater with reasonable accuracy. The assistance of NASA and contractor personnel was invaluable to make the demonstration happen.

In 2012, TEERM and NASA SSC will work together to demonstrate a new approach to chemical oxidation of organic contaminants in groundwater.

TEERM Support

Technical, engineering, business, and management support for TEERM is 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.

For more information, please visit our website at <http://teerm.nasa.gov>

If you have questions, please send us an email at teermnewsletter@itb-inc.com



Demonstration of compact real-time monitor for TCE contamination in groundwater at SSC