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NASA hosted a summit for medical technology companies in February 2003.

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Commercial Development Mission Update

Shuttle launch schedule is currently under review.

Partnering Allows NASA to Reach Further

By Guy Fogelman
Director, Bioastronautics Research Division

NASA's vision calls for us to improve life here, to extend life to there and to find life beyond. The researchers of NASA answer this call by working together to accomplish goals that enable space exploration while benefiting people on Earth. To this end, NASA's Office of Biological and Physical Research (OBPR) recently partnered with the Aerospace Technology Enterprise to host a Medical Technology Summit. OBPR is particularly excited about this summit because it offered an opportunity for our programs to continue working with other NASA offices and industry to extend the duration and boundaries of human space flight while creating opportunities for exploration and discovery.

The goal of the summit was to forge partnerships between NASA and the medical device industry to speed the development of technologies NASA needs, while helping create a new generation of medical devices that will enhance medical diagnosis and treatment capabilities for use by astronauts and by people here on Earth. The Medical Technology Summit was an opportunity for the medical device industry to learn about NASA, our capabilities and how our technologies can assist them with developing new devices and increasing the capabilities of existing technologies. Partnering with industry allows NASA the opportunity to reach further by leveraging the additional expertise and resources that industry has to offer.

NASA has provided an abundance of technology transfers throughout our history that have aided the medical community. Since the first space missions of the early 1960s, countless Americans have benefited from technologies that resulted directly from NASA's space program. The monitoring systems used in intensive care units and in heart rehabilitation wards are descendants of the systems used to monitor the heartbeats of astronauts during those early missions. During the 1980s, NASA researchers pioneered 3-D simulations that visualized portions of the body's balance organ in the inner ear to model physical adaptations in space. This software is now being used in hospitals around the country to aid surgeons in planning facial reconstructive surgery. America's space program continues to revolutionize the practice of medicine through improvements in ultrasound scanners, automatic insulin pumps, portable x-ray devices, MRIs, bone analyzers and a wearable heart rate monitor.

As humans continue to embark on missions of greater duration and distance, we must extend our current capabilities to work effectively in space. We must guarantee crew health and safety to allow space explorers to perform their duties throughout the mission and assure a safe return to Earth. OBPR is committed to forming partnerships with industry, business and academia to bring entrepreneurs in engineering research and technology development to space. These partnerships benefit businesses by offering opportunities to conduct research in the space environment, where processes and products can be researched, fabricated and tested in absence of gravity. Such research is not possible on Earth and may enhance industry's development of better manufacturing practices and products.

OBPR contributes to the Agency's vision by sponsoring its research to answer the following questions.

- How can we assure the survival of humans traveling far from Earth?
- How does life respond to gravity and the space environment?
- What new opportunities can our research bring to expand our understanding of the laws of nature and enrich lives on Earth?
- What technology must we create to enable the next explorers to go beyond where we have been?
- How can we educate and inspire the next generation to take the journey?

The current scope of OBPR includes developing products to support human exploration, such as radiation-protection strategies, new biomedical knowledge, procedures and tools, as well as technologies that sustain humans in the harsh environment of space. NASA can use the expertise of the US business community to turn research results into usable products that allow humans to venture into and explore space beyond where they have been. Understanding how humans and other life forms adapt to the effects of space flight is essential to providing appropriate medical tools that maintain human health. The biomedical, biological and engineering research communities will continue to be the centerpiece on which we rely to conduct the research and technology development that has high merit, significant benefit on Earth and direct relevance to the long-term success of space exploration. ❑

Cover Story

Enterprises Partner to Host First NASA Medical Technology Summit

Teamwork is a way of life at NASA, and the Aerospace Technology and Biological and Physical Research Enterprises are offering others the opportunity to team up with NASA.

In mid-February, NASA held a major event entitled NASA's Medical Technology Summit: Forging Partnerships to Develop Emerging Technologies. The goal of the summit was to forge partnerships between NASA and the medical device industry to accelerate the development of technologies critical to NASA, while also helping to create a new generation of medical devices. The event enabled the companies to learn about new advances from NASA and understand the Agency's goals and vision.

"NASA's technology transfer goals are focused on contributing to the advanced readiness of technologies essential to NASA missions while maximizing their economic impact," said Michael Weingarten, Director of NASA's Partnership Development Team.

NASA's Innovative Technology Transfer Partnerships Program worked together with the Biological and Physical Research Enterprise to identify more than 20 technologies with applications in biomolecular sensors, physiological monitoring, diagnostic instruments and techniques, therapeutic devices and advanced instruments.

"This was an opportunity for the medical device industry to really see what NASA is capable of . . . and how NASA technology can assist these companies with developing new devices and increasing the capabilities of existing technology," said Weingarten.

"This was an opportunity for the medical device industry to really see what NASA is capable of . . . and how NASA technology can assist these companies with developing new devices and increasing the capabilities of existing technology," said Weingarten.

Many of the technologies showcased are being developed in support of NASA's Space Flight program. As an example, NASA and the National Cancer Institute (NCI) are cosponsoring a new research program entitled Fundamental Technologies for the Development of Biomolecular Sensors. The goal of this program is to develop biomolecular sensors that will revolutionize the practice of medicine on Earth and in space. NASA and NCI are seeking innovations in fundamental technologies that will support the development of minimally invasive biomolecular sensor systems that can measure, analyze and manipulate molecular processes in the living body.

Examples included wearable multiparameter physiologic monitors for ambulatory personnel, rapid molecular diagnostics and related technologies. Such tools should find broad applications in the monitoring of patient populations ranging from space flight crews to cardiac patients, athletes in training and first responders.

"We were frankly amazed by the response from industry," said Weingarten. "We were able to engage senior-level decision-makers from many of the leading companies in the medical device industry. What made this event a success was the amount of homework we put into identifying companies ahead of the event who would make good research partners for NASA. This really paid off, as we had more than 130 private meetings with companies at the summit to begin exploring how we might collaborate together."

NASA is engaged in follow-up discussions in a number of promising areas, including biosensors for pathogen detection and quantification; Fourier imaging of gamma rays, hard x-rays and neutrons that have several medical applications; micro-encapsulation of drugs for treating anthrax; an anthrax detector; a nanotechnology chip for restoring vision; and advanced polymers for balloon angioplasty.

"The NASA Medical Technology Summit showcased many interesting technologies," said Frank Abrano, CEO of The Bryan Corporation. "I thought it was very successful and an excellent opportunity for anyone in the medical technology field." Abrano added he is currently negotiating licenses for technologies he learned about while attending the summit.

NASA has a promising history of successful technology transfer to the medical device industry. Two success stories include the MicroMed DeBakey VAD® and the The BioLuminate Smart Probe.

The MicroMed DeBakey VAD is a miniaturized heart pump designed to provide increased blood flow from the left ventricle of the heart throughout the body for patients in end-stage heart failure. Miniature in size and lightweight, the MicroMed DeBakey VAD reduces surgical time to about one-half the time of implanting pulsatile devices. It is less expensive than currently marketed pulsatile VADs, making the process more affordable to a wider group of patients, while enabling patient mobility. The MicroMed DeBakey VAD is based in part on technology used in space shuttle fuel pumps. It is intended as a long-term "bridge" to transplant, or as a more permanent device to help patients toward recovery. About five million Americans suffer from heart failure annually. Approximately 35,000 heart-failure patients need transplants each year, but only 2,500 donor hearts are available.

The concept for the pump began with talks between Baylor College of Medicine's Dr. Michael DeBakey and one of his heart transplant patients, NASA Engineer David Saucier, who worked at NASA Johnson Space Center in Houston. Saucier knew first-hand the urgency heart-failure patients feel while waiting for a donor heart. He also knew space shuttle technology. Six months after his own heart transplant in 1984, Saucier was back at work. With fellow NASA employees, Dr. DeBakey, Dr. George Noon and other Baylor College of Medicine staff, Saucier worked evenings and weekends on the initial pump design. During the effort Saucier said "Since my own transplant, I have spent a lot of time visiting people who are waiting for a donor heart." He felt a sense of urgency to develop the pump. NASA began funding the project in 1992. The result was a remarkable battery-operated pump—2 inches long, 1 inch in diameter and weighing less than 4 ounces—that seems to be an answer to the decades-long quest to develop an implantable ventricular-assist pump.

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NASA Ames Research Center licensed the Smart Surgical Probe to a Silicon Valley start-up company, BioLuminate, Inc. Ames originally developed this technology, which is a small multisensor probe using neural algorithms, to potentially analyze soil samples on Mars and other planets.

The BioLuminate commercial adaptation of the probe is to be used for real-time detailed interpretations of breast tissue from the tip of an inserted needle. This new instrument will allow health care providers to make accurate diagnoses with this less invasive procedure. In addition, it will enable physicians to diagnose tumors without surgery, thereby dramatically reducing the number of unnecessary breast biopsies women undergo annually. BioLuminate also has licensed and incorporated a technology from Lawrence Livermore National Labs to further miniaturize the probe.

These are just two examples of NASA technology changing the course of modern medicine. NASA's innovation and drive have affected other aspects of life, as well. As we move forward, NASA will continue to be a major player in developing innovations critical to supporting our space flight needs and making those innovations available to companies who can take them to market. ❑

For more information, visit *http://www.nasa.gov* and *http://www.hq.nasa.gov*
Please mention you read about it in Innovation.

Researcher Scans the Eye to Find Disease

Technology originally developed to study fluids' behavior in the environment of space (microgravity) is being used to detect various eye problems earlier and more accurately than ever before.

Dr. Rafat Ansari, Biofluid Sensor Systems Scientist at NASA Glenn Research Center, has utilized this "built-for-space" fiber-optic probe based on a technique called dynamic light scattering to detect cataracts and other eye diseases at the molecular level. The value of the probe in the early detection of cataracts already has been demonstrated in clinical trials at the National Eye Institute of the National Institutes of Health. An early detection of cataracts can help find nonsurgical cures for this disease.

Ansari has leveraged his work in the area of vision problems to collaborate with various organizations in planning the Ohio's Vision . . . Awaken to the Challenge conference on April 28, hosted by Glenn. The conference was open to the public and took place at the Ohio Aerospace Institute in Cleveland, adjacent to Glenn. The focus of the event was on social, economic and quality-of-life challenges that will result from increasing vision problems in the population, a growing statewide health issue. The scope of research being conducted in Ohio was reviewed at the conference, which included a review of Ansari's work.

The early emphasis on cataracts by Ansari was a result of his concern for his father, who had developed cataracts. Now he has modified the probe, and, with the help of renowned eye researchers around the world, is testing it as a noninvasive diagnostic measurement device for other eye diseases such as glaucoma and macular degeneration. Ansari also uses the eye as the "window to the body" to detect illnesses in the entire body. He is using the probe in tests to monitor diabetes and even Alzheimer's disease.

Dr. Rafat Ansari, Biofluid Sensor Systems Scientist at NASA Glenn Research Center, has utilized this "built-for-space" fiber-optic probe based on a technique called dynamic light scattering to detect cataracts and other eye diseases at the molecular level. The value of the probe in the early detection of cataracts already has been demonstrated in clinical trials at the National Eye Institute of the National Institutes of Health.

Sherry Williams, CEO of Prevent Blindness Ohio, and Dr. Rafat Ansari, NASA Glenn Research Center. Photo courtesy of Glenn Research Center.

NASA maintains its interest in Ansari's developments because the effects of aging, such as cataracts, are similar to what happens to the body during space travel. New instruments are being sought to diagnose and improve astronaut health. Ansari's probe currently is being used to explore the effects of reduced gravity on fluid flow in the eye through testing on the NASA KC-135 aircraft. A new instrument being developed, which resembles night-vision goggles, uses light in various forms to detect ocular and systemic abnormalities long before clinical symptoms appear. This instrument to be used in space also has obvious applications for remote health monitoring on Earth. This is an example of how space flight research is being used to do exactly what NASA's vision compels it to do—improve life here on Earth. ❑

For more information, contact Rafat Ansari at ✆ 216/433-5008, ✉ *Rafat.R.Ansari@grc.nasa.gov*. Please mention you read about it in Innovation.

NASA Contributes to Improving Health

An innovative technology developed by NASA to help its astronauts combat motion sickness during space flight will be available in March 2004 for a much wider range of human health and performance uses.

Dr. Mae C. Jemison, the nation's first African-American female astronaut, currently at BioSentient Corporation, Houston, obtained the license to commercialize the space-age technology known as Autogenic Feedback Training Exercise (AFTE) that originally was developed by Dr. Patricia Cowings of NASA Ames Research Center, Moffett Field, CA. The technique is a patented combination of biofeedback and autogenic therapy that allows individuals to eliminate or minimize their unwanted physical responses to outside stimuli by controlling their autonomic nervous system (ANS). The ANS is responsible for controlling and regulating involuntary bodily functions, such as breathing, heartbeat, sweating, blood vessel dilation and glandular secretions.

"What were previously considered involuntary, or autonomic, responses are in fact under voluntary control if you are taught properly," said Cowings. "I have never met anyone who could not control their bodily responses to some degree the first time they tried," she said. "It's a function of knowing what to do."

AFTE consists of a system of compact, ambulatory equipment to measure, record and display real-time ANS functions, combined with a unique 6- to 12-hour training

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NASA Partners with USDA on Variety of Projects

NASA Administrator Sean O'Keefe and Agriculture Secretary (USDA) Ann M. Veneman announced the two agencies will join forces on a series of programs drawing on NASA's capabilities in monitoring, mapping, modeling and systems engineering to help protect the environment and enhance American agriculture's ability to compete in the world market.

NASA and USDA representatives participated in a workshop in Denver recently to identify collaborative research and development programs for the joint program. The workshop concentrated on five focus areas identified as national priorities of mutual interest—carbon management, agricultural competitiveness, air quality, water management and conservation, and management of invasive species.

"NASA is pleased to be part of this worthwhile effort, benefiting all Americans and humankind in general," said Sean O'Keefe. "NASA's ability to view the Earth from the unique vantage point of space provides data to enhance our ability to predict climate, weather and natural hazards, as well as to mitigate and assess the effects of natural and human-induced disasters. As NASA works to understand and protect our home planet, the relevant and concise information we provide will allow USDA and other US government agencies to make critical, accurate and timely decisions," he said.

"We in USDA are very excited about the possibilities opened up by this new collaboration," Veneman said. "For example, to improve our agricultural competitiveness, we need a better understanding of weather and climate, especially the ability to predict weather events with more accuracy and longer lead times. The results from NASA research and development of Earth science and technology could lead to weather and climate predictions and observations that can be integrated into local and regional support systems used in agricultural management," she said.

Participants in the workshop discussed USDA policy and program needs that might be fulfilled by remote-sensing information provided by NASA; identified current research and capabilities of both NASA and USDA that could help address those needs; and pinpointed gaps in existing knowledge and research. They also outlined opportunities for collaborative research and development efforts between USDA and NASA to develop products and solutions to serve decision-makers. Information from the workshop will be used by a USDA/NASA Interagency Working Group in evaluating and establishing new research efforts, remote-sensing systems and models for decision support in agricultural systems. The information resulting from the workshop also will be incorporated into the plans of NASA's Earth Science Enterprise (*http://earth.nasa.gov/*), which seeks to meet NASA's mission of understanding and protecting our home planet. ❑

For more information about NASA's Earth Science Enterprise on the Internet, visit *http://earth.nasa.gov/*. Please mention you read about it in Innovation.

NASA Selects Its Inventions of the Year

Software technology, proven to be invaluable for law-enforcement investigations, and a mathematical method received NASA's Commercial and Government Invention of the Year Awards.

The Video Image Stabilization and Registration System (VISAR) received NASA's Commercial Invention of the Year. NASA Marshall Space Flight Center employees Dr. David Hathaway, a Solar Physicist, and Paul Meyer, an Atmospheric Scientist, created the basis for this innovative technology to aid in their space program research.

VISAR was first used in 1996 to help the FBI analyze video of the bombing at the Olympic Summer Games in Atlanta. Since then, Hathaway and Meyer have worked on more than a dozen criminal cases with police and the FBI.

VISAR works by turning dark, jittery images captured by home video, security systems and video cameras in police cars into clearer, stable images that reveal clues about crimes. It does what other image-stabilization processes cannot; it corrects for changes in orientation and size. The system also is being used in the Space Shuttle Columbia accident investigation.

The winner of the NASA Government Invention of the Year is a mathematical method called Computer Implemented Empirical Mode Decomposition Method, also known as the Hilbert-Huang Transformation (HHT) Method. Dr. Norden E. Huang, Director, Goddard Institute of Data Analysis at NASA Goddard Space Flight Center, Greenbelt, MD, invented it.

The HHT Method has many diverse applications. The method can be applied in a variety of fields to study things such as basic nonlinear mechanics, climate cycles, solar neutrinos variations, earthquake engineering, geophysical exploration, submarine design, structural-damage detection, satellite data analysis, nonlinear wave evolution, turbulence flow, blood pressure variations and heart arrhythmia.

This method also is used to analyze sea-surface temperature data collected by NASA satellites and instruments. The National Oceanic and Atmospheric Administration uses Huang's method to analyze images from some of its Earth-orbiting spacecraft. It has proven successful in connecting environmental changes to El Niño phenomena with weather changes.

Huang also won NASA's Exceptional Space Act Award in 1999, for which he was cited, "as having invented one of the most important applied mathematical methods in NASA's history," for his invention of the HHT Method. ❑

For more information, contact Goddard Space Flight Center Technology Transfer Program, ✉ *techtransfer.gsfc.nasa.gov*, ✆ 301/286-5810. Please mention you read about it in Innovation.

NASA Contributes

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that teaches individuals how to control their physiology using the feedback from the equipment. Advancing the original design, BioSentient has created a seamless system that includes a garment a person wears that can measure and wirelessly transfer physiologic data in real time; a small wrist display; and a computer station that a trainer can use to capture the data and teach a person the regulation techniques.

In various controlled studies conducted at NASA, Cowings found that AFTE is 85-percent effective in reducing motion side effects in both men and women, and is retained by individuals for up to 3 years after initial training. Since the mid-1980s, AFTE has been used successfully with US astronauts and to return US Navy pilots suffering severe airsickness to active duty in high-performance aircraft.

"BioSentient is examining AFTE as a treatment for anxiety, nausea, migraine and tension headaches, chronic pain, hypertension and hypotension, and stress-related disorders," said Jemison, who underwent the training and successfully used it during her space flight, STS-47, in 1992.

"Other potential beneficiaries of AFTE include business executives, homeland security and law enforcement officers, air traffic controllers, nuclear power plant operators and others working in hazardous materials occupations where optimal personal performance and situational awareness are essential," added Jemison, who also is a physician and chemical engineer.

Those who provide services to patients such as psychologists, cardiologists, neurologists, athletic trainers, biofeedback practitioners and rehabilitation and behavioral therapists can use AFTE. By training their patients, these specialists can teach people how to control their physiology with no pharmaceutical help. ❑

For more information, contact Dr. Patricia Cowings at *Patricia.S.Cowings@nasa.gov*, 650/604-5724. Please mention you read about it in Innovation.

High-Tech Infrared Detector Shows Promise

The world's first one-million-pixel Quantum Well Infrared Photodetector (QWIP) array has been fabricated and tested by a NASA-led team. The new detector promises to be a low-cost alternative to conventional infrared-detector technology for a wide range of scientific and commercial applications. "We are excited about the many potential applications for NASA's QWIP technology," said Dr. Murzy Jhabvala, Chief Engineer of NASA Goddard Space Flight Center's Instrument Systems and Technology Center, which led the development effort.

The Army Research Laboratory (ARL), Adelphi, MD, was instrumental in the design and fabrication of the QWIP array, and the Rockwell Science Center, Camarillo, CA, provided the silicon readout and hybridization. Engineers at NASA Jet Propulsion Laboratory (JPL), Pasadena, CA, and the Rockwell Science Center also participated in the project. The new array was fabricated in Goddard's Detector Development Laboratory and tested at both Goddard and the ARL.

Infrared light is invisible to the human eye, but some types are generated by and perceived as heat. A conventional infrared detector has a number of cells (pixels) that interact with an incoming particle of infrared light (an infrared photon) and convert it to an electric current that can be measured and recorded. They are similar in principle to the detectors that convert visible light in a digital camera. The more pixels that can be placed on a detector of a given size, the greater the resolution, and NASA's latest QWIP array is a significant advance over earlier 300,000-pixel QWIP arrays, previously the largest available.

NASA's new QWIP detector is a Gallium Arsenide (GaAs) semiconductor chip with 60 to 100 layers of detector material on top. Each layer is extremely thin, about 500 atoms thick, and the layers are designed to act as quantum wells. Quantum wells employ the physics of the microscopic world, called quantum mechanics, to trap electrons, the fundamental particles that carry electric current, so that only light with a specific energy can release them. If light with the correct energy hits one of the quantum wells in the array, the freed electron flows through a separate chip above the array, called the silicon readout, where it is recorded. A computer uses this information to create an image of the infrared source.

Quantum wells can be designed to detect light with different energy levels by varying the composition and thickness of the detector material layers. Thus, a detector using quantum well technology can be made to sense light (in this case, infrared) with a wide range of energy levels. This is called a broadband detector.

"The advantages of GaAs QWIP technology over other infrared-detector technologies are the relative ease of fabrication which translates to low production costs and high yield, the ability to spectrally tune the infrared response of the detector over a broad portion of the infrared region (3–18 microns), the very high pixel-to-pixel uniformity and the almost nonexistent low frequency (1/f) noise," said Jhabvala.

This work was conceived for and funded by NASA Goddard. The team has recently been selected to develop a broadband (8–14 micrometers) one-million-pixel QWIP array-based imaging system as part of the Advanced Component Technology (ACT) development for NASA's Earth Science Technology Office (ESTO). The initial development of a

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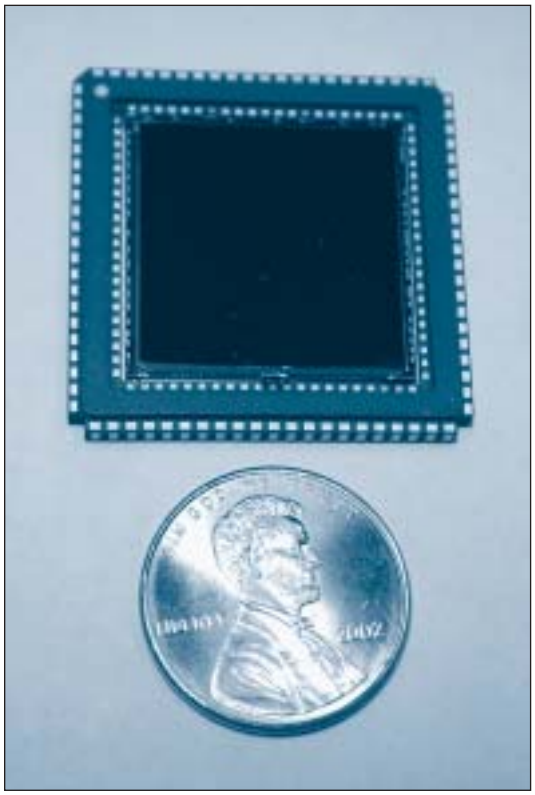

This is a picture of NASA's prototype one-million-pixel Quantum Well Infrared Photodetector array, next to a penny for scale. Then new detector promises to be a low-cost alternative to conventional infrared-detector technology for a wide range of scientific and commercial applications. Photo courtesy of Goddard Space Flight Center.

Langley Helps Nab Suspect

HAMPTON—Video images enhanced by NASA Langley Research Center helped police arrest a man Wednesday, July 16, 2003, accused of sexually assaulting an 11-year-old girl in a Target store in West Virginia.

"It was very helpful," Joy Hartwell, spokeswoman for the South Charleston Police Department, said of the enhanced images from Langley. Hartwell said a detailed, out-of-state tip also led police to the suspect, Allen D. Coates, 37, of Irvington, KY, who was arrested Wednesday [July 16, 2003].

Police asked NASA Headquarters to sharpen a fuzzy security video that showed a man stalking the girl before leading her into two different areas and assaulting her at knifepoint. The images funneled their way through a secure Internet network to NASA Langley late Tuesday [July 15, 2003] afternoon.

Langley researcher Glenn Woodell said he used the same technology that NASA used to enhance images from the final launch of the Space Shuttle Columbia. The computer technology, called Retinex, increases the sharpness and contrast to make the suspect more identifiable, Woodell said. Police in Norfolk and Philadelphia have used Retinex to investigate bank robberies and pedophile cases.

Woodell worked on security images from the Target store that showed the suspect, but not the girl or the assault. Woodell had to create smaller, cropped images of video stills that focused on the suspect's face. Woodell's six-year-old daughter watched him work.

"I tried to use it as a lesson," Woodell said. "I hope parents will be more aware of their children and where they are. Just because there are cameras around, doesn't mean you're secure."

Woodell said he sent the images back to investigators about 7:30 p.m. Tuesday [July 15, 2003]. Within 24 hours, police had their suspect.

To see how Retinex works, visit *dragon.larc.nasa.gov* or *www.truview.com* on the Internet. ❑

For more information, contact Stuart Pendleton at NASA Langley Research Center, ✆ 757/864-2943, ✉ *Stuart.E.Pendleton@nasa.gov*. Please mention you read about it in Innovation.

(This article originally appeared in the July 17, 2003 issue of the *Daily Press* of Hampton, VA. Reprinted with permission. Article written by Dave Schleck.)

High-Tech

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prototype narrowband one-million-pixel QWIP array is a critical first step that significantly contributes to the feasibility of building a broadband far-infrared QWIP camera system under the ESTO program.

"The spectral response of the prototype array was between 8.4 and 9.0 micrometers, and achieved background limited performance at an operating temperature of 76 Kelvin (minus 197 degrees Celsius or minus 323 degrees Fahrenheit). Numerous imaging experiments (f/2 lens) were performed at the ARL, and we are continuing to improve the detector fabrication processes and the detector performance," said Jhabvala.

There are many Earth-observing applications as well as potential commercial applications for QWIP detector arrays, including studying the troposphere and stratosphere temperatures, and identifying trace chemicals; measuring cloud layer emissivities, droplet/particle size, composition and height; SO_2 and aerosol emissions from volcanic eruptions; CO_2 absorption; ocean/river thermal gradients and pollution; coastal erosion; tree canopy energy balance measurements; tracking dust particles from remote areas of the world; analyzing radiometers and other scientific equipment used in obtaining "ground truthing" and atmospheric data acquisition; ground-based astronomy; temperature profiling; medical instrumentation; location of unwanted vegetation encroachment; monitoring crop health; monitoring deforestation of tropical rain forests; locating power line transformer failures in remote areas; monitoring pollution and effluents from industrial operations, such as paper mills, mining operations and power plants; searching for thermal leaks; possible earthquake detection; and locating new sources of spring water for bottling. ❑

For more information, contact Dr. Murzy Jhabvala, Chief Engineer, Instrument Systems and Technology Center, NASA Goddard Space Flight Center, ✆ 301/286-5232, ✉ *murzy.d.jhavala@nasa.gov*. Please mention you read about it in Innovation.

NASA Spins Up New Vehicle Rollover Test

NASA and the National Highway Traffic Safety Administration (NHTSA) joined forces to, literally, take vehicles out for a spin. The NHTSA wanted to research new methods for testing vehicle rollover resistance, and NASA's High Capacity Centrifuge (HCC) was exactly what was needed to spin up some unique and original vehicle testing.

Vehicles were spun, using the HCC at NASA Goddard Space Flight Center (GSFC), Greenbelt, MD, on a test platform, until inertia and centrifugal force caused them to tip.

NHTSA employs a consumer rating system, the Static Stability Factor, which uses an engineering formula to determine vehicle rollover rankings. NHTSA wanted to research alternative methods for determining rollover resistance. According to NHTSA's system, a one-star rating means a high likelihood of rolling over, and a five-star rating means a low likelihood.

Officials at NASA and NHTSA expect this first-of-its-kind test will enable them to gain valuable safety information about vehicles that move millions of Americans every day. "The NASA project gives us a chance to really explore the potential of centrifuge testing," said Stephen Kratzke, NHTSA associate administrator for rulemaking. "We were lucky to have a sophisticated facility like Goddard's to perform this valuable research. No one else has such a centrifuge, including the Department of Defense," Kratzke said.

NASA uses the HCC to test spacecraft before they're sent into space. Engineers use the HCC to approximate the effects encountered during the rigors of a rocket launch. By testing hardware on a centrifuge, a satellite's structural integrity can be validated prior to liftoff.

The HCC is a big machine, more than 150 feet in diameter, filling an entire circular building. With two powerful motors running at full tilt, the outer edge of the test arm can reach speeds of more than 200 miles per hour, producing a force 30 times Earth's gravity. It is also a finely tuned machine. At rest, the giant multi-ton arm sits on bearings so smooth just two or three people can push it around the room.

"We can control the centrifuge within a hundredth of an RPM (revolutions per minute)," said Carmine Mattiello, Section Head of NASA's Structural Dynamics Lab at GSFC. "So we can tell exactly when the wheels are coming off the ground," Mattiello said.

A crash-test dummy went along for the ride in each vehicle. Sitting in the driver's seat, the "passenger" was an important part of the physical test environment. The dummy, similar in shape and weight to a person, increased the realism and accuracy of the test results.

Since its inception, NASA has pursued a commitment to technology transfer to industry, academia and other government agencies. NASA makes technology, as well as facilities and expertise, available to help improve safety, security and quality of life. ❑

Prepping for a spin at NASA Goddard Space Flight Center. Photo courtesy of Goddard Space Flight Center.

For more information, contact Dwayne Washington at Goddard Space Flight Center, 301/286-8955. Please mention you read about it in Innovation.

NASA Research Could Improve Computer Performance

The life of the silicon chip industry may last 10 or more years longer, thanks to a new manufacturing process developed by NASA scientists.

The novel method, announced in the April 14, 2003 issue of the *Journal Applied Physics Letters*, includes use of extremely tiny carbon nanotubes instead of copper conductors to interconnect parts within integrated circuits (ICs). Carbon nanotubes are measured in nanometers, much smaller than today's components. A nanometer is roughly 10,000 times smaller than the width of an average human hair. ICs are very small groups of electronic components made on silicon wafers.

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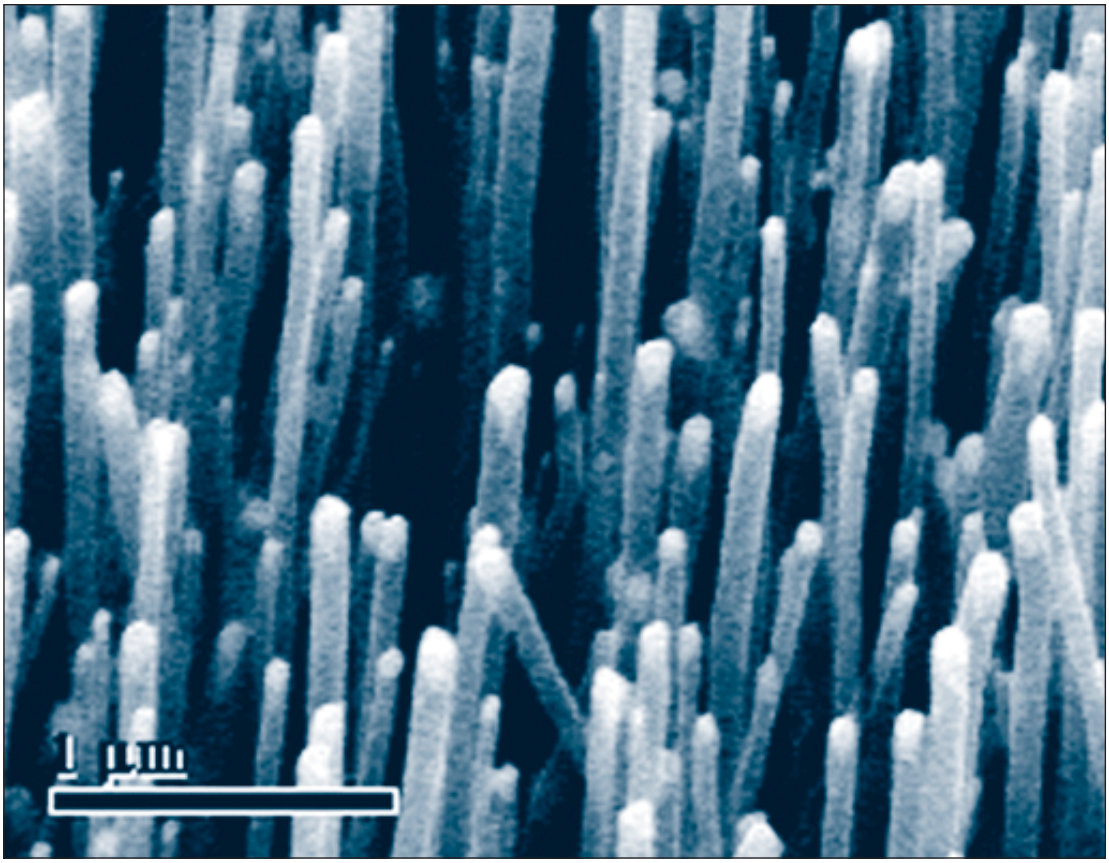
"NASA needs high-performance computing in small packages for future autonomous spacecraft," said Meyya Meyyappan, Director of the Center for Nanotechnology at NASA Ames Research Center in California's Silicon Valley and coauthor of the article. "The bottom line is that computer chips with more layers and smaller components can do more for us. While we are working



Vertically aligned carbon nanotubes about 100 nanometers in diameter. Photo courtesy of NASA Ames Research Center.

on carbon nanotube-based chips for long-term needs, we also are indirectly helping industry to keep silicon-based computer chips in use as long as possible."

"One advantage of using carbon nanotube interconnects within integrated circuits is that these interconnects have the ability to conduct very high currents, more than a million amperes of current in a one square centimeter area without any deterioration, which seems to be a problem with today's copper interconnects," said Jun Li, Lead Scientist of the team at NASA Ames that developed the new process. "Also, there is no need to create deep, narrow trenches on silicon wafers in which to bury copper conductors, a step that is becoming a problem as components are made smaller and smaller," Li added.

"Our process allows us to use the tiny carbon nanotubes to replace copper to interconnect network layers on silicon chips," Meyyappan said. "We think this new process may well help to sustain the Moore's Law growth curve."

Moore's Law stemmed from an observation made by computer chip pioneer Gordon Moore in 1964 that the number of transistors in a given area of an IC had doubled every year since its invention. Moore predicted the trend would continue at a rate of about 18 months between doublings. Continuing down this doubling path is becoming increasingly difficult, according to Meyyappan.

"Roadblocks exist in several common technologies such as interconnects, lithography and others currently used to make the chips," he said. "However, I think our new process could be in use by industry for the next generation of ICs, removing some of these roadblocks," Meyyappan added.

"Using the new process, manufacturers will be able to add more cake-like layers of components to silicon chips to increase computer capability," Li said. Because copper's resistance to electricity flow increases greatly as the metal's dimensions decrease, there is a limit to how small copper conductors can be. In contrast, extremely tiny carbon nanotubes can substitute for copper conductors in smaller computer chip electronic configurations because carbon nanotube electrical resistance is not high.

The new process includes growing microscopic, whisker-like carbon nanotubes on the surface of a silicon wafer by means of a chemical process. Researchers deposit a layer of silica over the nanotubes grown on the chip to fill the spaces between the tubes. Then the surface is polished flat. Scientists can build multiple layers with vertical carbon nanotube wires that can interconnect layers of electronics that make up the chip. ❑

"One advantage of using carbon nanotube interconnects within integrated circuits is that these interconnects have the ability to conduct very high currents, more than a million amperes of current in a one square centimeter area without any deterioration, which seems to be a problem with today's copper interconnects," said Jun Li, Lead Scientist of the team at NASA Ames that developed the new process. "I think our new process could be in use by industry for the next generation of ICs, removing some of these roadblocks," Meyyappan added. "Using the new process, manufacturers will be able to add more cake-like layers of components to silicon chips to increase computer capability," Li said.

For more information on this technology, contact M. Meyyappan, Director, Center for Nanotechnology, *http://www.ipt.arc.nasa.gov*, ✉ *meyya@orbit.arc.nasa.gov*, ✆ 650/604-2616. Please mention you read about it in Innovation.

NASA Tests Future Flight Vehicle Concepts

A hybrid rocket carrying futuristic space vehicle concepts completed its first flight on December 18 from the NASA Goddard Space Flight Center's Wallops Flight Facility, Wallops Island, VA. Launched at 6:15 a.m. EST, the rocket's bright plume was seen more than 200 miles away in New Jersey and Pennsylvania.

The rocket, built by Lockheed Martin Space Systems, New Orleans, was used to launch a NASA-designed payload containing three test articles.

The purpose of the Suborbital Aerodynamic Reentry Experiments (SOREX-2) payload was to develop new high-speed flight-test and control methods. These techniques may be applied to novel designs for high-speed flight and next-generation planetary entry technology.

"This suborbital rocket flight was intended to test these concepts at more than Mach five or five times the speed of sound during reentry," according to Marc Murbach, a Research Engineer from the NASA Ames Research Center, Moffett Field, CA. "We are trying to develop a wind tunnel in the sky. This capability may herald new techniques for the rapid development of innovative hypersonic flight concepts." The SOREX-2 project team is currently analyzing data on the payload's performance.

The payload, a joint project between Ames and Wallops, included a "wave rider" flying wedge, a linear aerobrake (or hypersonic parachute) and a Slotted Compression Ramp Probe (SCRAMP), a super-stable

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Fuel Cells Used for Space

Fuel cell power generation technology originally developed by NASA has seen extensive commercial development for future automotive and residential applications. NASA Glenn Research Center, Cleveland, is now leveraging those commercial developments to further advance the technology for space transportation applications. The power systems that result will be substantially advanced compared to today's alkaline units.

ElectroChem, Inc. of Woburn, MA and Teledyne Energy Systems, Inc. of Hunt Valley, MD each have delivered a breadboard proton-exchange-membrane (PEM) fuel cell power generation system to NASA Johnson Space Center, Houston, to be independently tested by NASA to verify performance, endurance and operational capabilities. ElectroChem delivered a 1-kW PEM fuel cell generation system and Teledyne a 5-kW PEM fuel cell power generation system.

A fuel cell is an electrochemical device that combines hydrogen and oxygen to produce electrical power, and its only byproduct is water. Alkaline fuel cells, a similar technology to PEM fuel cells, are the primary source of electrical power on the space shuttle. Although reliable, alkaline fuel cells are a costly and aging technology. The advantages of PEM technology over alkaline technology are numerous—higher power, lower weight, increased safety, longer life, improved reliability, reduced operations and lower cost. PEM technology also is being developed for future automotive and residential applications.

"PEM fuel cells are leading the way, having emerged as the leading fuel cell technology for near-term commercial applications," said Mark Hoberecht, Glenn Fuel Cell Technology Manager. "NASA recognizes the valuable attributes of PEM fuel cells and is partnering with commercial vendors to adapt this technology for future space applications."

The delivery of the breadboards is the end result of 16-month contracts that were awarded to both vendors in December 2001 to design, assemble and test breadboard power generation systems at the 1–5 kW power level. At the conclusion of the testing, one or both vendors may be awarded optional contract tasks to design, assemble and test engineering model PEM fuel cell generation systems as the next step in developing this technology for future space flight missions.

This is being done in support of NASA's Space Launch Initiative (SLI), which is the key to open further the space frontier for continued scientific exploration and economic expansion. The SLI goals are to ensure the provision of space access and improve it by increasing safety, reliability and affordability.

The PEM fuel cell development effort at Glenn is part of the Vehicle Systems Research and Technology Project led by NASA Langley Research Center, Hampton, VA, under the Next Generation Launch Technology program. ❑

For more information on this technology, contact Mark A. Hoberecht at ✉ *Mark.A.Hoberecht@nasa.gov*, ✆ 216/433-5362. Please mention you read about it in Innovation.

NASA Tests Environmentally Friendly Rocket Fuel

NASA has successfully tested an alternative rocket fuel that may increase operational safety and reduce costs over current solid fuels. The new paraffin-based fuel could eventually be used in space shuttle booster rockets.

Two years of collaboration between Stanford University and NASA Ames Research Center have led to the development of a nontoxic, easily handled fuel made from a substance similar to what is used in common candles. The byproducts of combustion of the new fuel are carbon dioxide and water; unlike conventional rocket fuel that produces aluminum oxide and acidic gasses, such as hydrogen chloride.

"There is great cost in making, handling and transporting traditional solid rocket fuels, but the new paraffin-based fuel is less expensive, nontoxic and nonhazardous," said Greg Zilliac of Ames. "Because the fuel is very stable and environmentally friendly, a hybrid rocket could be fueled at the launch site rather than at the factory, thereby saving money," he added.

The main goal of the NASA test program is to determine if the results will scale up to the combustion chamber conditions required for space launch operational systems. "The NASA combustion tests have been very promising and indicate the burn rate for the larger-scale apparatus is as high as that achieved in the small-scale Stanford tests," Zilliac continued. "This new fuel could significantly impact the future of space transportation," he said.

"Hybrid rockets, using the paraffin-based fuel, can be throttled over a wide range, including shut-down and restart. That's one reason why they could be considered as possible replacements for the shuttle's current solid rocket boosters that cannot be shut off after they are lit," he said. "One design concept being considered is a new hybrid booster rocket that is able to fly back to the launch site for recharging," he added.

A hybrid rocket uses a liquefied oxidizer that is gasified before being injected into the combustion chamber containing the solid fuel. Upon ignition, a flame develops over the fuel surface causing the solid to evaporate, thereby sustaining the combustion. Because current hybrid fuels, other than paraffin-based fuels, cannot sustain a high combustion rate, they have found only limited application and are not commercially viable for space applications. Tests at Stanford and Ames have shown the new paraffin-based fuel has a burn rate that is three times greater than that of other hybrid fuels.

Scientists are testing the new fuel at the Ames Hybrid Combustion Facility. The first successful test in the series took place on September 24, 2001. The heavy-duty test chamber can accommodate pressures up to 60 atmospheres.

The first phase of the program included approximately 40 runs. A new combustion chamber with sapphire windows will soon be installed to allow researchers to observe the combustion process using optical instruments. Scientists will study the underlying physical processes that produce the fuel's high performance.

NASA engineers will conduct roughly 200 test runs during the lifetime of the project. A maximum of

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NASA Tests Future

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planetary reentry probe. The wedge is about 50 inches (127 centimeters) long and was built to free fly like a glider after deployment.

The launch is the first test flight of a large hybrid propulsion system. Lockheed Martin's Michoud Operations designed and built the 60-foot-long (18 meters) rocket to demonstrate that hybrid-propulsion technology offers a low-cost solution for delivering payloads. The two-foot-diameter (.6 meters) rocket used liquid oxygen and solid fuel to provide a thrust of 60,000 pounds and achieved an altitude of approximately 43.5 miles (70 kilometers).

"Hybrid propulsion offers significant advantages over solid fuel propellants in that hybrids are nonexplosive, able to be throttled, low cost and environmentally benign," said Randy Tassin, vice president, Program Management and Technical Operations for Lockheed Martin Space Systems, Michoud Operations, LA.

Lockheed Martin signed a Space Act Agreement with NASA Marshall Space Flight Center, Huntsville, AL, in 1999 to develop, test and launch the hybrid sounding rocket. The program goal was to develop a single-stage hybrid-propulsion system capable of replacing existing two- and three-stage sounding rockets. ❑

For more information, contact Marc Murbach, Research Engineer at NASA Ames Research Center, Moffett Field, CA, ✉ *Marcus.S.Murbach@nasa.gov*, ✆ 650/604-3155. Please mention you read about it in Innovation.

Researchers Laud Collision-Avoidance Test Results

NASA and industry researchers are increasingly confident a pilot in a remote ground station can safely detect and avoid collisions between an Unmanned Aerial Vehicle (UAV) and other aircraft in the skies. Detect, See and Avoid (DSA) technology is vital if remotely piloted or autonomous aircraft are to be integrated into the airspace system shared with inhabited aircraft.

The latest round of flight tests, sponsored by NASA Dryden Flight Research Center, Edwards, CA, under the Environmental Research Aircraft and Sensor Technology (ERAST) program, took place April 1–4, 2003 near Mojave, CA.

"The goal of the test was to be able to make a decision based on radar data with enough lead time to maneuver the test aircraft to avoid a close encounter with the intruder aircraft," said Glenn Hamilton, UAV Subsystems Project Manager at Dryden.

Scaled Composites' Proteus aircraft, with safety pilots on board but controlled from the ground like a true UAV, was repeatedly directed away from conflicting flight paths with a variety of aircraft, some of which did not emit any signals to show their positions in the sky. Central to this round of tests was the Amphitech OASys radar system mounted on the chin of the Proteus.

In all 20 scenarios flown, Proteus' ground operator was able to detect the presence of other aircraft that posed the potential for collisions, maneuvering the test aircraft to keep the intruding aircraft outside an imaginary 500-ft. bubble of safe airspace surrounding Proteus. The conflicting aircraft ranged greatly in speed, from a NASA F/A-18 high-speed jet to several types of general aviation aircraft and an unpowered sailplane. A hot-air balloon had been on the roster, but winds at Mojave precluded its use in this round of tests.

"The detection ranges were a little less than we expected, but varied greatly from about 2.5 to 6.5 nautical miles, based on the structure and radar cross-section of the target aircraft," Hamilton recalled. "We picked up the F/A-18 farther out, due to its larger radar signature, but, because of its higher speed, it didn't give us a lot of extra time to make an avoidance decision. On one head-on scenario, we had a 610-knot closure speed—not a whole lot of time to decide."

An AMphitech OASys Kaband radar was the primary sensor installed on Scaled Composites' Proteus for the second phase of NASA-sponsored Unmanned Aerial Vehicle Detect, See and Avoid flight tests.

The use of radar to detect these aircraft included one surprise—a 1940s vintage fabric-covered Stinson Voyager made a larger-than-expected radar signature, possibly due to its large aluminum-covered tail surfaces.

The recent tests follow last year's series near Las Cruces, NM, in which Proteus' remote pilot, using data from another detection device, was able to avoid conflict with aircraft that used transponders to identify their positions. Researchers are encouraged by the results of both test series, but they say that more work is required before a refined operational DSA system can be fielded. ❑

For more information on this technology, contact Michael Braukus, Public Affairs Officer, Office of Public Affairs, NASA Headquarters, ✆ 202/358-1979, 202/358-3750. Please mention you read about it in Innovation.

NASA Tests Environmentally

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one test per day will take place, each lasting 20 seconds or less.

The concept of a fast-burning, low-cost, paraffin-based fuel was originally conceived by Dr. Arif Karabeyoglu of Stanford, Dr. David Altman, president of Space Propulsion Group Inc., Menlo Park, CA, and Cantwell. Karabeyoglu developed the theory in his doctoral thesis that was partially supported by Stanford and NASA. He leads the Stanford contribution to the fuel research. ❑

For more information, contact John Bluck at Ames Research Center at ✆ 650/604-5026. Please mention you read about it in Innovation.

SLM Technology Creates New Commercial Opportunities

Spatial Light Modulator (SLM) technology was significantly advanced by Boulder Nonlinear Systems under a NASA SBIR contract managed at Jet Propulsion Laboratory, opening the door to future NASA applications in spacecraft rendezvous and landing, and creating several exciting new commercial applications.

A spatial light modulator is a liquid crystal array capable of displaying images or serving as a tunable optical light filter. The 512 x 512 array developed by Boulder Nonlinear Systems is smaller than a dime and can change images as fast as 1,000 frames per second.

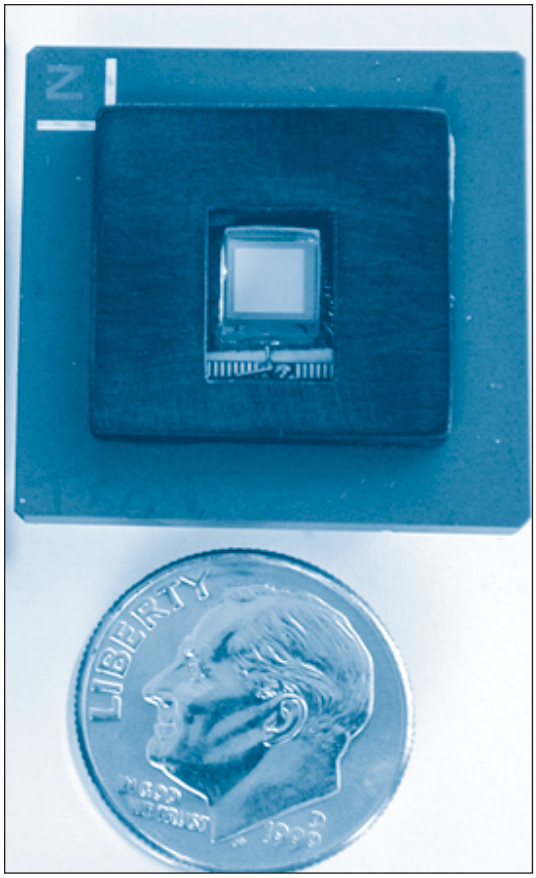
The NASA application for SLMs is in optical correlators—devices that are used for locating targets such as a spacecraft for rendezvous and docking, or identifying unique geographical features for landing on a planet or asteroid. A Mars sample return mission is a promising opportunity for the NASA application of the technology. Optical correlators compare current digital camera images with previously captured target images to determine location. The significant reduction in size achieved in SLM technology has resulted in a similar reduction in size of optical correlators, making spacecraft applications practical. The high frame rate has meant that optical correlators greatly surpass digital or computer-based approaches in the speed of their calculation.

Boulder Nonlinear Systems' SLMs have been integrated into several exciting new commercial products. One manufacturer has purchased them for their light tweezers. Light tweezers use laser beams focused through a microscope to move particles as small as individual molecules. At the microscopic level, the use of light beams makes it possible to move small particles within living cells without the danger of contamination associated with more invasive approaches. SLMs are used to tailor the laser beams to significantly enhance the capabilities of light tweezers.

Another promising commercial opportunity exists in searching visual records for matches. Comparing a known visual pattern such as a fingerprint to an unknown visual pattern requires very high-speed processing. Optical correlators using SLM technology are opening new opportunities in this field because of the speed at which they can make comparisons.

Other commercial opportunities exist in holography, optical information processing, image processing, neural networks, optical memory, biometric recognition, security systems and anti-counterfeiting. Early applications in these fields have contributed to the commercial success of this product. ❑

For more information, contact Byron Jackson at Jet Propulsion Laboratory SBIR Program Office at ✆ 818/354-1246. Please mention you read about it in Innovation.



The light square in the center is a 512 x 512 spatial light modulator capable of modifying the phase or amplitude of the light passing though each array element. Photo courtesy of JPL.

AeroAstro Completes Radio Compatibility Testing

AeroAstro, Inc. of Ashburn, VA recently completed successful compatibility testing of its X-Band Transponder with NASA's Deep Space Network (DSN). The completion of these tests marked a major milestone toward the flight validation of this transponder on the NASA Space Technology 5 (ST5) Nanosatellite Constellation Trailblazer mission, part of NASA's New Millennium Program (NMP). The two major objectives of the testing were to validate the testing AeroAstro performed by independently assessing the prototype transponder's performance and to verify its compatibility with the DSN ground system. Included in this testing was the first test of a new DSN uplink command module utilizing direct modulation, one of the elements being implemented to simplify the requirements on transponders utilizing DSN.

The major facets of the uplink testing included verification of acquisition and tracking, command detection and gain control. The receiver portion of the transponder is capable of tracking greater than ±40 kHz at 5 kHz/sec, 80 dB of linear automatic gain control, and is able to be directly commanded. On the downlink, the 2-watt transmit power and radiated emissions were verified compliant with all DSN requirements.

AeroAstro recently completed fabrication of a prototype of the transponder, and testing this transponder for operability with the DSN, the ground network to be used for the mission, was the next requirement for this flight on the ST5 mission. With the success of the DSN compatibility testing, AeroAstro is beginning the manufacture of a proto-flight unit with identical form and function to the flight units, which are each expected to weigh only 600 grams in an enclosure approximately 6 cm x 6 cm x 9 cm. This full duplex coherent transponder can transmit at a data rate of up to 750 kbps and receive at a rate of up to 4 kbps, with a power consumption of only 10 W for transmit and 4 W for receive. Compatibility testing of the proto-flight unit is scheduled for July 2003, after which flight model fabrication will begin, working toward the ST5 launch planned for 2004.

The NMP ST5 mission consists of three miniaturized satellites that are similar in size to a desktop computer, weighing only about 47 pounds each. These smaller satellites are much easier to manufacture than their large counterparts, bringing down the total mission cost. Flying clusters of multiple smaller satellites rather than a single larger satellite reduces the risk of an entire mission failing if one system or instrument fails. The goal of the ST5 mission is to flight-test its miniaturized satellites and the suite of innovative technologies it incorporates, within the Earth's magnetosphere, providing data for future development of spacecraft planned to study this region.

These smaller satellites are much easier to manufacture than their large counterparts, bringing down the total mission cost. Flying clusters of multiple smaller satellites rather than a single larger satellite reduces the risk of an entire mission failing if one system or instrument fails.

AeroAstro began development of the lightweight, compact X-Band Transponder via a 1998 Phase II SBIR award, and the technology was baselined for the Nanosatellite Constellation Trailblazer mission when it was selected for ST5 in 2000. Continued development is funded through a Phase III SBIR award. For its design of miniature X-Band transponders for small satellites, AeroAstro received the prestigious Tibbetts Award in 2000. The X-Band Transponder is just one of many innovative spacecraft systems in development at AeroAstro. AeroAstro manufactures low-cost satellite systems and components used in its own spacecraft and for spacecraft development in the US and abroad. ❑

For more information, contact Jim Ramsey at ✉ *jim.ramsey@aeroastro.com*, ✆ 703/723-9800, x115. Please mention you read about it in Innovation.

Scene Simulator for Hyperspectral Imagery

MCScene is a physics-based scene simulator developed by Spectral Sciences, Inc., of Burlington, MA, under a NASA SBIR program contract with Stennis Space Center. Development of MCScene was motivated by the need for an accurate, robust and efficient means of algorithm validation for the processing and analysis of hyperspectral imagery. The prototype, delivered to NASA Stennis in May 2002, has already proved beneficial to the NASA Earth Science Application Directorate (ESAD) program at its Verification and Validation range.

Hyperspectral imagery has great utility in a variety of commercial and government applications including, but not limited to, target detection and identification, precision agriculture, mineral exploration, forest management, ocean resource mapping and surface pollution detection. The quality of retrieved surface spectral reflectance from hyperspectral imagery depends on the accuracy of atmospheric compensation and surface retrieval algorithms. However, the use of field measurements for algorithm validation is expensive, time-consuming and impractical for data collection over the full range of atmospheric and surface conditions required to fully test the algorithms. Currently, there is no commercial software application available with this capability. MCScene was developed as a source of high-fidelity, highly characterized hyperspectral image data that can serve as substitutes for and supplements to field validation data.

Because MCScene is based on a Direct Simulation Monte Carlo (DSMC) approach for modeling 3-D atmospheric radiative transport as well as spatially inhomogeneous surfaces, including surface Bi-directional Reflectance Distribution Function (BRDF) effects, it is important to first understand the importance of the DSMC method in the realm of hyperspectral imagery.

Subtle features or small temporal changes in the surface spectral reflectance are often the markers of interest for commercial hyperspectral imagery applications, such as monitoring for crop stress or searching for valuable mineral deposits. Finding these spectral markers is challenging because of the corrupting influence of the atmosphere on the true surface spectrum. Virtually all scientific and commercial applications of hyperspectral and reflected light are in the visible near-infrared (VIS-NIR) spectral region, typically spanning the 400–2,500 nm region. The influence of the atmosphere in this range is significant, even in the case of a clear sky with moderate visibility. Compensation for these effects is complex because they arise from a variety of different sources, such as molecular absorption, aerosol and molecular scattering, and aerosol attenuation. The DSMC method is ideally suited to fully treat the spectral-spatial complexities of the simulation problem; it has the ability to handle complex geometries and allows the interactions of trial photons with the atmosphere and surface to be described with complete generality. It also enables upgrades and additional physical photon interaction models to be easily integrated into the simulation.

The well-known drawback to the DSMC approach is the very large number of trial photons needed to achieve an accurate result, thus leading to unacceptable computational times. However, recent advances in the processing speed of computer chips combined with practical and affordable parallel-processing software for PCs have helped to overcome this limitation to the DSMC approach. MCScene has proved to be a practical prototype DSMC hyperspectral imaging (HSI) simulation code. It has demonstrated its utility by simulating the effects of varying sensor altitude, atmospheric visibility and spatial adjacency on an atmospherically corrected HSI surface reflectance data cube. Thus, MCScene affords a practical means to extend the utility of costly field data by accurately simulating the effects of varying sensor, atmospheric and illumination conditions on real data.

The success of the prototype simulation code has benefited a number of other related projects at Spectral Sciences. For example, it has provided the foundation for an improved adjacency compensation algorithm in Spectral Science's atmosphere correction code (ACC), a MODTRAN4 radiation transport-based atmospheric correction code developed by Spectral Sciences and the Air Force Research Laboratory for analysis of hyperspectral radiance data. It also has enabled a rigorous validation for the DISORT multiple-scattering algorithm as implemented in MODTRAN. Finally, the simulation is being used to develop and evaluate a fast VISNIR cloud-masking algorithm under the ACC upgrade activities.

The commercial product of MCScene is computed in hypercubes, which will be used by HSI researchers for sensor and algorithm development and validation for the multitude of hyperspectral and multispectral satellite

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Scene Simulator

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and aircraft sensors under development by the Department of Defense, NASA and commercial companies. There is potential application to climatological research on atmospheric radiation budget assessment via coupled analyses of ground-, aircraft- and satellite-based sensor data. The simulation software will be provided to NASA Stennis for incorporation in its data simulation programs for scientific exploitation of hyperspectral data.

Spectral Sciences and its commercial partner, Research Systems, Inc. of Boulder, CO, are working to get MCScene ready for commercial release. Proven success of the package, such as with the NASA Stennis Verification and Validation (V&V) range, has allowed Spectral Sciences to win other government contracts to extend the technology to other uses. The company is in its second year of a Phase 2 SBIR with the National Imagery and Mapping Agency (NIMA) to, in part, extend MCScene to littoral regions, including simulation of transmission through water and reflection from water surfaces. It also is working on a Phase 2 SBIR with the US Air Force to extend MCScene to treat radiation at wavelengths through the long-wave infrared. Additionally, Spectral Sciences was awarded an STTR contract to adapt MCScene for the simulation of LIDAR in battlefield scenarios.

"This product would not be possible without the NASA SBIR program," said Fritz Bien, Spectral Sciences' president.

"The SBIR program provides an excellent avenue for small businesses like SSI to develop commercial products," said Steven Richtsmeier, principal investigator for the program. "Working with the people at NASA was extremely beneficial because it allowed us to tailor MCScene as it was being developed for the kind of customer we want to reach with a commercial product." ❑

For more information, contact Ray Bryant/SBIR Program Manager at Stennis Space Center, ✆ 228/688-3964. Please mention you read about it in Innovation.

Projects Selected for STTR

NASA has selected nine research proposals for negotiation of Phase 2 contract awards for the 2001 Small Business Technology Transfer (STTR) program.

Phase 2 continues development of the most promising previously selected Phase 1 projects. Selection criteria include scientific and technical merit, company capabilities, commercial potential, future importance and eventual value of the innovation to NASA. Funding for Phase 2 contracts may be up to $500,000 for a two-year performance period.

Contractors completing Phase 1 projects submitted a total of 18 Phase 2 proposals. All proposals were peer-reviewed for both technical merit and commercial potential. The combined award total for the nine Phase 2 contracts is expected to be $4.5 million.

The STTR program is designed to stimulate technological innovation; help small businesses become better qualified to assist NASA in its research and development; and increase private commercialization of federally funded research. The program also requires small businesses to conduct cooperative research and development by partnering with a research institution.

The goals of the STTR program are to stimulate technological innovation; increase the use of small business, including women-owned and disadvantaged firms, to meet federal research and development needs; and to increase private sector commercialization of federally funded research results. Two of the nine companies announced today are disadvantaged firms.

The STTR Program Management Office is located at NASA Goddard Space Flight Center, Greenbelt, MD. NASA's Office of Aerospace Technology provides executive oversight. Individual STTR projects are managed by the 10 NASA Field Centers.

A listing of the selected companies is on the Internet at: *http://sbir.nasa.gov* ❑

For more information, contact Michael Braukus, Public Affairs Officer, Office of Public Affairs, NASA Headquarters, ✆ 202/358-1979, ✉ *Michael.J.Braukus@nasa.gov*. Please mention you read about it in Innovation.

Software Study Yields Areas for Partnering

The US software industry, despite the passing of the dot-com phenomenon, remains a vital component of the nation's growth and competitiveness in the global economy. A recent study of the industry by Battelle Memorial Institute found that US firms currently account for about 90 percent of worldwide software sales. The US market for software alone is projected to reach $31 billion by 2006, an increase of nearly 37 percent since 2001. Moreover, the application of innovative software technology will continue to spur productivity and other competitive advantages for industries throughout the economy.

In view of the software industry's vitality, NASA's ongoing software R&D, and the common drive for new software capabilities, NASA is pursuing software technology transfer and partnering activities to leverage and bolster innovation in the nation's software sector. As part of this initiative, NASA recently completed a broad review of the software marketplace to assess opportunity areas for technology transfer and collaboration that intersect with advanced software technology that NASA is developing for its programs pushing the frontiers of science, technology and exploration.

The strategic assessment, which was performed by Battelle for NASA's Office of Aerospace Technology, first considered software technologies and projects reflecting NASA's investment in software R&D. Armed with this insight, Battelle undertook market research, including industry interviews, to gain commercial/market perspectives on potential areas for transfer, licensing and partnering. Targeted surveys of the NASA Tech Briefs readership provided additional depth to the more intensive review of several opportunity areas, confirming, among other findings, the positive interest in partnering with NASA to develop software solutions.

The strategic assessment resulted in several areas identified as having strong synergy with NASA software R&D and high potential for collaboration with industry. In recent years, the innovative application of software and associated computational technologies to manage, mine and analyze the deluge of biological data from genomics research and other fields has become a competitive necessity for firms operating in the life sciences marketplace. Likewise, in addressing the challenge of extracting knowledge from the immense volume of data generated by its Earth Science, Space Science and Aerospace Research Programs, NASA continues to develop novel software for data fusion, pattern recognition, feature extraction, modeling and simulation, automated knowledge discovery and other applications that are in sync with the needs expressed in the growing market for bioinformatics and other segments of the life sciences. Battelle's research also highlighted the growing challenge across many industries of exploiting data sets that are increasing in size and complexity. Thus, in addition to the life sciences, this trend presents a broad, crosscutting opportunity for exploring the transfer and collaborative development of software for data management, analysis and understanding.

Another high-potential area for NASA/industry collaboration centers on software for engineering design, analysis and modeling, and the need to integrate such software within projects and across the production process. From the pioneering introduction of NASTRAN for finite element analysis over 30 years ago to the more recent development of the revolutionary CART 3D for aerodynamic simulation and other advanced software tools, NASA has been and remains a significant source of innovation in the overall area of engineering software. In this and other key areas, NASA is seeking partners to transfer and develop software that advances the state of the art and the market. ❑

To learn more, go to *http://www.nctn.hq.nasa.gov/software/* or contact Jonathan Root, NASA Headquarters, ✆ 202/358-1845. Please mention you read about it in Innovation.

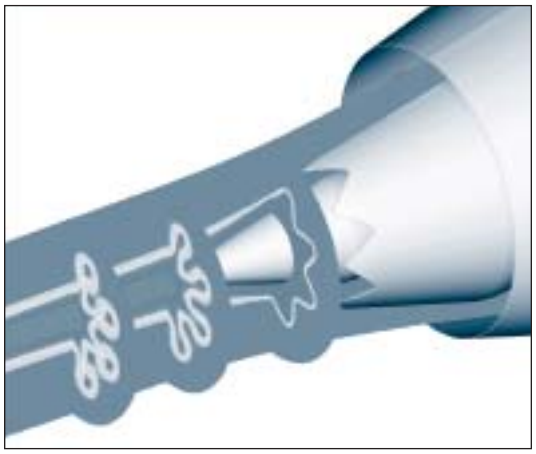

Image generated by the PAB3D code for three-dimensional aerodynamic flow simulation. Analytical Services & Materials, Inc. developed the code for NASA Langley Research Center and currently offers a commercial version of the PAB3D software. Photo courtesy of Analytical Services and Materials, Inc.

Technology Opportunity Showcase

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**.

Super Mirrors at Low Cost

NASA Goddard Space Flight Center is seeking companies to explore licensing a revolutionary process for precision optical polishing of bare aluminum.

The benefits of this process include low weight; thermal stability—bimetal thermal characteristics of nickel over aluminum are poor, and pure aluminum mirrors offer excellent thermal stability; low cost—plating aluminum surfaces with electroless nickel significantly adds to the cost of the optic; smooth surface—the process yields a 5-angstrom flat and spherical mirrors and 10-angstrom aspherical mirrors, which are ideal for high-quality mirrors; and consistent quality—plating electroless nickel onto aluminum can result in faults that preclude using the optic, whereas this process consistently yields a high-quality surface and form.

Manufacturers of optics, metal optics and diamond turning and polishing equipment could license and incorporate this method into their products. The high-quality optics achieved using this method can be used in a variety of applications, including x-ray telescopes, cryogenic instruments, interferometry and medical-imaging devices.

This method begins by using a single-point diamond turning machine. Grinding cannot be used on bare aluminum—it leaves behind particles that scratch the surface during polishing. Diamond turning alone typically produces a 30- to 80-angstrom finish on standard aluminum materials. Therefore, additional polishing is required to achieve the needed smoothness for low-scatter, high-quality bare aluminum optics.

The process uses a special compound to polish the mirror to a super smooth finish. This compound not only offers superb lubricating qualities, but it also contains suspended particles. These particles are extremely hard and small, making the compound ideal for mirror polishing.

Flat and spherical mirrors polished using this process have a roughness of 5 angstroms rms, while maintaining a surface-figure accuracy of 0.125 of a wave peak to valley. Aspherical mirrors can be polished to a 10-angstrom rms finish.

The major benefit of this innovative process is the ability to make pure aluminum mirrors. Aluminum optics are less expensive and lighter than optics made from other pure materials. ❑

For more information, contact Joe Famiglietti, Goddard Space Flight Center, Office of Technology Transfer, ✆ 301/286-2642, ✉ *Famiglietti@nasa.gov* Please mention you read about it in Innovation.

Graded Coatings

NASA Marshall Space Flight Center is seeking companies to license and develop graded coatings for commercial applications.

Marshall has developed a novel method of manufacturing and coating high-performance engine components to withstand violent combustion environments in which intense temperature and pressure could damage parts. The method relies on vacuum plasma spray (VPS) and other thermal spray techniques to produce parts for applications in which several materials are combined to meet demanding fabrication and performance requirements.

The technology can be used to form and coat parts that are associated with aerospace, automotive and commercial engines. Aerospace applications include forming or coating rocket engine combustion chambers and nozzles, as well as turbine vanes and combustors. The application can be utilized by the automotive industry for coating pistons, cylinder heads, valves and exhaust manifolds in diesel and high-performance engines. Potential commercial engine uses include industrial gas turbines, incinerators, furnaces and heat exchangers.

The technology promises to extend the life of high-performance parts. The method lowers operating temperatures; enhances resistance to thermal corrosion, oxidation and abrasion; and increases strength lubricity, bonding and/or ductility.

NASA uses the technique to combine two materials that together provide the desired properties for a rocket engine combustion chamber—good thermal conductance and resistance to thermal corrosion and oxidation. In this application, a protective nickel alloy coating protects a copper alloy combustion chamber lining. As a result of using the new method, NASA has been able to avoid previous problems with the coating blistering and separating under intense heat loads.

The method is being used at NASA to make small and large developmental engine parts. To date, NASA has formed coatings from Ni-, Cu-, ferrous- and ceramic-based material. Parts made using the method have been exposed to temperatures in excess of 3,500 to 5,000 °F and to pressures ranging from 500 to 3,000 psi. Depending on material selection, the resulting wall temperatures range from 1,000 to 1,700 °F. ❑

For more information, contact Sammy Nabors at ✆ 256/544-5226, ✉ *sammy.nabors@nasa.gov.* Please mention you read about it in Innovation.

NASA Technology Transfer Network Directory

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.

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.

Carolina Blake
Ames Research Center
Moffett Field, California 94035-1000
650/604-1754
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

Jenny Baer-Riedhart
Dryden Flight Research Center
Edwards, California 93523-0273
661/276-3689
jenny.baer-riedhart@mail.dfrc.nasa.gov

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

Larry Viterna
Glenn Research Center
Cleveland, Ohio 44135
216/433-3484
Larry.A.Viterna@grc.nasa.gov

Goddard Space Flight Center
Selected technological strengths are Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors.

Nona Cheeks
Goddard Space Flight Center
Greenbelt, Maryland 20771
301/286-5810
ncheeks@pop700.gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths are Deep and Near Space Mission Engineering and Operations, Microspacecraft, Space Communications, Remote and In-Situ Sensing, Microdevices, Robotics and Autonomous Systems.

Ken Wolfenbarger
Jet Propulsion Laboratory
Pasadena, California 91109
818/354-3821
James.K.Wolfenbarger@jpl.nasa.gov

Johnson Space Center
Selected technological strengths are Life Sciences/Biomedical, Spacecraft Systems, Information Systems, Robotic and Human Space Flight Operations.

Charlene Gilbert
Johnson Space Center
Houston, Texas 77058
281/483-0474
charlene.e.gilbert@jsc.nasa.gov

Kennedy Space Center
Selected technological strengths are Emissions and Contamination Monitoring, Sensors, Corrosion Protection and Biosciences.

Jim Aliberti
Kennedy Space Center
Kennedy Space Center,
Florida 32899
321/867-6224
jim.aliberti-1@kmail.ksc.nasa.gov

Langley Research Center
Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

Rick Buonfigli
Langley Research Center
Hampton, Virginia 23681-0001
757/864-6005
r.t.buonfigli@larc.nasa.gov

Marshall Space Flight Center
Selected technological strengths are Materials, Manufacturing, Non-Destructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing.

Vernotto McMillan
Marshall Space Flight Center
Huntsville, Alabama 35812
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Stennis Space Center
Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Non-Intrusive Instrumentation.

Robert Bruce
Stennis Space Center
Stennis Space Center, Mississippi
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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.

Bill Musgrave
Ames Technology Commercialization Center
San Jose, CA
408/557-6820

Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
228/688-3144

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
440/260-3300

David Kershaw
Florida/NASA Business Incubation Center
Titusville, FL
321/267-5601

Bridget Smalley
University of Houston/NASA Technology Center
Houston, TX
713/743-9155

Richard Reeves
Business Technology Development Center
Huntsville, AL
256/704-6000, ext. 602

Julie A. Holland
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Ann Lansinger
Emerging Technology Center NASA Business Incubator
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Small Business Programs

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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.

Ken Dozier
Far West Technology Transfer Center
University of Southern California
Los Angeles, CA 90007
213/743-2353

James Dunn
Center for Technology Commercialization
Westborough, MA 01581
508/870-0042

David Bridges
Economic Development Institute
Georgia Institute of Technology
Atlanta, GA 30332
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Gary F. Sera
Mid-Continent Technology Transfer Center
Texas A&M University
College Station, TX 77840
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Charlie Blankenship
Technology Commercialization Center, Inc.
Newport News, VA 23606
757/269-0025

Pierrette Woodford
Great Lakes Industrial Technology Center
Battelle Memorial Institute
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Joseph P. Allen
National Technology Transfer Center
Wheeling Jesuit University
Wheeling, WV 26003
800/678-6882

Dan Winfield
Research Triangle Institute Technology Applications Team
Research Triangle Park, NC 27709
919/541-6431

Moving Forward

NASA technology benefits our lives in many ways. NASA publishes formal technical reports describing research work conducted at its facilities. Visit *http://www.nasatechnology.com/* to access more information about NASA technologies.

Events

National Fall SBIR/STTR Conference

For more information about the conference and registration, visit *http://www.sbirworld.com/*

Tech Briefs

Nanotech 2003 Conference

For more information about the conference and registration, visit *http://www.nasatech.com/nano/*

9th Annual Small Business Innovation Research (SBIR) Conference

Virginia's 9th Annual Small Business Innovation Research (SBIR) Conference helps Virginia's small businesses increase their chances of winning SBIR and STTR awards to develop and commercialize their technologies. New this year are moderated afternoon panels on life sciences, sensors, IT and telecommunications. For more information about the conference and registration, visit *http://www.cit.org/sbir/*

Publications

Look for NASA *Spinoff* 2003 in September!

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