



# QuEST

## Qualifying Environmentally Sustainable Technologies

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### Message from the Principal Center Manager

This past year, TEERM was awarded the opportunity to make a significant impact on one of NASA's latest and most challenging missions: the transformation of NASA John F. Kennedy Space Center (KSC) into an active, multi-use spaceport. TEERM is partnering with the Ground Systems Development and Operations (GSDO) Program to help achieve NASA's sustainability goals, particularly in its use of environmentally-responsible materials and processes.

TEERM's emphasis on qualifying sustainable products and processes will help broaden the options available to those involved in the construction and use of this future spaceport. Our approach of leveraging our domestic and international partnerships, collaborative research efforts, and expertise acquired through experience will be used to support the GSDO Program mission. So far, extended partnerships include the United States (U.S.) Department of Defense (DOD), the European Space Agency (ESA), private industry, and other NASA Centers/Programs.

NASA requires technical options that are flexible as well as sustainable. Considering that the products and systems devised under the GSDO Program could be used at other launch sites, it is conceivable that any successes in qualifying environmentally-safe systems can be shared globally and used outside of space exploration applications. It is exciting to realize that the benefits can have practical applications worldwide in the present while also supporting environmental stewardship for the future.

TEERM looks forward to this next step in NASA's evolution.

Thank You,

### Chuck Griffin

TEERM Principal Center Manager  
KSC/AD-T

## TEERM Partners with GSDO Program

The GSDO Program, formerly known as the 21st Century Ground Systems Program, is on its way to making KSC a spaceport of the future. The GSDO Program is preparing KSC to process and launch the next generation of rockets and spacecraft in support of NASA's exploration objectives. To achieve this transformation, program personnel are developing multi-use ground systems while refurbishing and upgrading infrastructure and facilities with sustainability and affordability in mind. One way that long-term sustainability is being ensured is through the GSDO Program's incorporation of environmentally-responsible processes, products, and materials.

One of the GSDO Program's biggest issues is combating corrosion in a sustainable way. Located on Florida's Atlantic Ocean coastline, KSC is an extremely corrosive site, and one for which the costs to mitigate corrosion are comparably high. Traditional methods of preventing corrosion of launch pads and ground support equipment sometimes involves the application of hazardous products for preparing and coating metallic surfaces. For example, harmful chemicals such as hexavalent chromium (CrVI) and volatile organic compounds (VOCs) sometimes comprise the formulations of coatings. Concentrated nitric acid is often used to clean and protect stainless steel alloys. Although these chemicals have a proven reliability, they are unsustainable due to their hazardous attributes and risk of obsolescence. Potential replacement materials can reduce the costs associated with regulatory compliance, worker health and safety protection, and numerous environmental risks to NASA's mission.

In response to this mission risk, TEERM and the GSDO Program began working together in 2012 on three projects to identify and validate environmentally-preferable replacements for nitric acid passivation, coatings containing CrVI, and coatings with high levels of VOCs. TEERM is leveraging its own resources, along with those of active project participants from other NASA Programs/Centers, DOD, ESA, and industry partners, to maximize the value of GSDO Program funding. Mr. Bill Simmonds, Project Manager for Environment and Infrastructure observed, "The GSDO Program is dedicated to performing its mission using the most sustainable and cost effective technologies. TEERM's leveraged resources coupled with this GSDO Program mission objective is a logical partnership to invest in."

In addition to executing projects for the GSDO Program, TEERM also monitors other GSDO Program-funded projects of allied interest to TEERM. Examples of three such projects being led by KSC researchers are the development of "smart coatings," corrosion preventative compounds (CPCs), and alternative solvents using "green" chemistry. The "Smart Coatings" project is developing microcapsules containing both a corrosion indicator and corrosion inhibitor to be incorporated into commercial coatings. The CPCs project is developing qualification

criteria and identifying and testing environmentally-friendly CPCs for use on flight hardware and ground support equipment. The “Alternative Solvents through Green Chemistry” project aims to provide environmentally benign cleaning technology for space and aviation systems that require precision cleaning operations.

TEERM and the GSDO Program both employ the approach of distributing costs among participants. The GSDO Program does this by making processing and launch infrastructure available to commercial and other government customers, thereby distributing the cost among multiple users and reducing the cost of access to space for NASA. TEERM reduces NASA’s cost burden by creating partnerships that provide additional funding, resources and expertise for its projects. These collaborations reduce the individual contributors’ shares of total research costs and the duplication of effort that might otherwise occur if individual organizations worked alone. TEERM’s expertise joined with that of the stakeholders also broadens the knowledge base available to NASA overall. TEERM will continue to aid the GSDO Program through the vital partnerships it has developed and the extensive research it has performed in locating and testing environmentally-friendly technologies.



*NASA Headquarters Environmental Management Division personnel and TEERM Program Manager at KSC Beach testing facility during a visit to view GSDO/TEERM project test panels*

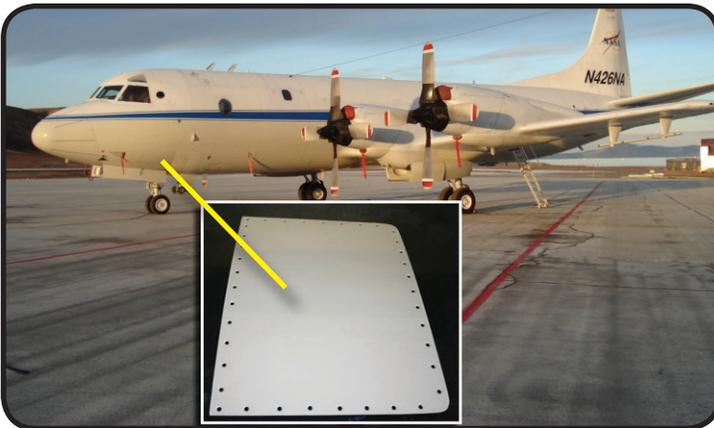
## Materials Management and Substitution Efforts

### Hexavalent Chrome-Free Coatings

Working jointly with the GSDO Program, NASA Corrosion Technology Laboratory (CTL), NASA Centers, DOD, ESA, and industry, TEERM is evaluating new coatings as replacements for CrVI coatings for several NASA applications including: aerospace vehicle exteriors, ground support equipment, and electronic enclosures.

### Aircraft Flight Testing

NASA Wallops Flight Facility (WFF) is allowing TEERM and Naval Air Systems Command (NAVAIR) to coat components on active P-3 Orion and C-23 Sherpa aircraft for testing new CrVI-free pretreatment and primer coatings.



*P-3 Orion and one of the coated sample test panels (insert) used for the Aircraft field demonstration*

Validating new technologies for aerospace applications through flight testing is just as critical for coatings as it is for equipment and processes. TEERM often used Space Shuttles for testing, but when the Program was completed, new assets for flight testing were needed. TEERM engineers turned this hurdle into an opportunity to test on aircraft owned and operated by NASA instead. The P-3 Orion, an aircraft that exists in both the WFF and NAVAIR fleet, was chosen. Aircraft managers at WFF also offered several components from a C-23 Sherpa to be included in the study.

During 2013, the P-3 Orion will spend a considerable amount of time in the U.S., Arctic, and Antarctic encountering many temperature extremes and climates. Additionally, representative test panels

will also be prepared with the same coating systems used on the P-3 Orion and C-23 Sherpa and placed at the KSC Beachside Atmospheric Test Facility for comparison.

### ESA & NASA Collaboration

ESA and TEERM made further progress in their effort to find CrVI alternatives. Working together, ESA and TEERM developed a preliminary ranking system for evaluating the pretreatment test panels. In addition, initial testing was completed in June and yielded unexpected findings.

The initial testing results showed poor performance across all pretreatments, including the controls. The outcome indicated that the processing procedures needed to be adjusted. Based on manufacturer and lab recommendations, TEERM tested several new processes to improve performance of CrVI and non-CrVI pretreatments. Compared to the results of the initial testing, corrosion resistance improved for panels made of 6061-T6 and 7075-T6 for all pretreatments tested. Panels made from 2024-T3 and 2219 alloys, however, still exhibited poor results in corrosion testing for all pretreatments tested. TEERM engineers are continuing to search for appropriate process procedures for 2000-series alloys. Down-selection of the best performers for the next round of testing is also underway.

### Electronic Enclosures

TEERM is continuing its collaboration with over 40 public and private organizations, including the GSDO Program and DOD, to test CrVI-free coatings for electronics enclosures. Testing continues in accordance with the team-approved test plan and the final report is expected in 2013.

### Environmentally Preferable Coatings for Launch Facilities

The NASA technical standard for protecting structural steel assets contains a relatively short list of approved coatings, many of which contain very high VOC levels. These coatings are no longer compatible with current environmental regulations and pose a materials obsolescence risk. In response, TEERM is leading a project, supported by the GSDO Program, NASA CTL, multiple NASA Centers, and Air Force Space Command, to qualify more environmentally friendly coatings for use on launch facilities and ground support equipment.

TEERM developed the test plan, which identified performance requirements and acceptance criteria. Alternatives to be tested were selected based on their hazard rating, regulatory compliance, and anticipated performance. Testing, which includes 18 months of

exposure at the KSC Beachside Atmospheric Test Facility, is currently underway. Other potential coatings for future testing are being investigated.

### Alternative to Nitric Acid Passivation

Passivation is used to clean and protect stainless steel from corrosion. Nitric acid, a chemical with burdensome environmental and occupational safety concerns, is the standard used for passivation by NASA, DOD and industry worldwide. TEERM is working with the GSDO Program, NASA CTL, numerous NASA Centers and the DOD to determine whether citric acid is as effective as nitric acid. Citric acid is naturally occurring and biodegradable, rarely classified as a hazardous waste upon disposal, and does not create toxic fumes during the passivation process. Stakeholders developed a joint test plan that identifies performance requirements and alloys of interest. Testing is currently underway and thus far, citric acid is showing comparable performance.



*Sorting and processing of test panels and specimens for the Alternative to Nitric Acid Passivation Project*

## Recycling and Pollution Control Efforts

### Evaluation of Non-Hazardous Spent Blast Media in Concrete Applications

Historically, one of KSC's largest waste streams is spent blast media (SBM) generated from abrasive blasting. TEERM is helping NASA reduce the amount of disposed non-hazardous SBM by adding it as an alternative aggregate to concrete in a project being constructed on site at KSC. For the project, KSC Construction of Facilities and Environmental Management Division are building two small concrete structures made of the modified concrete mixture and will be observing how it performs. As a result of TEERM's collaborative efforts, KSC has referenced the spent media recycling process in its 2012 Sustainability Plan, recommending contract language to require the use of recyclable blast media in future KSC concrete work.

## Alternative Energy Efforts

### Concentrated Solar Air Conditioning for Buildings

In September 2012, TEERM and NASA representatives visited the Davis-Monthan Air Force Base in Tucson, Arizona to observe construction of a new concentrated solar air conditioning system. The project aims to demonstrate that solar energy can be used to provide a renewable energy based source for air conditioning, thus addressing a common need by NASA and DOD to reduce air conditioning energy demand in hot, sunny climates.

During the site visit, the team was also given a tour of energy project initiatives by the 309th Aerospace Maintenance and Regeneration Group (309 AMARG). The 309 AMARG provides critical aerospace maintenance and regeneration capabilities to customers such as the U.S. Air Force, U.S. Navy, U.S. Marine Corps, U.S. Army, U.S. Coast Guard, and several other federal agencies including NASA.

## 2012 International Workshop: Enabling Sustainable Space Exploration

More than 100 individuals from eight countries attended the TEERM-supported International Workshop on Environment and Alternative Energy held in December at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. The workshop was a collaborative effort of NASA, ESA, and the Portuguese Center for Pollution Prevention (C3P). International and U.S. subject matter experts presented on environmental and energy-related topics correlated to the theme "Enabling Sustainable Space Exploration." Students from around the globe also gave presentations on the latest technologies being developed at universities. Funding for selected student participants was provided by NASA Education, ESA Student Sponsorship, and the Portuguese Luso-American Development Foundation (FLAD).

Please visit our website for more information on our upcoming 2013 workshop, themed "Increasing Space Mission Resiliency through Sustainability," as well as past workshops at <http://teerm.nasa.gov/workshop.htm>.



*US and international student workshop participants receiving recognition from NASA supporters at GSFC*

## KSC Hydrogen Fuel Cell Mobile Lighting Tower

TEERM completed the field demonstration of a prototype hydrogen fuel cell mobile lighting tower at KSC in September 2012. The light tower is innovatively powered with a hydrogen fuel cell and features high-efficiency plasma lighting. Compared to traditional diesel-powered lighting towers, the fuel cell lighting tower significantly reduces noise, eliminates diesel particulate emissions and increases energy efficiency. The unit also allows for both indoor and outdoor operation.

The objective over the past year was to observe the tower's operation in a hot, humid, and corrosive environment. During the field trial, TEERM monitored the unit for corrosion issues, which were photo-documented, and worked with operators to evaluate the performance of the unit. Operators were pleased with the reduced noise and the light output of the unit. TEERM provided feedback to the product development team led by Sandia National Laboratories. The lighting unit was returned to Sandia National Laboratories and will be redeployed to the San Francisco International Airport.

In recognition of the success of the Lighting Tower Project, TEERM engineers received the Federal Laboratory Consortium for Technology Transfer (FLC) Award for Excellence in Technology Transfer. The honor is given for outstanding work in the process of transferring federally developed technologies.

## Alternative Fuel Buses for KSC Visitor Complex

The KSC Visitor Complex seeks to inspire environmental stewardship, as well as imagination, among the throngs of curious minds visiting each year. TEERM is supporting the Complex in its movement toward instituting environmentally-friendly transportation for its guests by helping to facilitate a study of alternative fuel options for the Complex's bus fleet. Alternatives such as compressed natural gas, electricity and hybrid fuels will be compared with the current diesel fleet operations, particularly in regards to total life cycle costs. The selected consultant firm, evaluated with TEERM assistance, is set to begin the study in early 2013.

# Other TEERM Efforts

## Energy/ Water Management Task Improves Reporting

Every year, Energy/Water Management Task engineers from TEERM assist NASA Headquarters—Environmental Management Division (HQ EMD) with collection of data for annual reporting to the Department of Energy. The energy task monitors not only energy and water consumption and cost data, which is collected several times a year, but also multiple items which are collected once a year, such as conservation projects, facility square footage, and progress in metering all buildings. The annual data was traditionally reported at the end of each fiscal year; however, the energy team observed that some of the data is available months before the end of the fiscal year. The team moved the collection and preliminary analysis of data earlier in the year. Consequently, NASA Centers were able to report energy usage earlier, and HQ EMD, in-turn, was able to make strategic plans earlier, thereby assisting NASA in meeting federal energy mandates.

TEERM engineers also assist HQ EMD in the tri-annual Environmental and Energy Functional Reviews (EEFR) for each NASA Center. To help streamline the process, engineers worked with the Agency's Energy Manager to create new tools and reports including a summary that is provided to Center Energy and Water Managers within days of their EEFR. Before the Energy/Water Management Task, EEFRs could take six months or longer for reports to be produced. With the implementation of continuous improvement and excellent communication with the Agency's Energy Manager, reports are now completed within a few weeks of the EEFR.

# Project Highlight

## In-Situ Chemical Oxidation Pilot Test

Typical remediation methods often employ pump-and-treat systems, but newer technologies have become available that can improve their performance. TEERM engineers worked with Remediation Project Managers (RPMs) at NASA John C. Stennis Space Center (SSC) to review and chart years of historical groundwater monitoring data to evaluate the effectiveness of their existing operational pump-and-treat systems. The charts revealed that the pump-and-treat technology was having little impact and cleanup progress had stalled.

One method to enhance conventional groundwater remediation pump-and-treat systems is to couple them with in situ (in place) treatment schemes that degrade contaminants prior to excavation or removal. Seeking a potential solution, TEERM researched in situ technologies and service providers to find a good match for SSC needs. One vendor's approach featured a safe and slow-reacting oxidizer and sustainable, self-contained, solar/water pressure-powered automated injection system. The injection process involved the slow release of hydrogen peroxide and a proprietary catalyst into the contaminated aquifer through small-diameter wells. The injection rate of the automated system could also be adjusted to achieve maximum contact with contaminants.

In 2012, TEERM facilitated a field demonstration project at SSC to evaluate the effectiveness of the innovative in situ chemical oxidation (ISCO) product and injection process. The objective of the field test was to determine whether the ISCO technology can augment an existing pump-and-treat system and accelerate the remediation of groundwater contaminated with VOCs, including the chlorinated solvent trichloroethylene (TCE). TEERM coordinated the work plan and negotiated the donation of vendor services and materials. SSC approved the demonstration, and work began in March 2012.

The demonstration resulted in a 100% reduction of residual "sorbed" contaminant mass in saturated soil and an approximate 50% reduction of dissolved-phase groundwater concentrations within the treatment zone. RPMs at SSC were pleased with the pilot-scale demonstration results and the process transitioned to full-scale implementation in August 2012. Demonstrating their confidence in the new technology, the test results were featured in SSC's Comprehensive Environmental Response, Compensation, and Liability Act 5-Year Review Presentation to the Mississippi Department of Environmental Quality.

# TEERM Support

Technical, engineering, business and management support for TEERM is provided by personnel 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.

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](mailto:teermnewsletter@itb-inc.com)