

National Aeronautics and Space Administration

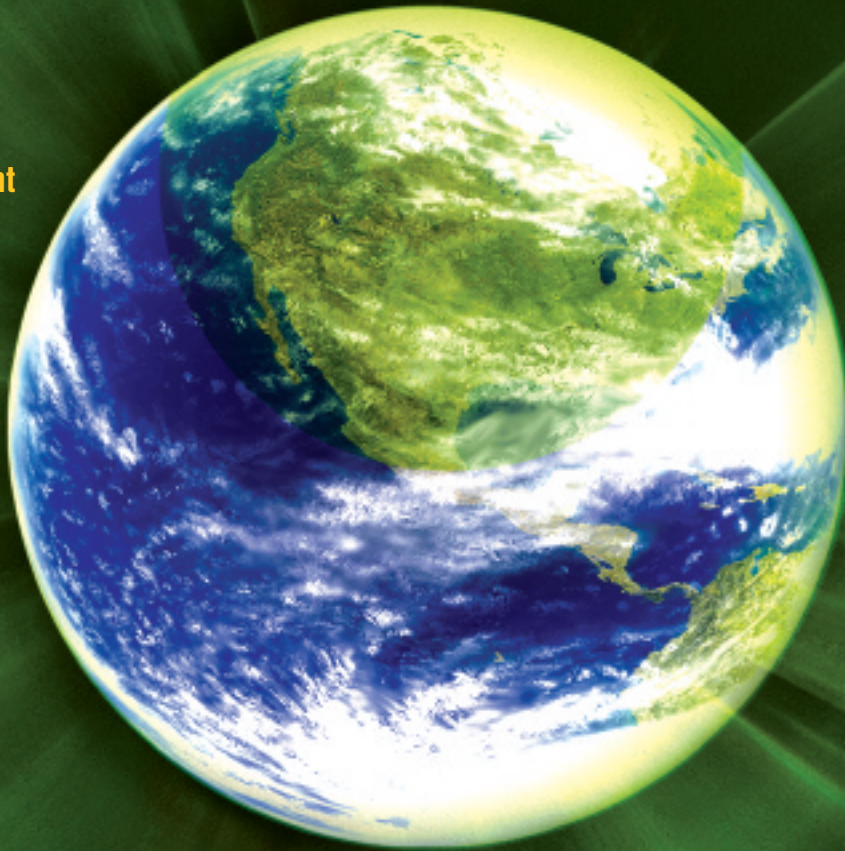


# **TECHNOLOGY** **INNOVATION**

MAGAZINE FOR BUSINESS & TECHNOLOGY

Volume 15 • Number 1 • 2009

## **SUSTAINABILITY**



### **PLUS**

**Wastewater Treatment  
Technology with  
Applications in  
Space and on Earth**

**A Green  
Technology  
Initiative  
Addresses NASA's  
Technology Needs**

**Ocean Surface  
Satellite Aids  
in Extreme Event  
Warnings**

NASA Innovations: Helping to Sustain the

## **EARTH AND ITS RESOURCES**

# How You Can Participate in the Space Program

## Centennial Challenges

<http://centennialchallenges.nasa.gov/>

### **April 29 — May 1, 2009: Power Beaming and Tether**

Cape Canaveral Area, FL

#### **PURSE UP TO \$2M EACH**

Wireless power transmission and super-strength materials

Managed by: Spaceward Foundation

<http://www.spaceward.org/elevator2010-pb>

<http://www.spaceward.org/elevator2010-ts>



### \* **Spring 2009: Astronaut Glove** Location TBD

**2009 PURSE \$400K** Innovative spacesuit glove designs

Managed by: Volanz Aerospace, Inc.

<http://www.astronaut-glove.us>



### **Expires June '09: MoonROx** Competitor's location

**PURSE \$1M** Producing oxygen from simulated lunar material

Managed by: California Space Education & Workforce Institute

<http://moonrox.csewi.org/>



### \* **Later in 2009: Lunar Lander** Location TBD

**REMAINING PURSE \$1.65M** Rocket vehicles simulating lunar takeoff and landing

Managed by: X PRIZE Foundation

<http://www.xprize.org/lunar-lander-challenge>



### \* **August 2009 (tentative): Regolith Excavation**

California

**2009 PURSE \$750K** Robotic devices to excavate simulated lunar soil

Managed by: California Space Education & Workforce Institute

<http://regolith.csewi.org/>



### \* **Summer 2010: General Aviation Technology**

Sonoma County Airport, Santa Rosa, CA

**2010 PURSE \$1.1M** Safer, quieter & more efficient aircraft

Managed by: Comparative Aircraft Flight Efficiency Foundation

<http://cafefoundation.org>



\*Date and/or location of event are tentative. For a complete listing of competitions, descriptions and dates please visit:

## Technology Flight Test Opportunity

### **March 20, 2009: Facilitated Access to the Space environment for Technology development and training (FAST) opportunities**

A new call for FAST proposals has been posted. The call is open to all U.S. companies, individuals, research institutions, universities and government agencies. The proposal deadline is March 20, 2009, and flights are expected to occur in August 2009, pending availability of appropriated funds.

[http://lipp.nasa.gov/ii\\_fast.htm](http://lipp.nasa.gov/ii_fast.htm)

## NASA Showcase

### **June 8-10, 2009: NASA Showcase, with the Navy Opportunity Forum**

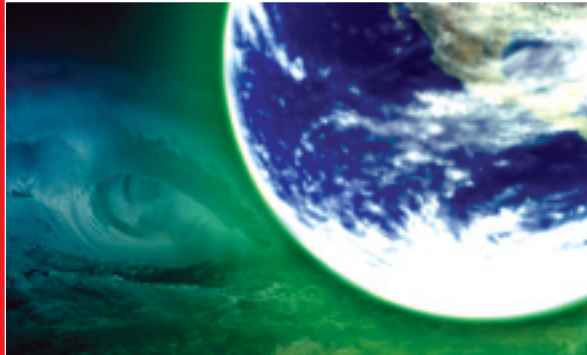
Location: Hyatt Regency; Crystal City, Va.

Registration: Mike Morgan, (585) 617-6285

<http://www.navyopportunityforum.com/>

Upcoming Events

**COVER STORY**



**PAGE 24**

**NASA TECHNOLOGY CONTRIBUTES TO SUSTAINABILITY OF THE EARTH**

BY SHANA DALE, NASA DEPUTY ADMINISTRATOR

While NASA's mission is space exploration, some of the Agency's greatest contributions are data, knowledge and understanding that its satellites and research provide about our planet.

**feature articles**

**34**



**REVOLUTIONIZING WASTEWATER TREATMENT**

Ames Research Center develops a sustainable water reclamation treatment system for long-duration space missions and Earth-related applications.

**36**



**OCEAN SURFACE SATELLITE IS A BOON FOR EXTREME EVENT FORECASTS AND WARNINGS**

NASA's new "eye in the sky" will help experts better predict hurricanes and tsunamis.

**38**



**GLENN RESEARCH CENTER LAUNCHES GREEN TECHNOLOGY INITIATIVE**

With its well-known expertise in power and propulsion, Glenn leads a new effort in green energy research and development.

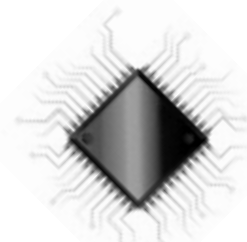


**28 Innovator's Corner**

—California Firefighters Aided by NASA Technologies

—Weather Monitoring Technologies Go Mainstream

**42 Tech Talk**



—Ames and Google Partner on New Green Technologies

—Northrop Grumman Teams with NASA



departments

To view online and for past issues, visit <http://www.ipp.nasa.gov/innovation>



A NEW NASA PARTNERSHIP WILL IDENTIFY AND DEMONSTRATE TECHNOLOGIES TO AUTONOMOUSLY MONITOR PIPELINE RIGHTS-OF-WAY.

**6 NASA NEWS BRIEFS**

- Innovations Improve Pipeline Monitoring
- Clean Water for Needy Communities
- New Fuel Cells and Batteries Increase Efficiency
- Biogasification Plant Considered for JSC
- NASA Researchers Receive R&D 100 Awards
- New “Smog Blog” Improves Public Safety
- Conrad Awards Competition
- Goddard and Northrop Grumman Tackle Climate Change Questions

**16 FACILITY FOCUS**

- Kennedy’s Cryogenics Test Laboratory
- NASA Buildings Go Green

**20 INFUSION**

- Deployable Antennas
- NTTC Technology Portfolios
- SBIR Technologies Help Explore Mars

**46 INNOVATIVE RESEARCH**

NVision Adapts HazNet Emergency Management System for NASA Projects

**49 OPPORTUNITIES FOR PARTNERSHIP**

- Fire-resistant, Lightweight Electrical Insulation Material
- Highly Aligned Electrospun Fibers and Mats
- Fluid Measurement Sensor
- Low-Profile Wireless Sensor
- EBF3: The Future of Art-to-Part Manufacturing
- Polymer Cross-Linked Aerogels
- Systems Maintenance Automated Repair Tasks (SMART)
- Bimetallic Treatment System for Paints
- Ice Liberation Coating For Use As Ice Adhesion Reduction Coating

**58 NASA IPP NETWORK**

A directory of NASA’s IPP national offices and allied organizations

**PAGE 22**

THE NTTC HAS CREATED A SERIES OF CDS CONTAINING PORTFOLIOS OF INFORMATION ON SELECT SBIR/STTR TECHNOLOGIES AND THE COMPANIES THAT DEVELOPED THEM



# UPFRONT with...

## Douglas A. Comstock

Director, NASA Innovative Partnerships Program



Since its creation 50 years ago, NASA has nurtured partnerships to transfer NASA-derived technologies for public benefit. These benefits have reached throughout the economy and around the globe. NASA's research has not only enhanced our understanding of air and space, but also our understanding of the Earth and how to sustain the Earth and its resources. This issue of *Technology Innovation* is dedicated to highlighting a few of the important contributions made by NASA technology towards sustainability of our planet.

In the cover story, NASA's Deputy Administrator, the Honorable Shana Dale, introduces some of the many areas in which NASA and its technologies are making a positive contribution to sustainability. Other stories provide a more detailed look at some of these exciting projects and technologies, including the following:

- A satellite system helping researchers improve current models for predicting hurricane intensity and tsunami warnings,
- Software and a hotspot-detecting sensor that were instrumental in helping firefighters battle the 2008 wildfires in southern California,
- A wastewater treatment system that is under development for long-duration missions on the moon and Mars, and is also being considered for use at Earth-bound water treatment facilities,
- Technologies to monitor oil and gas pipelines to detect leaks, encroachment and intrusions, and ground disturbances and movements,
- A "smog blog" to help government and health officials as well as the public monitor air quality and mitigate negative health issues in Central America and the Caribbean.

NASA also is applying sustainability practices in our facilities and operations. In this issue, you will read about how NASA is using "green" materials and practices in new construction of Agency facilities, and how NASA is studying the feasibility of building a biogasification plant that would provide an alternate fuel source at Johnson Space Center and help scientists there to study the technology for use in addressing waste issues and energy needs for operations on the moon and Mars.

NASA works with partners from industry, academia and other federal agencies in developing technologies for the space program and also in adapting them for other applications including sustainability. For example, you will read about how NASA is actively working with Google and the environmental community to identify new areas for partnership.

These stories on sustainability represent a few of the many ways that NASA's expertise and technologies are contributing to a cleaner and safer Earth. I hope you enjoy reading about them in this issue of *Technology Innovation*. As always, I welcome your feedback. Please feel free to contact me at [doug.comstock@nasa.gov](mailto:doug.comstock@nasa.gov).



**CHIEF EDITOR**  
Janelle Turner  
NASA

**MANAGING EDITOR**  
Kathryn Duda  
National Technology  
Transfer Center

**ART DIRECTOR/PRODUCTION**  
Dennis Packer  
National Technology  
Transfer Center

### CONTRIBUTING AUTHORS

Stephen Ambrose  
Vincent Ambrosia  
Donna Anderson  
Deborah E. Bazar  
Alan D. Buis  
Douglas A. Comstock  
Shana Dale  
Cynthia Dreibelbis  
Carol Ann Dunn  
James E. Fesmire  
Kathryn Hansen  
Glenn J. Higgins  
Everett Hinkley  
Byron Jackson  
Dave Jones  
Valerie J. Lyons  
Eugene Mszar  
Felix Miranda  
Jennifer Morcone  
Nancy E. Oates  
Nicole Quenelle  
Robert Romanofsky  
Kevin Schultz  
William M. Toscano  
Kenneth Wright  
Thomas Zajkowski

*Technology Innovation* is published by the NASA Innovative Partnerships Program. Your feedback provides important contributions to this publication.

please visit our Web site:  
[www.ipp.nasa.gov/innovation](http://www.ipp.nasa.gov/innovation)

Material from this publication MAY be reproduced without the permission of the publisher.

# NASA News Briefs

## Pipeline-Monitoring Partnership Aids Safety and Homeland Security

**W**ith the increase in security risks to our nation's energy infrastructure — refineries, chemical plants and pipelines — in this post-9/11 era, monitoring liquid pipelines and pipeline rights-of-way (ROW) has become more and more critical. Pipeline operators are looking to improve monitoring instruments and systems and to migrate from piloted to unpiloted aerial systems (UAS) and satellites for more frequent, consistent and accurate surveillance. These steps would effectively address security threats and help meet Department of Transportation regulations requiring safe and reliable operations.

NASA Ames Research Center and the Petroleum Research Council International (PRCI) have initiated a new public-private collaboration to identify and demonstrate technologies for autonomously monitoring pipeline ROW. This multi-phase, multi-year program will focus on remotely detecting three types of issues along the ROW: encroachment and intrusions, ground disturbances and movements, and leaks of hydrocarbon gases and liquids.

The Rights-of-Way Autonomous



PHOTO CREDIT: NASA

A NEW PUBLIC PRIVATE PARTNERSHIP BETWEEN NASA AND THE PETROLEUM RESEARCH COUNCIL INTERNATIONAL WILL IDENTIFY AND DEMONSTRATE TECHNOLOGIES TO AUTONOMOUSLY MONITOR PIPELINE RIGHTS OF WAY. THE PROJECT WILL FOCUS ON REMOTELY DETECTING ENCROACHMENT AND INTRUSIONS, GROUND DISTURBANCES AND MOVEMENTS, AND LEAKS OF HYDROCARBON GASES AND LIQUIDS.

Monitoring Project evolved from an earlier project with BP Pipelines and Logistics North America and is partnered with the Department of Transportation/Pipeline and Hazardous Materials Safety Agency. Broader industry interest in the project resulted in PRCI allocating resources and coordinating the project on behalf of its membership. PRCI serves as a bellwether for the industry by identifying and researching emerging issues and technologies affecting energy pipeline transportation.

A key goal is "near real-time" detection and reporting. The first objective is to deploy the new technology package on UAS aircraft

(fixed-wing and helicopter). However, as UAS and satellites become commercially available and cost effective, the technology package developed for manned aircraft would migrate to these new advanced monitoring platforms. At regular intervals throughout the development process, assessments will be conducted to identify applicable emerging technologies that can be leveraged.

Other potential applications for this technology within the oil and gas industry as well as for the power transmission/distribution and railroad transportation industries are also being explored.

Building on past research funded by



**NASA TECHNOLOGY TRANSFER AND INDUSTRY-RELATED NEWS**

PRCI and current work in progress by member companies, as well as work by independent researchers, institutions and commercial resources, a new generation of surveillance and encroachment management systems promises to deliver a significant improvement in the proactive prevention of third-party damage. Imagery acquisition, change-detection analysis, subsequent automated hazard assessment and alert notification processes may be scalable for security surveillance for airborne vehicles, mounted on stationary structures or ground patrol vehicles. The deployment of helicopters, fixed-wing aircraft, UAS, in addition to weekly manned flights, can increase ROW surveillance capability and capacity. Additional surveillance will help to reduce pipeline damage as well as provide enhanced security.

Further, as optimization of routes, technology and other factors come into play, the cost per mile for UASs will be equivalent to or lower than costs for current manned flights. Through early detection and response, there is potential to avoid significant costs of repairing third-party damages caused by unauthorized third-party strikes.

This project supports the active remote sensing program at NASA Ames Research Center's Earth Science Division and has support of the Earth Science Division's Applied Sciences

Program. The program has utilized space-based, manned and unmanned aerial platforms for more than 26 years. Research activities in biospherics and atmospheric have resulted in new instrument development, new and unique flight platform integration and new data analysis and visualization techniques. Current demonstration programs showcase the value of new miniature remote sensing instruments, integrated with small UASs with varying levels of mission autonomy depending upon the complexity of the tasks. Further development of remote sensing capabilities for manned and unmanned aerial systems under this project will enhance rapid data collection efforts in the early phases of science missions and enhance methane detection capabilities for improved environmental monitoring.

The project is sponsored by the Department of Transportation's Pipeline and Hazardous Materials Safety Administration and supported by the Transportation Safety Administration. ■

*For more information, please contact William M. Toscano in the Entrepreneurial Initiatives Division of NASA Ames Research Center, at (650) 604-0894, or [William.M.Toscano@nasa.gov](mailto:William.M.Toscano@nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

**Johnson Engineers Bring Clean Water to Needy Communities**

Employees and contractors at NASA's Johnson Space Center in Houston are volunteering their time to bring clean water, energy and food to rural communities in Rwanda and Mexico through Engineers Without Borders (EWB)-USA. These individuals, along with other local professionals, make up the EWB-Johnson Space Center Chapter, which in 2005 became involved in the organization's efforts in Rwanda. Through this project, volunteers have installed several surface water treatment systems for rural communities.

Based on these efforts, the Manna Energy Foundation, a Houston-based non-profit, is negotiating an agreement with the Government of Rwanda to install water treatment systems at every secondary school in Rwanda over the next several years. EWB-JSC has been asked to take the technical lead in this venture, installing the first treatment system.

The team is now in the process of developing, testing and producing an improved surface water treatment system for Puerto de Aguilar in Mexico. This project takes the Rwanda water treatment concepts and accommodates

# NASA News Briefs

the Mexican community's request for a flat-land or pump-based system.

These are only a few of the projects in which the EWB-JSC members volunteer their time and expertise to help communities and individuals who lack access to safe drinking water, reliable sources of energy and sustainable sources of food and revenue. ■

*For more information about the group and its humanitarian work, visit <http://www.ewb-jsc.org/new/Joomla/>.*

*Please mention that you read about it in Technology Innovation.*

## New Technologies Replace Chemical Batteries

At NASA's Glenn Research Center (GRC), the Hybrid Power Management Program (HPM) is exploring the use of ultracapacitors in place of rechargeable batteries. The applications examined to date include everything from electrical power storage on the International Space Station to powering electric toothbrushes on Earth. Most recently, the HPM has focused on the control and regulation of hybrid propulsion systems.

A capacitor is a device that can store electrical energy. It consists of two conductors, or "plates," separated

by an electrical insulator, or "dielectric." When the capacitor is subjected to an electrical current, a charge builds on the plates. Since the charge remains after the current is removed, energy can be stored in the electric field between the plates. The maximum charge that can be stored in a capacitor is a function of the size of

ultracapacitor technologies have a lower charge density than electrochemical batteries, the technologies have several advantages. In particular, ultracapacitors can be recharged in a matter of seconds, compared with the hours required to recharge a standard battery. Ultracapacitors also have a much longer life – they can be

PHOTO CREDIT: NASA



THE NASA FUEL CELL POWERED UTILITY VEHICLE COMBINES SEVERAL ADVANCED TECHNOLOGIES IN AN OPTIMAL CONFIGURATION.

the plates and how well the dielectric can insulate the charge. A better dielectric provides higher charge and results in greater capacity for energy storage.

Ultracapacitors can store significantly more charge than regular capacitors due to the use of highly effective materials. Although current

recharged more than one million times, compared with a few hundred recharges for a battery. They are not susceptible to deterioration when exposed to cold temperatures, and their turn-around efficiencies (the percentage of charge energy that can be recovered) are more than 90 percent, compared with typical battery turnaround efficiencies of 50 percent. In addition, ultracapacitors are made of nonhazardous materials.

One of the early HPM projects involved design and development of the power control system for a hybrid electric transit bus (HETB), which was found to have improved fuel efficiency of more than 21 percent over



NASA TECHNOLOGY TRANSFER AND INDUSTRY-RELATED NEWS

the standard, diesel-powered RTA bus when regenerative braking was used.

The HPM now is evaluating a system that utilizes a combination of ultracapacitors and fuel cells as the primary power source. The system is mounted on a utility vehicle and includes two proton exchange membrane fuel cells powered by hydrogen. The hydrogen is stored at low pressure (200 psi) in a metal hydride canister.

Ultracapacitors are used for energy storage and to protect the fuel cell membranes from power transients (surges). This arrangement demonstrates how the optimized components of a system's architecture can complement each other. The fuel cells have excellent energy density, but not good power density; the ultracapacitors have excellent power density, but not very good energy density. The combination of the fuel cells and ultracapacitors, then, results in a power source with excellent power density and energy density.

The propulsion system has been demonstrated and in the future could serve as the basis for a planetary rover's propulsion system, likely extending operational life and performance characteristics. Furthermore, the total weight of the hybrid power source is comparable to the weight of an equivalent battery power source; however, the volume required is smaller. Thus, a

hybrid power source utilizing ultracapacitors provides more space for other items than would be provided by the equivalent battery power source. ■

*This news brief was previously published by the Federal Laboratory Consortium – Midwest Region.*

*For more information, contact Laurel Stauber in the NASA Glenn Technology Transfer and Partnership Office, (216) 433-2820, laurel.j.stauber@nasa.gov.*

*Please mention that you read about it in Technology Innovation.*

**Biogasification Plant Considered for Johnson Space Center**

**T**he Sustainability Partnership Team at Johnson Space Center (JSC) has received funding from NASA's Innovative Partnerships Program (IPP) to study the feasibility of a waste biogasification plant at JSC.

Biogasification is the process of converting biomass (biodegradable, or organic matter) to biogas (combustible gas produced by anaerobic decomposition of organic material), which then can be used as a fuel.

Michael Ewert, co-chair of the JSC Sustainability Partnership Team, says that ultimately, the goal is to replace some of the natural gas used at JSC with the methane product created through biogasification. The plant also would help NASA scientists study how biogasification can be applied to Constellation, the NASA program to send human explorers back to the moon, Mars and other destinations in the solar system.

“This infusion is more for Mars and can address waste issues and energy needs to sustain a habitat on the planet,” he adds.

The particular biogasification technology under study was originally developed through a NASA Commercial Center program funded through the IPP several years ago. With the more recent funding, the partnership team has entered into a cooperative agreement with the University of Florida, which is collaborating with URS Corporation to further develop the technology.

“This is a good terrestrial application of the technology,” Ewert says of the possible biogasification plant at JSC. “The university is at the point to take it out of the lab and do demo projects.”

The study will address the organic waste streams from JSC, such as cafeteria waste, office trash and landscape

# NASA News Briefs

PHOTO CREDIT: NASA



IN A DEMONSTRATION SYSTEM FOR A BIOGASIFICATION PLANT, WORKERS INSTALL A VALVE TO PREVENT UNINTENTIONAL DRAINING. JOHNSON SPACE CENTER IS STUDYING THE FEASIBILITY OF CONSTRUCTING A SIMILAR PLANT TO CONVERT WASTE TO NATURAL GAS.

waste. According to Ewert, specific formulas for successful biogasification of the organic waste must be developed to produce the most efficient forms of energy through the system.

According to Michele Brekke, director of the JSC Technology Transfer Office, through which the IPP funding came, green technologies are getting a great deal of attention at the Center.

“We wanted to add a green project to our portfolio,” says Brekke, adding that sustainability is an issue to be addressed for crews on the lunar surface. Brekke adds that the investment

in a biogasification technology study has potential for direct applications in space. “We are supporting the investigation of a sustainable energy closed-loop system to reduce dependency on non-renewable resources.”

JSC’s Sustainability Partnership Team, formed by a memorandum of understanding between Engineering and Center Operations, is charged with promoting spinoff technologies and implementing NASA policy directives to reduce the Center’s environmental impact. The purpose for

the partnership is to coordinate innovative sustainability ideas and projects and to augment ongoing efforts by the JSC Environmental Office and the energy manager.

“There are natural synergies between the two organizations,” says Ewert. “Our focus in engineering technology for human space flight includes the requirements for crew habitation and environmental systems, and the production and wise use of energy.”

The team has several other initiatives in place, including the JSC Child

Care Center that features a multi-platform test bed for solar panels (see Facility Focus in this issue), wind turbines and a solar-powered hot water heater.

The team also has developed a working relationship with the City of Houston. JSC personnel are serving as technical advisors to the city’s award-winning Houston Solar Initiative Committee and the Green Building Committee. The JSC team hopes that this relationship will enhance some Center efforts with the City of Houston and its involvement in facilitating a solar-powered initiative at the Sonny Carter Training Center and Neutral Buoyancy Lab (<http://dx12.jsc.nasa.gov/site/index.shtml>), which houses one of the largest pools in the world.

“JSC’s role in a sustainable future can be one of leadership and innovation. Sustainability is a unifying theme that ensures JSC will continue its mission well into the future,” says Ewert. ■

*For more information on the JSC Sustainability Partnership Team and its projects, contact Michael Ewert at [michael.k.ewert@nasa.gov](mailto:michael.k.ewert@nasa.gov). For more information on the JSC Technology Transfer Office, contact Donna P. Anderson at [donna.p.anderson@nasa.gov](mailto:donna.p.anderson@nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

## NASA TECHNOLOGY TRANSFER AND INDUSTRY-RELATED NEWS

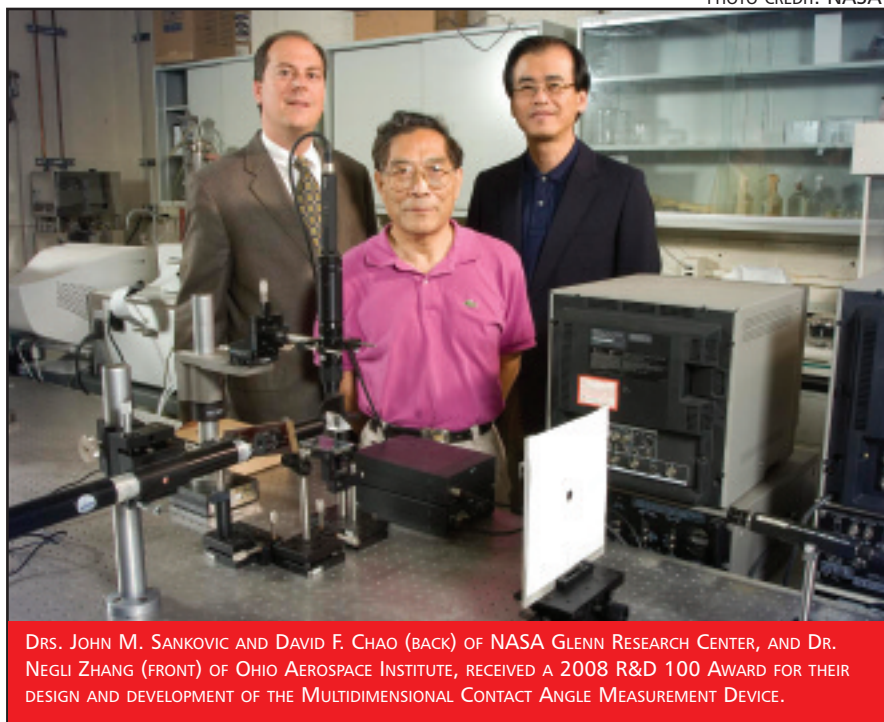
## NASA Researchers Receive R&D 100 Awards

**N**ASA researchers and contractors are among the 100 winners of the prestigious 2008 R&D 100 Awards, prizes known throughout industry, government and academia as acknowledgement that a product is one of the year's most innovative. Often called the "Oscars of Invention," R&D 100 awards have given many new products the important initial push they need to compete successfully in the marketplace.

David F. Chao and John M. Sankovic of NASA Glenn Research Center, and Nengli Zhang of Ohio Aerospace Institute, were honored for their design and development of the Multidimensional Contact Angle Measurement Device (MCAMD).

MCAMD enables measurement of transparent liquid drops on a solid surface. It collects a host of crucial information simultaneously in a 360-degree view and allows scientists to see how those droplets interact with different surfaces. This way of measuring is superior to any currently available contact angle meters. The previously used method measured a contact angle from a single side view only.

Although MCAMD's direct application involves NASA space missions, the technology has industrial applica-



DRS. JOHN M. SANKOVIC AND DAVID F. CHAO (BACK) OF NASA GLENN RESEARCH CENTER, AND DR. NENGLI ZHANG (FRONT) OF OHIO AEROSPACE INSTITUTE, RECEIVED A 2008 R&D 100 AWARD FOR THEIR DESIGN AND DEVELOPMENT OF THE MULTIDIMENSIONAL CONTACT ANGLE MEASUREMENT DEVICE.

tions in coating, painting, lubricating, gluing, film cooling, biological cell adhesion and boiling heat transfer.

Donald J. Roth of Glenn, William P. Winfree of NASA Langley Research Center and Jeffrey P. Seebo of Lockheed Martin received an R&D 100 award for their design and development of the Terahertz Density Thickness Imager.

Terahertz imaging permits scientists and engineers to analyze the quality, compactness and dimensions of non-conducting materials or products, including materials such as foams, over a large continuous region, without having to cut out sections.

With the new technology, NASA now has the option of performing

process and quality control of foams and other thermal protection system materials without destructively cutting and using laborious conventional quality control methods.

Using revolutionary methods and software, the Terahertz Density-Thickness Imager extends the ability of conventional terahertz imaging. It allows NASA scientists and engineers to measure foam spray quality in terms of thickness and density variations over a large area that might occur as a result of hail damage, improper processing or worker handling.

The technology is currently used exclusively by NASA, but it may have application not just for foam but for

PHOTO CREDIT: NASA



# NASA News Briefs

plastics, wood, paper, ceramics and pharmaceutical materials.

Langley's Stanley Woodard and ATK Space Division's Bryant Taylor developed the SansEC Geometric Sensing Patterns, also an R&D 100 award winner. The SansEC is a wireless sensor that is damage tolerant and requires no electrical connections.

NASA scientists originally developed SansEC as a method of having thermal insulation serve as a damage detection system for inflatable space structures, but they discovered the technology had additional unique qualities as a new way of creating electrical systems.

Each open-circuit SansEC sensor uses a single geometric pattern that eliminates the need for electrical connections – SansEC or "without electrical connection" – and needs no solder or other types of mechanical connections such as pressure or screws. It has no "Achilles" point that could render the circuit inoperable, and it continues to function even when punctured or torn.

At NASA's Goddard Space Flight Center, Dan Mandl led the 16-member innovation team that developed the R&D 100 award-winning Sensor Web 2.0, a Web services-based software that gathers and assimilates data from a network of sensors, including seismic and GPS ground sensors, firetower sensors,

weather radar devices and satellite sensors. Sensor Web 2.0 enables them to operate as a cohesive whole.

Sensor Web 2.0 can be applied to all manner of natural and manmade disasters, including giving advance warning of a tsunami approaching land; precisely determining hurricane strength, location and trajectory; and detecting oil spills soon after they occur.

Other NASA researchers on the Sensor Web 2.0 team are Stephen G. Ungar from Goddard; and Steve A. Chien, Daniel Tran and Mark Johnson from the Jet Propulsion Laboratory.

Sensor Web 2.0's developers are now working with the U.S. Department of Defense (DoD) to infuse the technology to create a cross-domain sensor web that enables automatic declassification and sharing of DoD satellite data for disaster response and humanitarian assistance during emergencies.

Sensor Web 2.0 is open-source software and is available for commercial and public safety applications. ■

*For more on the R&D 100 Awards, visit <http://www.rdmag.com/awards.aspx>*

*For information on the technologies in this article, contact the appropriate NASA Field Center. See inside back cover of this issue.*

*Please mention that you read about it in Technology Innovation.*

## New "Smog Blog" Improves Public Safety

**N**ASA and its partners recently unveiled a new way to connect satellite air quality data with communities in Central America and the Caribbean – the MesoAmerican and Caribbean Smog Blog, a Web site interpreting local and regional air quality.

The Smog Blog provides timely information about air pollution and its sources in the region, helping the public, governments and health officials monitor air quality and mitigate negative health impacts.

The blog is written by faculty and students at the University of Panama and staff from the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC). It is the newest addition to SERVIR (Spanish for "to serve"), a regional environmental monitoring system, developed by researchers at NASA's Marshall Space Flight Center. SERVIR leverages the satellite resources of the United States and other countries to put Earth observation data and other tools into action in Central America.

"CATHALAC has truly taken a leadership role in understanding how NASA atmospheric research informa-

**NASA TECHNOLOGY TRANSFER AND INDUSTRY-RELATED NEWS**

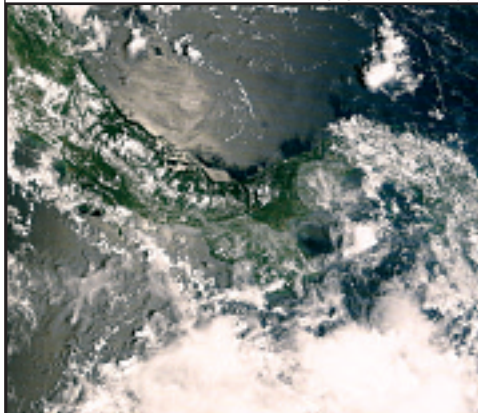
tion can benefit the citizens of Mesoamerica," said Teresa Fryberger, associate director of the Applied Sciences Program in NASA's Earth Science Division and co-chair of the U.S. Group on Earth Observations. "With Smog Blog, Central American environmental and health officials will be able to better communicate warnings about hazardous air quality conditions so the public can take appropriate precautions."

Posts are made at least three times a week by trained personnel using information from satellites, air quality forecast models and soon-to-be-operational ground-based monitors. Satellites from NASA and the National Oceanic and Atmospheric Administration (NOAA) provide air quality measurement information of use to the region. Data from NASA's Terra and Aqua satellites provide a variety of atmospheric measurements. The NASA-French Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite mission provides bloggers with data about regional airborne particles. NOAA's Geostationary Operational Environmental Satellites provides continuous monitoring of Earth necessary for timely, intensive data analysis. Another NOAA data asset providing material is an interactive Hazard Mapping System that allows meteorologists to analyze wildfires from satellite

data and depicts tracks of the smoke that they produce.

"In our region, this exciting initiative is going to improve the quality of life in vital sectors, including public health, energy, economy, weather, climate and agriculture," said Emilio Sempris, director of CATHALAC.

PHOTO CREDIT: NASA



THIS SEPTEMBER 22, 2008, IMAGE OF PANAMA IS FROM THE NASA TERRA SATELLITE, MODERATE RESOLUTION IMAGING SPECTRORADIOMETER (MODIS) SENSOR. THE AREA HAS RELATIVELY CLEAN AIR DUE TO CLOUD COVER AND RAIN, BUT ISOLATED SPOTS OF POLLUTION MAY EXIST NEAR URBAN OR AGRICULTURAL AREAS.

A precursor to the SERVIR system is a U.S. Smog Blog, which has been operated for five years by a team at the University of Maryland – Baltimore County. The site draws 35,000 visits each month, mainly state and local air quality forecasters. It is a daily resource for "big picture" analysis of nationwide air quality and insights into how national trends may affect communities locally. Through a NASA cooperative agreement, the U.S. Smog Blog

team is working with SERVIR to bring this communications tool to Central America.

"The Smog Blog has been a powerful communications tool here in the United States," said Erica Zell, co-developer of the Smog Blog and research scientist for Battelle Memorial Institute. "We hope through sharing real-time air quality information in this region we will make an impact in preventing future harm. Pollution and acid rain have damaged ancient Mayan ruins and air quality has immense public health impacts in this region."

Support for the new Smog Blog is provided by CATHALAC, the University of Panama, the University of Maryland—Baltimore County, Panama's national environmental authority, the World Bank and Battelle Memorial Institute. NASA, the U.S. Environmental Protection Agency and the U.S. Agency for International Development fund this initiative. ■

*Access the MesoAmerican and Caribbean Smog Blog at <http://www.nasa.gov/servir>. For more information please contact Jennifer Morcone at Marshall Space Flight Center, [Jennifer.j.morcone@nasa.gov](mailto:Jennifer.j.morcone@nasa.gov); or Stephen Cole at NASA Headquarters, [Stephen.e.cole@nasa.gov](mailto:Stephen.e.cole@nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

# NASA News Briefs

## Conrad Awards Competition Sparks Youth-based, Entrepreneurial Movement

In today's economic climate, the need for innovation has never been more important. While the current workforce can do its part to continually develop new and better products and processes to keep the United States economically strong, the real "movers and shakers" lie in America's youth.

To encourage young people in the area of science and technology, the Conrad Foundation is conducting its second annual Pete Conrad "Spirit of Innovation" Awards. The competition challenges teams of U.S. high school students to create an entrepreneurial enterprise in personal spaceflight, lunar exploration or renewable energy.

The Conrad Foundation is a not-for-profit foundation designed to energize and engage students in science and technology through unique entrepreneurial opportunities. Founded by Nancy Conrad, wife of the late Apollo XII astronaut Charles "Pete" Conrad, the foundation offers rich programs that combine education, innovation and entrepreneurship in order to shape the workforce of tomorrow.

More than 50 high school teams registered for the competition in

September 2008 spending their fall semesters developing technical reports, business plans and graphical representations of their innovative concepts. Entries were submitted in January 2009 and finalists were recently chosen.

"Pete was an extraordinary man whose accomplishments spanned the entire history of manned space flight – from his days as a moon walker to his business career as a key player in the launch of the commercial space industry," says Nancy Conrad. "He was a passionate innovator and skilled entrepreneur. The Conrad Foundation builds on his legacy and gives our youth the opportunity to discover these tremendous traits in themselves. Such a discovery provides a bold platform for enriching human capital."

The finalist teams will soon advance to the Innovation Summit™, taking place April 2-4 at NASA Ames Research Center. At the Summit, teams will present their ideas to an expert panel and compete for more than \$120,000 in prize money. In addition, there will be workshops and other activities for all finalists.

Winning teams will have the opportunity to network with scientists, university professors and world business leaders in order to further develop the proposed concepts and introduce them to the commercial marketplace. Profiles on all candidates are available for viewing at

[www.conradawards.org](http://www.conradawards.org).

"Innovation is what this country does best," Conrad continues. "It is what sent Pete to the moon and it is the very foundation of our knowledge-based economy. Through this competition, we are growing the future innovators that will keep America economically and intellectually solid."

"This competition is the pipeline from education to industry – we are moving the needle in education and increasing the depth and breadth of human capital in this country," she adds. "We've not only created a program, we're driving a movement." ■

*To learn more about the Conrad Foundation or to become a partner, visit [www.conradawards.org](http://www.conradawards.org).*

*Please mention that you read about it in Technology Innovation.*

## Goddard and Northrop Grumman Answer Key Questions in Climate Change and Planetary Science

Answering bold questions about life and climate on Earth and other planets is the goal behind a new Space Act Agreement between NASA Goddard Space Flight Center and Northrop



**NASA TECHNOLOGY TRANSFER AND INDUSTRY-RELATED NEWS**

Grumman's Electronic Systems sector. Through the agreement, researchers from the two Maryland-based organizations will collaborate on the development of advanced civil radar system architectures that can be leveraged into new space-based remote sensing instruments with revolutionary performance characteristics. These systems will help scientists measure with far greater accuracy, precision and detail such things as three-dimensional characteristics of Mars and other planets, as well as cloud composition and other characteristics on Earth, to better understand climate change.

The project is expected to yield the following results:

- A better understanding of the history and habitability of Mars and other planets
- A better understanding of global warming and the carbon cycle
- Opportunities for NASA to conduct more exploration with less of its own investment
- Significant expansion of NASA's instrument development programs with new hardware capabilities
- Leveraging of Northrop Grumman's mature radar technology developed for Department of Defense applications into a valuable scientific tool to benefit emerging science needs

The collaborative agreement brings together the best of Northrop

Grumman's radar technology and Goddard's scientific expertise. The technology to be used includes the company's space-qualified electronically scanned arrays, wideband electronics and lightweight mesh antenna technology. Goddard will add remote sensing expertise, testing facilities and insight into applications that would help scientists answer key space and Earth science questions. Specific topics that may be more closely studied as a result of this technology include the following:

- Observing our planetary neighbors to improve our understanding of the evolutionary processes of Earth
- Understanding the climate change that Mars experienced as it relates to the possibility of life on that planet
- Understanding the history of oceans and resurfacing on Venus as a way to understand whether it may have ever been habitable
- Ascertaining the structure of possible oceans on icy moons, such as Jupiter's Europa
- Characterizing in 3D the global lunar soil cover where resources are located
- Evaluating the Earth's climate system and how it is evolving
- Understanding the carbon cycle via distribution of above-ground biomass

- More thoroughly understanding Earth's water cycle
- Monitoring changes in the Earth's ice cover at the margins of the planet's largest ice sheets

The current state of the art for remote sensing of planetary and Earth science measurements is large, uses a tremendous amount of power, and is expensive to fly on space missions. By combining the best in space-qualified radar and expertise, researchers at Northrop Grumman and Goddard plan to demonstrate the feasibility of a smaller, lighter, less costly radar system for science and exploration initiatives. In short, such a system would enable scientists to measure what is currently inaccessible. Such observations include aspects of the carbon and water cycles on Earth, the nature of Martian water and ice reservoirs in 3D, and the surface of Venus (and history of its ancient oceans) at never-before-possible scales. ■

*For more information, contact the Innovative Partnerships Program Office at Goddard, (301) 286-5810, or [techtransfer@gssc.nasa.gov](mailto:techtransfer@gssc.nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

*To read more about NASA's collaborations with Northrop Grumman, please see the Tech Talk column in this issue.*

## Kennedy's Cryogenics Test Laboratory: Playing a Key Role in the Future of Energy

By Carol Anne Dunn and James E. Fesmire  
NASA Kennedy Space Center

The Cryogenics Test Laboratory at NASA's Kennedy Space Center (KSC) is one of the nation's premier laboratories covering thermal insulation systems, propellant process systems, cryogenic components and low-temperature applications.

Cryogenics, the art and science of achieving very cold temperatures, from 123 K (-283 °F) to almost absolute zero (-459 °F), is highly energy-intensive. Cryogenic technologies are used by the space program to enable many things, ranging from launch vehicle propulsion to spacecraft sensor cooling.

People may not realize, however, that cryogenics touches many other aspects of our lives. For example, cryogenics is used in biology and medicine for the destruction of cancer cells and storing blood cells and tissues at super-cold temperatures, in the food industry for better-tasting foods and preservation, in the transportation industry for liquid hydrogen and liquefied natural gas cars, and in the electric power industry for superconducting power cables.

NASA's primary interest in cryogenics, naturally, is for the space program and its missions. Space exploration is a very energy-intensive endeavor, which leads to critical needs for cryogenics. Propulsion, power, life support and science research all rely on cryogenic engineering and technology to some extent. Ground test facilities are then installed for use in addressing these needs, finding out details and verifying safe, reliable systems. The Cryogenics Test Laboratory at KSC works regularly with many lab groups throughout

PHOTO CREDIT: NASA



A CRYOGENIC GLOBE VALVE UNDERGOES DESIGN IMPROVEMENTS AND REFURBISHMENT IN PREPARATION FOR FUTURE LAUNCH PAD SERVICE.

NASA to help meet these needs and solve issues that are relevant to the larger mission.

The Cryogenics Test Laboratory, or CryoTestLab as it is familiarly known, was founded in 1997 based on the testing of thermal insulation materials, including new technology aerogel materials, and fluid handling components. The lab has been at its present facility since 2000 and is organized by four technology focus areas – thermal insulation systems, cryogenics components, propellant process systems and low-temperature applications. The main facility is similarly organized, consisting of three lab rooms, a large high-bay room and a clean room, along with a library, conference room and common space totaling about 7,000 square feet. They use liquid nitrogen (LN<sub>2</sub>, 77 K) and liquid helium (LHe, 4 K) and have 6,000 psi high-pressure, high-flow gas supplies. Capability with liquid hydrogen (LH<sub>2</sub>, 20 K) is currently being added.

Collaboration is the CryoTestLab's foundation. The lab networks with other labs and institutions throughout KSC, NASA and the nation. The team consists of 22 employees, both NASA and ASRC Aerospace, including technicians, engineers and scientists. Their work is often in collaboration with both aerospace and general industry, where the focus is on solving problems that require a combination of expertise in materials science, testing and engineering application.

PHOTO CREDIT: NASA



CRYOSTAT-4 (THERMAL INSULATION TEST APPARATUS FOR FLAT SPECIMENS) IS FILLED WITH LIQUID NITROGEN IN PREPARATION FOR TESTING NEW TECHNOLOGY MULTILAYER INSULATION SYSTEMS FOR FUTURE NASA EXPLORATION MISSIONS.

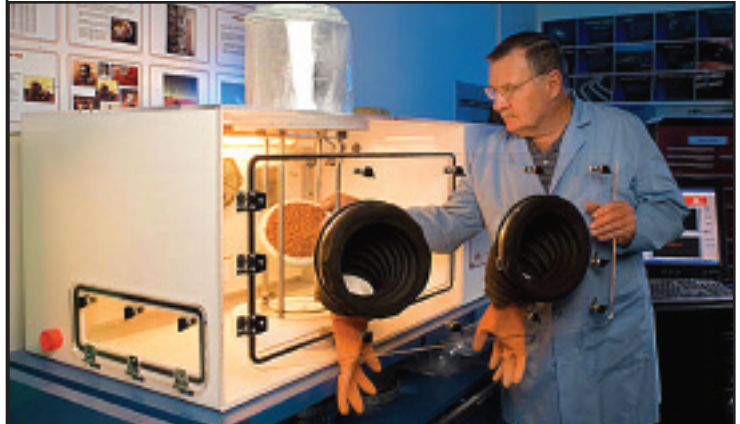
The collaborative nature of the lab is unique, as is its approach – long-term research with a right-now problem-solving attitude. Common challenges are sought among different systems, and work is promoted along the lines of technical disciplines. Also unique is the lab’s test capabilities – thermal conductivity of materials and thermal performance of systems under actual-use cryogenic-vacuum environments.

The list of customers served by the CryoTestLab is broad, including most of the NASA Centers (Shuttle, Station, Expendables and Constellation), the Department of Defense, the Department of Energy, aerospace companies and others. Working with industry is a core part of the lab’s work, and energy-efficient cryogenics is its enduring theme.

The long-term objectives at the CryoTestLab are simple – to make cryogenics easier to control for improved operations and less constraints; develop lower heat leak systems for improved propellant quality and less cool-down losses; design high-reliability, low-maintenance systems for robust performance; and reduce life-cycle costs and dependence on non-renewable resources such as helium.

The future of cryogenics, in terms of engineering, is closely

PHOTO CREDIT: NASA



IN NASA’S CRYOGENICS TEST LAB, A FOAM INSULATION TEST SPECIMEN IS INSTALLED FOR THERMAL PERFORMANCE TESTING USING THE CRYOGENIC MOISTURE UPTAKE APPARATUS. THIS EQUIPMENT MEASURES MOISTURE OR ICE THAT COLLECTS INSIDE MATERIALS SUBJECTED TO CRYOGENIC CONDITIONS ON ONE SIDE AND AMBIENT ENVIRONMENTS ON THE OTHER.

related to energy on all fronts. As cryogenics becomes more and more a part of modern life, it must also become more “invisible” and energy efficient, and it has a key part to play in pursuing energy independence on the global scale, with important implications in both transportation and electric power. Technology advancements will make cryogenics less exotic and more practical for additional applications.

The science element of cryogenics – producing and using temperatures toward absolute zero – will continue to be useful in exploring the fundamentals of how matter is put together and how it interacts at the quantum level. These very low-temperature studies constitute a broad area of investigation including, for example, the Large Hadron Collider now being activated at CERN in Europe. The CryoTestLab asks, “What is next?” and “How do we best go forward?” The knowledge gained from all of these cryogenic efforts – from physics experiments to research testing to system demonstrations – will be integral in finding the answers. ■

*Carol Anne Dunn is project specialist and James E. Fesmire is senior principal investigator at the Cryogenics Test Laboratory at Kennedy.*

*For more information about the lab, visit <http://technology.ksc.nasa.gov/> or call (321) 867-7557.*

*Please mention that you read about it in Technology Innovation.*



# Facility Focus

## NASA Buildings Go “Green”

By Eugene Mszar

NASA Facilities Engineering & Real Property Division

**N**ASA has taken a “giant leap” into green building practices through an Agency-wide facilities sustainability program. Inspired by an executive order requiring federal agencies to significantly improve energy management by reducing greenhouse gas emissions, reduce energy consumption by improving energy efficiency and expand the use of renewable energy, NASA is developing strategies and best practices to meet federal goals and guidelines for high-performance and sustainable buildings.

Green design refers to design and construction practices that significantly reduce negative impacts of buildings on the environment and are more pleasing to occupants.

As a result of the executive order, NASA issued a new policy that laid out instructions for incorporating sustainable design principles for all of the facility projects planned, designed and constructed under Agency authority or control. Partnering with NASA’s Environmental Management Division, the Agency’s Facilities Engineering and Real Property Division (FERP) provided direction for the new design and construction. FERP strives to meet the U.S. Green Building Council Leadership in Energy and Environmental Design (LEED®) guidelines, which incorporate innovative design, construction, maintenance and emerging technologies. NASA’s new building policy stipulated that projects planned for fiscal year 2006 and beyond must meet the minimum LEED® rating of Silver and strive to meet a rating of Gold. LEED® credits toward certification are obtained in five broad areas: sustainable sites, water efficiency, energy and atmosphere, materials and resources and indoor environmental quality. Following is a sample of the NASA facilities incorporating green design principles.

### Building 4600 at Marshall

NASA’s first LEED® Silver building was completed at the George C. Marshall Space Flight Center (MSFC) in 2005. Building 4600, a five-story, 139,000-square-foot office building, has a capacity for housing 392 employees. As designed, the operational energy consumption of the facility was specified to be at least 20 percent below the 2010 energy efficiency goals of the executive order, based on the existing energy usage baseline.

Building 4600 features an open floor plan to maximize natural light; uses day-lighting sensors, photovoltaic parking lot lighting and a reflective ENERGY STAR® roof membrane; and has photovoltaic roof panels that provide 35 kilowatts directly to the electrical grid.

Twenty percent of the building material is made of recycled content, and more than 85 percent of all construction waste was re-used or recycled. The building is currently operating at 47 percent of the electrical consumption of comparable structures throughout the campus, and it was one of four facilities throughout the nation to receive the 2005 Federal Energy Showcase Award.

### Health and Fitness Center at White Sands

The second NASA building to receive a LEED® Silver rating is the Columbia Health and Fitness Center at the White Sands Test Facility (WSTF). Features include designated parking for carpools and vehicles using alternative fuel; a system that reduces storm water run-off by 25 percent; the use of desert landscaping, which requires no irrigation; and incorporation of items that reduce water use, such as waterless urinals and low-flow toilets, sinks and shower fixtures.

LEED® energy credits include ENERGY STAR® compliance, highly reflective and high-emissivity roofing, and 20 percent use of construction materials manufactured within a 500 mile radius. NASA also improved the fitness center’s indoor environmental quality by installing CO2 monitoring devices; maximizing day-lighting and using low-VOC adhesives, sealants and paints.

### Astronaut Quarantine Facility at Johnson

One of the most challenging LEED®-rated buildings that NASA designed and constructed is the Astronaut Quarantine



THE CHILD CARE CENTER AT JOHNSON SPACE CENTER USES MULTIPLE RENEWABLE ENERGY PLATFORMS.

Facility (AQF), which is located at the Johnson Space Center (JSC). The AQF was constructed with energy-savings features that reduce annual energy consumption by 15.8 percent, relative to energy code requirements.

Astronauts begin adjusting their circadian rhythms prior to flight by being exposed to normal daylight conditions using artificial light that is turned on and off to coincide with the mission work schedules. Requirements for this process create a challenge in the area of energy conservation. At the AQF, four rooms are constructed with high-output fluorescent fixtures that occupy 90 percent of the ceiling space. The lights consume electricity and generate heat in quantities well above those of most buildings. This added heat must be removed by the building's air conditioning system, adding significantly to energy consumption.

But by utilizing energy-saving techniques, the AQF meets this challenge 15.8 percent more efficiently than the energy code requires. The savings were accomplished by installing extra insulation in walls and the roof, reducing solar heat gain through windows and using high-efficiency HVAC equipment. The HVAC system includes motors that operate at variable speeds to match heating and cooling loads, and variable flow control for chilled water pumps. In addition, heat and moisture is exchanged with air that is exhausted from the building through an "enthalpy" wheel. The wheel cools and dehumidifies incoming outside air during summer

and warms the outside air during winter, thereby reducing energy consumption.

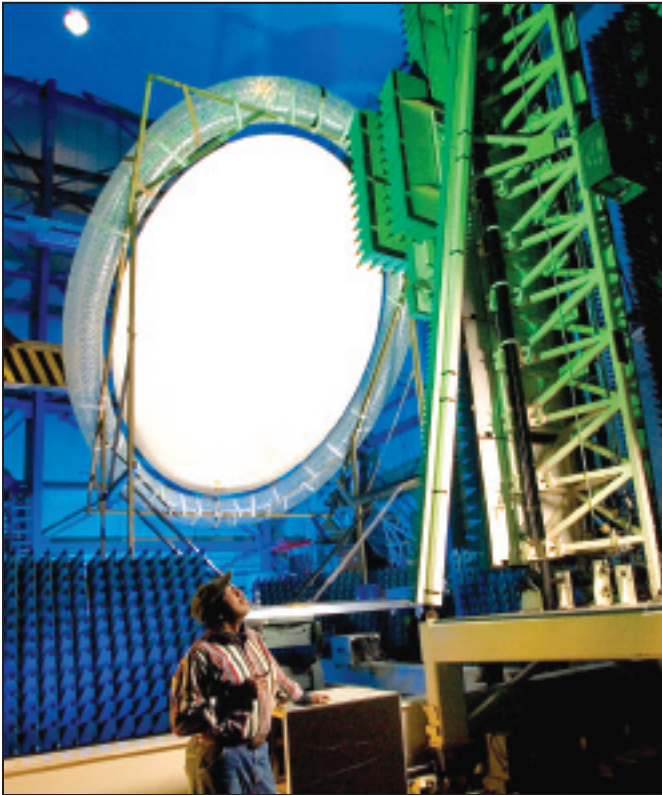
Other green strategies and materials used at the AQF include landscaping with native grasses and many trees to drastically minimize irrigation needs; permeable paving and a retention pond to reduce storm water runoff; an energy-efficient, highly reflective roofing system that reduces heat buildup and cooling requirements; recycled building materials, such as 100-percent recycled steel in the structure and concrete reinforcing, and flooring made from used tires; and purchasing 100-percent wind-generated electricity for the building's first two years of operation.

### Child Care Center at Johnson

In 2007, JSC designed and installed a Multi-Platform Renewable Energy System (MPRES) at its Child Care Center. This project supports JSC's Engineering Directorate mission by providing an opportunity to better understand large, surface-based photovoltaic (PV) arrays necessary for lunar surface exploration. It also allows JSC to gain experience with various renewable energy technologies, demonstrates sustainable building principles and assists in meeting federal energy mandates. The Child Care Center was selected for the project because the size of the facility allows for renewable energy system flexibility and a manageable tie-in

*Continued: see **GREEN** on pg. 57*

PHOTO CREDIT: NASA



## Large Aperture Deployable Antennas for Use at NASA and Beyond

By Felix Miranda, Robert Romanofsky and Cindy Dreibelbis  
NASA Glenn Research Center

The NASA Glenn Research Center's (GRC) Antenna and Optical Systems Branch develops antenna, microwave and optical systems and techniques in support of NASA's communication needs. Emphasis is on the development and characterization of phased array antennas and array feeds, large-aperture inflatable antennas, miniaturized antennas and tradeoff studies among different antenna technologies and novel antenna concepts for space and ground communication applications.

While GRC is an organization of excellent researchers, it

frequently works with partners that provide exceptional technologies to support NASA's communications needs. One of these partners is SRS Technologies (now ManTech SRS Technologies Inc.) of Huntsville, Ala.

Starting with a Small Business Innovation Research (SBIR) award to the company in 1998, GRC's efforts with SRS addressed large aperture deployable reflectors for space power and communications applications, culminating in the world's first inflatable antenna to be certified by the Federal Communications Commission (FCC).

While SRS's work during phases 1 and 2 of the SBIR was on deployable collectors for advanced space power and propulsion systems, it soon became obvious that the same basic technology was applicable in the communications area, specifically for large aperture inflatable antennas.

Over the next several years, the company was able to attract Phase 3 funding totaling more than \$847,000 to develop the communication applications of the technology with contributions from NASA's Space, Communications and Navigation (SCaN) project. GATR Technologies was formed in 2004 and teamed with SRS to focus attention on developing the antenna concept into an FCC-licensed product for ground-based communications.

"Our initial prototypes ended up supporting and helping hundreds of citizens shortly after Hurricane Katrina," says Paul Gierow, GATR president and principal inventor of the ground-based antenna.

In 2005, SRS received a patent for the Ground-Based Inflatable Antenna. GATR licensed the technology from SRS in 2006 to continue to develop and seek markets for it. The GATR development effort was greatly enhanced by an award of a competitive Department of Defense procurement for \$1.8 million to mature the ground-based antenna system, which came to be known as the "Beach Ball" because of its appearance.

As is frequently the case, once work progressed to this level, numerous activities were being undertaken simultaneously. SRS and GATR each were recognized with a prestigious

PHOTO: THE 4-M X 6-M INFLATABLE OFFSET PARABOLIC MEMBRANE ANTENNA TEST IN THE NEAR FIELD FACILITY AT GLENN RESEARCH CENTER.



Tibbetts Award, acknowledging that they exemplified the best in SBIR achievement, while still working to attract multiple funding sources using a variety of vehicles. In December 2006, GATR entered into a Space Act Agreement worth \$39,000, which leveraged the SCA-N project to continue the research and testing of the Beach Ball antenna at GRC.

Continued testing of the inflatable large aperture antennas resulted in the issuance of the world's first FCC-certified inflatable antenna in July 2008. With this certification, the Beach Ball inflatable antenna concept achieved a maturity level that enables its availability for a variety of communication applications within NASA, other government agencies and commercial entities. In the interim, the Beach Ball concept joins other large aperture deployable antenna concepts being considered for inclusion in the next-generation NASA Communication Architecture.

NASA GRC and ManTech SRS are currently evaluating the possibility of integrating inflatable membrane antenna technology into aerostat vehicles for aerial reconnaissance and surveillance in support of first responders and Homeland Security operations.

Meanwhile, GATR Technologies continues to pursue a longer-term relationship with NASA GRC in formation of a new Space Act Agreement for future testing and evaluation of emerging antenna products.

Not only does this example demonstrate how the technology readiness level (TRL) of the Beach Ball concept progressed, but it also highlights how the SBIR program fostered the creation of a new company and generated additional revenue for ManTech SRS. In addition, it illustrates how the SBIR Program can benefit NASA missions and other industries, as well as spur economic growth in the United States.

The technology maturation sequence also demonstrates that developing SBIR technologies to the point where they can be used in NASA missions, or "infused," is a complicated, long-term process requiring a substantial amount of effort and flexibility on the part of everyone involved.

"The technical and management teams at NASA GRC have been instrumental in supporting our efforts to receive FCC certification for our antenna," Gierow says. "The tech-

nical staff and unique facilities at NASA GRC have provided help to develop a more in-depth technical understanding of this unique product."

From his company's experience in this process, Gierow offers the following lessons learned:

- Work with the technical and contractual point of contact at GRC to understand the Space Act Agreement process early on.
- Scope the technical objectives with the desired milestone completion dates and maintain flexibility in methods to achieve the milestones.
- Add contingency plans in working with the government point of contact. Recognize the technical point of contact is working within a variety of constraints and additional mission and program milestones unrelated to the company's desires sometime take priority.
- Most technical development programs slip due to delays in on-going tests, facility interruptions and instrumentation issues. Recognize that this "just happens" in the course of development work. All plans change during the development cycle and all parties should be flexible within reason when scheduling requirements in the Space Act Agreement.
- Write a simple plan of roles and responsibilities for all team members. Each member should agree and participate in the generation of the roles and responsibilities.
- Remember that innovation and technology development take effort, dedication and a sense of urgency. Don't let the details and paperwork keep you from getting into the lab to have fun and develop a success story. ■

*Authors Felix Miranda (chief) and Robert Romanofsky (senior research engineer) are in the Antenna and Optical Systems Branch; and Cynthia Dreibelbis is awards liaison specialist, at NASA Glenn Research Center.*

*For additional information on this antenna concept or the SBIR program, please email [TTP@grc.nasa.gov](mailto:TTP@grc.nasa.gov) or call (216) 433-3484.*

*Please mention that you read about it in Technology Innovation.*

## NTTC Technology Portfolios Facilitate Collaborations

By Kathryn Duda  
National Technology Transfer Center

NASA technologists have a new and efficient tool for searching out companies and available technologies that meet NASA project and program needs: Technology Portfolios developed by the National Technology Transfer Center (NTTC).

In response to requests from NASA Mission Directorates, the NTTC has created a series of CDs containing portfolios of information on select Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) technologies and the companies that developed them, grouped according to the NASA SBIR/STTR technology taxonomy and relative to select NASA SBIR/STTR solicitations. Included are thoroughly researched Phase 1 and Phase 2 technologies that received SBIR/STTR funding from either NASA or the Department of Defense.

Information on each technology is presented in easy-to-use quad-chart format showing the technology's description, technical objectives and technology readiness level (TRL), applications within NASA and the commercial sector, company history and contact information and a photo or other relevant image depicting the technology. Links take viewers to the SBIR/STTR solicitation, proposal summary and company Web site.

In addition to technologies, each Technology Portfolio contains articles and publications from NASA NTRS, and patents and applications from the U.S. Patent and Trademark Office and the World Intellectual Property

Organization.

To date, Technology Portfolios are available on Navigation, Small Spacecraft, Inflatable Structures, Advanced Space-Rated Batteries, Wireless Communications – Delay and Disruption-Tolerant Networking and Wireless Communications – Deployable Antennas. A portfolio on Composite Structures is in progress, and additional portfolios are in the planning stages, according to NASA's needs.

The NTTC's objective in creating the Technology Portfolios is to increase R&D efficiency and supplement the development of other technologies, thus speeding the process of infusing new technologies into NASA programs.

The process of creating a Technology Portfolio begins with the identification of a technology need by a NASA Mission Directorate, and the categorization of that need according to the NASA SBIR/STTR technology taxonomy. Technologies relevant to that need are selected by the NTTC from existing NASA and DoD



SBIR/STTR databases (and in some cases, databases from other federal agencies), screened and evaluated for applicability and categorized by the NASA SBIR/STTR technology taxonomy. A portfolio of technologies is the result.

For ease of distribution, the portfolios are packaged on CDs and available from the NTTC. CDs have been distributed within NASA and to other interested agencies and contractors. Technology portfolios are also available on the NTTC's Small Business Innovative Partnership Program Web site at [www.sbipp.com](http://www.sbipp.com).

The portfolio format has considerable potential in many other government and commercial applications where there is a need to identify, qualify and screen technologies from accessible databases. In addition, the portfolios can be utilized for marketing technologies to a broad potential user base.

Located on the campus of Wheeling (W.Va.) Jesuit University, the NTTC was established by the U.S. Congress in 1989 to expedite the transfer and commercialization of federally funded research and development. In that role, the NTTC links industry with federal laboratory and university technologies, facilities and world-class researchers and scientists.

The NTTC has been working with NASA since 1989, initially dealing with traditional technology transfer, partnership development and commercialization issues. While the NTTC continues to support traditional technology transfer activities, its current effort with NASA involves identifying and qualifying NASA technologies that may be infused into specific NASA mission applications.

The NTTC's capabilities include technology and market evaluation/assessment, technology marketing and partnership development, computer information services, strategic technical services, public affairs and publications, and consulting services for technology-based small businesses. ■

*Kathryn Duda is assistant manager of public affairs at the NTTC.*

*For more information on the Technology Portfolios, or on how the NTTC can assist you, please call 1-800-678-NTTC (6882), or visit [www.sbipp.com](http://www.sbipp.com).*

*Please mention that you read about it in Technology Innovation.*

# SBIR Innovations Support NASA's Mars Missions

By Byron Jackson  
Jet Propulsion Laboratory

**T**he NASA Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) Program offers the small business community not only funding opportunities for research and development work, but opportunities to partner with NASA on missions.

In fact, a number of small companies have used SBIR contracts to position themselves and their technologies for a trip to Mars. SBIR technology is at work on three locations on Mars right now. Three SBIR companies supplied technology for the current Phoenix Lander mission. The Phoenix mission landed in the Mars arctic region where the Mars Odyssey spacecraft previously identified the presence of water. The Phoenix Lander has a robotic arm to retrieve soil and water ice samples for sophisticated scientific analysis onboard the spacecraft.

Supporting the Phoenix mission, Yardney Technical Products Inc. provided lithium-ion batteries, which help to power the spacecraft.

Starsys Research, now part of SpaceDev Inc., provided key elements of the spacecraft's wet chemistry laboratory. Based on its successful SBIR work, Starsys joined with the Jet Propulsion Laboratory (JPL) scientists on several research contracts to advance its wet chemistry laboratory equipment to meet the needs of a future NASA mission.

Honeybee Robotics, which has used its SBIR contract work to build a strong relationship with JPL's robotic development program, supplied the icy soil acquisition device for the Phoenix Lander. The company also provided two rock abrading tools for the Mars Exploration Rovers – Spirit and

*Continued: see **MARS** on pg. 56*



# NASA Technology Contributes to **SUSTAINABILITY** of the **EARTH**



**By Shana Dale**

*NASA Deputy Administrator*

**W**hile most people identify with NASA's mission to explore new worlds and the mysteries of our universe, some of NASA's greatest contributions are the data, knowledge and understanding that the Agency's satellites and research provide about our planet.

Sustainability of our Earth permeates NASA's missions.

For example, to survive on the moon's surface, we must discover ways to create, collect, store and use energy without access to fossil fuels. Other sources of energy must be developed into practical resources that humans

can use in extreme environments.

As we continue to explore new sources of energy and delivery methods, these efforts can help to address the pressing demand for energy right here on Earth. Space exploration demands cleaner and more efficient sources of energy that can operate in

extreme environments without toxic effects. One example of a relatively clean energy source offering tremendous potential is solar power.

NASA pioneered the use of solar cells in the Apollo Program and continues to push the limits of this technology today, with the solar “wings” that collect the sun’s energy for use onboard the International Space Station.

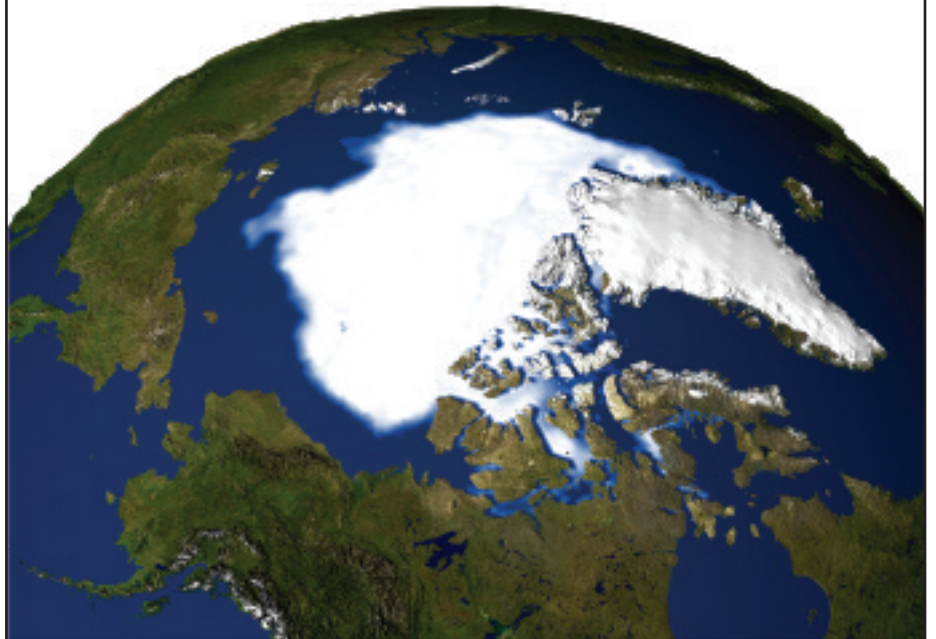
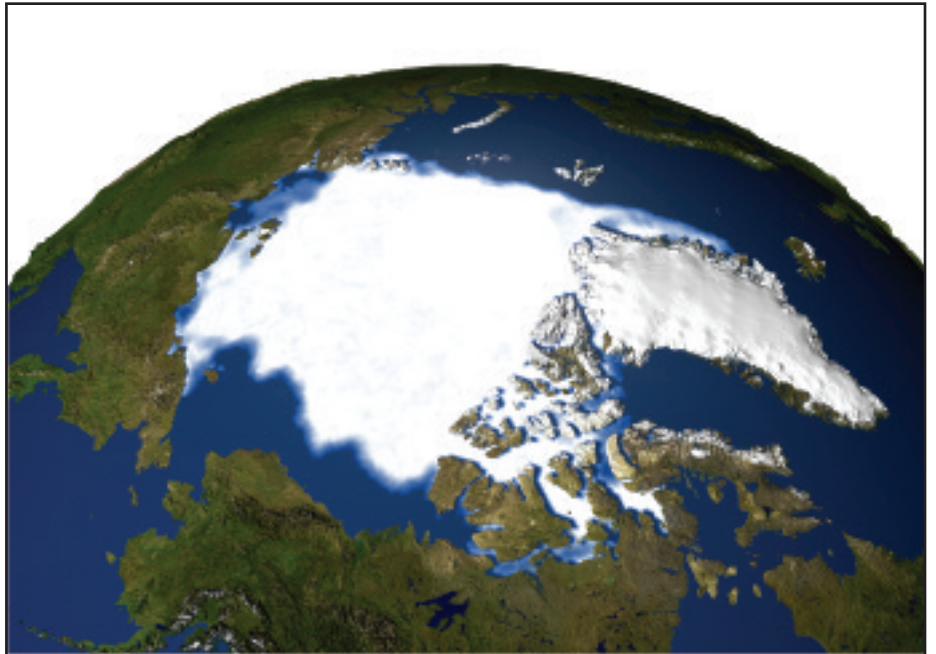
Technologies for capturing and utilizing solar power hold the promise of a clean and abundant energy source, one that is virtually limitless for as long as the sun endures.

The potential impact of these alternate, clean energy sources is so great that we can hardly imagine it. Availability of clean energy resources will affect the lives of not only Americans but of every person on the face of the planet.

NASA’s work has led to discoveries that contribute to sustainability in many other ways. For instance, in space travel, physical space is limited, weight is critical and resources are severely constrained. Every watt of energy is accounted for; every resource is transported and monitored.

Space exploration drives the development of technologies with minimal impact to these tiny ecologies – and, by extension, to the ecology of Planet Earth. These technologies include advanced recycling techniques, treating waste and converting it back into usable resources as well as new, green power systems.

Perhaps NASA’s biggest contribution to sustainability is the development and operation of Earth-observing



THE ARCTIC SEA ICE MINIMUM MARKS THE DAY, EACH YEAR, WHEN THE SEA ICE EXTENT IS AT ITS LOWEST. THE SEA ICE MINIMUM OCCURS AT THE END OF THE SUMMER MELTING SEASON. USEFUL SATELLITE DATA CONCERNING SEA ICE BEGAN IN LATE 1978 WITH THE LAUNCH OF NASA’S SCANNING MULTICHANNEL MICROWAVE RADIOMETER (SMMR) SATELLITE. WHEN SCIENTISTS COMPARE AVERAGE SEA ICE CONDITIONS BETWEEN YEARS, THEY OFTEN USE A REFERENCE PERIOD THAT BEGINS WITH 1979. THE AMOUNT OF SEA ICE REACHED A RECORD LOW IN 2005. THE TWO PHOTOS ABOVE SHOW THE ARCTIC SEA ICE MINIMUM IN 1979 (TOP) AND IN 2005 (BOTTOM).



PHOTO CREDIT: NASA



HURRICANE IKE AS SEEN FROM THE INTERNATIONAL SPACE STATION

satellites. With today's constellation of NASA satellites covering the spectrum of Earth science measurements of our land, sea, air, and space, NASA supplies more global climate-change data than any other organization in the world, and it is the largest contributor to the federal government's inter-agency Climate Change Science Program, providing the most research grant funding of any organization. A new satellite was added recently to this constellation with the launch of the Ocean Surface Topography Mission, or Jason-2 (see image, pg. 24), on June 20

from Vandenberg Air Force Base in California. Like most NASA missions, Jason-2 is a partnership with other countries of the world, because NASA recognizes that the forces at work affecting global climate change know no boundaries.

Built by the engineers at the Jet Propulsion Laboratory in Pasadena, Calif., Jason-2 will join a comprehensive suite of missions and instruments such as ICES at and GRACE in orbit today to monitor how sea level is rising around the world, mostly due to expansion from ocean heat absorbed

from the atmosphere and melting mountain glaciers and ice sheets (e.g., Greenland, Antarctica). In September 2007, NASA scientists observed the smallest Arctic sea ice coverage ever recorded. The sea ice coverage in September 2007 was smaller than in September 2006 by an area that exceeded the combined geographical areas of California and Texas. After decades of monitoring our Earth from NASA satellites, this was the largest ice-free area of the Arctic that our NASA researchers have witnessed since monitoring started.



Along with increased heat stored in the oceans and melting ice sheets, NASA is helping the nation understand other harmful phenomena affecting our coastlines. For instance, NASA researchers use measurements of ocean color to understand biological changes, including the incidence of harmful algal blooms, often referred to as red tides. NASA has partnered with other federal agencies to help deal with these harmful red tides and their impact on our coastal regions. NASA's Earth science missions provide the National Oceanic and Atmospheric Administration (NOAA) with data on environmental conditions that NOAA uses to inform beach managers and local public health officials in the Gulf of Mexico region about occurrences of harmful red tides and other phenomena.

It is only through our nation's investment in NASA over the past 50 years that we have such insights and

understand its implications to our home planet. We better understand our sun's irradiance of the Earth. We better understand the moon's effects on tides and the Earth's rotation. And we better understand the complex forces among various greenhouse gases, both man-made and natural, along with their effects on the Earth's various systems and our way of life.

Earth maps. They probably don't realize that underlying the commercial imagery is NASA satellite mapping data from space shuttle radar and Landsat.

Working with various federal, regional and state agencies as well as international aid organizations, NASA tries to put its research information and analytical capabilities into practical

NASA's sustainability practices protect its missions, its space explorers and the future of our Earth.

Last summer, NASA worked with the California Air Resources Board to examine the chemical dynamics of smog and greenhouse gases in the atmosphere by flying the Agency's airborne laboratories from NASA Dryden and Ames Research Centers.

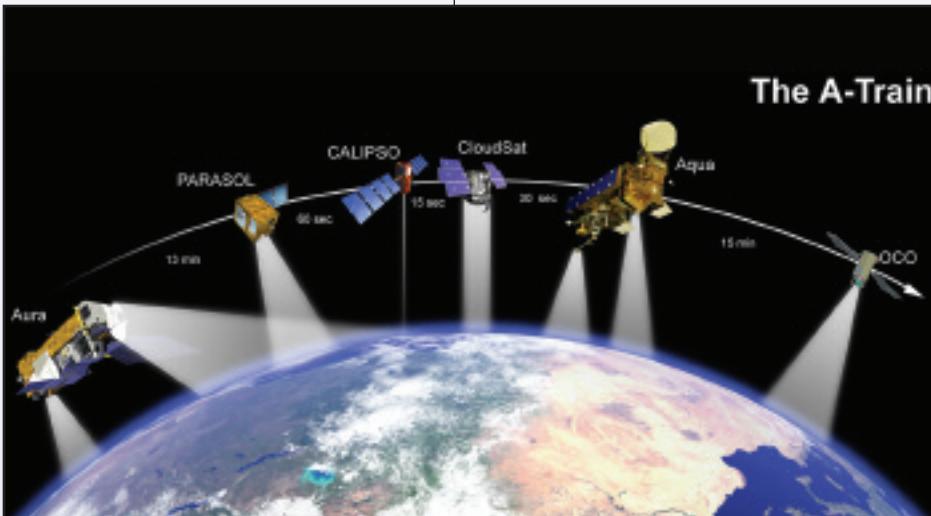
Many people routinely use Google

use for coastal, drought and disaster management as well as aviation safety like wind shear and icing conditions and agriculture market conditions and policies.

Using the vantage point of space and sensors that span the spectrum of advanced capabilities, NASA is providing insights about our world by looking at our world in ways we never imagined.

NASA's sustainability practices protect its missions, its space explorers and the future of our Earth. Through space exploration, quality of life on Earth is improved today and for the next generation. We often hear that to truly understand ourselves we must look within. For NASA, as we look out to explore our solar system and what lies beyond -- we discover more about our own world in ways we never imagined and with benefits we are only beginning to understand. ■

GRAPHIC CREDIT: NASA

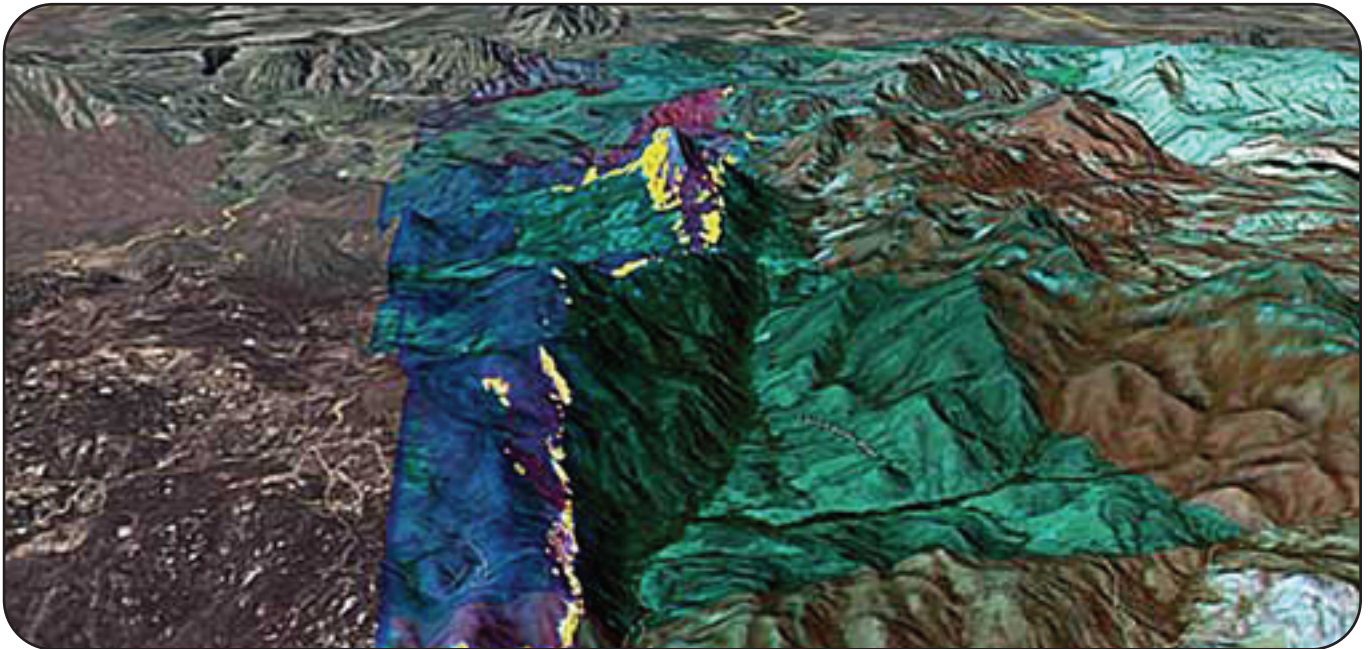


THE "A-TRAIN" SATELLITE FORMATION CONSISTS OF SIX SATELLITES FLYING IN CLOSE PROXIMITY. BY COMBINING THE DIFFERENT SETS OF OBSERVATIONS, SCIENTISTS GAIN A BETTER UNDERSTANDING OF IMPORTANT PARAMETERS RELATED TO CLIMATE CHANGE.



## NASA Partners with Forest Service on Fire Mission

PHOTO CREDIT: NASA



By Everett Hinkley, U.S.D.A. Forest Service; Vincent Ambrosia, California State University—Monterey Bay; William M. Toscano, Ames Research Center; and Thomas Zajkowski, RedCastle Resources

Unmanned aircraft missions typically fall within at least one of the "3 Ds": dirty, dull and dangerous. However, they are well suited for fire support operations because of the challenging nature of the wildfire environment. While current manned aviation assets perform admirably for most fire support opera-

tions, there is always a need for the United States Department of Agriculture Forest Service to improve upon the support it supplies to the incident command, both in terms of cost and safety. Fire imaging for the purpose of providing mapping support is an area that can clearly benefit from the use of unmanned airborne systems (UAS).

The recently completed Western States Fire Mission was a five-year collaborative effort between NASA Ames Research Center and the Forest Service to develop, test and evaluate improved data-gathering and distribution technologies that enable enhanced deci-

sion-making capabilities during wildfire incidents. The following four key technologies were tested during the mission: a high-altitude, long-endurance UAS; an improved multi-channel line scanning sensor; an onboard Over-The-Horizon (OTH) telecommunication package with real-time data communications capabilities and a tool for improved mission management and data visualization.

The overarching objectives of this joint project included the following:

- Successful demonstration of high-altitude data collection by an unmanned aircraft over wildfires

## GOVERNMENT AGENCY PARTNERSHIPS WITH NASA

within the national airspace, showcasing UAS platform capabilities

- Improved fire imagery collection and onboard processing capabilities
- Demonstration of telemetry capabilities
- Decision-support system delivered via an intelligent mission management client (Google Earth™)

During the mission, flights occurred over wildfires in 2006, 2007 and 2008 in a region extending from the Rocky Mountains to the Pacific Ocean, and from the Canadian border to the Mexican border.

The Western States Fire Mission successfully demonstrated the collection and distribution of tactical real-time, geo-registered, thermal multiple wildfire image data from an unmanned aircraft operating at altitudes between 23,000 and 43,000 feet. The missions involved flight and data collection over various fire events, and varying mission length from eight to 24 hours, providing critical thermal infrared imagery to fire incident command centers through an OTH satellite communications data stream.

An intelligent mission management agent was integrated to facilitate improved pre-flight planning, in-flight collection status and image viewing, and an after-action flight record. These demonstrated capabilities provided the

Forest Service fire incident managers with the tactical information and visualization tools necessary to make more rapid and improved decisions on wildfire management strategies.

When the request came in from the California Department of Forestry and Fire Protection to help battle the 2008 wildfires, Ames equipped a remote-controlled \$6-million Ikhana aircraft with an Autonomous Modular Scanner (AMS) and sent it out from NASA's Dryden Flight Research Center at Edwards Air Force Base. The Federal Aviation Administration (FAA) allowed NASA unprecedented flexibility to fly the missions in support of the fire-fighting effort.

Ames obtained the Ikhana, which is based on the same airframe as the military's Predator drones manufactured by General Atomics Aeronautical Systems, to use as a test bed for advanced sensor projects.

The AMS operates like a digital camera, with specialized filters to detect light energy at visible and thermal infrared wavelengths. The scanner had been calibrated to register discrete temperature changes of 0.5 °C to about 1,000 °C, a change from the typical thermal systems that do not accurately measure these high-temperature target ranges. The scanner uses an advanced mercury-cadmium-telluride detector that can be tuned to any

desired infrared wavelength.

"It basically lets us look right through the smoke and essentially create a discrete thermal profile of the fire, with complete geospatial awareness," said Steve Hipskind, chief of the Earth Science Division at Ames.

To more easily detect hot spots, Ames researchers crafted an algorithm to call out the hot pixels that indicate the hottest parts of a fire. During one flight in 2008, the Ikhana and its sensors detected a hot spot on the eastern edge of the town of Paradise. That information played a key role in the order for a mandatory evacuation of 10,000 people at risk.

Although the Ikhana has enough on-board data storage for more than 20 hours of image scans, the sensor streamed its data in real time while flying over the fire areas, sending its images through a communications satellite to Ames. There, data were autonomously integrated with Google Earth™ and Microsoft Virtual Earth™ maps to see the location and scope of the fires. Within about 10 minutes, those images were received and fire information was distributed to the field.

The flight sequence over specific fire events was dictated by National Interagency Fire Center personnel in order to direct the platform to incidents deemed of highest priority. The aircraft-vectoring process relied heavily on the use of the Forest Service MODIS Rapid Response System data

PHOTO (OPPOSITE PAGE): THERMAL INFRARED IMAGING SENSORS ON NASA'S IKHANA UNMANNED RESEARCH AIRCRAFT RECORDED THIS IMAGE OF THE HARRIS FIRE IN SAN DIEGO COUNTY WEDNESDAY, OCT. 24, WITH HOT SPOTS ALONG THE RIDGELINE IN LEFT CENTER CLEARLY VISIBLE. THESE IMAGES WERE USED TO DIRECT FIREFIGHTERS IN REAL TIME TO THE HOT SPOTS.





# Innovator's Corner

GOVERNMENT AGENCY PARTNERSHIPS WITH NASA

## NASA Technology Draws Praise

The technology that NASA Ames Research Center brought to the 2008 firefighting efforts drew praise from dignitaries such as California Governor Arnold Schwarzenegger and United States Department of Homeland Security Secretary Michael Chertoff, both of whom visited Ames to learn how NASA helps the nation deal with natural disasters.

Gov. Schwarzenegger called the Ikhana “one of the most exciting new weapons in our firefighting arsenal” and “a true lifesaver.”

During his visit, the governor examined hyperwall-2, a 23-foot-long state-of-the-art visualization system developed at Ames. It displays the locations of the fires and is used by scientists for data interpretation. Researchers also use the system, which can show images containing up to 250 million pixels, to view simulations generated by Ames' supercomputers.

Chertoff also was briefed on NASA's role in fighting the California wildfires and saw a demonstration of the hyperwall-2 during his visit to Ames. He learned about the key role that Ames' Disaster Assistance and Rescue Team (DART) plays in preparing for earthquakes, floods and fires.

PHOTO CREDIT: NASA



NASA'S IKHANA UNMANNED AIRCRAFT

to derive fire locations and incident priority.

The flight endurance of the large unmanned platform allowed extended surveillance over particularly active fire events to which frequent revisits are extremely desirable.

For incident command teams on individual fire events, the large UAS provided a real-time assessment of fire conditions within minutes of image acquisition. These tactical observations are most desirable during critical moments of fire expansion, generally during daylight hours when larger imaging platform assets are not readily available.

Although UASs are viewed as innovative aerial fire imaging platforms, they are not intended to replace manned aircraft. Rather, they are meant to augment current capabilities, especially in those situations where manned aircraft are not practical because of safety concerns and/or long-duration surveillance requirements. It is clear that UAS technology can make significant contributions to the national wildland fire imaging and mapping operations if mission goals are clearly defined and cost goals are met.

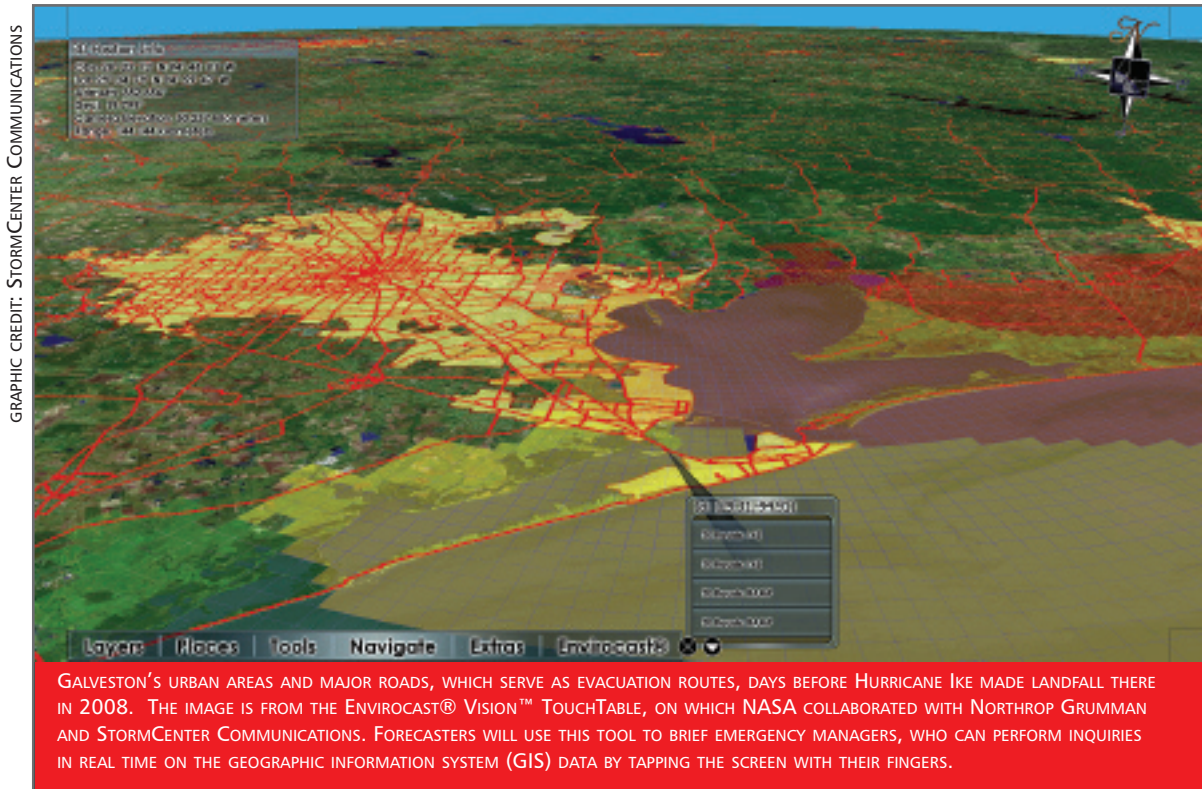
NASA's Applied Sciences and Airborne Science programs and the Earth Science Technology Office funded development of the fire sensor and the research teams. ■

*Everett Hinkley is manager of the National Remote Sensing Program at the U.S.D.A. Forest Service – Washington Office. Vincent Ambrosia is senior research scientist/adjunct faculty member at California State University – Monterey Bay, co-located at NASA Ames Research Center. William M. Toscano is senior marketing manager in the Entrepreneurial Initiatives Division at Ames. Thomas Zajkowski is a remote sensing analyst at RedCastle Resources Inc., a U.S.D.A. Forest Service contractor.*

*For more on the Western States Fire Mission, visit <http://www.nasa.gov/centers/dryden/research/wsfm.html>, or contact Vincent Ambrosia at (650) 604-6565, [vincent.g.ambrosia@nasa.gov](mailto:vincent.g.ambrosia@nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

# Public-Private Partnership Yields New Technology For Weather and Emergency Response Operations



By Dave Jones  
 StormCenter Communications  
 Stephen Ambrose  
 NASA Applied Sciences Program

When Hurricane Ike approached the Texas Gulf Coast on September 12, 2008, the storm surge began inundating roads and homes more than 18 hours before landfall. The sky was clear and the sun was hot, but the water kept rising and people living on the Bolivar Peninsula at the

entrance to Galveston Bay wanted to know what was going on. Even residents of Galveston, Tex., just to the south, were amazed at the pounding waves that were already attacking the seawall with incredible force. Eerie thoughts of the 1900 Galveston Hurricane, which killed 6,000-8,000 people, came to mind as some residents decided to stick this one out. Ike was a large category 2 hurricane, but it was pushing a category 4 storm surge.

At 2:10 a.m. on September 13, Ike made landfall. One day later, the

Galveston County Department of Emergency Management issued an order for all people on Bolivar Peninsula to immediately vacate, since more than 90 percent of all structures had been destroyed. The peninsula suffered extreme and extensive damage, and it will take years for residents of the upper Texas Gulf Coast to recover.

In an effort to improve delivery of weather and emergency information to decision makers and citizens, NASA, Northrop Grumman Corporation and StormCenter Communications have



## Innovator's Corner

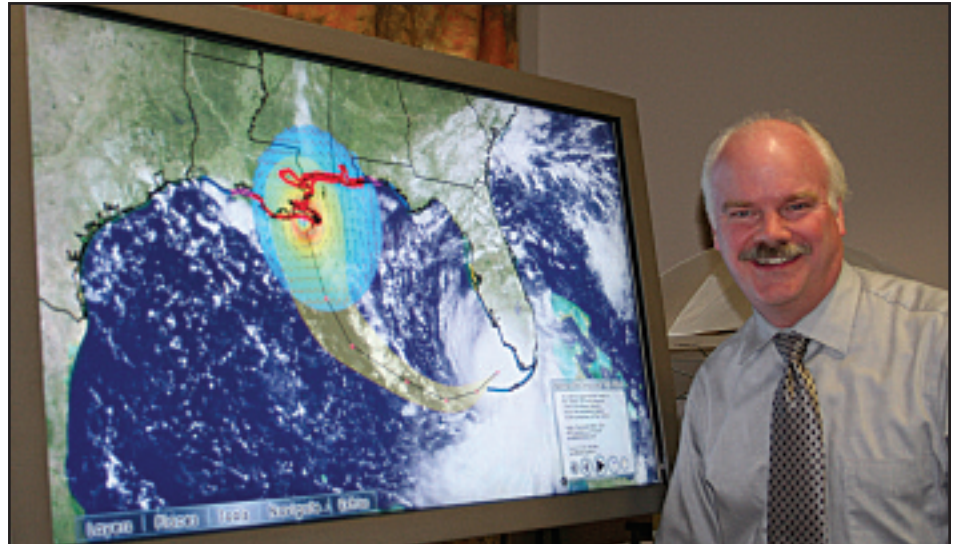
PHOTO CREDIT: STORMCENTER COMMUNICATIONS

united in the development of a technology that visualizes the potential impact to communities and helps federal officials communicate and collaborate in real time.

This important public/private partnership will expand and enhance data visualization and collaboration capabilities that were developed originally for military and intelligence applications. The result will be an enhanced decision-making process between the Federal Emergency Management Agency (FEMA) and NOAA's National Weather Service (NWS).

The technology is the Envirocast® Vision™ TouchTable, a collaborative tabletop system that is based on commercial off-the-shelf (COTS) hardware and software. It is being introduced into the civil sector as an innovative capability based on proven military and intelligence technology developed at the Northrop Grumman Futures Lab.

The Envirocast® Vision™ TouchTable will interoperate with and support open-consensus standards for both data input and export. It will also make use of spatial data and metadata information. For data retrieval it will be able to utilize the appropriate Web service as defined by Open Geospatial Consortium (OGC) best practices in order to access data sources that adhere to open-consensus standards. The system permits a significant increase in the amount and type of geoscience and



DAVE JONES OF STORMCENTER COMMUNICATIONS WITH THE ENVIROCAST® VISION™ TOUCHTABLE, WHICH VISUALIZES THE POTENTIAL IMPACT OF A STORM OR OTHER EMERGENCY AND HELPS OFFICIALS COMMUNICATE AND COLLABORATE IN REAL TIME.

GIS data available to forecasters and others for improved decision support, and for media and emergency management use for briefings to management, first responders and the public.

A grant from NASA enabled StormCenter to integrate the Envirocast® Vision™ Touchtable into the NWS Southern Region HQ and FEMA Region VI operations to test the system's utility. Just two days after installation, the NWS and the Department of Homeland Security's FEMA were collaborating and displaying NASA satellite data.

It is truly exciting to see FEMA connected directly with the NWS operations conducting active briefings through interactive discussions about a weather situation with real data in real time. Emergency managers can now, more than ever, draw upon the

strengths of the NWS to support preparation, response and recovery missions.

The Envirocast® Vision™ TouchTable also has the capability to be used in the NWS Advanced Weather Interactive Processing System II (AWIPS II). An enhancement to the current system, AWIPS II is the backbone of the NWS forecast and warning operations and is set to become a robust data visualization system allowing meteorologists, hydrologists and others to improve communication with constituents and the public for disaster management situations such as threatening weather, climate change, ocean- and solid-Earth-related events and extremes.

In a letter of support for the Envirocast® Vision™ Touchtable project, Bill Proenza, director of the



## GOVERNMENT AGENCY PARTNERSHIPS WITH NASA

NWS Southern Region, said, “This added ability to operationally see and convey NASA satellite data and modeling research within the Advanced Weather Information Processing System II (AWIPS II) and the NWS has the potential to not only contribute to more timely weather support services to our entire community, but also to make our warning services more effective in the protection of life. I am also hopeful this project will facilitate the transition of cutting-edge research and science into our operations by also allowing better utilization of new geophysical parameters and data sets that have not been available in an operational mode.”

The partnership among StormCenter Communications, Northrop Grumman, NASA, NWS and FEMA developed from a proposal that StormCenter Communications submitted through NASA’s Research Opportunities in Space and Earth Science (ROSES) decisions solicitation announcement. (More information on NASA’s ROSES and Applied Sciences Program is available at <http://nasa-science.nasa.gov/researchers/sara>.)

NASA’s Applied Sciences Program, which made the award, embarked on the effort to support partner agencies in data visualization and access to new technologies. The Applied Sciences Program was created at NASA to discover and demonstrate uses of NASA Earth science to help organizations make smart decisions. The program has already contributed to decision

PHOTO CREDIT: STORMCENTER COMMUNICATIONS



BILL PROENZA (LEFT) OF THE NATIONAL WEATHER SERVICE - SOUTHERN REGION, AND STEPHEN AMBROSE OF NASA MEET REGARDING THE COLLABORATIVE EFFORT IN WHICH BOTH AGENCIES ARE INVOLVED, THE ENVIROCAST® VISION™ TOUCHTABLE PROJECT.

making in compelling ways. Based on NASA Earth science research and technology achievements, the program developed advanced tools to track and manage wildfires. The tools provided key support to fighting the devastating wildfires in California in 2007-2008 (see related story in this issue).

The program also works with public health officials to reduce the impacts of malaria and other vector-borne infectious diseases on a global level, and it has enhanced integrated decision-support systems with developing countries and regions, such as Central America, to help them better manage their natural resources and respond to natural disasters.

StormCenter Communications is a global monitoring and communications company dedicated to “raising the environmental IQ of America™”

by working with government agencies, corporations and the media on new technology applications using remote sensing and other data inputs to enhance data access, communication and coordination of critical information for decision makers.

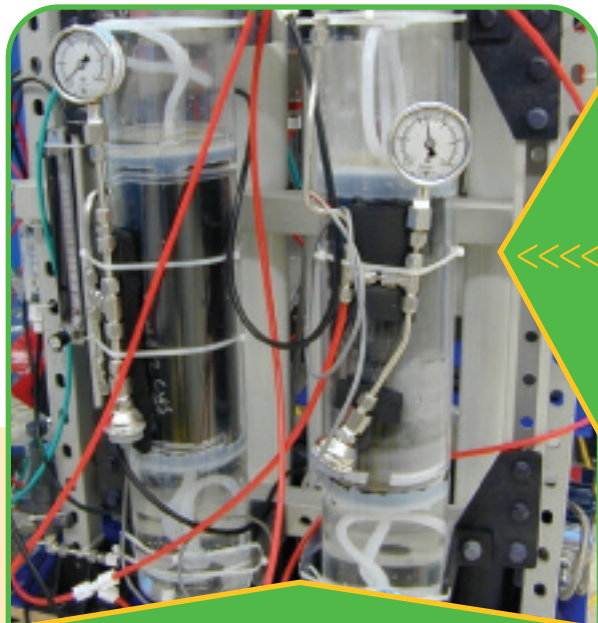
Northrop Grumman Aerospace Systems is delivering real value to the project by leveraging technology developed for use in military and intelligence applications. Brian Baldauf, the project co-investigator, says, “We are pleased to be able to identify civil applications from this proven military technology. By leveraging previously developed capabilities in a military and intelligence environment, costs are lowered significantly for other federal partners who want to implement it into their operations.” ■

*Dave Jones is the project principal investigator, as well as founder, president and chief executive officer of StormCenter Communications. Stephen Ambrose is the Disaster Management Program Manager in the Applied Sciences Program at NASA Headquarters.*

*For more information on the Envirocast® Vision™ TouchTable system, contact Jones at StormCenter Communications, (410) 203-1316 or [dave@stormcenter.com](mailto:dave@stormcenter.com). Contact Ambrose at (202) 358 0851 or [sambrose@nasa.gov](mailto:sambrose@nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

PHOTO CREDIT: NASA



SHOWN IS A PROTOTYPE OF THE OSMOTIC POWER GENERATION SYSTEM UNDER DEVELOPMENT AT AMES, WITH TWO ELEMENTS INSTALLED AND PLUMBED INTO A FULLY FUNCTIONAL WATER TREATMENT SYSTEM.

# REVOLUTIONIZING WASTEWATER TREATMENT: A SUSTAINABLE SYSTEMS ARCHITECTURE FOR EARTH AND SPACE

By Deborah E. Bazar  
NASA Ames Research Center

The Earth provides humans with the fundamentals required for our survival—air, food, water and tolerable temperatures. But to send humans safely to the moon and Mars, NASA engineers and scientists must develop systems and technologies that provide these essentials in the harsh environment of space. For long-duration missions, astronauts must bring with them everything they will need to survive, and the habitat systems must reuse as much as possible. These requirements call for innovative approaches to developing closed-habitat life support systems.

The Membrane Laboratory in the Bioengineering Branch at NASA Ames Research Center is developing groundbreaking designs in wastewater treat-

ment systems for human spaceflight missions. The laboratory starts with proven technologies and assembles them in new ways to create systems that maximize efficiency, reduce power consumption and minimize waste production. This systems architecture approach has led to revolutionary breakthroughs in ultra-efficient resource management.

## Pushing the Envelope in Systems Design

The Membrane Laboratory has developed an osmosis-based water reclamation treatment system for spacecraft and planetary habitats that incorporates different processes working in parallel and in series to treat various wastewater streams.

Here is some background on how it works: Osmosis is the movement of a solvent (usually water) through a semi-permeable membrane. On one side of the membrane is a solution with a low concentration of a solute (Side A), and on the other side is a solution with a high concentration (Side B). Based on

the principles of equilibrium and entropy, the solvent will flow through the membrane from Side A to Side B until both sides have equal concentration. When this happens, the level of the liquid on Side A is lower, since some of it has traveled through the membrane. The difference in height between the two sides is the result of force put on the system as osmotic pressure.

This naturally occurring phenomenon is known as forward osmosis (FO), and it generates power in the form of osmotic pressure. Traditional water treatment systems utilize reverse osmosis (RO), which is basically the opposite process—moving the solvent from the side of higher concentration through the membrane to the side with lower concentration. The membrane acts as a filter to catch the material that the treatment plant is trying to remove from the water (the solute). The output is clean water, but it requires the input of energy to overcome the osmotic pressure that naturally keeps the system in equilibrium. Additionally, the RO process is suscep-

tible to membrane clogging, since it uses significant pressure to push the solvent through, forcing the clumps of unwanted material into the membrane pores. This issue, plus the power requirement, are dealt with in water treatment systems here on Earth. But in space, where energy is precious and resources are limited, RO alone is not an ideal solution.

The Membrane Laboratory uses a novel system architecture called direct osmotic concentration (DOC) in the water reclamation treatment it developed for use in space. DOC includes a FO and RO subsystem for hygiene (gray) water, and a membrane distillation subsystem for the treatment of urine and humidity condensate. The products of these subsystems are then combined and treated by a catalytic oxidation subsystem.

In the FO/RO subsystem, FO forces hygiene water through a membrane to a tank of salty water. This process, unlike RO, generates energy and is resistant to fouling by high soap concentrations. The diluted salt water is then sent through a RO system, extracting water and reconcentrating the salty solution.

Meanwhile, the Direct Contact Membrane Distillation (DCMD) subsystem heats the urine and humidity condensate to form water vapor. The difference in vapor pressure across a hydrophobic membrane drives the water vapor across the membrane while rejecting everything except the volatiles carried in the vapor. The DCMD process removes non-volatile organics that normally pass through RO membranes. Finally, this treated water, and the treat-

ed water from the FO/RO subsystem, are passed through a catalytic oxidation system that removes any remaining organics, bacteria and viruses.

### Space Technology Benefits Us on Earth

With Small Business Innovative Research (SBIR) funding (<http://www.sbir.gov/>) from Ames, Osmotek Inc., of Corvallis, Ore., worked with the Membrane Laboratory to create a direct osmosis system for the International Space Station and a system for cleaning commercial landfill leachate (<http://www.sti.nasa.gov/tto/spin-off2000/er3.htm>).

The membrane technology that was developed as a result of this collaboration led an offshoot company, Hydration Technologies Inc. (<http://www.htiwater.com/>), to develop the membrane bag used in the Lightweight Contingency Urine Recovery System. This technology uses an activated carbon treatment followed by FO to create a sports drink for consumption. Urine is collected into a specially designed IV drip bag and put in contact with activated carbon. Then the urine is transported through a FO cell and drawn through the membrane by a high-sugar solution on the other side. This technology has been transferred back to NASA for astronaut crew use. Hydration Technologies Inc. has created other recovery systems to process saltwater or contaminated water so that it can be used safely for emergency situations and recreational activities such as hiking, camping and yachting.

### The Future

The Membrane Laboratory at Ames is exploring new ways to take advantage of osmotic power generation in water treatment systems. While conventional water treatment facilities use power-intensive RO systems, the Ames team is researching how to generate power by capturing the osmotic pressure difference between the dirty water, the output of water treatment facilities, and/or the salty or brackish water into which the output is discharged.

In this scenario, a pressure difference could be produced across a semi-permeable membrane by allowing FO water flux to occur through the membrane, but at a slowed flow rate. The passive resistance the membrane would apply to the water flux is then available as hydrostatic pressure (referred to as hydrostatic head in hydropower engineering terms). This hydrostatic head could be used to drive a conventional water turbine to generate mechanical power that is then transferred via the turbine shaft to an electrical generator for electrical power production, as is done in conventional hydropower.

Currently, this research is being supported by a partnership with Google. (See related article on this and other Ames/Google collaborations in this issue.) ■

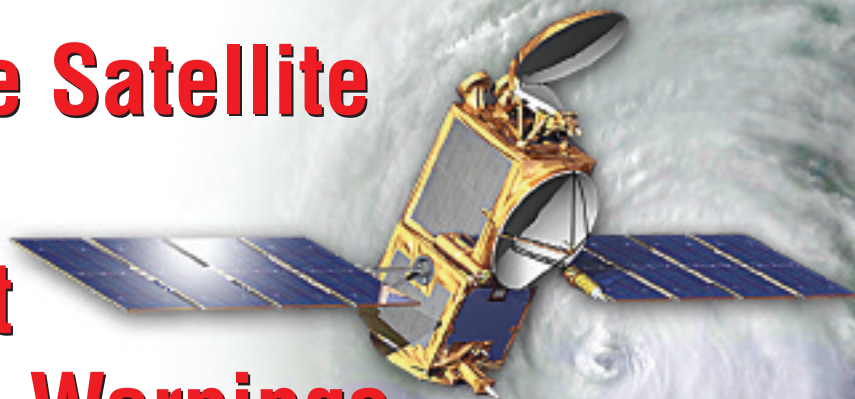
*Deborah E. Bazar is a technology partnership specialist at Ames Research Center.*

*For more information on the technology discussed here, contact William M. Toscano at (650) 604-0894, [William.M.Toscano@nasa.gov](mailto:William.M.Toscano@nasa.gov).*

*Please mention that you read about it in Technology Innovation.*



# Ocean Surface Satellite is a Boon for Extreme Event Forecasts and Warnings



By Kathryn Hansen  
NASA Goddard Space  
Flight Center

For humans in the path of destructive hurricanes and tsunamis, an accurate warning of the pending event is critical for damage control and survival. Such warnings, however, require a solid base of scientific observations, and a new satellite is ready for the job.

The Ocean Surface Topography Mission (OSTM)/Jason 2 (see artist's concept above) adds to the number of eyes in the sky measuring sea surface and wave heights across Earth's oceans.

The increased coverage will help researchers improve current models for practical use in predicting hurricane intensity, while providing valuable data that can be used to improve tsunami warning models.

"When it comes to predicting hurricane intensity, the curve in the last 40 years has been somewhat flat, with little advance in how to reduce error in predicted intensity," said Gustavo Goni of the National Oceanic and Atmospheric Administration (NOAA) in Miami.

Maps of sea surface height created from satellites, however, could help change the curve.

## Increasing Coverage for Better Results

Satellites that measure sea surface height have been running, operationally, nonstop since November 1992. But more than one is needed to fly at the same time in order to identify all the features that could be responsible for intensification of tropical cyclones all over Earth. The OSTM/Jason 2 mission will help make the additional coverage possible.

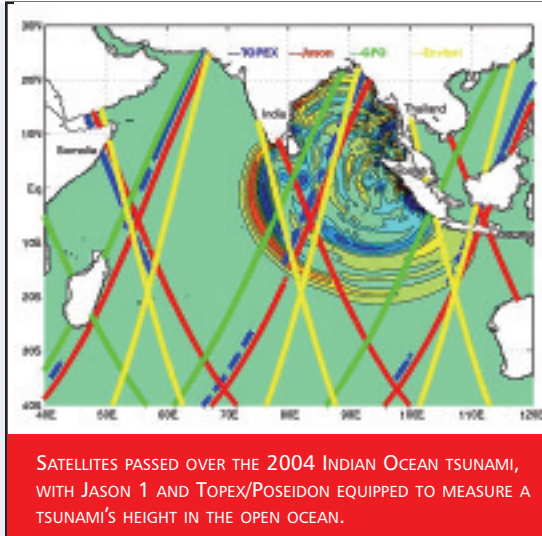
NASA, along with university and NOAA investigators, including Goni, work to transform sea surface height information obtained from satellites, such as OSTM/Jason 2, into maps of ocean heat content. Forecasters can use the maps as input to models that predict how hurricanes will strengthen.

Determining heat content from sea surface height is possible because warm water is less dense and hence sits higher than cooler water. In some regions, such

as inside and outside the Gulf Stream current, the temperature differences result in more than a one-meter (three-foot) difference in sea surface height. Goni and colleagues use this established concept to estimate from sea level variations how much heat is stored in the upper ocean in areas where hurricanes typically develop and intensify.

While sea surface height may not necessarily be the most significant parameter for hurricane intensity forecasts, researchers now know that if sea surface height is accounted for in current forecast models, errors in forecasts for the most intense storms are reduced. For weak storms, the reduction in error is not very significant. However, for storms in the strongest category 5 range, the heat content in the upper ocean derived from sea surface height becomes increasingly important. "This is a good thing,

GRAPHIC CREDIT: NASA



because these are the storms that produce the most damage," Goni said. "OSTM/Jason 2 will help us keep the necessary coverage that we need to identify ocean features that can be linked to tropical cyclone intensification, because with only one satellite we may miss some of them."

Upper ocean heat content derived from sea surface height is now used in operational and experimental forecast models in all seven ocean basins where tropical cyclones exist.

In December 2004, two satellites happened to be in the right place at the right time, capturing the first space-based look at a major tsunami in the open ocean. Within two hours of a magnitude 9 earthquake in the Indian Ocean southwest of Sumatra, the Jason 1 and Topex/Poseidon satellites fortuitously passed over the path of the resulting tsunami as it traveled across the ocean. It measured the leading wave, traveling hundreds of miles per hour in the open ocean, at about 0.5 meters (1.6 feet) tall.

## A New System on the Way

Wave height measurements like those of the Indian Ocean tsunami do not provide an early warning because the information is not relayed to ground stations in real time. That job is done by early warning systems operated by NOAA and other global organizations that currently employ a network of open-ocean buoys and coastal tide gauges. Sea surface height measurements of tsunami can, however, help scientists test and improve ground-based models used for early warning,

One such system developed at NASA's Jet Propulsion Laboratory (JPL), Pasadena, Calif., and undergoing tests at NOAA's Pacific Tsunami Warning Center, Ewa Beach, Hawaii, could become operational within three years.

Most tsunamis are caused by under-sea earthquakes. Using the JPL-developed system, when seismometers first identify and locate a large earthquake, scientists can use Global Positioning Satellite, or GPS, measurements to search around the earthquake's source to see if land has shifted, potentially spurring a tsunami. Scientists can then immediately compile the earthquake's size, location and land movement into a computer program that generates a model tsunami to determine the risk of a dangerous wave. After the wave passes, scientists can search through wave height data from satellites and verify what the model predicted.

"Satellite data play the crucial role of verifying tsunami models by testing real tsunami events," said JPL research scientist Tony Song. "If an earthquake generates a tsunami, does the satellite

data match observations on the ground and model predictions?"

"One of the unique pieces of satellite observations is the large-scale perspective it has," said JPL research scientist Philip Callahan. Tsunamis can have waves more than 161 kilometers (100 miles) long. Such a wave would likely go unnoticed by an observer in a boat on the ocean's surface. But satellite altimeters like OSTM/Jason 2 can see this very long wave and measure its height to an accuracy of about 2.5 centimeters (one inch).

Scientists' ability to test tsunami warning models will be aided by OSTM/Jason 2. With the Topex/Poseidon mission now ended, the currently orbiting Jason 1 has been joined by and will eventually be replaced by OSTM/Jason 2. This will help ensure that future tsunamis will also be observed by satellites as well as by buoys and coastal tide gauges.

"The biggest value in satellite measurements of sea surface height is not in direct warning capability, but in improving models so when an earthquake is detected, you can make reliable predictions and reduce damage to property and people," Callahan said. ■

*Kathryn Hansen is a science writer at Goddard Space Flight Center.*

*For more information on OSTM/Jason 2, visit [www.nasa.gov/ostm](http://www.nasa.gov/ostm).*

*For more information on JPL's climate change research programs, visit: <http://climate.jpl.nasa.gov>.*

*Please mention that you read about it in Technology Innovation.*



Glenn  
Research  
Center  
Launches

# GREEN

## TECHNOLOGY INITIATIVE



By Valerie J. Lyons  
NASA Glenn Research Center

Building on its long-time expertise in power and propulsion and its 30-year history of successful partnerships in developing alternative-power systems, NASA Glenn Research Center (GRC) has launched a green initiative that addresses NASA's technology needs, yet reduces stress on the environment.

NASA's Innovative Partnership Program (IPP), centered at NASA Headquarters and represented at all NASA Field Centers, has joined this effort through two programs within its

Technology Infusion element – the IPP Seed Fund and the Small Business Innovation Research (SBIR) Program.

This article provides an overview of GRC's past accomplishments and current efforts in this critical area. It also is an invitation to readers who may be conducting related work and would like to discuss potential collaboration.

### Green Energy at GRC

GRC has a legacy of well-known, world-class achievements in power and propulsion solutions for NASA. Part

of this legacy includes GRC's collection of work with the Environmental Protection Agency, the Energy Research and Development Agency and the Department of Energy, as well as GRC's collaborations and co-development work with companies with energy technologies in areas such as photovoltaics, fuel cells and batteries.

### Photovoltaics and Solar Energy

Using solar arrays to generate renewable electricity has long been a GRC showcase technology. NASA GRC



personnel designed, fabricated and installed 58 photovoltaic (PV) systems in 28 developing countries between 1975 and 1985, demonstrating space solar power technology for terrestrial use. In 1978, NASA PV technology made possible the world's first solar-powered village — the Village of the Papago Tribe in Schuchuli, Ariz.

Currently, GRC is working on PV technology in support of NASA's Exploration Program. GRC also is in the process of tying PV arrays into the local power grid to generate electricity as part of the Center's facility-wide green efforts. In addition, Glenn is pioneering the use of coupled solar energy and advanced ground source heat pump technology in five buildings to reduce energy use and emissions as part of the center's master plan. (See "greening" efforts at other NASA Field Centers in the Facility Focus section of this issue.)

### Fuel Cells/Batteries

GRC is developing advanced lithium-ion batteries, fuel cells and regenerative fuel cells for NASA's future exploration missions. A regenerative fuel cell system will enable a solar power system to store energy for night-time use, and advanced batteries will power mobile systems such as extravehicular activity (EVA) suits and rovers. In addition, fuel cell and advanced battery systems will power the lunar lander's descent and ascent stages respectively.

Glenn is also proposing to work with the Great Lakes Science Center, Cleveland State University, Case

Western Reserve University, Parker-Hannifin and other partners to construct a hydrogen fueling station at the Science Center. The station will generate hydrogen by splitting water, using an electrolyser to be powered renewably from wind turbines and solar arrays. The hydrogen will be used to fuel a fuel-cell-powered bus on loan from United Technologies, among other applications. (See News Briefs in this issue for more on fuel-cell applications at GRC.)

### NASA Green Forums

GRC showcased its "green thumb" in 2008 during the Global Research into Energy and Environment at NASA (GREEN) Forum held at NASA Ames Research Center (see story pg. 42).

ARC established the GREEN seminars to increase awareness of environmental issues for Ames employees and their industry and academic colleagues. GRC held a similar series in 2008, with the following topics and speakers: Algae and Biofuels by Jonathan Trent, NASA Ames Research Center; The Role of CO<sub>2</sub> in Future Power Systems by Prof. Ashwani Gupta, University of Maryland; the new Ohio Energy Policy by Kimberly Gibson, State of Ohio Dept. of Development; the future plans of GRC's local energy company, FirstEnergy Generation, by Gary Leidich, FirstEnergy executive vice president and president; NASA's Role in the Energy Challenge by Prof. Marty Hoffert, New York University; Building an Advanced Energy Industry

in Northern Ohio by Richard T. Stuebi, BP Fellow for Energy and Environmental Advancement, the Cleveland Foundation; and four full days of classes on a wide range of GRC renewable energy technologies by professors Ali Shakouri and Glenn Alers of the University of California, Santa Cruz.

### IPP Support of Green Energy at GRC

NASA's Innovative Partnerships Program is working with the Agency's missions and external partners in a variety of ways to support the GRC green initiative. Current projects range from using alternative fuels in aviation, to converting energy from the sun, to developing safer nuclear power systems.

### GRC Alternative Fuels Research: The IPP Seed Fund at Work

GRC leads NASA's research efforts to convert some of the nation's natural energy sources — coal, natural gas, biomass and shale oil — into cleaner and more accessible alternatives to traditional conventional jet fuel. In this era of shrinking petroleum resources and growing air travel, this work is critical for economic, environmental and safety reasons.

GRC's work in support of the NASA Subsonic Fixed Wing project was recently supplemented through a partnership with the Air Force Research Laboratory and Pratt & Whitney Aircraft to conduct tests using Fischer-Tropsch (F-T) fuels provided under an IPP seed fund

PHOTO CREDIT: NASA



NASA GLENN RESEARCH CENTER IS WORKING WITH PARTNERS IN CLEVELAND, OHIO, TO CONSTRUCT A HYDROGEN FUELING STATION AT THE GREAT LAKES SCIENCE CENTER. THE STATION WILL GENERATE HYDROGEN THAT WILL BE USED BY A FUEL CELL POWERED BUS, AMONG OTHER APPLICATIONS. CONCEPTUALIZATIONS OF THE STATION AND BUS ARE SHOWN ABOVE.

project. F-T fuels were first developed in the 1920s and convert carbon monoxide and hydrogen to liquid fuel. This provides the potential for America's abundant coal reserves to be converted to gasoline, diesel fuel and jet fuel. F-T fuels produce no sulphur, the primary component of acid rain, and reduced amounts of aromatics. The tests at GRC have also demonstrated that F-T fuels significantly reduce gaseous and particulate matter emissions measurements, and that blended F-T fuels/jet fuels can run in advanced high-pressure ratio engines with no combustor or fuel compatibility issues.

GRC currently has partnerships with Air Force Research Laboratory, Boeing and Pratt & Whitney to further explore the use of not only F-T fuels, but of biomass fuels in aircraft engines. The results of these tests are expected to have impacts on producing cleaner fuels for ground transportation as well.

GRC operates an Alternative Fuel Research Laboratory, funded under the Fundamental Aeronautics Research Program, within the center's recently remodeled Heated Tube Facility to conduct alternative fuels utilizing the F-T process.

### **Stirling Convertors: From SBIR to Space, with a Stop on Earth**

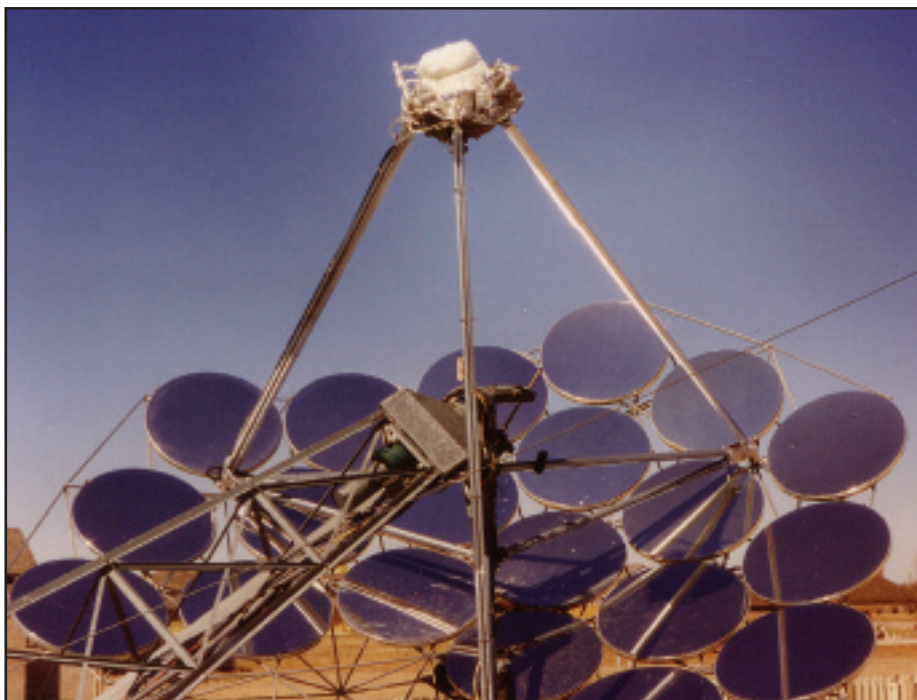
At GRC, 30 years of Stirling energy conversion expertise dating back to the energy crisis of the 1970s is now being applied to a 5-MW Stirling utility



project in southern California. The system utilizes a field of solar concentrators, each one heating a working fluid to drive a Stirling engine. The piston motion is converted to electricity, providing renewable power from the sun.

NASA is currently developing the free-piston Stirling convertors to be used with nuclear fuel to generate electricity for deep-space missions. Critical factors under consideration for any deep-space mission are the power system's affordability, reliability and safety, and the Stirling technology being developed at GRC is just the system to address these factors. The Advanced Stirling Convertor (ASC) now being integrated into the Advanced Stirling Radioisotope Generator (ASRG) is an outgrowth of an award through GRC's SBIR Program as well as other research contracts that GRC has managed with Sunpower Inc. GRC is providing supporting technology to Sunpower in the development of the ASC and in the integration of the convertor into the generator.

Under the SBIR Program, a smaller version of the convertor was developed. Some of the advancements achieved through this work include an efficiency greater than 28 percent, which reduces the radioisotope inventory by a factor of four or greater as compared with conventional Radioisotope Thermoelectric Generators (RTG). A second achievement is a two-fold increase in specific power as compared with the RTG's



NASA GLENN RESEARCH CENTER IS AN ADVISOR FOR THIS 5 MW STIRLING UTILITY PROJECT IN SOUTHERN CALIFORNIA, WHICH INCLUDES A SOLAR CELL CONCENTRATOR THAT HEATS CONTAINED HYDROGEN TO DRIVE PISTONS, PROVIDING UTILITY POWER.

power, to levels greater than 7 We/kg.

Lockheed Martin is developing the ASRG under contract for the Department of Defense, with Sunpower producing the ASC for GRC under a NASA Research Announcement (NRA) award. The Stirling convertor demonstrated an improvement in specific power by a factor of six as compared with previous convertors for radioisotope power systems. In addition, it was physically about half the size, and it used gas bearings for non-contacting operation to enable long life. The ASRG engineering unit recently completed system integration and testing at Lockheed Martin, and GRC will conduct further testing.

This work is intended to demon-

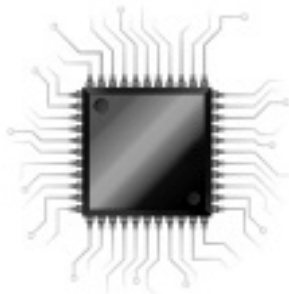
strate the technology readiness level, so it is an option when NASA selects the power source for a Mars surface or deep-space mission. The radioisotope power systems are currently being considered for potential use on the future Discovery and Scout missions in the 2014 timeframe. ■

*Valerie Lyons is chief of the Power and In-Space Propulsion Division at NASA Glenn Research Center.*

*For more information on these and other green technologies, as well as information on the variety of ways you can partner with GRC, please visit <http://www.grc.nasa.gov> or email [TTP@grc.nasa.gov](mailto:TTP@grc.nasa.gov).*

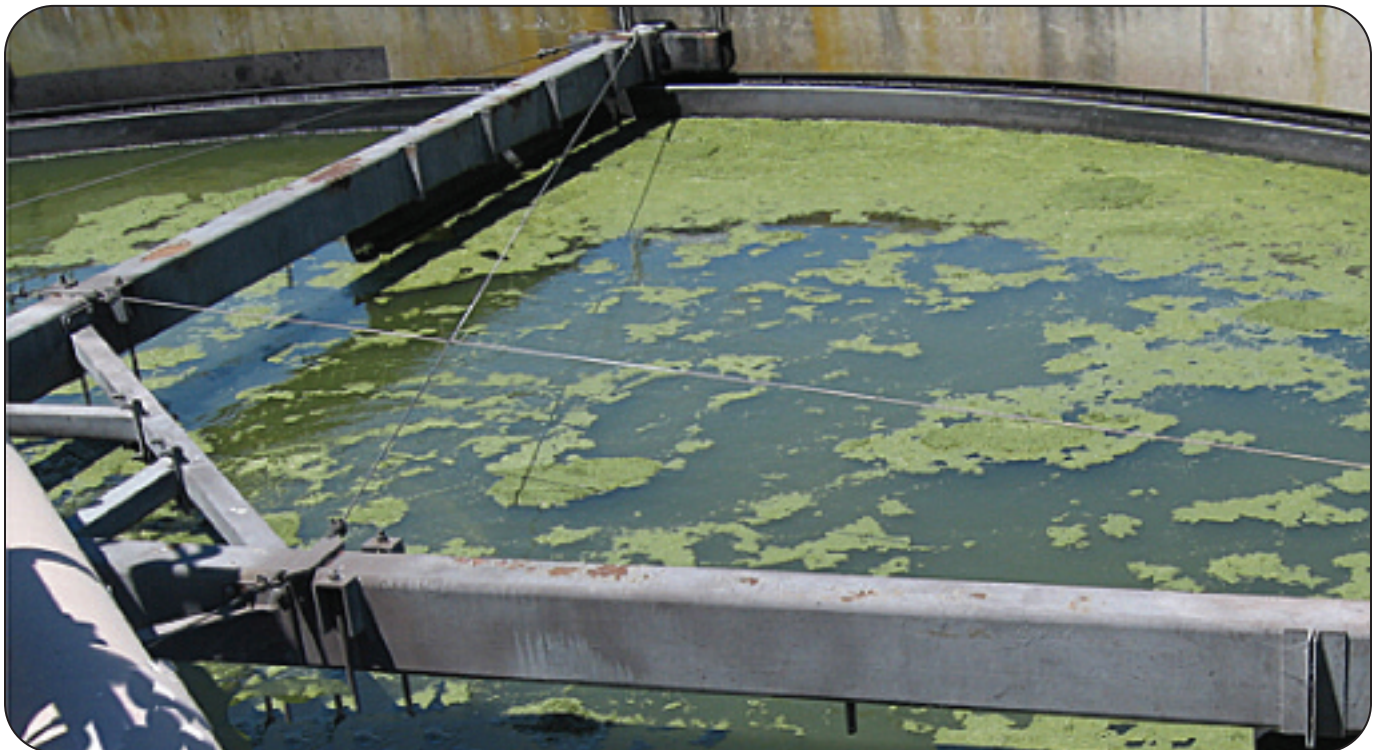
*Please mention that you read about it in Technology Innovation.*





## NASA and Google Seek New Energy Sources in GREEN

PHOTO CREDIT: NASA



By William M. Toscano  
NASA Ames Research Center

In 2007, NASA Ames Research Center collaborated with Google on an initiative entitled Global Research into Energy and the Environment at NASA (GREEN) to explore how the extraordinary combination of information scientists, computer engineers, Earth and atmospheric scientists, astrobiologists, ecologists,

nanotechnologists, modelers, robotics and sensor engineers, fluid dynamicists and life support systems engineers at NASA Ames might have the potential to make a significant contribution to the vital transition from petroleum-based energy to sustainable, carbon-neutral energy sources.

As part of this initiative, Ames and Google hosted five technical seminars on topics including future transportation, clean energy and global change,

featuring such notable speakers as William McDonough, a designer and architect known for creating environmentally sustainable buildings; R. Jim Woolsey, former CIA chief and proponent of ending U.S. dependence on oil; and Martin Hoffert, New York University physics professor with research interests in global environmental change and alternate energy technology. Additionally, theme teams were formed consisting of scientists

and engineers with similar interests and expertise in the areas of solar energy, wind energy, transportation and carbon sequestration.

Based on the significant NASA interest and identified capabilities, NASA and Google agreed to continue the GREEN collaboration in 2008 by conducting three pilot projects in the areas of clean energy and global prediction/monitoring. Each of these pilot projects takes advantage of Ames' strengths in science, technology development, facilities and capabilities, as well as Google's global coverage, information management and renewable energy expertise.

The first project, Clean Energy – Biofuels for Sustainable Space Exploration, is developing methods of tenable biofuels production by improving the transformation of cellulose biomass into useable fuels. Cellulose is the most abundant polymer on Earth and is made by plants. By breaking down cellulose into its constitutive sugars, it can be made into ethanol for fuel.

The Cellulose Research Team is improving enzyme activity by arranging them on a scaffold, which allows the enzymes to work synergistically—a process that is known to occur in nature. The Algae Team is taking a systems approach to analyzing existing algae cultivation methods as they apply to non-arable land and is developing

new systems for these locations. This project element supports a postdoctoral fellow in providing critical chemical engineering capability to help both teams take the final critical steps in transforming biomass into useable fuels.

The second project, Clean Energy – From Water Purification to Water Power, Efficient and Effective, is evaluating the overall feasibility of transforming a NASA water treatment system into a power generation system. The Water Purification and Power Team is developing a forward osmosis power generating test system in which critical parameters for membrane/power production potential can be measured and monitored. NASA has invested in the development of advanced membranes and membrane treatment methods for the treatment of spacecraft wastewater, identifying a technique that can generate energy from the mixing of waters of differing salinity or osmotic potential. (See related feature article in this issue.)

The third project, Global Prediction and Monitoring – Remote Sensing Imaging of Urban Areas for Public Awareness, is bringing NASA-unique remote sensing data and analysis, focused on issues of regional and global climate change, to the public through a common architecture, such as Google Earth. Research goals for this project are focused on the utilization and

development of novel sensing technologies and models that are accurate enough to be used to study basic issues affecting local, regional and/or global elements of climate change. The Remote Sensing Team is collaborating with Google, industry, academia and/or local, state and regional governments to leverage NASA Ames airborne sciences missions to acquire remote sensing images and in situ measurements for analysis of regional climate impact.

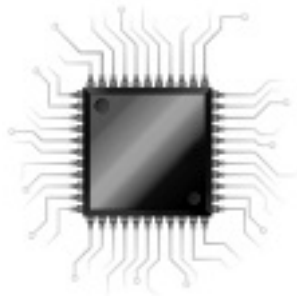
Also, as a result of the success of the GREEN Initiative, NASA Ames management created the Greenspace Initiative (<http://green.arc.nasa.gov>). Greenspace is committed to the establishment of Ames Research Center, located in Moffett Field, Calif., as a leader for green and clean technologies in Silicon Valley. This initiative aligns Ames' green research and institutional activities with NASA missions and green activities at other NASA Centers by providing strategy, integration and implementation support for a diverse portfolio of alternative energy and environmental projects. ■

*William M. Toscano is in the Entrepreneurial Initiatives Division at NASA Ames Research Center*

*For more information, contact him at (650) 604-0894, [William.M.Toscano@nasa.gov](mailto:William.M.Toscano@nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

PHOTO (OPPOSITE PAGE): ALGAE FEEDSTOCK GROW IN A TREATMENT FACILITY AS PART OF A CLEAN ENERGY PROJECT AT NASA AMES RESEARCH CENTER.



## Northrop Grumman Partners with NASA on Software Integration and Visualization

By Glenn J. Higgins  
Northrop Grumman Corporation

Northrop Grumman is proud to have been NASA's partner on a number of significant programs, including Aqua, Aura, James Web Telescope, Joint Base Operations and Support Contract (J-BOSC) and the National Polar-orbiting Operational Environmental Satellite System (NPOESS). Recently, Northrop Grumman entered a Space Act Agreement with NASA to jointly develop advanced civil radar system architectures that can be leveraged into new space-based remote sensing instruments. These large, complicated programs are indicative of the diverse expertise that a company like Northrop Grumman can leverage to support major missions. This article focuses upon a relatively smaller program with NASA Goddard's Software Integration and Visualization Office (SIVO) within the Science Mission Directorate. Despite the smaller size of this program, it demonstrates the partnership that can exist between NASA and one of its larger contractors, to the benefit of both.

### History of Collaboration

Northrop Grumman's SIVO IT Services contract with NASA Goddard began in 2005 to support the newly formed SIVO organization. Under the contract, Northrop Grumman provides applications support to users of NASA's High Performance Computing (HPC) systems. The support includes everything from code performance optimization to exploring new technologies to benefit SIVO customers. Although the dominant application types are climate models, they also include space environmental and other Earth system models. Going back to 1999, Northrop Grumman has been a contractor with NASA in the development of the Earth System Modeling Framework (ESMF) and we continue to support its development and use under the SIVO IT Services contract. Another project is developing a workflow tool to provide a seamless Graphical User Interface (GUI) to aid scientists running their models and visualizing output.

Over the past several years, Northrop Grumman has invested internal funds to conduct research and

provide capital investments, specifically aimed at allowing us to provide hands-on experience and thought leadership in areas important to our customers. Those areas include High Performance Computing (HPC) and High Performance Networking (HPN). We believe integrating HPC and HPN is critical to many of our customers, who are challenged with assimilating ever-increasing volumes of data to meet time-sensitive, mission-critical needs. The data volumes and timelines often dictate HPN to move data and HPC to process it. These technologies have been leveraged over the past few years to conduct collaborative research with NASA Goddard.

At our Business Integration Competency Center (BICC) laboratory in McLean, Va., we have established a 512 processor Linux Cluster on which we demonstrate the utility of HPC to our customers. We have also demonstrated customer applications on hybrid technologies such as Field Programmable Gate Arrays (FPGAs) and General Purpose computing on Graphics Processing Units (GPGPUs) and have similarly supported SIVO in



## INDUSTRY PARTNERSHIPS WITH NASA

investigating the IBM cell processor. In the HPN area, we have developed software to dynamically control optical networks so that we can set up and break down circuits to effectively enable 10Gbs, point-to-point communication of data. This capability is integrated into the back end of our McLean cluster and has been used successfully over the Dynamic Resource Allocation via GMPLS Optical

Composition, Cloud and Climate Coupling (TC4) mission. Since that time, the cluster has been upgraded to 512 Intel Xeon processors and has been renamed "Argo." Again, Northrop Grumman gained more experience with new technology and NASA was able to better support its mission.

Similar examples over the past few years include collaboration on

time changes to the weather/climate forecasting system. Performance is measured by comparing forecasts of the system with and without the change. Northrop Grumman will provide computational resources and leverage existing corporate simulation tools to provide synthetic data for proposed new sensors.

The Climate Modeling Downscaling project will conduct research in taking the low-resolution global forecasts and providing higher-resolution regional forecasts from which regional decision aids can be derived. Northrop Grumman will provide computational resources and will leverage its Numerical Weather Prediction expertise to support the research.

Finally, the willingness to collaborate and push technology must be worked hard on both the government and contractor sides in order to flourish. These projects have been successful due partly to the SIVO government staff's dedication to fruitful joint initiatives. ■

### Northrop Grumman gained more experience with new technology and NASA was able to better support its mission

Network (DRAGON) operated by the Mid-Atlantic Crossroads (MAX) as well as the Internet 2 network.

In spring 2006, prior to the establishment of our cluster, we set upon an ambitious plan with SIVO to provide operational support to the NASA African Monsoon Multidisciplinary Analysis (NAMMA) mission for later that summer, running GEOS-5 and WRF on the planned cluster. We transferred data to and from NASA over the DRAGON network using our optical networking technology. This successful collaboration benefited both Northrop Grumman and NASA: Northrop Grumman was able to demonstrate our integrated solution on a real problem; and NASA was able to support its mission with timely weather forecast products.

A similar collaboration occurred in 2007 supporting the Tropical

LambdaRAM, a technology for caching data over high-speed networks and workflow automation software. In each case the combined HPC and HPN networks served as testbeds for NASA to explore new technologies, prior to rolling them out to NASA users.

#### A Look to the Future

We now are embarking on a more challenging collaboration, which should eventually evolve into a Space Act Agreement with NASA. Northrop Grumman has agreed to provide joint research on two projects that will provide critical technologies to optimize resources that address climate change issues: the Sensor Web Simulator (SWS) project and the Climate Modeling Downscaling project.

The SWS is designed to quantify the impact on performance of prospec-

*Glenn J. Higgins is manager of the Atmospheric Sciences and Engineering Department, Northrop Grumman Information Technology, Intelligence Group.*

*For more information, contact him at [Glenn.Higgins@ngc.com](mailto:Glenn.Higgins@ngc.com). Visit the company's Web site, [www.northrop-grumman.com](http://www.northrop-grumman.com); and the High Performance Computing and Communications Web site, <http://www.it.northropgrumman.com/offer/technologies/scs.html>.*

*Please mention that you read about it in Technology Innovation.*

# Innovative Research

## NVision Adapts HazNet Emergency Management System for NASA Projects

By Kevin Schultz  
NVision Solutions Inc.

**R**ecent natural and man-induced disasters have given the emergency management arena opportunities for developing valuable lessons learned.

Hurricane Katrina devastated the Gulf Coast in 2005, demanding immediate responses from emergency relief organizations. Government agencies and non-government organizations worked frantically to aggregate the best available geospatial data as a baseline for mapping and tracking the devastation, supplies, relief, search and rescue, debris removal, reconstruction and other response and recovery efforts.

Both during and after the storm, data providers quickly generated new geospatial data, digital imagery, feature datasets and location-based content. Operating independently, these organizations often struggled to effectively communicate, collaborate and share data. Problems such as licensing, data ownership restrictions and a non-existent centralized data repository complicated efforts to work together. Moreover, tools did not exist for exploiting geospatial data from various stakeholders.

To alleviate some of these problems, NVision worked with NASA, the Department of Homeland Security (DHS), the Federal Emergency Management Agency (FEMA), Boeing and NAVTEQ to develop the Web-based, Geographic Information System (GIS)-centric “All Hazards Network” (HazNet) application.

HazNet provides a coherent, real-time, Common Operating Picture (COP) for public safety, homeland security,

counter-terrorism, anti-force protection, emergency management and disaster planning, response and recovery. HazNet incorporates the DHS strategy-oriented National Incident Management System (NIMS), the procedure-oriented Incident Command System (ICS) and the standardized government formats, nomenclature and icons.

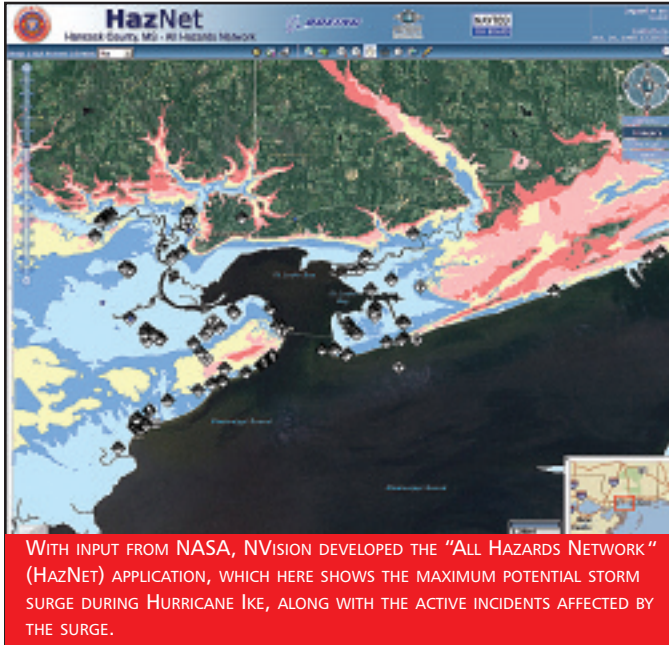
Based on its interoperable design, HazNet communicates with existing systems and tools, networks with remote incident reporting devices (i.e., portable field units) and integrates the relevant information for innovative crisis situational awareness and collaborative decision-making. HazNet leverages ESRI ArcEngine and Leica Geosystems ERDAS TITAN geospatial technology to host, serve, share and manage the data. By employing these technologies, NVision provides a secure, permission-based, real-time data sharing, access and distribution solution while simultaneously protecting licensing and ownership rights.

The Real-time Emergency Action Coordination Tool (REACT) forms the core of HazNet, which connects multiple REACT systems together into an overarching network. REACT is NVision’s original low-cost and easy-to-use first responder decision support system built with geospatial technology to provide scalability and vertical integration. The portable field units use the latest smart-phone technology equipped with GPS, digital camera, voice recorder and real-time wireless connectivity. The HazNet application only requires Internet access, a HazNet user account and access permissions set.

Emergency management officials in Hancock County, Miss., and St. Tammany Parish, La., use the current HazNet version, whereas Jefferson Parish, La., employs an older customized version of REACT. NVision and Hancock County Emergency Operations Center (EOC) staff deployed HazNet during Hurricane Ike. Staff generated mapbooks, modeled the potential impact, collected real-time incidents using portable field units, assessed damaged areas and created detailed damage reports.

## EXAMPLES OF HOW NASA IS WORKING WITH SMALL BUSINESSES AND ACADEMIA

PHOTO CREDIT: NVISION SOLUTIONS INC.



### NASA Upgrades, Enhancements and Customization

Through a NASA Small Business Innovation Research (SBIR) Phase 3 contract, NVision is upgrading, enhancing and customizing the HazNet EMS for use at NASA's Stennis Space Center (SSC), Michoud Assembly Facility and Headquarters.

One enhanced capability involves integrating an intuitive large-format multi-user interactive touch-table display device ([www.intuiface.com](http://www.intuiface.com)) to aid NASA in visualizing and managing hazardous situations, enabling collaborative problem-solving and decision-making and conducting preparedness exercises. For the first time, the customized HazNet system will provide the NASA EOC staff with a seamless system for accessing information from the following sources:

- SSC's institutional GIS
- Recent studies on hurricane flood and wind effects for SSC, Michoud and surrounding areas
- NASA's soon-to-be-installed automated mass notification system

- NASA's CCTV cameras that monitor hazardous areas
- SSC's upgraded weather station array

NVision is providing some additional enhancements and customization of HazNet. These capabilities and features include the following:

- Incorporating 3D building displays
- Adding known or measured flood inundation data
- Working with NOAA to develop a Web-based ALOHA (Areal Locations of Hazardous Atmospheres) program for air dispersion modeling
- Incorporating existing NASA management software modules for establishing security and safety zones required in emergency situations
- Deploying within NASA network security and Web standards
- Integrating emergency vehicle and asset tracking
- Including a shelter management system
- Providing other emergency management capabilities

This SBIR Phase 3 contract will provide a significant upgrade to the currently available NASA EOC technology. Moreover, NASA awarded Geospatial Research Innovation an SBIR Phase 3 contract for upgrading the SSC weather station array and providing the capability to extract data from NOAA coastal tide stations and from the National Weather Service for integrating into HazNet.

### Tips for Partnering with NASA

For businesses that are or will be working with NASA on similar partnerships, the following tips may be of assistance:

- Find partners outside of NASA who can either help pilot the technology or provide partial or full matching funds for the project. In addition to NASA, NVision received support from federal and local government (e.g., USDA; USGS; St. Tammany Parish, La.; and Hancock County, Miss.), the private sector (e.g.,



PHOTO CREDIT: NVISION SOLUTIONS INC.



DISPLAYED ARE THE HANCOCK COUNTY, MISS., HAZNET APPLICATION, BASEMAP DATA LAYERS, ACTIVE INCIDENTS FROM HURRICANE IKE, AND DETAILS OF TWO ACTIVE INCIDENTS. NVISION WORKED WITH NASA AND OTHER PARTNERS TO DEVELOP HAZNET FOR PUBLIC SAFETY, EMERGENCY MANAGEMENT AND OTHER APPLICATIONS.

Boeing), academia (e.g., University of Mississippi) and others to "snowball" the project into something bigger and directly relevant to the general public.

- Secure support letters from subject-matter experts whom you have briefed or to whom you have demonstrated the project. They can be of great help in making the project as widely relevant as possible.
- Justify the project's value in terms of commercial use, benefits to society and benefits to NASA. Use keywords and address critical and/or emerging issues, needs and initiatives.
- Build a public relations machine around the project with these activities: Construct creative press releases to highlight your project. Ask your local newspaper and TV news station to do a feature story. Inform your state and national representatives about the project. Give presentations and demonstrations at conferences. Submit the project for industry and government awards.

Below are links to the IntuiLab's IntuiFace multitouch

interactive surface and application platform, which NVision will integrate with HazNet:

- Virtual Earth Demo: <http://www.youtube.com/watch?v=4R7yO-6S-u0>
- Multitouch Show Off: <http://www.youtube.com/watch?v=8pwo0o5150s>
- More videos: [http://www.intuiface.com/index.php?option=com\\_content&task=view&id=16&Itemid=30](http://www.intuiface.com/index.php?option=com_content&task=view&id=16&Itemid=30) ■

*Kevin Schultz is lead proposal writer for NVision Solutions Inc.*

*For more information, please contact the author at [kschultz@nvisionsolutions.com](mailto:kschultz@nvisionsolutions.com).*

*To view a video demonstrating HazNet, please visit: <http://www.jumpcut.com/fullscreen?id=DA594AB6204E11DD8AEF000423CF4092&type=movie>.*

*Please mention that you read about it in Technology Innovation.*

# Opportunities for Partnership

Technologies are available for licensing and joint development at each of the NASA Field Centers through their Innovative Partnerships Program (IPP) offices. Here are details on several available technologies. For a comprehensive list, go to <http://ipp.nasa.gov>

## Fire-resistant, Lightweight Electrical Insulation Material

NASA's Langley Research Center has developed a new class of polyimide composite electrical insulation materials for wires, cable and bus pipe. These materials have been shown to withstand a 12-hour gas flame test while maintaining structural and electrical circuit integrities. They show promise for use in high-voltage, high-power systems and can improve survivability and continuity of the electrical power supply. Besides fire resistance, these materials also provide weight and space savings because of their lightweight nature and exceptionally high performance capability.

NASA developed the wire insulation for exploration and space operations. The technology also has applicability to other high-voltage, high-power systems for the Navy, high-rise building construction and other industries.

### Technology Details

The technology combines the superb heat resistance and dielectric properties of the RP46 polyimide, reinforced with glass or quartz fibers or fabric. RP46, developed at NASA, exhibits high mechanical strength and structural durability at elevated temperatures. It



PHOTO CREDIT: NASA

A MOTORCYCLE MUFFLER PROTOTYPE MADE FROM RP46, WHICH EXHIBITS HIGH MECHANICAL STRENGTH AND STRUCTURAL DURABILITY AT ELEVATED TEMPERATURES.

also features significantly less moisture absorption and is therefore less susceptible to moisture-induced damage. RP46 demonstrates excellent thermal oxidative stability and chemical corrosion resistance. The advantage of using glass or quartz fiber reinforcement is their ability to maintain physical integrity over a wide range of temperature, humidity, voltage and frequency.

A copper or aluminum bus pipe insulated with the material withstood several rounds of three-hour gas flame tests, each time being exposed to temperatures between 2,100°F and 2,300°F. No fire or fuse failure was observed. Results show that the insulated bus pipe has the ability to maintain both structural and electrical circuit integrity in extreme and corrosive environments.

### Benefits

- Safety and reliability – reductions in fire hazards as the insulation is rated for use at 2,300°F
- Weight reductions – lighter weight than similarly performing insulations
- Space reductions for wiring installations that are constrained by space limits
- Higher power, higher voltage systems due to lighter weight and higher temperature performance capability
- Improved properties compared to current insulation materials:
  - low dielectric constant (2.9 at 10 GHz), low dissipation factor, and permittivity
  - excellent moisture and chemical resistance
  - Halogen-free

### Applications

- Aerospace – space operations and exploration
- Marine – all-electric ships that require large amounts of power to be moved about the ship
- Construction – enables higher voltage power lines needed for high-rise buildings ■

For details about licensing or joint development opportunities associated with this technology, or information on partnering with NASA, contact Langley at (757) 864-1178 or LARC-DL [technologygateway@mail.nasa.gov](mailto:technologygateway@mail.nasa.gov), or visit [technologygateway.nasa.gov](http://technologygateway.nasa.gov).

Please mention that you read about it in *Technology Innovation*.

# Opportunities for Partnership

## Highly Aligned Electrospun Fibers and Mats

NASA Langley has created a modified electrospinning apparatus for spinning highly aligned polymer fibers. Fiber placement, orientation and porosity are difficult to control using conventional electrospinning apparatus. Conventional electrospinning creates randomly oriented fibers that are well suited to nonwoven mats, but not to other applications.

Now, NASA Langley has developed the capability to control the alignment and porosity of fibers for mats, which will broaden the range of engineering applications of electrospun materials to include new tissue engineering scaffolds, membrane filters, textiles and embedded sensors and actuators. The new apparatus provides a simple and inexpensive means of producing fibers and mats of controlled fiber diameter, porosity and thickness.

### Technology Details

The apparatus uses an auxiliary counter electrode to align fibers for control of the fiber distribution during the spinning process. The electrostatic force imposed by the auxiliary electrode creates a converged electric field, which affords control over the distribution of the fibers on the rotating collector surface.

The process begins when a pump slowly expels polymer solution through the tip of the spinneret at a set flow rate as a positive charge is applied. The auxiliary electrode, which is negatively charged, is positioned opposite the charged spinneret. The disparity in charges creates an electric field that effectively controls the behavior of the polymer jet as it is expelled from the spinneret; it ultimately controls the distribution of the fibers and mats formed from the polymer solution as it lands on the rotating collection mandrel. A broad range of fiber diameters can be manufactured by modifying various parameters of the process and/or polymer solution. Performance data has confirmed the substantial role that the electric field plays in the significant improvement in fiber alignment and control relative to using the rotating collector alone.

Prototypes have been produced, and the repeatability of the process has been confirmed. A patent application has been filed.

### Benefits

- Consistency and control of fiber distribution, porosity and fiber alignment
- Versatility – adaptable to micro and nano fiber sizes
- Repeatable results – amenable to mass production
- Capable of manufacturing single fibers
- Compatible with most polymer solution systems

- Inexpensive processing method

### Applications

- Biomedical – tissue engineering scaffolds for cell formation, drug delivery, wound dressing, membranes
- Military – smart textiles and embedded sensors/actuators
- Filters – industrial, environmental, automotive
- Instrumentation – sensors for spectroscopy
- Chemical and biological sensors
- Fuel cells and solar cells ■

*For details about licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact The Technology Gateway at Langley, (757) 864-1178 or LARC-DL-technologygateway@mail.nasa.gov, or visit [technologygateway.nasa.gov](http://technologygateway.nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

## Fluid Measurement Sensor

NASA Langley researchers have developed a wireless, thin-film fluid measurement sensor that uses a magnetic field response measurement acquisition system to provide power to the sensor and to acquire physical property measurements from it. In addition to measuring fluids within an enclosed container, it can be placed external to a non-conductive container to measure the level of any non-



gaseous substance, including liquids, solids and semi-solids such as powder or granular substances.

**Technology Details**

The fluid measurement sensor is configured with a spiral electrical trace on flexible substrate. The sensor receives a signal from the accompanying magnetic field data acquisition system. Once electrically active, the sensor produces its own harmonic magnetic field as the inductor stores and releases magnetic energy. The antenna of the measurement acquisition system is switched from transmitting to receiving mode to acquire the magnetic-field response of the sensor. The magnetic-field response attributes of frequency, amplitude and bandwidth of the inductor correspond to the physical property states measured by the sensor. The received response is correlated to calibrated data to determine the physical property measurement. When multiple sensors are inductively coupled, the data acquisition system only needs to activate and read one sensor to obtain measurement data from all of them.

Fluid level measurement occurs in several ways. In the immersion method, the capacitance of the sensor circuit changes as it is immersed in fluid, thus changing the frequency response as the fluid level rises or falls. Fluid level also can be measured from the outside of a non-conductive container. The response frequency from the sensor is dependent upon the inductance of the container plus the combination of fluid and air inside it, which corresponds to the level of

liquid inside the container.

Roll and pitch are measured by using three or more sensors in a container. With any given orientation, each sensor will detect a different fluid level, thus providing the basis for calculating the fluid angle.

Volume can be measured in the same way, using the angle levels detected by the sensors and the geometric characteristics of the container to perform the volume calculation.

The fluid measurement sensor technology includes U.S. patent application 20070157718 and U.S. patent 7,255,004.

**Benefits**

- Receives power wirelessly, eliminating the need for a sensor power source
- Sends signals wirelessly to the data acquisition device, eliminating signal wiring
- Reduces system weight due to less wiring
- Non-mechanical method for fluid measurement – no moving parts, reducing the probability of failure
- Eliminates potential for arcing (safer use in fuel tanks)
- Lightweight
- Can measure fuels without opening the tank, reducing emission of harmful gases

**Applications**

- Fuel and other liquid measurements in vehicles
- Above- or below-ground fuel storage tanks
- Cryogenic fluid tanks ■

*For details about licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact The Technology Gateway at Langley, (757) 864-1178 or LARC-DL-technologygateway@mail.nasa.gov, or visit technologygateway.nasa.gov.*

*Please mention that you read about it in Technology Innovation.*

**Low-Profile Wireless Sensor**

NASA Langley researchers have developed a wireless low-profile sensor that uses a magnetic field response measurement acquisition system to provide power to the sensor and to acquire physical property measurements from it. Unique to this sensor is the shape of the electrical traces, which eliminates the need for separate inductance, capacitance and connection circuitry. This feature gives the sensor a smaller circuit footprint to enable a smaller, flexible and easy-to-fabricate sensor package. The shape of the electrical trace can be readily modified to sense different physical properties. Also, arranging multiple low-profile sensors together can permit the wireless data acquisition system to read the responses from all the sensors by powering just one of them.

**Technology Details**

The low-profile sensor is configured with a spiral electrical trace on flexible substrate. In typical inductor designs,

# Opportunities for Partnership

the space between traces is designed to minimize parasitic conductance to reduce the impact of the capacitance to neighboring electronics. In the low-profile sensor, however, greater capacitance is desired to allow the operation of an inductor-capacitor circuit. This allows the traces to be closer together, decreasing the overall size of the spiral trace.

The sensor receives a signal from the accompanying magnetic field data acquisition system. Once electrically active, the sensor produces its own harmonic magnetic field as the inductor stores and releases magnetic energy. The antenna of the measurement acquisition system is switched from a transmitting to a receiving mode to acquire the magnetic-field response of the sensor. The magnetic-field response attributes of frequency, amplitude and bandwidth of the inductor correspond to the physical property states measured by the sensor. The received response is correlated to calibration data to determine the physical property measurement. When multiple sensors are inductively coupled, the data acquisition system needs to activate and read only one sensor to obtain measurement data from all of them.

The low-profile sensor technology includes U.S. patent application 20070181683.

## Benefits

- Receives power wirelessly, eliminating the need for a sensor power source
- Sends signals wirelessly to the data acquisition device, eliminating signal wiring
- Reduces system weight due to less

wiring

- Eliminates risk of electrical arcing in explosive conditions
- Capacitor and inductor combined to allow for a smaller profile
- Reduces the number of electrical connections within the circuit, improving reliability
- Easily modified to provide different response characteristics for sensing different physical properties
- Inductive coupling of adjacent sensors requires only one sensor to be powered to obtain a full response from all sensors
- Enables use under corrosive, radioactive, extreme temperature, and other hazardous conditions
- Enables measurements in areas previously impractical to reach due to wiring constraints

## Applications

- Automotive, motor sports, and trucking – tire pressure, tread wear, wheel speed, fuel level and engine temperature
- Aerospace – landing gear health, fuselage integrity
- Industrial – foundry kiln temperature, cryogenic liquid level, materials cure process ■

*For details about licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact The Technology Gateway at Langley, (757) 864-1178 or LARC-DL-technologygateway@mail.nasa.gov, or visit [technologygateway.nasa.gov](http://technologygateway.nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

## EBF3: The Future of Art-to-Part Manufacturing

Companies are invited to license a patented system for performing electron-beam freeform fabrication (EBF3) that offers significant advantages over traditional e-beam and laser-based systems. Developed to enable parts manufacturing in the zero-gravity environment of space, NASA's EBF3 system delivers quality parts that are better than cast and similar to wrought materials while optimizing material consumption. This system costs significantly less than others to build, enabling companies previously hesitant to enter the market to compete and win in the expanding rapid prototyping and manufacturing market.

## Technology Details

The system consists of an electron-beam gun, wire feeder and positioning system enclosed in an aluminum vacuum chamber. Like other e-beam systems, the NASA system focuses the electron beam to melt a material, in this case metal wire, which is then accurately deposited layer by layer according to computer-aided design (CAD) data, fabricating a three-dimensional structural part without the need for a die or mold.

Unlike other e-beam systems, which operate at 60–200 kV, NASA's technology can create the parts using about 20 kV of power. The system can be used to make parts from a wide range of materials (e.g., titanium, aluminum,

nickel, stainless steel) as well as alloyed and layered parts via multiple wire feeders. The size of parts is dependent upon the size of the system, which is scalable; NASA has been using the system to make parts six inches and smaller.

**Benefits**

- Lowest TCO – offers the lowest total cost of ownership (TCO) through the low cost for a commercialized system as well as its low energy consumption
- Quality parts – produces fully dense parts using real engineering alloys with no material waste
- Lower material costs – requires less material to make a quality part than with powder-based e-beam systems
- Multiple material manufacturing – allows multiple materials to be co-deposited, enabling fabrication of alloy-based and layered parts
- Environmentally friendly – makes it easier to comply with the regulations associated with chrome plating
- Lower power, higher safety – uses about 20 kV, lowering not only operation costs but also radiation, thereby improving safety conditions
- Versatile part envelope – creates the widest spectrum of quality parts of varying sizes up to six inches long (or even larger with scale-up)
- Mobile and rugged – can be relocated and has been demonstrated successfully on an aircraft in 0-g flight without requiring time-consuming alignment procedures

**Applications**

- Three-dimensional models for new designs
- Custom parts and small-batch production for medical devices, motorcycle parts, sports equipment, tool and die, etc.
- Chrome plating for automobile and motorcycle parts, bicycle parts, household appliances, etc.
- Replacement parts in remote or hostile locations ■

*For details about partnering with NASA to license the Wire-Feed E-Beam Freeform Fabrication technology (MSC-23518 patented under U.S. #7,168,935) for commercialization, please contact the Johnson Technology Transfer Office, (281) 483-3809 or jsc-techtran@mail.nasa.gov.*

*Please mention that you read about it in Technology Innovation.*

**Polymer Cross-Linked Aerogels**

NASA Glenn Research Center (GRC) seeks to transfer technology for further development and production of its polymer cross-linked aerogels (X-Aerogels). These mechanically robust, highly porous, low-density materials are three times denser than native aerogels, but more than 100 times stronger.

**Technology Details**

Aerogels are ultra-lightweight glass foams with very small pores (on the

order of 10 to 50 nanometers). They are extremely good thermal insulators, with R values ranging from two to 10 times higher than polymer foams. Unlike multilayer insulation, aerogels do not require a high vacuum to maintain their low thermal conductivity and can function as good thermal insulators at ambient pressure. In addition, they are good electrical insulators and have low refractive indices — both approaching values close to air. Aerogels are also excellent vibration-damping materials.

One undesirable quality of traditional aerogels, however, is their fragility and poor environmental durability. Researchers at GRC have developed an approach to significantly improve the mechanical properties and durability of aerogels without adversely affecting their desirable properties. This approach involves coating conformally and cross-linking the individual skeletal aerogel nanoparticles with engineering polymers such as isocyanates, epoxies, polyimides and polystyrene. The mechanism of cross-linking has been investigated carefully and is made possible by two reactions: one between the cross-linker and the surface of the aerogel framework, and another propagated by the cross-linker with itself.

GRC's approach to creating aerogels helps to sidestep the fragility and durability shortcomings of conventional aerogels, making them more desirable for both aerospace applications and commercial terrestrial applications. The resulting materials can have compressive strengths more than 100 times that of conventional aerogels, and still offer low thermal conductivities, good



# Opportunities for Partnership

optical transparency and low densities. By tailoring the aerogel surface chemistry, GRC's approach accommodates a variety of different polymer cross-linkers, including isocyanates, acrylates, epoxies, polyimides and polystyrene—enabling customization for specific mission requirements. For example, polystyrene cross-linked aerogels are extremely hydrophobic, while polyimide versions can be used at higher temperatures.

Recent work has led to the development of strong aerogels with better elastic properties, maintaining their shape even after repeated compression cycling. By tailoring the internal structure of the silica gels in combination with a polymer conformal coating, the aerogels may be dried at the ambient condition without supercritical fluid extraction.

NASA GRC is seeking patent protection for this technology.

## Benefits

- Improved strength – more than 100 times stronger than conventional aerogels
- Low thermal conductivity – enables application for a variety of temperature-challenging environments
- Good optical transparency – some formulations offer light filtration while maintaining good insulation
- Customizable – tailored chemistry enables customized polymers for specific mission requirements
- Improved elasticity – maintain their shape even after repeated compression

## Applications

- Thermal insulation for cryogenic propellant tanks
- Acoustic and vibration-damping materials
- Ballistic impact-absorbing materials
- Hose insulation
- Thermal pane skylights
- Catalytic supports
- Dielectrics for fast electronics
- Filtration membranes
- Membranes for fuel cells and batteries
- Optical sensors
- Aerospace components ■

*For details about licensing this (LEW-17685-1) and other technologies, please contact the Technology Transfer and Partnership Office at Glenn, (216) 433-3484 or [ttp@grc.nasa.gov](mailto:ttp@grc.nasa.gov); or visit <http://technology.grc.nasa.gov/>.*

*Please mention that you read about it in Technology Innovation.*

## Systems Maintenance Automated Repair Tasks (SMART)

**N**ASA's Kennedy Space Center seeks partners interested in the commercial application of the Systems Maintenance Automated Repair Tasks (SMART) technology. SMART is an interactive decision analysis and refinement software system designed to use evaluation criteria for discrepant conditions to automatically populate a

document with the steps necessary to repair a discrepancy in a safe, accurate and efficient manner.

SMART was originally developed for the Orbiter Electrical Engineering group, part of the Space Shuttle Ground Operations team that is responsible for all electrical interconnect modifications, inspections and discrepancy repairs. Implemented at Kennedy with great success, SMART has been instrumental in avoiding costs, saving time, ensuring that requirements are met, capturing knowledge and improving quality, technical accuracy and safety.

## Technology Details

SMART gives the user a single interface point that merges information on the configuration, safety and technical requirements, corporate knowledge, sequential process, decision analysis process and hardware requirements, all of which previously had to be manually compiled from multiple sources and databases, to create a repair procedure. It is a front-end, on-line application whose Oracle-based output can be used by any repair-procedure-authoring environment. SMART captures information from existing legacy database systems and provides that data for incorporation into a repair procedure document. This flexible software allows the SMART configuration to be tailored to meet organizational needs.

NASA has acquired a copyright for the SMART software, has applied for a U.S. patent and is seeking licensees for the patent and copyright.

**Benefits**

- Time Savings – time required to produce repair documents is reduced by up to 50 percent
- Minimizes human error – typographical and cut-and-paste errors are reduced or eliminated
- Consistent disposition – uses controlled set of repair sequences and steps
- Consistent evaluation – provides method for consistent evaluation of discrepancies
- Transferable – product and concept are transferable to many different engineering disciplines and hardware types
- Safety – ensures proper procedures are followed, preventing injuries and hardware damage
- Knowledge – provides a tool to capture valuable knowledge about a system – knowledge goes in and out of SMART in the same way a person uses information to solve problems
- Intellectual capital – provides a mechanism to retain/transfer institutional knowledge of system processes

**Applications**

- Commercial/military aviation
- Commercial/military spacecraft
- Automotive
- Industrial process machines
- Nuclear
- Marine
- Electronics ■

*For details about licensing this technology, please reference Case Number KSC-12909 and contact Lew Parrish in the Kennedy Innovative Partnerships Program Office, (321) 867-5033; Lewis.M.Parrish@nasa.gov.*

*Please mention that you read about it in Technology Innovation.*

**Bimetallic Treatment System for Paints**

NASA’s Kennedy Space Center seeks partners interested in the commercial application of the Bimetallic Treatment System (BTS) for Paints. Kennedy is offering companies licensing or partnering opportunities in the development of this innovative remediation technology.

Polychlorinated biphenyls (PCBs), found in painted surfaces, have been shown to cause cancer in animals and to have other adverse effects on immune, reproductive, nervous and endocrine systems. Although the production of PCBs in the United States was banned in the 1970s, many surfaces are still coated with PCB-laden paints, which adds complexity and expense for disposal. Some treatment methods (e.g., use of solvents, physical removal via scraping) are capable of removing PCBs from surfaces, but these technologies create a new waste stream that must be treated. Other methods, like incineration, can destroy the PCBs but destroy the painted

structure as well, preventing reuse.

In contrast, BTS removes PCBs and breaks them down into benign by-products. Therefore, no additional waste stream is created. Also, because the treated surface can be reused following application, BTS has advantages over methods like incineration, which destroys the underlying material.

**Technology Details**

Developed by researchers at Kennedy and the University of Central Florida, BTS consists of a solvent solution (e.g., ethanol, d-limonene) that contains a catalyzed zero-valent metal (e.g., magnesium coated with small quantities of palladium). BTS is first applied to the painted surface, and the solution extracts the PCBs from the paint. The extracted PCBs react with the micro-scale metal catalysts and are degraded into benign by-products. This technology can be applied without removing the paint or dismantling the painted structure. In addition, the surface can be reused following treatment.

BTS is patented and available for licensing.

**Benefits**

- Non-destructive – does not affect the material beneath the paint and allows for the surface to be repainted/reused following application
- In situ – treats PCBs in place, versus traditional abatement methods that generate a secondary waste stream

# Opportunities for Partnership

- Cost-competitive — requires none of the costs associated with placing a building under vacuum; or transporting, treating, and/or disposing of a secondary waste stream
- Effective — has been shown in lab-scale tests to remove approximately 80 percent of PCBs from paint (three layers in thickness with initial PCB concentration as high as 700 parts per million) within four hours, and approximately 100 percent of PCBs within 48 hours
- Safe — produces benign by-products
- Versatile — can be used as a paint-on/wipe-off method for in-situ applications or as an immersion method (e.g., for dismantled parts awaiting disposal)

## Applications

- Soils
- Waste oils
- Electrical transformers
- Waste clothing
- Capacitors
- Other debris
- Transformer oils ■

## Ice Liberation Coating For Use As Ice Adhesion Reduction Coating

The unique formulation of this coating changes the adhesion of ice on surfaces to which it is applied by an order of magnitude, resulting in the fracturing and release of ice from the ET during engine ignition prior to liftoff of the vehicle from the launch pad. Although not an ice prevention coating, this technology may in some cases prevent or delay ice formation due to its high contact angle causing water to run off the coating even if the surface is a very slight angle. Extensive testing of the coating, conducted by the U.S. Army Corps of Engineers' Cold Regions Research and Engineering Laboratory, showed that the performance and durability of this coating is excellent.

A patent is pending on this technology, and it is available for licensing.

## Benefits

- Reduces surface ice adhesion by up to 90 percent
- May prevent the formation of ice altogether under certain conditions due to high contact angle causing water runoff
- Excellent durability to environmental weathering
- Can withstand several cycles of ice growth/removal without loss of performance
- Can be buffed until application surface appears transparent with no loss of performance

- Can be used to coat surfaces that require transmission of optical light
- Inexpensive to produce

## Applications

- Aerospace vehicles
- Commercial and military aircraft
- Commercial vehicle windows
- Ships, boats and submarines
- Military vehicles (tanks and infantry fighting vehicles)
- Hydropower and waterway navigation facilities ■

*For details about licensing this technology, please reference Case Numbers KSC-13100 or KSC-13101 and contact Lew Parrish (321) 867-5033, [Lewis.M.Parrish@nasa.gov](mailto:Lewis.M.Parrish@nasa.gov) at the Kennedy Innovative Partnerships Program Office.*

*Please mention that you read about it in Technology Innovation.*

## MARS continued from pg. 23

Opportunity – and is scheduled to provide a similar device for the Mars Science Laboratory, scheduled for launch this year.

The Rovers also are equipped with the lithium-ion batteries that Yardney supplied for the Phoenix Lander. These batteries provide the Rovers with efficient, durable and reliable energy storage, having already contributed to the mission's extension from a few months to more than five years. Yardney's batteries have been selected for the Mars Science Laboratory.

The Mars Rovers also contain several paraffin-based heat switches developed by Starsys (SpaceDev). Functioning

*For details about licensing this technology, please reference Case Number KSC-12878 and contact Lew Parrish (321) 867-5033, [Lewis.M.Parrish@nasa.gov](mailto:Lewis.M.Parrish@nasa.gov); or Jim Nichols, (321) 867-6384, [James.D.Nichols@nasa.gov](mailto:James.D.Nichols@nasa.gov), at the Kennedy Innovative Partnerships Program Office.*

*Please mention that you read about it in Technology Innovation.*



**GREEN** continued from pg. 19

to the electrical grid, and because the location would provide excellent educational opportunities for the children.

The MPRES includes three renewable energy technologies: PV panels and wind turbines to generate electricity, and a solar thermal panel to provide hot water. Data is collected in real time and is displayed locally and online, showing performance figures on each individual system as well as historical information. (To view the real-time performance and energy savings, go to <http://view2.fatspanel.net/SacredPower/nasa/HostedAdminView.html>.)

**Goddard Exploration Sciences Building**

One of 12 additional NASA buildings in design or under construction that will have or will register for LEED®

certifications, the Exploration Sciences Building at Goddard Space Flight Center is to be the first high-performance building at the Goddard complex. NASA is using more than 35 strategies within the LEED® rating system to pursue the Silver rating, with a focus on sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

The 193,000-square-foot building -- the first new structure to be added at Goddard in more than a decade -- will house three stories of offices and laboratories. The facility will enable cutting-edge research and promote greater internal collaboration among Goddard scientists. It is the first project in a campus-wide master plan and is to be the centerpiece of a unified campus that will help meet a goal of consoli-

dating related research initiatives.

Also at Goddard, methane gas from a nearby landfill is used to heat the 33 buildings that dot the Center's 1,270-acre campus. Using methane instead of natural gas at Goddard eliminates the equivalent of pollution generated annually by 35,000 cars, and it will save NASA more than \$3.5 million in energy costs over the next decade.

(See feature story in this issue for information on other green initiatives at GSFC.) ■

*For more information, contact Eugene Mszar, experimental facilities development engineer, in NASA's Facilities Engineering & Real Property Division, at [Eugene.a.mszar@nasa.gov](mailto:Eugene.a.mszar@nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

autonomously, these heat switches control radiators for electronics packages.

Maxwell Technologies fabricated and tested an ASCII chip for memory modules and analog-to-digital converters on the Rovers. The chip contains single-event latch-up protection technology. By enabling the use of commercial chip technology in space missions, use of this chip provides higher performance at a lower cost.

NASA has taken steps to increase the utilization of SBIR-developed technology in its programs and missions. A number of NASA programs are looking to the small business community for innovative technology requirements. These requirements are expressed each year in the SBIR/STTR Program annu-

al solicitation. Interested companies can visit the SBIR/STTR Program's Web location (<http://sbir.nasa.gov>) to learn more. Descriptions of the many other technology innovations and commercial accomplishments of NASA SBIR contractors are available at this same Web location.

Irene Yachbes of Honeybee offers these tips for working with NASA:

- Involve yourself and educate yourself about NASA's needs continuously.
- When a new NASA SBIR solicitation comes around, be sure that you understand NASA's needs well enough to respond well.
- When you have received a Phase 1 award, establish a good relationship

with your COTR (Contracting Officer's Technical Representative, or NASA contract monitor).

- Keep in touch to inform them of your progress.
- Generate a buzz in the community about your work. Find out who can be end-users other than just your COTR.
- Don't let your SBIR project end with a completed Phase 1 or Phase 2. You must actively market yourself in the NASA community. ■

*For more information, please contact Byron Jackson in the SBIR Program Office at JPL, (818) 354-1246, [byron.l.jackson@jpl.nasa.gov](mailto:byron.l.jackson@jpl.nasa.gov).*

*Please mention that you read about it in Technology Innovation.*

# NASA'S IPP NETWORK

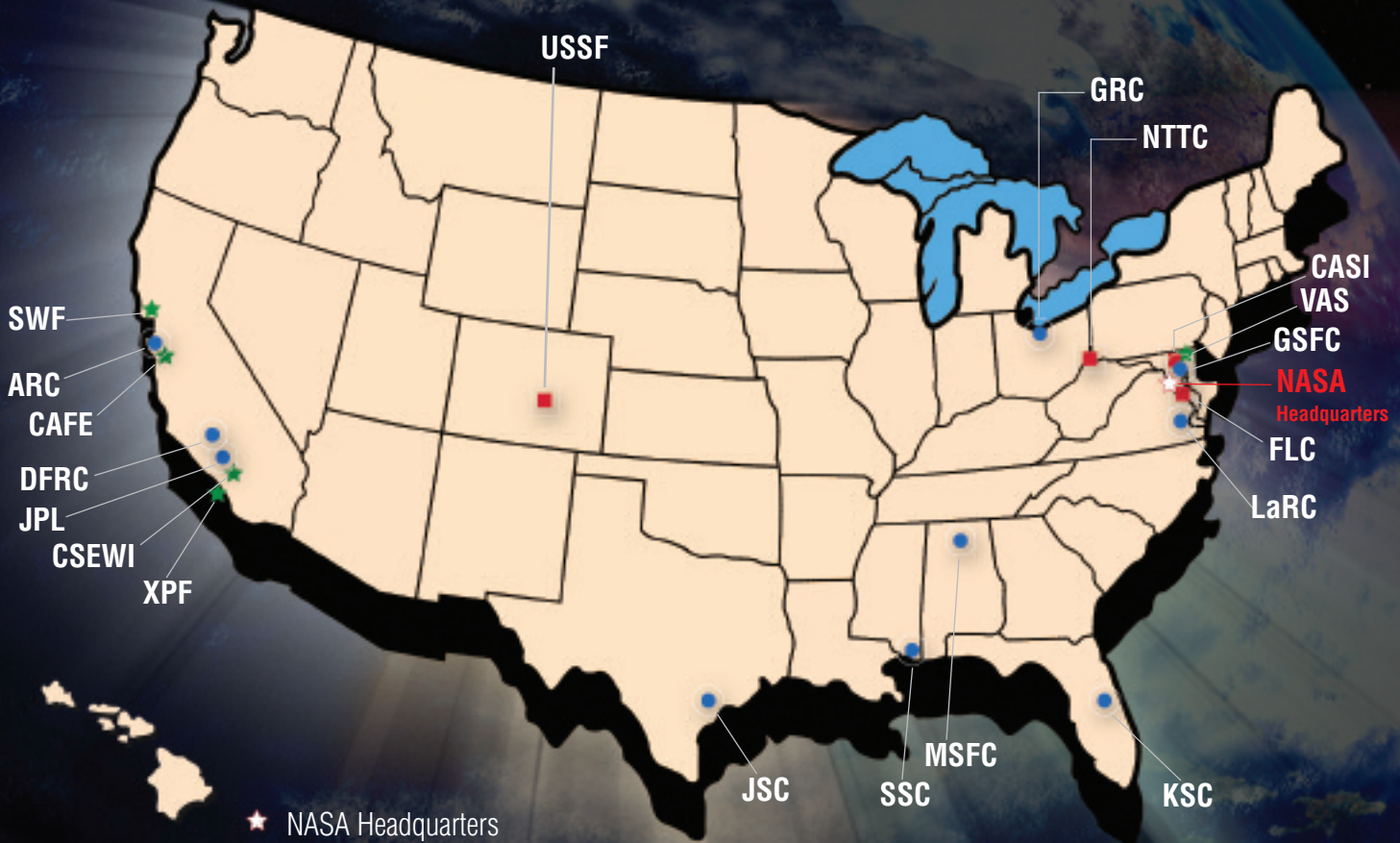
visit [www.ipp.nasa.gov](http://www.ipp.nasa.gov)

## NASA CENTERS:

- ARC – Ames Research Center
- DFRC – Dryden Flight Research Center
- GRC – Glenn Research Center
- GSFC – Goddard Space Flight Center
- HQ – Headquarters
- JPL – Jet Propulsion Laboratory
- JSC – Johnson Space Center
- KSC – Kennedy Space Center
- LaRC – Langley Research Center
- MSFC – Marshall Space Flight Center
- SSC – Stennis Space Center

## ALLIED ORGANIZATIONS:

- CAFE – Comparative Aircraft Flight Efficiency Foundation
- CASI – NASA Center for AeroSpace Information
- CSEWI – California Space Education & Workforce Institute
- FLC – Federal Laboratory Consortium
- NTTC – National Technology Transfer Center
- USSF – United States Space Foundation
- SWF – The Spaceward Foundation
- VAS – Volanz Aerospace, Inc./Spaceflight America
- XPF – XPRIZE Foundation



- ★ NASA Headquarters
- Innovative Partnerships Program Offices at each of NASA's 10 Field Centers represent NASA's technology sources and manage center participation in technology transfer activities.
- Allied Organizations support NASA's IPP objectives.
- ★ Centennial Challenges Allied Organizations

# National Aeronautics and Space Administration Innovative Partnerships Program (IPP) Network

## NASA Headquarters

300 E Street, SW  
Washington, DC 20546

### Douglas A. Comstock

Director, IPP  
Phone: 202/358-2221  
E-mail: doug.comstock@nasa.gov

### Carl G. Ray

Program Executive, Technology  
Infusion, IPP Office  
Phone: 202/358-4652  
E-mail: carl.g.ray@nasa.gov

### Janelle Turner

Program Executive, Outreach,  
IPP Office  
Phone: 202/358-0704  
E-mail: janelle.b.turner@nasa.gov

## NASA Field Centers

### Ames Research Center

Moffett Field, California 94035  
(see pgs. 6, 28, 30, 34, 42)  
Aviation Safety, Airspace Systems, Avionics  
and Software, Protection Systems, Space  
Radiation, Small Spacecraft, Information  
Technologies, Integrated Health System  
Management

### Lisa Lockyer

IPP Chief  
650/604-1754  
lisa.l.lockyer@nasa.gov

### Dryden Flight Research Center

4800 Lilly Drive, Building 4839  
Edwards, California 93523-0273  
(see pgs. 27, 29, 30)  
Aviation Safety, Atmospheric Research

### Gregory Poteat

IPP Chief  
661/276-3872  
gregory.a.poteat@nasa.gov

### Glenn Research Center

21000 Brookpark Road  
Cleveland, Ohio 44135  
(see pgs. 8, 11, 20, 38, 53)  
Aviation Safety, Fundamental Aeronautics,  
Aeronautics Test Technologies,  
Environmental Control and Life Support,  
Extra Vehicular Activity, Lunar Operations,  
Energy Generation and Storage, Protection  
Systems, Exploration Crew Health  
Capabilities, Spacecraft and Platform  
Subsystems, Space Communications and  
Navigation, Processing and Operations

### Kathleen Needham

IPP Chief  
216/433-2802  
Kathleen.K.Needham@nasa.gov

### Goddard Space Flight Center

Greenbelt, Maryland 20771  
(see pgs. 12, 14, 44, 57)  
Structures, Materials, Mechanisms, Sensors,  
Detectors, Instruments, Advanced Telescope  
Systems, Spacecraft and Platform  
Subsystems, Information Technologies,  
Space Communications and Navigation

### Nona Cheeks

IPP Chief  
301/286-5810  
nona.k.cheeks@nasa.gov

### Jet Propulsion Laboratory

4800 Oak Grove Drive  
Pasadena, California 91109  
(see pgs. 12, 23, 26, 37)  
Sensors, Detectors, Instruments, Advanced  
Telescope Systems, Robotics, Space  
Communications and Navigation

### Andrew Gray

IPP Manager  
818/354-4906  
gray@jpl.nasa.gov

### Johnson Space Center

Houston, Texas 77058  
(see pgs. 7, 9, 18, 52)  
Sensors for Autonomous Systems,  
Environmental Control and Life Support,  
Extra Vehicular Activity, Lunar In Situ  
Resource Utilization, Lunar Operations,  
Thermal Management, Exploration Crew  
Health Capabilities, Space Human Factors  
and Food Systems, Space Radiation

### Michele Brekke

IPP Chief  
281/483-4614  
michele.brekke@nasa.gov

### Kennedy Space Center

Kennedy Space Center, Florida 32899  
(see pgs. 16, 54-56)  
Space Transportation, Processing and  
Operations, Launch Site Technologies

### David R. Makufka

IPP Chief  
321/867-6227  
david.r.makufka@nasa.gov

### Langley Research Center

Hampton, Virginia 23681-2199  
(see pgs. 11-12, 49-52)  
Aviation Safety, Fundamental Aeronautics,  
Airspace Systems, Avionics and Software,  
Structures, Materials, Mechanisms, Sensors,  
Detectors, Instruments, Atmospheric  
Research

### Brian F. Beaton

IPP Manager  
757/864-2192  
brian.f.beaton@nasa.gov

### Marshall Space Flight Center

Marshall Space Flight Center,  
Alabama 35812  
(see pgs. 12, 18)  
Structures, Materials, Mechanisms,  
Propulsion and Cryogenic Systems,  
Advanced Telescope Systems, Space  
Transportation

### James Dowdy

IPP Chief  
256/544-7604  
jim.dowdy@nasa.gov

### Stennis Space Center

Stennis Space Center, Mississippi 39529  
(see pg. 47)  
Space Transportation, Rocket Propulsion  
Testing, Remote Sensing Applications

### Ramona Pelletier Travis

IPP Chief  
228/688-3832  
ramona.e.travis@ssc.nasa.gov

## Allied Organizations

Working with NASA to advance the  
objectives of the Innovative Partnerships  
Program.

### National Technology Transfer Center (NTTC)

Wheeling, West Virginia

Helping to meet NASA's technology needs  
through innovative products and services  
to facilitate infusion and partnership  
development.

### Darwin Molnar

Vice President  
dmolnar@nttc.edu  
www.nttc.edu

### United States Space Foundation

Colorado Springs, Colorado

### Kevin Cook

Director, Space Technology  
Awareness  
kevin@spacefoundation.org  
www.spacefoundation.org

### Federal Laboratory Consortium

Washington, DC

### John Emond

Collaboration Program Manager  
john.l.emond@nasa.gov  
www.federallabs.org

### NASA Center for AeroSpace

Information  
Spinoff Project Office  
Hanover, Maryland

### Daniel Lockney

Editor/Writer  
dlockney@sti.nasa.gov  
www.sti.nasa.gov/tto

### Tech Briefs Media Group

New York, NY

### Joe Pramberger

Publisher  
joe@techbriefs.com  
www.techbriefs.com

### Systems Planning Corp.

Arlington, Virginia

### James Kudla

Vice President, Corporate  
Communications  
jkudla@sysplan.com  
http://sysplan.com/

### Fuentek, LLC

Apex, North Carolina

### Laura A. Schoppe

President  
laschoppe@fuentek.com  
http://www.fuentek.com

## Centennial Challenges

Partnering with NASA to manage prize  
competitions for the citizen inventor.  
(see pg. 2)

### The X PRIZE Foundation

Santa Monica, CA  
<http://space.xprize.org/>

### Volanz Aerospace, Inc./

Spaceflight America  
Owings Mills, MD  
<http://www.astronaut-glove.us>

### The Spaceward Foundation

Mountain View, CA  
<http://www.spaceward.org/>

### California Space Education & Workforce Institute

Pasadena, CA  
<http://csewi.org/>

### Comparative Aircraft Flight Efficiency Foundation

Santa Rosa, CA  
<http://cafefoundation.org/>



# Trace space back to you!

Have you ever wondered how space exploration impacts your daily life?  
Pick a starting point to see how space traces back to you.



[www.nasa.gov/city](http://www.nasa.gov/city)

View Technology Innovation

# Online

and Register for  
Additional Copies! Go to

<http://www.techbriefs.com/tech-exchange>.

National Aeronautics and Space Administration

**Innovative Partnerships Program**

Washington, DC 20546-001

[www.nasa.gov](http://www.nasa.gov)

NP-2009-01-563-HQ