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Aerospace Technology
INNOVATION

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COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
11/01	STS-108/ISS Flight "UF-1"	Advanced ASTROCULTURE™	Wisconsin Center for Space Automation and Robotics
		Zeolite Crystal Growth (ZCG)	Center for Advanced Microgravity Materials Processing
		Microencapsulation Electrostatic Processing System (MEPS)	Center for Space Power
		Commercial Biomedical Testing Module (CBTM) (Sortie)	BioServe Space Technologies

* As of October 2001.
STS—Space Transportation System
ISS—International Space Station

The RTTCs Strengthen the NASA Link to U.S. Industry

By Carolina Blake
Chief, Commercial Technology Office
Ames Research Center

THE TECHNOLOGY TRANSFER AND COMMERcialization of NASA-funded research is an important contributor to the economic well-being of the United States. The NASA Commercial Technology Network (NCTN) is NASA's official arm to aid technology transfer and commercialization. NASA established the NCTN as the foundation for its technology transfer and commercialization mission, and has built an extensive infrastructure in support of this important goal.

The NASA Technology Utilization (TU) program was created in 1962 in response to the congressional mandate contained in the National Aeronautics and Space Act of 1958, to disseminate and encourage the rapid commercialization and use of the Agency's technology to both the public and private sectors of the U.S. economy. In 1994, the NCTN refined its services and network to better support the mandated mission. To this end, a national network of Regional Technology Transfer Centers (RTTCs) was created to promote NASA technology transfer and commercialization opportunity to U.S. industry.

Today, the NASA RTTCs continue evolving to better fit the needs of U.S. industry and to work with potential partners in U.S. industry and the government to:

a) facilitate and promote enhanced access to NASA's wealth of technology and information;
b) stimulate the widest possible use of NASA technology in the national interest; and
c) increase the dissemination and commercial application of technologies in the U.S. resulting from NASA-funded programs.

There are six RTTCs located throughout the country: Far West Technology Transfer Center, Los Angeles, California, *http://www.usc.edu/dept/engineering/TTC/NASA/index.html*; Center for Technology Commercialization, Westborough, Massachusetts, *http://www.ctc.org/*; Economic Development Institute, Atlanta, Georgia, *http://www.edi.gatech.edu/nasa/*; Mid-Continent Technology Transfer Center, College Station, Texas, *http://www.mcttc.com/*; Technology Commercialization Center, Inc., Newport News, Virginia, *http://www.teccenter.org/*; and Great Lakes Industrial Technology Center, Cleveland, Ohio, *http://www.glitec.org/*

The RTTCs, each with strong affiliates in every state in its region, are tasked with encouraging and assisting companies interested in partnering with NASA. The RTTCs actively work with companies that desire to partner with NASA to develop joint research relationships or license NASA's commercially available technologies and participate in the NASA Small Business Innovation Research Program (SBIR).

Some of the standard services provided by the RTTCs include: Information Services—provide information on Field Center technologies and capabilities, computerized database searches, and exhibit a retrospective and current awareness of report literature from a wide variety of sources; Technology Needs Assessments—conduct identification of clients' technological needs/problems and applications analyses involving technical support, engineering reports and/or evaluations; Commercialization Services—provide technology and business analyses, venture capital resource information and technology brokering; and Technology Marketing—conduct outreach and other promotional activities to generate a broad national awareness of and access to NASA technology transfer capabilities, services and commercialization opportunities.

Other selected services varying by region include: Identification of user constituencies for specific NASA-developed technologies; arrangement and/or sponsorship of regional conferences, seminars or workshops for industry; coordination of regional inter-organizational linkages for cooperative activities in technology transfer; and supporting commercialization/market assessment of specifically identified technological advancements, including SBIR and Small Business Technology Transfer commercial applicability assessments.

The RTTC contracts are regularly awarded through an open competition process to ensure that all qualified entities are given a fair opportunity, while also ensuring that the taxpayer gets the highest return on investment by the selection of the best candidates.

One of the great strengths of the RTTCs is their strong bond within their region and their intimate knowledge of the local communities.

By working with one another, the RTTCs can use their collective experience to help businesses through customer-oriented service with specialized knowledge about NASA, its Field Centers and Field Center endeavors. This cooperative network works together to ensure a favorable outcome for both NASA and U.S. business, and provides a measurable return on investment to the American taxpayer.

RTTC Network Partners in NASA Knowledge Transfer

Knowledge Transfer

WITH THE BENEFIT OF PUBLIC INVESTment, NASA's achievements in aerospace research and space exploration have been unparalleled. The knowledge gained in pursuit of space exploration has purposefully found its way into scores of consumer and industrial applications, providing an enormous return on investment for our country.

The benefits of NASA's efforts can be seen through the high-technology jobs created within globally competitive, domestic companies such as those in the aerospace industry, which employ over one million Americans, generate over $40 billion in exports and provide a $30-billion positive trade balance. Also, NASA research contributes to quality-of-life improvements afforded to our citizens by important medical breakthroughs such as medical imaging, heart monitors and laser surgery.

NASA RESEARCH CONTRIBUTES TO QUALITY-OF-LIFE IMPROVEMENTS AFFORDED TO OUR CITIZENS BY IMPORTANT MEDICAL BREAKTHROUGHS SUCH AS MEDICAL IMAGING, HEART MONITORS AND LASER SURGERY.

RTTC Network Formation

Much like the process of innovation, the method for successfully transferring knowledge from NASA to industry is complex. Although each of the 10 NASA Field Centers has its own dedicated Commercial Technology Office (CTO), NASA felt that it needed a broader grassroots effort, providing representation in each of the 50 states.

In 1992, NASA created six Regional Technology Transfer Centers (RTTCs), each with affiliates in every state within its region, to assist local companies interested in commercializing NASA technologies, developing joint research relationships or soliciting awards such as the Small Business Innovation Research (SBIR) program. This network was created to focus on representing the interests of industry companies, establishing an advocate for business that understands how to form partnerships with NASA. "These six centers were selected through a nationwide competition in 2000 and formally joined the NASA team in early 2001," said Dr. Robert Norwood, director of the Commercial Technology Office at NASA Headquarters.

Benefit to Industry

Many services are available to companies seeking the assistance of a local Regional Technology Transfer Center representative. RTTCs routinely provide:

- Guidance in finding the right technology from an inventory of more than 17,000 NASA inventions, disclosures and patents;
- Assistance in understanding and navigating the process for licensing technologies;
- Help in identifying and selecting commercialization partners;
- Guidance in locating NASA research capabilities that can augment a company's research and development needs; and
- Support in pursuing funded research opportunities within NASA.

RTTC and Company Successes

Over the past nine years, RTTCs have assisted numerous companies located in their respective regions. A sampling of some prominent success stories follows.

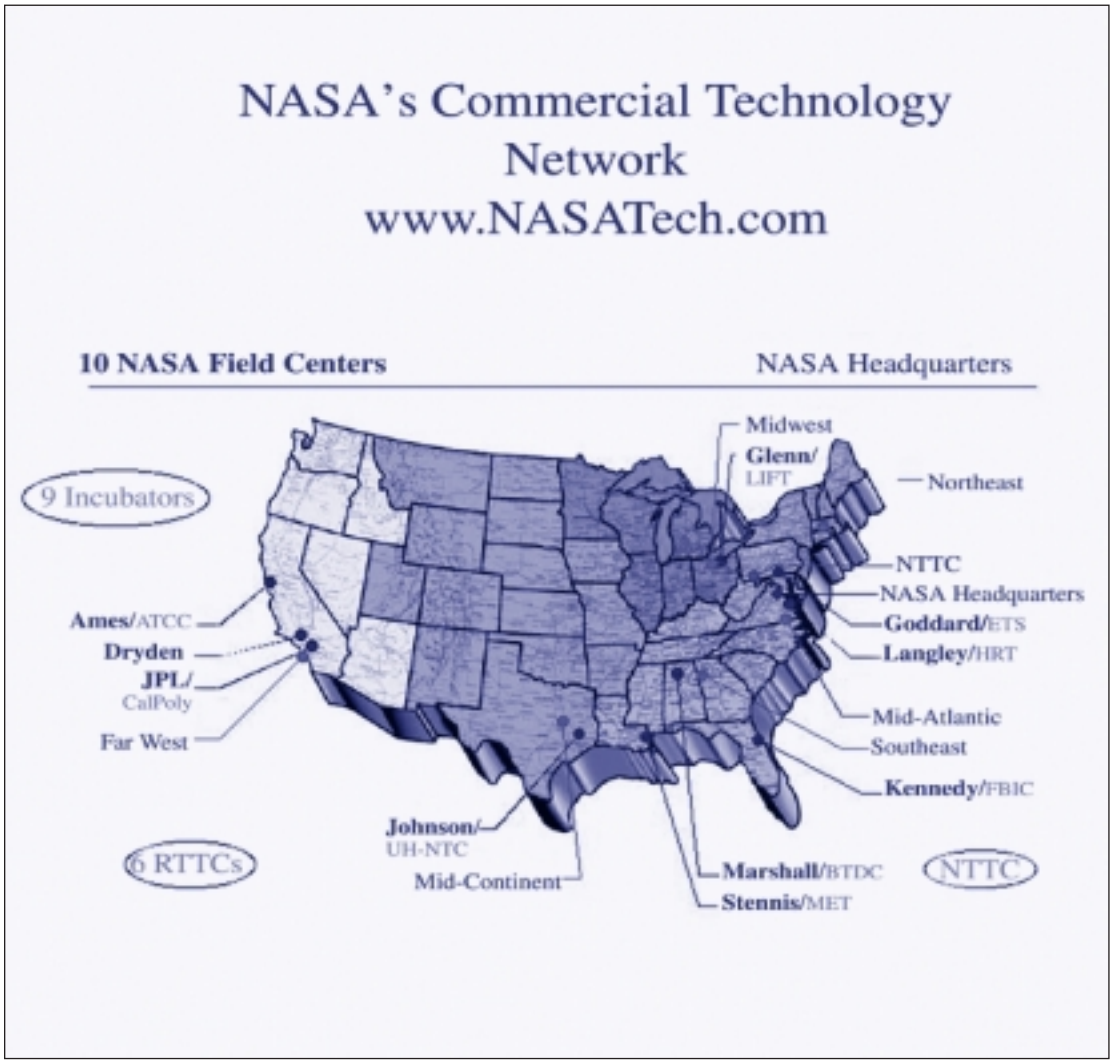
Praxair, the largest industrial gas supplier in North and South America, sought the assistance of an RTTC to determine if NASA had the capability of producing high-temperature ceramic seals for industrial gas containment. The RTTC was able to match a NASA Glenn Research Center technology with Praxair's needs. The NASA technology suc-

cessfully completed a two-phase test program and was subsequently licensed by the company.

In 1999, Pioneer Astronautics, headed by Dr. Robert Zubrin, won a Phase I Small Business Innovation Research grant from NASA to aid in the development of a self-contained breathing apparatus. A subcontractor and regional affiliate of an RTTC, Joe Breddan, worked with Pioneer to find and qualify leads for potential commercialization partners. Interest in the technology generated by RTTC has already produced a partnership for Pioneer Astronautics, and allowed for additional options as well. The strong commercialization interest in the technology helped Pioneer win a Phase II SBIR grant and has preloaded the technical development with commercialization success.

One RTTC linked GSYS Corporation LLC with the design and evaluation expertise of the NASA Glenn Optical Instrumentation Branch to develop a collision avoidance system for the trucking industry. This innovation is an improvement over currently available technology in that truckers can now see what is in their blind spots, not just what is in front of them. Fleet enterprises spend an average of $90,000 to cover losses for each truck accident. The GSYS collision avoidance system offers better protection for the trucking industry's drivers, trucks and freight. Safeguarding the 19 million trucks on our highways with the GSYS system can reduce accidents and, more importantly, save lives.

An RTTC has been closely working with BreakAway Technologies and NASA Ames Research Center to



A mapped depiction of the NASA Commercial Technology Network and their strategic locations.

commercialize a NASA patent for the Multi-Channel Spatialization System for Audio Signals. After licensing the NASA patent, BreakAway Sound was formed as a new company to focus on the development of dynamic sound immersion technology for multimedia development, streaming media for Internet applications, entertainment and game technologies, and other commercial applications. BreakAway Sound technology will be licensed to third-party manufacturers and multimedia, game and software developers for their own audio products or game/software applications. (See related story on page 8)

RTTC Cross-Region Partnerships

The six RTTCs have found that internal communication and cooperation lead to greater opportunities for successful outcomes for both industry and NASA. Industry does not recognize regional boundaries when it comes to customer service and neither does the RTTC network.

Therefore, the RTTCs are focused on providing the best service to industry, whether it means matching a manufacturer and distributor in two different parts of the country to successfully license a technology or finding ways to bring innovations from any NASA Field Center to a company in any region of the country. Several examples of the cross-region partnerships appear below.

The **Medical Device Initiative** was formed at the Johnson Space Center (JSC) with the assistance of its RTTC. The initiative grew out of JSC's desire to have companies involved in conducting joint research activities. A second RTTC began searching for potential industry partners and located Viragen, Inc. Viragen successfully utilized the NASA Rotating Wall Bioreactor to produce longer living interferon, an immune system stimulant used to fight diseases such as hepatitis, multiple sclerosis, certain cancers and HIV/AIDS. Bolstered by this successful project, NASA and all the RTTCs are actively involved in promoting this initiative.

The **Southeastern Universities Research Association (SURA)** is a 53-member association through which colleges, universities and other organizations may cooperate with one another and with government in acquiring, developing and using laboratories and other research facilities. It also enables collaboration in applying that knowledge in the physical, biological and other natural sciences and engineering. SURA and several RTTCs have embarked on a partnership designed to match NASA's transitional research needs with the capabilities of SURA member labs. In addition, the RTTCs and SURA will share company referrals, ensuring that industry has the opportunity to tap the best NASA and academic research resources.

THE RTTC NETWORK IS A PARTNERSHIP OF SIX REGIONAL ENTITIES WITH ONE COMMON GOAL: TO GIVE ANY COMPANY IN ANY REGION OF THE COUNTRY THE BEST POSSIBLE ACCESS TO ALL OPPORTUNITIES, RESOURCES AND INNOVATIONS THAT NASA OFFERS.

Commercial Assessment Process (CAP) Tools are online resources developed by an RTTC to perform market research on NASA technologies. CAP Tools reside in a proprietary area of an RTTC computer network. All RTTCs have access to this unique system for generating consistent, up-to-date, primary market research and market assessments of technology. CAP Tools were developed in an effort to standardize the process of generating market assessments of NASA technologies. These online resources were developed with input from NASA Field Centers and members of the RTTC network.

RTTC Network Partnership Is Here to Help

The RTTC Network is a partnership of six regional entities with one common goal: To give any company in any region of the country the best possible access to all opportunities, resources and innovations that NASA offers.

For more information, or to reach your RTTC, call 800/472-6785. Please mention you read about it in *Innovation*.

Arizona Company Commercializes KSC Gauge

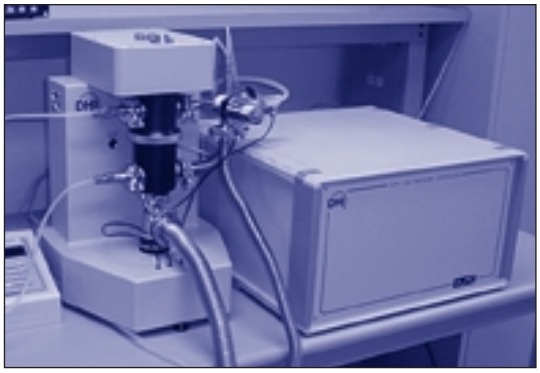
AN ARIZONA COMPANY IS COMMERCIALIZING the Force-Balanced Piston Gauge (FPG), originally designed for the NASA Kennedy Space Center (KSC) Metrology Laboratory to provide a Very Low-Pressure Primary Standard (VLPPS). Metrology deals with the science of weights and measures.

DH Instruments, Inc. (DHI) of Phoenix, a leading supplier of high-end calibration solutions for pressure and flow, is offering the FPG to industry for the first time, as an automated primary standard for very low-gauge and absolute pressures. DHI is currently making a limited commercial release of the FPG on a case-by-case basis to high-end metrology laboratories, according to Martin Girard, DHI's chief executive officer.

Three systems have already been installed worldwide, including the Japanese National Research Laboratory for Metrology (NRLM) in Tsukuba, Japan; the National Measurement Institute (MIKES) in Helsinki, Finland; and Sandia National Laboratories in Albuquerque, New Mexico, the Department of Energy's Primary Metrology Laboratory. DHI expects to deliver five more systems in a limited release phase and full commercial release to the general public in the summer of 2002.

Girard said that the origins of the FPG are in the recognition of the need for a primary pressure standard for both gauge and absolute pressures to cover the range under that covered by conventional piston gauges or deadweight testers (roughly 0 to 10 kilo pascals (kPa), and especially under 1 or 2 kPa). The first concepts for the product, based on the combination of a high-precision piston cylinder and a digital mass comparator, were developed in the late 1980s. In the early 1990s, in a NRLM and DHI joint effort, conceptual drawings were produced but not taken further until NASA requested calibration support for components of the International Space Station. DHI has been a supplier to the KSC Metrology Laboratory since the mid 1980s.

In late 1994, KSC expressed the need for an easy-to-use, low-pressure primary standard to support the calibration of instrumentation for the International Space Station. DHI provided an unsolicited proposal based on the work from the early 1990s. In July 1996, the proposal resulted in a contract to provide the FPG for use in the KSC Metrology Laboratory.



A force-balanced piston gauge developed for KSC is being commercialized by DK Instruments, Inc. Photo courtesy of Kennedy Space Center.

The KSC system was inspected and accepted for installation in August 2000. A major benefit of having the FPG at KSC means savings in time and money, since NASA no longer has to send components to the National Institute of Standards and Technology (NIST) for calibration. The innovation provides the lab with a traceable, primary calibration standard for measuring pressures in the ranges near absolute pressure (hard vacuum) or gauge pressure (atmospheric) within about one pound per square inch (psi) of either baseline. The hardware combines a large area piston-cylinder with a load cell measuring the force resulting from pressures across the piston. The mass of the piston can be tared out, allowing measurement to start from zero. A pressure higher than the measured pressure, which keeps the piston centered, lubricates an innovative conical gap located between the piston-cylinder. This eliminates the need for piston rotation. A pressure controller based on the control of low gas flow automates the pressure control.

The FPG is of great interest to a variety of industries, due to the critical nature of accurate measurements of very low absolute and gauge pressures, said Girard.

These include, but are not limited to, semiconductor manufacturing—measurement of residual pressure in process chambers; aerospace—measurement of very high altitude; and nuclear fuel processing—measurement of residual pressure in process chambers. Though calibration capability exists in this range, it is typically too expensive, too difficult to use and/or has uncertainties that are too high to satisfy the needs of industry.

DHI, founded in 1980 in Pennsylvania and now

located in Phoenix, Arizona, has reached sales of more than $10 million in 2000. DHI's customers include various types of organizations with high-end pressure and flow calibration needs, including aerospace, the military, semiconductor manufacturing, energy production, pharmaceutical, process control and national measurement institutes, like NIST.

For more information, contact Thomas Gould at Kennedy Space Center, 321/867-6238, *Thomas.Gould-1@ksc.nasa.gov* Please mention you read about it in *Innovation*.

System Analyzes Water Samples at Sea

NASA CHIEF SCIENTIST AND BIOLOGICAL oceanographer Dr. Richard Miller of the Earth Science Applications Directorate at Stennis Space Center in Mississippi needed a more efficient method of analyzing water samples at sea. The development of Ultrapath™ (an optical sample cell system with user-selectable path lengths), by World Precision Instruments Inc. (WPI), appears to suit his needs.

Miller conducts research aboard ships in ocean systems around the globe to support NASA's satellite programs. Water samples are obtained to verify the observations from space, particularly the concentration of Chlorophyll A, a molecule that absorbs light and is found in all plants. Colored Dissolved Organic Matter (CDOM) that is generally associated with land runoff is an important component that controls ocean color in coastal waters. The presence of CDOM complicates the use of color satellite sensors. Determining how CDOM absorbs light helps us evaluate the accuracy of products developed from satellite imagery, Miller explained.

"Until now, the standard procedure for processing seawater samples was to freeze them and then ship them to port for spectral analyses," Miller explained. "The procedure was time-consuming and costly. I had an idea there should be a better way."

Stennis Space Center's Office of Technology Transfer teamed Miller with WPI, a Florida-based, international manufacturer of laboratory equipment.

"The combination of significant commercial potential and government need made the arrangement of a cost- and risk-sharing agreement a natural for this project. This dual-use approach for government investment in technology development ensures that commercialization happens," said Kirk Sharp, manager of the Office of Technology Transfer.

Working together under a cooperative agreement, the company has developed and is now marketing the Ultrapath.

"Dr. Miller's design requirements over the last two years of development defined the need for a rugged instrument system to be used in the field that was capable of high-sensitivity measurements across widely divergent sample types," Mathias Belz, senior scientist for WPI, said. "It was a challenge to configure the solution."

Miller said the flexibility of the system solves a critical problem for oceanographers and opens the doors to numerous other applications.

For more information, contact Paul Foerman at Stennis Space Center, 228/688-1880, *paul.foerman@ssc.nasa.gov* Please mention you read about it in *Innovation*.

RTTC Delivers Licensee for Ames Technology

WORKING IN CONCERT WITH THE NASA AMES Commercial Technology Office, the Far West Regional Technology Transfer Center (RTTC) has pioneered a novel approach to technology transfer. A pilot project demonstrated the success of the approach when the Far West RTTC identified BreakAway Technologies and brought the company to Ames. BreakAway, a small, minority-owned business based in Los Angeles, licensed the Ames Spatial Auditory Display communications tool. The firm is focused on creating "smart neighborhoods" in which residents, businesses, churches, community-based organizations, social services and health agencies, schools and libraries are connected via digital technologies and have access to a virtual community of goods, services and information. Since 1998, BreakAway has established more than 200 community technology centers throughout the United States, primarily in California, whose function is "to strengthen the technological infrastructure of the urban community," according to Joseph Loeb, founder and president of BreakAway Technologies.

The December 2000–January 2001 issue of *Zone News* magazine hailed Loeb as one of a small number of architects and pioneers of the business world for the

year 2000. With corporate sponsors such as Microsoft, Sony, AT&T and Pacific Bell, BreakAway is in a strong position to create the strategic alliances that will enable successful commercialization of NASA technologies. BreakAway is interested in commercializing several Ames technologies, but initially selected the Multichannel Spatialization System for Audio Signals, also known as the Ames Spatial Auditory Display (ASAD), for its immediate promise in the field of audio technology.

The ASAD is a three-dimensional (3-D) audio processor designed to manipulate multiple sources, which places up to five different communication channels at fixed virtual auditory positions about the listener. This capability gives the listener a spatial sense of each channel originating from a unique position outside the head, as if five people were standing around the listener, speaking from different directions. BreakAway Technologies intends to further develop the technology for the computer and entertainment industries.

Over a period of several months, the Far West RTTC worked with the NASA Ames Technology Commercialization manager, David Lackner, and the small business to prepare and submit a license application and business plan for ASAD. As part of the license application effort, the Far West RTTC helped BreakAway collect market and competitor information for the enhanced technology. In May 2001, BreakAway Technologies negotiated and signed a non-exclusive license agreement with NASA for the ASAD patent.

Before the license application was prepared, the Far West RTTC assisted BreakAway Technologies in defining several technological enhancements and extensions to the basic NASA technology. This approach to technology transfer strengthens the value proposition by bringing NASA/Ames R&D closer to a viable product. BreakAway and the Far West RTTC feel that these extensions to the basic, underlying ASAD technology could lead to a vastly improved commercial position for the resulting enhanced technology. RTTC's involvement in the project continues, as they assist the nascent venture in securing funding.

"We applaud the efforts of our Far West Regional Technology Transfer Center in supporting the transfer of this NASA technology, while at the same time assisting a small, minority-owned empowerment zone company with the commercialization process," said Carolina Blake, chief of the NASA Ames Commercial Technology Office.

For more information, contact David I. Lackner, Technology Commercialization Office, NASA Ames Research Center, 650/604-5761, 650/604-1592, *dlackner@mail.arc.nasa.gov* or Durand R. Begault, Spatial Auditory Display Laboratory, NASA Ames Research Center, 650/604-3920, 650/604-0255, *dbegault@mail.arc.nasa.gov* Please mention you read about it in *Innovation*.

NASA MATERIAL HELPS COMPANY'S BOTTOM LINE

NASA technology helped ADMA president Vladimir Moxson improve his company's bottom line. ADMA, which specializes in powder metallurgy, had used NASA's composite material, PS200, for eight years. When NASA developed the newer PS300 composite, ADMA recognized its potential to make parts such as journal bearings more robust.

The PS300 composite, a self-lubricating bearing material containing chromium oxide, was developed as a coating to increase the life of foil bearings in oil-free systems. Because PS300 is stable at high temperatures under high loads, it is better suited than other materials for applications in many areas, such as aerospace, turbomachinery, rotary engines and transportation vehicles, including off-road and military vehicles. PS300 is applicable wherever there is a desire for lower weight, less maintenance or higher operating speeds and temperatures.

ADMA's initial application to license PS300 was not accepted by NASA. The Great Lakes Industrial Technology Center (GLITeC) was available to help the company. GLITeC interviewed company management, organized and defined the company's markets and customers, reviewed pricing and developed a plan for promotion and sales of the new product. GLITeC also evaluated the manufacturing economics to justify necessary capital expenditure. With GLITeC's help, the company submitted a new commercialization plan, and NASA granted ADMA's license application.

Dr. Moxson was pleased with the results, saying, "We have a considerable amount of time invested in working with PS300. Obtaining a license is critical to our business strategy, which calls for increased sales over the next five years and beyond. GLITeC stepped up to the plate for us and quickly facilitated our license."

Within two months of ADMA receiving the license from NASA, ADMA began to ship a new product made of the PS300 composite. During that time, ADMA also worked closely with the NASA developers to optimize the manufacturing processes and maximize yield. Working closely with NASA, ADMA was able to increase yields of the key starting material from five percent to 45 percent. These improvements reduced the price of the PS300 composite, reduced delivery times and increased ADMA's profits.

For more information, contact Mike Trzcinski at GLITeC, 216/898-6434, *trzcinskim@battelle.org* Please mention you read about it in *Innovation*.

Scientist Seeks to Improve Weather Prediction

A NEW NASA-DEVELOPED TECHNIQUE TO improve numerical weather prediction—one that looks to the ground as well as the clouds—may one day help forecasters improve the accuracy of spring and summer weather predictions.

Atmospheric scientist Bill Lapenta, of the Global Hydrology and Climate Center, based at the National Space Science and Technology Center (NSSTC) in Huntsville, Alabama, is researching a new method for improving numerical weather prediction in the Southeast United States. Funded through the U.S. Weather Research Program, the research is a cooperative effort between NASA and the National Oceanic and Atmospheric Administration (NOAA).

Numerical weather prediction is a complicated business, using data from many sources and combining them to form a prediction of tomorrow's weather. Like a chef creating a favorite dish, Lapenta's recipe, or equation, for weather prediction includes ingredients used by many, along with specialty items used by few.

LIKE A CHEF CREATING A FAVORITE DISH, LAPENTA'S RECIPE, OR EQUATION, FOR WEATHER PREDICTION INCLUDES INGREDIENTS USED BY MANY, ALONG WITH SPECIALTY ITEMS USED BY FEW.

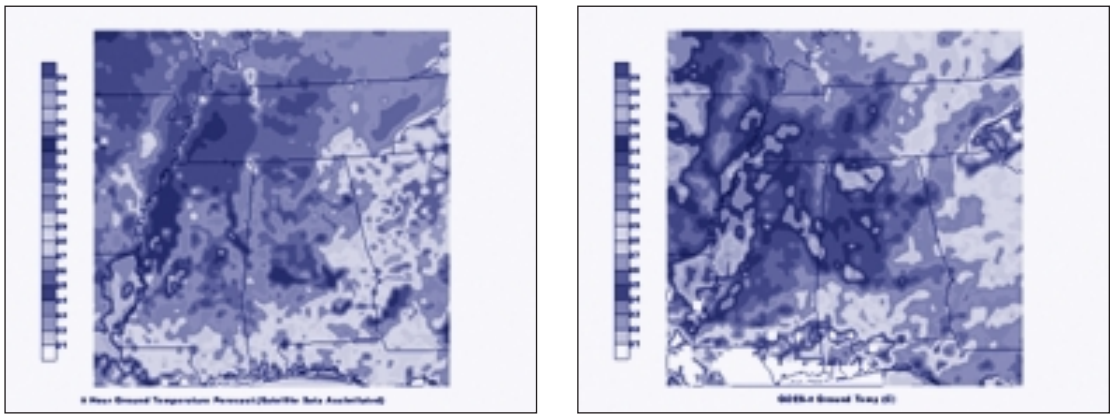
In addition to standard data—such as current air temperature, humidity and wind speed—he adds a dash of specialized data from Geostationary Operational Environmental Satellites maintained by NOAA.

Using the satellite data adds detailed ground-level information to the numerical forecasts—something Lapenta believes can help forecasters increase the accuracy of predictions. "Understanding weather is more than understanding what's happening high in the clouds," he said. "The satellite data takes into account conditions at ground level, where the weather impacts most people."

This method incorporates factors such as variations in the way different land surfaces react to the energy emitted by the sun.

"From prior NASA research, we know that parking lots, which absorb and hold heat, tend to become much hotter during the day than forests, which are cooled by evaporation," he said.

"Also, the amount of water in the top layers of the soil affects how the Sun's energy heats the overlying air. If the soil is wet, more energy is used to evaporate



Left: A nine-hour ground temperature forecast, made at 3 p.m. September 19, 2000, reflects the addition of satellite data to a previous forecast. Right: The actual temperature, measured at 3 p.m. September 19, 2000, appears similar to the forecast which was adjusted using satellite data. Photo provided by Marshall Space Flight Center.

moisture than to heat the land and air. We adjust the initial estimate of moisture availability so that the predicted air temperature follows what the satellite senses. The satellite data helps the model to account for such differences in the temperature of the land surface."

Even though the weather-prediction equations are complex, the concept is quite straightforward. Lapenta's model uses an array of geographic grid points. Using these points, the method starts by creating a "snapshot" of the current state of the atmospheric winds, temperatures and humidity. The next step is to use mathematical equations to predict the evolution of the atmosphere over the course of 48 hours.

"Many details are factored into the weather-prediction equations," he said. "For example, today's rainfall may become tomorrow's humidity through evaporation from the wet soil."

When all standard factors are calculated into his formulas, there is enough information for an initial forecast, but that's not where it ends. He then adds the satellite data, which makes adjustments to the soil moisture availability at each grid point—this can have a dramatic impact on the original prediction.

Lapenta is concentrating on spring and summer weather, because precipitation during warm-weather seasons has been traditionally more difficult to predict.

In addition to improving the accuracy of short-range (0–48-hour) predictions of temperature, humidity and precipitation, Lapenta's goal is seeing this new method implemented within other models, including those used by the National Weather Service. He also sees potential for using the method to improve urban and air-quality modeling.

This is a joint research project with Dick McNider of the University of Alabama in Huntsville, and supported by Ron Suggs and Gary Jedlovec, NASA scientists in the Global Hydrology and Climate Center, who process the satellite data. All are located at the National Space Science and Technology Center.

A collaboration that enables scientists, engineers and educators to share research and facilities, the NSSTC is a partnership with NASA's Marshall Space Flight Center (in Huntsville, Alabama), Alabama universities and federal agencies. Opened in 2000, it focuses on space science, materials science, biotechnology, Earth sciences, propulsion, information technology, optics and other areas that support NASA's mission.

For more information, contact Al Jordan at Marshall Space Flight Center, 256/544-6532, *Alton.F.Jordan@msfc.nasa.gov* Please mention you read about it in *Innovation*.

Helping Farmers Compete in World Markets

THE UNITED STATES HAS THE LARGEST AND most productive agricultural sector in the world, but high production costs, low commodity prices and an overall high level of risk increasingly challenge American farmers. NASA's John C. Stennis Space Center is taking a lead role in helping farmers meet these challenges.

To help American farmers better compete in the world market, NASA and the United States Department of Agriculture (USDA) started the Ag 20/20 program in 2000. The aim of Ag 20/20 is to utilize NASA research and technology to create tools that a farmer can use to more efficiently manage production, save money and help preserve the environment.

"The program demonstrated opportunities for significant savings for farmers with new fertilizer, herbicide and pesticide application techniques last year. This summer, the program is seeing even more positive results," said Ag 20/20 technical manager Rodney McKellip of NASA's Earth Science Applications Directorate at Stennis.

Dr. Jay Hardwick's 7,200-acre cotton farming operation near Newellton, Louisiana is a site of one Ag 20/20 project this year. NASA researchers are teaming with Louisiana State University (LSU) to use digital photographs taken from an airplane or satellite to determine where in a field the farmer needs to apply such things as pesticides or plant growth regulators. The images are used to create a color vegeta-

Using the same handheld computer systems similar to many of today's personal data assistants, downloaded images are matched with GPS data to give their exact location on a grid of farmland. Researchers offer their entomological expertise to determine what areas of the research fields need to be sprayed with pesticides or plant growth regulators. Photo provided by Stennis Space Center.

tion index map that separates the field into several categories of vegetation health.

"This is the crucial step in the project, because certain crop-damaging insects are first drawn to the most healthy areas of a cotton field," McKellip said. "By knowing where these harmful pests are most likely to be, we are better able to prescribe a cost-efficient treatment that applies pesticides only to at-risk areas of the field. In addition to saving the farmer money, using less pesticide to control bugs in cotton has the added benefit of less impact on the environment."

Technicians, scientists and students from LSU working on the ground utilize the NASA imagery. Using the same handheld computer systems similar to many of today's personal data assistants, downloaded images are matched with GPS data to give their exact location on the farmland grid. The LSU researchers offer their entomological expertise to determine what areas of the research fields need to be sprayed after scouting a number of locations in the fields. The technicians then transmit insect infestation data back to Stennis.

From there, the researchers work with the farmer and his consultants to determine an exact insecticide prescription to apply—one that adequately controls the insect pressures while saving the farmer money on labor and chemicals. In similar tests last year, this "precision" approach to pesticide application for cotton was shown to be 22 percent less costly than the traditional whole-field application. That savings is significant, since insecticides represent one of the largest variable costs for a cotton farmer.

The Ag 20/20 program is involved with other projects beyond the cotton fields of the Hardwick farm. Corn, cotton, soybean and wheat growers in the West, Midwest and Southeast are currently involved in the projects that address other priority issues in commodity production. NASA and the USDA remain committed as a team, working together toward the benefit of American agriculture.

As the program knowledge and methods mature, and U.S. farmers continue to compete in the world market, the Ag 20/20 program may well prove a defining edge for future American farming viability in the global economy.

For more information, contact Paul Foerman at Stennis Space Center, 228/688-1880, *paul.foerman@ssc.nasa.gov* Please mention you read about it in *Innovation*.

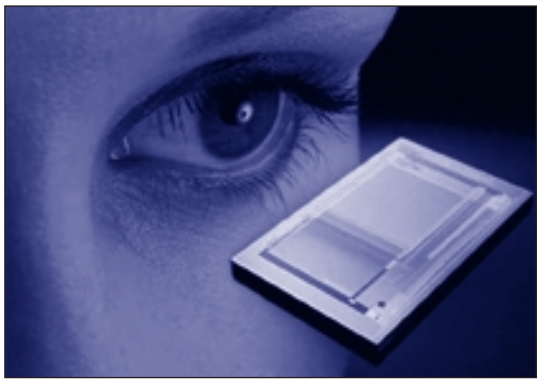
A Computer Like Your Brain

A NEW NASA-DEVELOPED COMPUTING DEVICE allows machines to work much like the brain. This technology may allow fast-thinking machines to make decisions based on what they see. A planetary rover might use this technology to avoid obstacles, select scientifically interesting spots to explore just by what it sees and navigate through terrain on its own without review from ground controllers. A spacecraft might use the technology to avoid hazards and identify a pre-selected landing site with very high precision.

"This may well be recognized as a quantum leap in the pursuit of intelligent vision, allowing machines to be significantly more autonomous," said Dr. Anil Thakoor, supervisor of the Bio-Inspired Technology and Systems Group at NASA's Jet Propulsion Laboratory in Pasadena, California.

The device works much like the brain, whose power comes from the complex networks of interconnections called "synapses" between brain cells. Networks of these brain cells, called neurons, allow humans to make instant decisions based on an observed image or scene. The new processor captures the same capability to process images in real time as a scene unfolds.

The Three-Dimensional Artificial Neural Network processor is capable of recognizing objects in real time and in highly cluttered background scenes. It can process an image and is capable of a certain degree of judgment about the objects, much the same



The Three-Dimensional Artificial Neural Network processor is capable of recognizing objects in real time and in highly cluttered background scenes. Photo provided by Jet Propulsion Laboratory.

way a person looks at a variety of objects and makes judgments about the nature of those objects.

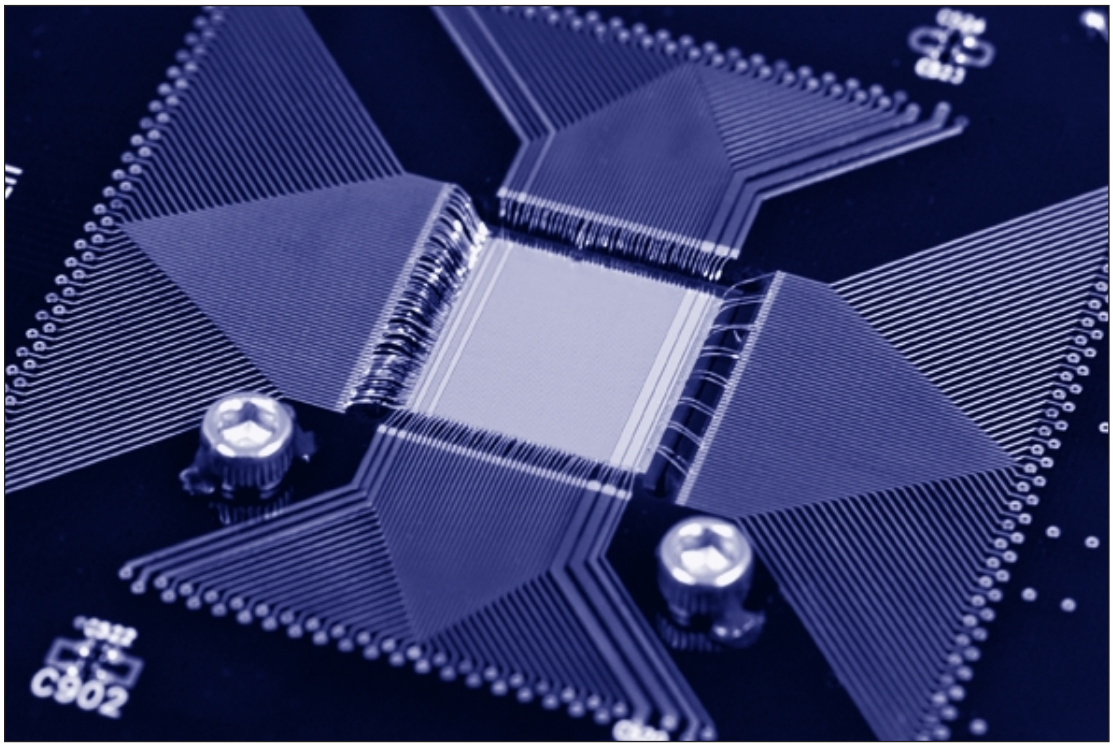
Two technologies give the compact processor an unprecedented ability to process a stream of images in a way similar to that used by the human eye-brain combination. One is the JPL-pioneered, highly interconnected networks of ultra-low-power electronic synapses on very large-scale-integrated (VLSI) chips that mimic the core of a brain. The other is the three-dimensional stacking of those chips in a sugar cube-sized package developed by Irvine Sensors Corporation of Costa Mesa, California. Irvine Sensors is a successful NASA SBIR firm that has commercialized the stacked chip technology.

The device achieves a computing speed of more than a trillion operations per second, using only eight watts of power. That is more than a thousand times faster than a typical commercially available desktop computer that consumes more than 100 watts of power. Engineers believe potential commercial benefits for the new technology may be found in public safety and in creating a personal computer that can respond to users' emotional states by simply recognizing the users' facial expressions. The development may also be useful to the video game industry in improving interactive technologies.

> "This may well be recognized as a quantum leap in the pursuit of intelligent vision, allowing machines to be significantly more autonomous"
>
> –Dr. Anil Thakoor, supervisor of the Bio-Inspired Technology and Systems Group at NASA's Jet Propulsion Laboratory

JPL's Center for Space Microelectronics Technology, under sponsorship from the Ballistic Missile Defense Organization, developed the processor. It allows real-time onboard target recognition by an interceptor for missile defense.

For more information, contact Dr. Anil Thakoor at Jet Propulsion Laboratory, 818/354-5557, *anilkumar.thakoor@jpl.nasa.gov* Please mention you read about it in *Innovation.*



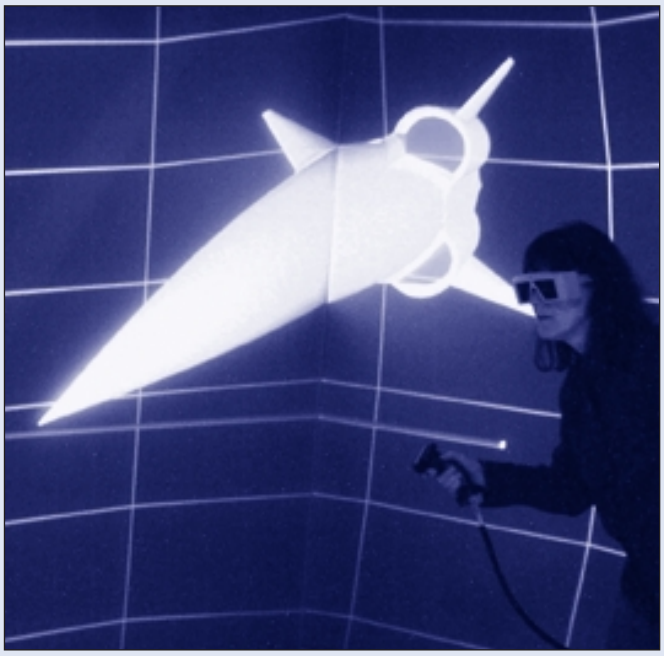
The 3DANN-R chip is especially good at searching for objects, such as craters on a planet or details of terrain on Earth. Low-power consumption combined with high performance are key attributes to this innovative technology. Photo provided by Jet Propulsion Laboratory.

RAVE ABOUT NEW GLENN FACILITY

The ability of researchers to become completely immersed in an exploration of their data or to realistically simulate how a potential experiment would be performed in space is becoming a reality—a virtual reality—using 21st century technology.

A new facility, the Glenn Reconfigurable User Interface and Virtual Reality Exploration Laboratory, known as the GRUVE Lab, at NASA Glenn Research Center in Cleveland, Ohio, has made that possible.

The GRUVE Lab features a RAVE (Reconfigurable Advanced Visualization Environment), which enables the user to be immersed in a virtual environment created through computer imaging. The RAVE consists of three large eight-foot by eight-foot, rear-projection screens housed in large, moveable boxes. Each unit is equipped with air casters and can be raised and rolled into different viewing configurations, forming a flat display wall, a panoramic view or a CAVE (Configurable Automated Virtual Environment). The CAVE configuration is achieved when the two outer units are moved inward until they are at a 90-degree angle to the one in the center. Another projector and a retractable mirror are positioned to generate an image on the flooring surface of this three-sided room.



A model is positioned in the RAVE by a user wearing stereoscopic glasses and using a handheld wand. Photo provided by Glenn Research Center.

"The display wall is ideal for displaying large amounts of data where researchers can look up close at small details or step back to see the big picture," said Jay Horowitz, manager of Glenn's GRUVE Lab. "The panoramic view configuration is good for flight simulator-type visualization or for displaying several panels of data and video like a virtual control room. The CAVE gives one the sense of being fully immersed in a virtual reality simulation."

Although none of the configurations is unique in itself, what makes Glenn's GRUVE Lab different from most other virtual reality facilities is the ability to reconfigure the RAVE into any of the three positions and to do it in a few hours. Usually, the CAVE is a fixed configuration with walls that cannot be moved.

"Initially, Glenn engineers and scientists, whose data will be adapted to the RAVE or who are already doing research with universities that have similar technology, will use the GRUVE Lab," said Horowitz. "We foresee supporting a larger range of applications that could include work with local Cleveland businesses and organizations in the areas of education, biomedicine and art."

The GRUVE Lab can be networked to other NASA Centers to allow data, voice and video communication among researchers at the remote sites to "share" the virtual space. Researchers working on a common project would be able to discuss the data they are looking at while pointing out various features to one another and manipulating data to see it from other angles.

The GRUVE Lab uses a Fakespace Systems Inc. RAVE and Silicon Graphics, Inc. graphic supercomputers.

For more information, visit *http://gruve.grc.nasa.gov* or contact Dorothy Carney, 216/433-8261, *Dorothy.V.Carney@grc.nasa.gov* Please mention you read about it in *Innovation*.

Engine Technology Completes Aggressive Test Schedule

THE TEST TEAM AT NASA'S STENNIS SPACE Center in south Mississippi successfully completed an accelerated test schedule with the third and final test of a three-part test series of the Electro-Mechanical Actuator (EMA) technology used on the former X-33 program's XRS-2200 Linear Aerospike flight engine set. The test began at 7:58 p.m., Monday, August 6, and ran for a full 90 seconds, reaching the planned maximum power of 85 percent.

"This was a very aggressive test schedule," said NASA's Dr. Don Chenevert, EMA project manager at Stennis. "In less than three months, the test team brought the engine back on line and prepared it for the three hot-fire tests which began with a 5.32-second start-sequence test July 12. We couldn't be more pleased with the program or the results."

With the Linear Aerospike XRS-2200 flight engine set already mounted on the A-1 test stand when funding for the X-33 program was discontinued in March, testing of the EMA technology was a unique opportunity for NASA to effectively gain valuable experience and data from existing commercial technology.

The series was conducted as part of NASA's Second-Generation Reusable Launch Vehicle Program—also known as the Space Launch Initiative. The program is led by NASA's Marshall Space Flight Center in Huntsville, Alabama. The technology development program is designed to increase safety and reliability while reducing costs for space travel.

Electro-mechanical actuators electronically regulate the amount of fuel and oxidizer flowing to the engine. The new technology is a potential alternative and improvement to the older pneumatic and hydraulic-fluid systems currently used by the aerospace industry to drive and control critical rocket engine valves.

"Because every engine proposed by industry for a second-generation vehicle has EMAs, we took advantage of these aerospike engines already in position on the test stand at Stennis to explore this relatively new technology now—saving us valuable time later," said Garry Lyles, Propulsion Projects Office manager of the Second-Generation Reusable Launch Vehicle Program at Marshall. "This data is critical toward developing the confidence required to support the use of these actuators on future launch vehicles."

"This series of engine firings tested the actuator control system in what we call a 'real condition of use' environment," said Dr. Chenevert. "Firing allows us to see how the integrated system handles the extreme cold of cryogenic propellants, the stress loads of the propellants pushing through the valves and the dynamic response to commanded flow rate changes. Additionally, we have many other unique conditions such as shock and vibration loads not found in a lab, so we capture more realistic data about the true performance of the actuators."

The Rocketdyne Propulsion and Power Unit of The Boeing Company in Canoga Park, California developed the aerospike engine and supported the engine tests at Stennis.

Stennis Space Center conducted the final test of a three-part test series of the Electro-Mechanical Actuator (EMA) technology used on the former X-33 program's Linear Aerospike XR-2200 flight engine. Photo provided by Stennis Space Center.

For more information, contact Paul Foerman at 228/688-1880 or paul.foerman@ssc.nasa.gov Please mention you read about it in *Innovation*.

Airborne Tracking System Being Tested

KEEPING UP WITH AIRCRAFT FLYING OVER the Gulf of Mexico is difficult if not impossible in some instances. Now that may change, with the help of NASA and the Department of Transportation (DoT), which are testing a new in-flight tracking system that is smaller, less costly and more flexible than anything seen to date.

The Advanced Air Transportation Technologies (AATT) project, led by NASA's Ames Research Center, Moffett Field, California and the DoT's Volpe National Transportation Systems Center in Cambridge, Massachusetts, is being put through its paces in Louisiana, offshore from Intercoastal City. The current testing is designed to evaluate the operational benefits of the system for fleet management in the Gulf.

The in-flight tracking system uses multiple small ground stations to triangulate on an aircraft's transponder signal, accurately determining its position. "Radar coverage, particularly at low altitudes, is non-

existent over most of the Gulf of Mexico. The in-flight tracking system will provide operators with precise aircraft position data. The data from the tests will be evaluated by operators as a possible flight tracking system," said Mike Landis, AATT project manager at Ames.

The system's attributes permit ground stations to be placed in areas that are not feasible for beacon radar. This includes remote areas, open water and sites with mountainous terrain. These characteristics make the system particularly suitable for tracking low-flying aircraft that cannot be monitored adequately by standard radar systems.

For more information, contact Cathy Pochel at NASA Ames Research Center, Commercial Technology Office, 650/604-4595, *cpochel@mail.arc.nasa.gov*, *http://ctoserver.arc.nasa.gov/* Please mention you read about it in *Innovation*

SATS Teams Selected

NASA HAS SELECTED FOUR TEAMS TO PARTICIPATE in the first phase of the new Small Aircraft Transportation System (SATS) research and development program. SATS is a five-year, $69-million proof-of-concept program managed by the NASA General Aviation Programs Office, NASA Langley Research Center, Hampton, Virginia.

Through shared public and private investments in the Advanced General Aviation Transportation Experiments (AGATE) project, and (in part) due to the General Aviation Revitalization Act of 1994, improvements are being made to small aircraft that make them easier to fly, safer to fly and more affordable to purchase and operate. New general aviation

INFLATABLE WING PROVES ITSELF

During test flights of the I2000 inflatable wing aircraft, the radio-controlled (R/C) I2000 was airlaunched from an R/C utility. As the I2000 separated from the carrier aircraft, its inflatable wings "popped-out," deploying rapidly via an onboard nitrogen bottle. Photo provided by Dryden Flight Research Center.

Dryden Research Engineering staffers and Projects personnel have been flying a deployable, inflatable wing technology demonstrator experiment. The inflatable wing team includes Jeff Bauer, Jim Murray, Joe Pahle, Tony Frackowiak, Bob Allen and John Redmond. They have worked hard to get the test vehicle, the I2000 radio-controlled (R/C) airplane, to the project's current point of success.

Three successful flights have taken wing. During the flights, the team air-launched the I2000 from an R/C utility vehicle airplane at an altitude of 800–1,000 feet. As the I2000 separated from the carrier aircraft, its inflatable wings "popped-out," deploying rapidly via an onboard nitrogen bottle. The aircraft remained stable as it transitioned from wingless to winged flight. The unpowered I2000 glided down to a smooth landing under complete control.

Dryden's inflatable aircraft project manager Jeff Bauer noted that, "with these tests we have put some reality behind the many imagined applications for inflatable winged aircraft."

There is data to verify and validate computer models of inflatable wings for the future. The I2000 was equipped with a miniature flight data recorder designed by Jim Murray. That data, in addition to video and the photographic records, provides valuable insights into the aircraft's flight dynamics.

"We are particularly interested in the dynamics of the vehicle during the rapid wing deployment, the transition from wingless flight to winged flight. We proved that we have a good flying vehicle during the transition to wings fully deployed," says Joe Pahle, project engineer.

Flight testing of the I2000 followed a conservative "build-up" approach common in developmental flight testing. They began flying the I2000 with rigid wings having the same physical dimensions as the inflatable wings. Following successful flights with the conventional rigid wings, the actual inflatable wings were flown pre-inflated on the I2000. These risk-reduction efforts were all geared to narrowing the possibility of trouble in launching and flying with the deployable wings. Tony Frackowiak, of Dryden's model shop, built all the glider models and the R/C aircraft used in the project, and served as the I2000 pilot.

"There were no surprises since I was well-prepared for the actual wing deployment flights," says Frackowiak. "We flew the I2000 build-up style in the powered mode with the wings pre-inflated. The drop and wing deployment was so smooth that the rest of the flight and landing was uneventful."

aircraft will use advanced technology control and display systems, data communications systems and navigation and weather systems. They will also have new landing systems that allow operation in nearly all weather conditions at non-radar, non-towered landing facilities.

Four teams will participate in the initial research and development phase. Each team is a partnership of industry, state government, nonprofit organization and academic institution.

The teams have signed cost-sharing agreements with NASA that provide a total investment of approximately $13 million for the first year of the program. The NASA portion of the investment is approximately $7.5 million. The four teams will work independently on portions of the total effort.

Each team has provided a brief description of their agreement with NASA. Those descriptions are included below.

Maryland SATS Lab Team

The Maryland Advanced Development Laboratory (MADL) of the University Research Foundation has formed the Maryland SATS Laboratory (SATS Lab) team.

The local synergy required to coordinate and execute the SATS initiative will be provided by state agencies and industries such as the Maryland Aviation Administration, Hinson Corporate Flight, Inc., ARINC Inc., Airpark Sales and Services, and the University of Maryland Labs. The Maryland team has partnered its local assets with leading corporations including Applied Science Technology (ASI), Cirrus Design, Decision Studies Inc. (DSI), Lancair Company, UPS Aviation Technologies and Science Applications International Corporation (SAIC).

The inflatable wing has a span of 5.5 feet. In the undeployed stowed state, the wings fit in a container the size of a small coffee can.

An onboard compressed nitrogen gas source at 1,800 psi is used to inflate the wings in flight. Wing deployment time is typically on the order of 0.33 seconds, almost faster than the human eye can see. The wing pressure after inflation (180–200 psi) is sufficient to give the 15-lb I-2000 aircraft a load capability in excess of 3 g.

With the I2000 flights completed, the project's impending goal is to successfully fly a four-foot-long X-24A model with inflatable wings. The X-24A model effort is a complementary but separate effort in demonstrating the utility of inflatable wings.

The X-24A shape was chosen due to the fact that it has a well-established aerodynamic database. It represents lifting body vehicles in general and has upper body flaps for additional roll control. The inflatable wings do not have flight controls, so the body flaps are critical for flight control. The I2000's tail surfaces filled the gap on the standard configuration airplane. Potential advantages of utilizing inflatable wings on future lifting body vehicles include providing greater cross-range and lower landing speeds than totally wingless vehicles.

Potential applications of inflatable wings include Earth science aircraft, any volumetrically limited aircraft and planetary research aircraft. In addition, a Helios-type high-altitude, long-endurance platform could conceivably carry multiple small deployable inflatable wing aircraft to release as "probes" to more closely investigate areas of interest located by the platform's sensors.

The deployable inflatable wings were constructed by Vertigo, Inc., as a subcontractor for a U.S. Navy Phase II Small Business Innovation Research contract. The contract previously utilized the wings tested on a gun-launched vehicle to add glide capability.

Inflatable aircraft have been around since the 1960s. Goodyear Tire Company built and flew several full-sized, entirely inflatable two-person aircraft under military contract. Furthermore, Goodyear lab-tested several small inflatable lifting body reentry vehicle models. These models rapidly inflated rearward out of solid ballistic reentry nosecones. The nosecones remained attached, forming the nose of the inflated vehicles.

However, these aircraft used low-pressure (7–9 psi) air to inflate and keep the structures inflated. The wings of the Goodyear aircraft were not cantilevered, therefore requiring external support in the form of cables running from the fuselage to the wings.

The deployable inflatable wings used by Dryden team members are relatively high pressure at 180–200psi. The current wings are manufactured differently using an advanced high-pressure material known as Vectran. As they are cantilevered, the tough wings support their own weight, as well as the weight of the aircraft in flight.

For more information, contact James Murray at Dryden Flight Research Center, 661/276-2629, *murray@rigel.dfrc.nasa.gov* Please mention you read about it in *Innovation*.

The focus of the Maryland team will be to evolve existing flight-related procedures, integrate the team's existing and developmental technology, and study the human factor requirements for both the experienced pilot and novice aircraft operator. The team's ability to perform these tasks is aided by the use of multiple small civil aircraft already configured with developmental systems, recording and analysis equipment.

North Carolina—Upper Great Plains SATS Lab Team

The North Carolina—Upper Great Plains SATS Lab team partners state aviation authorities, small airports, industry, universities and other private and nonprofit organizations in an ambitious plan to implement a three-tier air transportation system in North Carolina by 2003.

Participating states include Kansas, Nebraska, North Carolina, North Dakota, Oklahoma and South Dakota. Industry partners include ARNIC, Cessna, Nav3D, Piedmont Hawthorne Aviation, Rannoch, Raytheon, Rockwell Collins, Seagull Technology, Telford Aviation, UPS Technologies and United Airlines. Private partners include Hoh Aeronautics and Human-Machine Solutions. Academic and nonprofit partners include the University of Kansas, University of Nebraska at Omaha, University of North Carolina's Keenan Institute, North Carolina State University and the Research Triangle Institute. The NASA portion of the project over the next year is roughly $1.5 million, and the cost share from the partnership is approximately $1 million.

Seven small airports, located primarily in North Carolina, will participate in the initial demonstrations. The team will focus on the integration of technology advances in Ssynthetic Vvision, Highway in the Sky (HITS) and advanced flight controls. The premier demonstration will occur at Kitty Hawk at the Dare County Airport in celebration of the Centennial of Flight, December 2003.

Southeast SATS Lab Consortium (SESLC)

Southeast SATS Lab Consortium (SESLC), led by Embry-Riddle Aeronautical University, was officially incorporated in the state of Florida in September 2000. This represented the direct membership of the SESLC, including more than 40 aviation and technology companies, airframe manufacturers, aviation infrastructure providers, universities, airport managers and aviation authorities, pilots and professional associations across the nation. Through members like the Florida Space Grant Consortium, The National Safe Skies Alliance and the Florida Aviation Trades Association, the SESLC reaches more than 200 aviation-related organizations that are interested in changing the future of personal transportation. More than two dozen airports in the Southeastern United States are either SESLC members, or becoming members, and each has expressed interest in hosting SATS experiments and demonstrations. States represented in the membership include Florida, Georgia, Tennessee, Ohio, New York, Massachusetts, Maryland, Michigan, Oregon, Arkansas and Virginia. Other government organizations participating in the project include the FAA Southern Region, Florida Department of Transportation, FAA Orlando Airports District Office and Enterprise Florida.

The Southeast SATS Lab Team expects to receive $2.5 million from NASA. Another $2.5 million is expected from member industry and airport organizations. The funding will enable experiments and demonstrations in a network of airports throughout the Southeastern states.

Virginia SATS Lab

The Virginia SATS Lab Research Alliance, led by George Mason University, is expected to receive $2.5 million to conduct research and analysis that will lead to a state-based Small Aircraft Transportation System flight demonstration in 2005.

The alliance includes George Mason University, Virginia Tech, Ohio University, Virginia Department of Aviation, Arthur D. Little, Athena Technologies, Inc., Aurora Flight Sciences Corp., ARNAV, Inc., ARINC, Aviation Systems Engineering, Inc., Cirrus Aircraft, Colgan Air, Dulles Aviation, Rannoch, Inc., The Preston Group, Trios Associates, Inc. and the American Institute of Aeronautics and Astronautics. The Virginia project includes five airports and utilizes the statewide data link services funded by the Virginia Department of Aviation (VDOAV) and provided by ARNAV, Inc. The Alliance project hopes to prove that a single-pilot small aircraft can be safely sequenced and separated in Instrument Meteorological Conditions (IMC) at higher volume airports without a terminal radar controller or a control tower with mixed aircraft equipage, can land in low-visibility weather conditions at minimally equipped airports and can accomplish autonomous operations while flying in uncontrolled airspace.

For more information, contact Keith Henry at Langley Research Center, 757/864-6120, *H.K.Henry@larc.nasa.gov* Please mention you read about it in *Innovation*.

New Aircraft Ice-Protection System

FOR THE FIRST TIME IN 40 YEARS, A NEW AIRcraft ice-protection system has been approved by the Federal Aviation Administration (FAA) for use on a new business jet. The NASA Glenn Research Center in Cleveland, Ohio supported the development of the ice-protection system through its Small Business Innovation Research (SBIR) funding program and through technical and testing support of researchers at Glenn.

The ice-protection system, built by Cox & Company, Inc., New York, New York, is a hybrid that uses both thermal anti-icing and mechanical de-icing to keep wings and other lifting surfaces clear of ice. The anti-icing part of the system heats the front (or leading) edge of the airfoil, preventing any ice from forming there. Past the heated leading edge, the mechanical de-icing part periodically deflects the wing skin to break and remove any ice that forms there. The mechanical de-icer is a new ice removal technology called the Electro-Mechanical Expulsion De-icing System (EMEDS). Together, the anti-icing and de-icing parts form an ice-protection system well-suited for airfoil leading edges where ice contamination can degrade aerodynamic abilities. The system uses much less energy than other systems that provide equivalent protection.

"Their idea to combine two ice-protection schemes was particularly innovative," said Andrew Reehorst, an icing research engineer at Glenn. "For us, the FAA approval culminates 20 years of NASA efforts to foster the development of a practical, low-power ice-protection technology."

The system is in production for Raytheon Aircraft's new Premier I business jet, where it is used on the horizontal stabilizer. Cox expects its revenues to be more than $10 million over the next several years.

"Now that we have FAA certification, we have a credibility that nothing else can give us," said Warren Achenbaum, chairman and CEO of Cox & Company. "EMEDS is very efficient and adaptable. While our emphasis has been on the Premier I, it also has been selected by VisionAire for the Vantage. Other companies are considering its use." Achenbaum added, "the support from NASA and its SBIR program, and from Raytheon, during the development of the system was invaluable to our company."

Glenn, now celebrating its 60th year as a federal research facility, began testing ice-protection systems in 1944 when its Icing Research Tunnel was completed. Most ice-protection technologies in use today were largely developed at the tunnel. In 1987, the American Society of Mechanical Engineers designated the Icing Research Tunnel an International Historic Mechanical Engineering Landmark for its leading role in making aviation safer for everyone.

A new aircraft ice-protection system, developed by Cox and Company, with support from Raytheon and NASA, is prepared for testing in GRC's Icing Research Tunnel. Photo provided by Glenn Research Center.

For more information, contact Dean Miller at Glenn Research Center, 216/433-5349, *Dean.R.Miller@grc.nasa.gov* or Andrew L. Reehorst at Glenn Research Center, 216/433-3938, *Andrew.L.Reehorst@grc.nasa.gov* Please mention that you read about it in *Innovation*.

Space Shuttle AI Software Commercialized

THE SAN MATEO, CALIFORNIA COMPANY Stottler Henke Associates, Inc. (SHAI) is commercializing an artificial intelligence (AI)-based software system developed to help NASA with complex space shuttle scheduling decisions.

The Automatic Scheduling System, known as the Automated Manifest Planner (AMP) at Kennedy Space Center, was designed using AI techniques, allowing expert shuttle schedulers to input their knowledge to create a working automatic scheduling system. SHAI president Richard Stottler said his firm is marketing this software tool and other related products and services to industries involved with many resources, activities and constraints, particularly when it is desirable to plan and project changes for many cycles or years ahead.

This type of scheduling is common in vehicle assembly plants, batch processing plants, semiconductor manufacturing, printing and textiles, surface and underground mining operations, and maintenance shops, where scheduling the use of different

pieces of equipment that work together impacts production rates and costs. For most of SHAI's commercial sales, the company obtains a service contract to customize AMP to a specific domain and then issues the customer a user license, Stottler explained.

NASA/KSC is using the AMP product to develop optimal manifest schedules which support ongoing shuttle program efforts to reduce labor costs. Current commercial sales total $400,000, exceeding NASA's SBIR investment, and private investment is at $50,000.

AMP can be readily adapted by end-users for a variety of domains. A key advantage of the tool is that it enables advanced use of rules of thumb (heuristics) developed by expert schedulers to be used to automatically schedule activities based on resource limitations and a wide range of other constraints. It also provides a constraint-authoring system for adding other constraints to the scheduling process. The product is extremely flexible and user-friendly, and can plan orders of magnitude faster than existing tools. One user recently reported that he had to perform more than 100 planning studies in a year, which would have been impossible without AMP.

Other NASA Centers are also benefiting from this technology. With an increased workload for the planners to schedule the International Space Station assembly and operations, NASA needed more automation in their scheduling process. SHAI developed the Intelligent Flight Activity Planner (IFAP) to address this need. IFAP provides both a planning and scheduling component. In the weeks prior to the actual time of activity performance, NASA planners use the high-level planning component to lay out tentative plans that assign flight activities to specific days.

Also, an SBIR contract with Johnson Space Center led to the development of an intelligent fault diagnosis and recovery planning system designed to help astronauts minimize the need for ground support during long-duration missions. The new software will enable astronauts to diagnose problems and affect repairs in their advanced life support systems without assistance from engineers on the ground.

The AMP was developed under a Phase II Small Business Innovation Research (SBIR) contract involving SHAI and NASA at Kennedy Space Center, from 1992 to 1994. It was developed in response to NASA's need to automate the scheduling decision-making associated with maintaining the long-term shuttle-processing schedule. NASA's Mission Planning Office used AMP to perform scheduling studies and maintain the schedule known as the "mission manifest."

In 1994, the Mission Planning Office was dissolved, and the long-term planning component was transferred to United Space Alliance (USA), the primary shuttle contractor at KSC. The system allowed personnel unfamiliar with long-term scheduling to maintain it without years of previously required training. AMP has now been used on a daily basis for seven years to maintain manifests, perform advanced "what if" studies and produce manifest reports for all NASA Field Centers. USA also adapted AMP to automatically schedule the detailed, short- and long-term External Tank and Solid Rocket Booster (ET/SRB) and orbiter processing schedules, vastly improving the previous manual scheduling process.

For more information, contact Tom Gould at Kennedy Space Center, 321/867-6238, *Thomas.Gould-1@ksc.nasa.gov* Please mention you read about it in *Innovation*.

SBIR AND STTR PROJECTS SELECTED

NASA has selected a total of 325 research proposals for negotiation of Phase I contract awards. Of the 325 projects, 305 have been selected for NASA's 2001 SBIR Awards, and 20 have been selected for the STTR Program.

The goals of SBIR and STTR are to stimulate technological innovation, to increase the use of small business—including women-owned and disadvantaged firms—in meeting federal research and development needs, and to increase private sector commercialization results of federally funded research.

The 2001 SBIR and STTR combined solicitation closed on June 6, 2001. NASA received 1,659 SBIR and 57 STTR proposals submitted by small, high-technology businesses from 34 states. The combined award total for the 325 Phase I contracts is expected to be $23.4 million, with $21.4 million going to SBIR Awards and $2 million to STTR.

Nine of the 10 NASA Field Centers reviewed SBIR and STTR proposals for technical merit and feasibility, and relevance to NASA research and technology requirements. The Jet Propulsion Laboratory evaluated SBIR proposals only. The selected firms will be awarded fixed-price contracts valued up to $100,000 for STTR and $70,000 for each SBIR to perform a Phase I feasibility study.

Companies successfully completing the Phase I activities are eligible to compete for Phase II selection the following year. The Phase II award allows for a two-year, fixed-price contract up to $600,000 for SBIR and $500,000 for STTR.

The NASA SBIR/STTR Program Management Office is located at the Goddard Space Flight Center, Greenbelt, Maryland, with executive oversight by NASA's Office of Aerospace Technology, NASA Headquarters, Washington, DC. Individual SBIR and STTR projects are managed by the NASA Field Centers.

For more information, contact Carl Ray, NASA SBIR/STTR Program Management Office, Goddard Space Flight Center, 202/358-4652. Please mention you read about it in *Innovation*.

SBIR Inflatable Concentrator Tested for Space

BALLOONS IN SPACE MAY SEEM IMPROBABLE, but researchers have just finished testing an inflatable solar concentrator system, using an SBIR-developed component, that will lead to just that outcome. The system and its variations—while orbiting Earth, sitting on the Moon or flying through space—will collect and concentrate sunlight or any other form of radiant energy for solar-power generation, thermal propulsion and even satellite communications.

The test is part of the Electro-Magnetic Radiation Control Experiment (EMRCE), a joint Air Force, NASA and industry effort to bring the technology to flight status within two years. The test took place in a solar simulator facility at the NASA Glenn Research Center, Cleveland, Ohio.

The facility is a large vacuum chamber fitted with a 288-kilowatt solar spectrum light source and liquid-nitrogen-chilled walls that can be cooled to temperatures approaching those experienced in space. The test simulated Earth-orbital conditions of Sun and shadow, first at room temperature and then at cold, space-like temperatures.

"The tests show that we're on the right path toward flight capability," said Wayne Wong, Glenn's EMRCE test manager. "The concentrator performed within 10 percent of predictions and held its shape to within 0.8 mm. The focus controller, which had never been used in a vacuum before, performed remarkably well, and the rigidized, thin-film struts behaved as predicted."

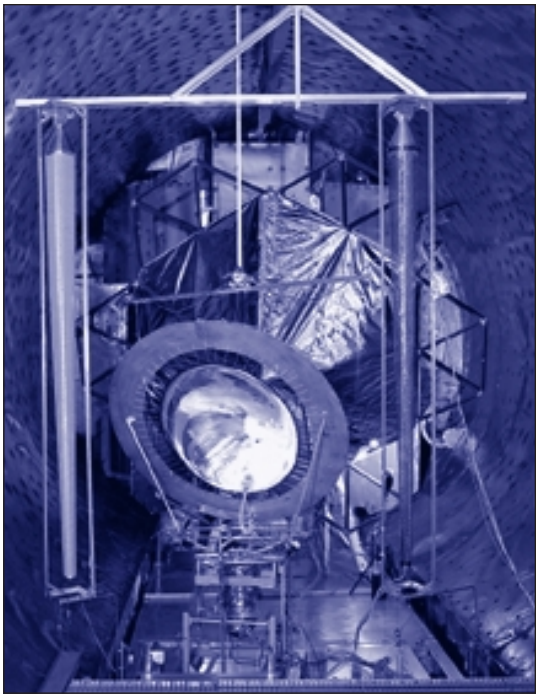
Several components were tested, including the SBIR-developed inflatable concentrator, a hexapod focus controller and inflatable, thin-film struts.

The inflatable concentrator is made of a thin, polyimide material that is already being used in space. It is formed with a transparent front canopy and an aluminum-coated rear reflector that takes on a dish shape when the concentrator is inflated. The concentrator was designed and built by SRS Technologies of Huntsville, Alabama, under an SBIR contract with Glenn.

The hexapod focus controller keeps the concentrator aimed at the Sun or other light source and holds the focal spot to a small area by adjusting the position of the concentrator. The focus controller was designed and built by ATK Thiokol Propulsion Corp. of Brigham City, Utah.

The inflatable, thin-film struts become rigid on inflation and exposure to ultraviolet radiation. To isolate their behavior, the rigidized struts were not attached to the other components for these tests. The struts were also manufactured by ATK Thiokol.

Inflatable systems have many potential advantages. On launch, they can be many times lighter than rigid concentrator systems. A very small volume, the size of an overnight bag during launch, could be inflated to the size of a basketball court in space. Inflation deployment is relatively simple and eliminates the need for mechanical actuators or human assembly. The low-mass, low-launch volume and simple deployment mean lower costs and greater safety.



EMRCE components set up in the GRC solar concentrator facility. Photo provided by Glenn Research Center.

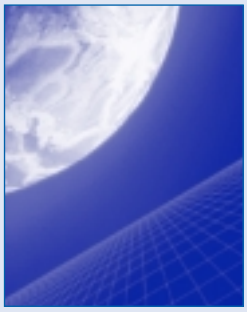
Because solar concentrators can produce high temperatures (upwards of 2,000° K, 3,140° F), they may be the ideal heat sources for Stirling engines, which are very efficient at converting heat to electricity; for future thermal propulsion engines, which provide thrust by rapidly expanding a propellant at high temperatures; and for solar furnaces for materials processing in space. Although the tested system will concentrate sunlight, inflatable reflectors, or dishes, are also being designed for space communications antennas.

EMRCE is funded by the Air Force Research Laboratory's (AFRL) Dual Use Science & Technology (DUS&T) office, Wright-Patterson Air Force Base, Ohio. Engineers from AFRL Propulsion Directorate at Edwards Air Force Base, California are providing technical oversight. Other partners in the industry and government EMRCE team are NASA Marshall Space Flight Center, Huntsville, Alabama; Boeing, Huntington Beach, California; and AFRL Space Vehicles Directorate, Kirtland Air Force Base, New Mexico.

For more information, contact Wayne A. Wong at Glenn Research Center, 216/ 433-6318, *wayne.wong@grc.nasa.gov* Please mention you read about it in *Innovation*.

TECHNOLOGY OPPORTUNITY SHOWCASE

Moving Forward



Technology Opportunity Showcase *highlights some unique technologies that NASA has developed and that we believe have strong potential for commercial application. While the descriptions provided here are brief, they should provide enough information to communicate the potential applications of the technology. For more detailed information, contact the person listed. Please mention that you read about it in* Innovation.

MEMS Packaging Techniques

NASA Glenn Research Center's Manufacturing Engineering Division has developed micromachining and microfabrication techniques that can be applied to Micro-Electro-Mechanical (MEMS) packaging, and is seeking commercial partners to explore traditional micromachining techniques and equipment to apply this research to MEMS packaging technology. The difficulties involved with commercializing MEMS technology have been described as being 90 percent packaging and 10 percent chip design (Madou). Miniature MEMS housings, wire passages and slots that use traditional machining processes (drilling, milling and machining), along with electric discharge machining, can enhance design capabilities for MEMS packaging. The processes involved with this technique are already developed and proven, and have little environmental impact. In addition, a wide variety of metals, composites and plastics can be machined. This traditional machining approach is not to be confused with electromechanical micromachining. Traditional micromachining refers to the mechanical removal of material by conventional machining methods—only on a much smaller scale. With precision equipment and specialized processes developed at Glenn, a hole can be mechanically drilled as small as 0.0005 inches. Traditional micromachining techniques can also produce mirrored surfaces from aluminum by utilizing a high-precision, air-bearing lathe. This machine can hold tolerances to the millionth-of-an-inch range. The quality of the finished cut is so precise that no polishing is necessary.

For more information, contact Casey Blaze at Glenn Research Center, 216/433-2119, *Casey.Blaze@GRC.NASA.Gov* Please mention you read about it in *Innovation*.

Low-Cost, Passive Light Exposure Monitor

NASA Marshall Space Flight Center is seeking qualified partners to license and manufacture a low-cost, Passive Light Exposure Monitor (PLEM). The PLEM represents a breakthrough for users of large and expensive light exposure equipment. The invention is: handheld—smaller than current light exposure equipment; passive—requires no batteries, power supply or communication link; inexpensive—costs only $70 in small prototype quantities; accurate—compared favorably to expensive meters in NASA's space experiments; flexible—can be engineered for various wavelengths and exposure times; and reusable—can be reset with accompanying equipment.

PLEM can be designed for specific wavelengths of light and for varying amounts of total exposure. This flexibility, along with the low cost, makes a variety of applications possible. The device can be used to monitor sun exposure tests for consumer products, materials and chemicals; material tests in space; ultraviolet (UV) applications, including curing processes and electronics data erasing; light output over time from solar simulators; and sunlight over a large area. Versions can also be easily configured for month- or year-long sun exposure readings for climate studies and UV-only monitoring for studying ozone layer depletion.

PLEM offers dramatic improvements in cost and size over existing equipment. It requires no batteries, external power source or communications link to operate, and it can accurately measure total light exposure over a wide range of wavelengths and exposure magnitudes. A small visual indicator, intended only for rough resolution exposure readings, shows the amount of total light exposure that has occurred.

To derive a more resolved and accurate reading of total light exposure, users can post-process the device with a standard companion tool of moderate cost. Then the exposure reading will be as accurate as larger, more expensive exposure monitors. The post-processing operation also resets the device for reuse, if reuse is desired. As an alternative to reusing the PLEM, its low cost allows it to be simply discarded.

Four prototypes of the PLEM were tested on NASA's Passive Optical Sample Assembly (POSA I and POSA II). Light exposure monitors were used in testing new Space Station materials for the degrading effects of solar exposure in space. Post-processed PLEM readings were compared to readings from the highly accurate exposure monitors. It was determined that the devices had accurately recorded total integrated light exposure.

For more information, contact Sammy Nabors at Marshall Space Flight Center, 256/544-5226, *Sammy.Nabors@msfc.nasa.gov* Please mention you read about it in *Innovation*.

NCTN DIRECTORY

Moving Forward

NASA Field Centers

Ames Research Center
Selected technological strengths are Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Computational Fluid Dynamics and Aviation Operations.

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Dryden Flight Research Center
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Glenn Research Center
Selected technological strengths are Aeropropulsion, Communications, Energy Technology and High-Temperature Materials Research, Microgravity Science and Technology, and Instrumentation Control Systems.

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Goddard Space Flight Center
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Jet Propulsion Laboratory
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Johnson Space Center
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Kennedy Space Center
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Marshall Space Flight Center
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Stennis Space Center
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NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint-sponsored research agreements and incubate small start-up companies with significant business promise.

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David Kershaw
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NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D agencies and to foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

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Atlanta, GA 30332
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National Technology Transfer Center
Wheeling Jesuit University
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Dan Winfield
Research Triangle Institute Technology Applications Team
Research Triangle Park, NC 27709
919/541-6431

NASA ONLINE

Go to the **NASA Commercial Technology Network (NCTN)** on the World Wide Web at ***http://nctn.hq.nasa.gov*** to search NASA technology resources, find commercialization opportunities and learn about NASA's national network of programs, organizations and services dedicated to technology transfer and commercialization.

Events

NASA will be showcasing medical-imaging technologies at the ***International Society for Optical Engineers SPIE Conference***, February 23–28, 2002 in San Diego, California. This meeting is the internationally recognized forum for reporting state-of-the-art research and development in medical imaging. SPIE is encouraging contributions in all aspects of the full range of medical-imaging modalities, from the underlying fundamental scientific principles to clinical evaluations. The symposium covers a wide range of topics including medical image acquisition, display, processing, understanding, perception, storage and transmission, imaging physics and picture archiving and communication systems (PACS). For more information, contact Mr. Michael Weingarten at NASA Headquarters, *mweingarten@hq.nasa.gov*

The ***2002 IEEE Aerospace Conference*** will occur March 9–16, 2002. This is fertile ground for developing lasting relationships benefiting participants, their organizations and the engineering, scientific and aerospace communities far beyond the Conference. Topic areas will include aerospace systems, their underlying science and technology, and their applications to government and commercial endeavors. Additional information can be obtained at *http://www.aeroconf.org*

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