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Aerospace Technology

# INNOVATION

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Aerospace Technology
# INNOVATION

Volume 6, Number 1 January/February 1998



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**About the Cover:**
"One Small Step for a Man" is an acrylic by Alan B. Chinchar commemorating the 20th Anniversary of the first lunar landing (July 20, 1969). Apollo 11 Astronaut Buzz Aldrin is depicted in the painting with the image of the Earth reflected in his visor. (NASA Art Program)

**On-Line Edition:** Go to **http://nctn.hq.nasa.gov** on the World Wide Web for current and past issues.

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## COMMERCIAL DEVELOPMENT MISSION UPDATE

| Date* | Flight | Payload | Sponsor/Coordinator |
|---|---|---|---|
| 5/98 | STS-91<br>Shuttle/Mir-09 | Commercial Protein Crystal Growth-11<br>(secondary payload; "sortie" mode) | Center for Macromolecular Crystallography |
| 8/98 | STS-93<br>AXAF | AEROGEL<br>Commercial Generic Bioprocessing Apparatus-04** | Marshall Space Flight Center<br>BioServe Space Technologies |
| 10/98 | STS-95 | Includes eight commercial development payloads: | Commercial Space Centers and NASA Centers |
| | BioTechHab<br>(SPACEHAB<br>short module) | Advanced Organic Separation Unit (ADSEP)<br>AEROGEL<br>ASTROCULTURE™<br>BioDyn-A<br>Commercial Generic Bioprocessing Apparatus<br>Commercial ITA Biomedical Experiments<br>Commercial Protein Crystal Growth-15<br>Microencapsulation Electrostatic Processing System | Consortium for Materials Development In Space<br>Marshall Space Flight Center (MSFC)<br>Wisconsin Center for Space Automation & Robotics<br>Consortium for Materials Development In Space<br>BioServe Space Technologies<br>Instrumentation Technology Associates, Inc.<br>Center for Macromolecular Crystallography<br>Johnson Space Center/MSFC |

Key STS—Space Transportation System ITA—Instrumentation Technology Associates, Inc. *As of 30 March 1998 **Being considered for manifesting

# WELCOME TO INNOVATION

## The Promise of NASA's Commercial Technology Network

**by Robert Norwood**

THE NASA COMMERCIAL TECHNOLOGY PROGRAM is proud to be a part of NASA on its 40th anniversary. With the Space Act of 1958, Congress not only gave NASA direction for leading America's space program, but also a mandate to work with U.S. industry. This partnership captures the imagination of the world as NASA explores space. It has also created economic wealth here on Earth. Forty years later, NASA's technology transfer and commercialization program has generated exciting new technologies in the United States and abroad that positively impact our economy and boost our global competitiveness.

While NASA's role at the cutting edge of research in space exploration is well known, the potential commercial applications of this effort are equally inspiring and renowned. The benefits of NASA technology to everyday life are wide ranging—from scratch-resistant sunglasses, home water filters and athletic shoes to advances in medical research, airline safety and firefighting techniques. The applications of NASA's technologies also have the ability to create jobs, new companies and entire industries.

Understanding gained through NASA research and space exploration promotes more effective skills in a wide range of everyday technologies and aids in producing and processing many materials, including metals, semiconductors, polymers and glass. A great example is the area of semiconductors, which have contributed improved efficiency in the computer and electronic communications revolution and support today's information-driven society. We drive cars and fly airplanes that were designed using NASA computer software. We live in homes and work in office buildings that carry electricity through flat conductor cables that incorporate NASA technology.

Many other examples will result from NASA's strategic plan to advance and communicate scientific knowledge and understanding of Earth and space, to explore, use and enable the development of space for human enterprise and to research, develop, verify and transfer advanced aeronautics, space and related technologies.

Technology transfer and commercialization is growing in importance to our economic well-being as well as contributing more than one-third of all U.S. business technology needs. The NASA Commercial Technology Network (NCTN) is seeing a huge industry demand for NASA technologies as U.S. companies reach out to public sector research and development (R&D) as a means of responding to increased international competition.

Congress and NASA recognized as far back as 1958 that federally sponsored R&D is an enormous but underutilized economic resource. As we grow closer to the next century, it is imperative to vigorously form and continue these partnerships essential to U.S. economic growth. From that 1958 Space Act, Congress has passed a series of laws urging our universities and federal laboratories to aggressively pursue these R&D arrangements. Successfully utilized partnerships with industry benefit not only NASA and the industrial customer, but also the economy and U.S. taxpayer. As federal budget cuts continue to tighten the availability of R&D funds, these partnerships assume greater importance to all federal agencies in meeting their own missions.

The International Space Station (ISS) will provide the opportunity for long-term research that can be applied to commercially viable products and processes. By working with private and public sector partners, it is hoped that the ISS will help facilitate our commercial partners' access to space. The commercial goals for the ISS are to foster space commerce, improve industrial processes and keep America competent and competitive in the growing international marketplace and at home.

NASA established the NCTN as a foundation for its technology transfer and commercialization mission and has built an extensive infrastructure toward this end. It began with NASA's Centers of Excellence (field centers): Ames, Dryden, Goddard, Johnson, Kennedy, Langley, Lewis, Marshall and the Jet Propulsion Laboratory. NCTN was expanded to include:

- Regional Technology Transfer Centers and National Technology Transfer Center
- Commercialization and incubation centers
- Affiliated organizations

NASA is to be commended for not only embracing this mission from Congress, but also strengthening it in documents such as Administrator Goldin's *Agenda for Change,* which reestablishes NASA's commitment to work with industry to move federally funded R&D into the marketplace. All of us in the NCTN look forward to continuing NASA's dynamic role of expanding the horizon of knowledge, while benefiting humanity through new commercial products and services well into the next century.

# NASA Celebrates Its 40th Year

OCTOBER 1, 1998, MARKS THE 40TH ANNIVERSARY of NASA's creation. Throughout the year, the Agency will celebrate its achievements and the significant highlights, discoveries and events of its past, present and future—accomplishments and contributions that enhance our knowledge of the universe and the quality of our everyday life.

NASA was born during the Cold War struggle with the Soviet Union, but its core went back much further, to an organization known as the National Advisory Committee for Aeronautics (NACA), founded in 1915 by farsighted men who were concerned with the then-primitive state of aviation technology in the United States. By the 1950s, the NACA's members had become increasingly involved in missile research and were contemplating a move into space exploration. The NACA had a network of laboratories around the country, which today are NASA's Ames, Dryden, Langley, Lewis and Wallops field centers, as well as a longtime relationship with industry and the military.

In April 1958, Congress began examining a bill to establish NASA as the organization to continue aeronautics research and push forward a national space program. Originally proposed as the "National Aeronautics and Space Agency," the name was changed a few months later during the bill's debate to "Administration." President Eisenhower signed the legislation on July 27, 1958. With the NACA as the core of the new agency, it soon incorporated the space exploration projects of the Naval Research Laboratory (now Goddard Space Flight Center), the Army's Jet Propulsion Laboratory and the Army Ballistic Missile Agency (now Marshall Space Flight Center). Thus, NASA picked up the threads of an embryonic and fragmented space program initiated largely by a U.S. Army team of rocket technicians, who had launched the first American satellite, Explorer I, on the last day of January 1958.

In just over a decade, three Americans were reading passages from the Book of Genesis while they were orbiting around the Moon! For more than four decades, NASA has been guiding the American aerospace effort, establishing the United States as the preeminent nation in aerospace technology and exploration. NASA is still heavily engaged in research and development work in all aspects of aviation and space. What NASA accomplished yesterday has built the foundation for what it is doing today. Its experiments and technological research efforts fuel the hopes that embody the future, thus paving the way for a permanent human presence in space, increasing our understanding of the solar system and Earth, maximizing the competitive position of today's aviation, space launch and communications industries, and continuing to enhance the quality of life on Earth.

To most Americans, NASA means no more than aerospace exploration. However, the NASA Technology Transfer Program, established 40 years ago under congressional mandate to promote the transfer of aerospace technology to the public and private sectors of America, has given an enormous wealth of knowledge and expertise to U.S. industry, touching every part of life. *Aerospace Technology Innovation* serves as a primary source of information about NASA projects and opportunities in the areas of technology transfer/commercialization, aerospace technology development and the commercial development of space. To celebrate NASA's 40th year, this and subsequent issues of *Innovation* will examine the many ways the Agency's research and development results have affected our everyday lives—from the many products, services and enhancements used daily that originated from NASA technology and know-how to how NASA has progressed through the years.

Research and development has generated technology for decades and is available to private industry in a vast storehouse easily accessible through the NASA Commercial Technology Network. Technology transfer helps the United States meet international challenges and keeps U.S. industry competitive in global scientific and technological innovation. Technology transfer and commercialization increases productivity, which brings about new products and processes that meet consumer demands. Through NASA's research and the participation of entrepreneurs and industry, thousands of spinoff products and processes have been derived from NASA-developed technology. Examples are:

## Our Daily Bread

***What to feed the astronauts—***The Hazard Analysis and Critical Control Point (HACCP) method addressed NASA's need for absolute freedom from potentially catastrophic disease-producing bacteria and toxins. The food industry has adopted this


*NASA food technology first resulted in Action Snacks, but now contributes to food safety, hydroponics and crop management.*

method. HACCP establishes control over the entire food preparation process, raw materials and people involved to prevent food safety problems instead of catching them after an occurrence. Other government agencies are considering extending HACCP to meat/poultry and seafood inspection operations. Today, food plants are still operating under HACCP.

***Partnering with Disney—***The ripe tomatoes exhibited at Disney's EPCOT Center are real and represent a project that is increasing the Earth's food-growing capacity. NASA's Kennedy Space Center and Disney World are collaborating to use human and industrial waste to provide ingredients needed for growing edible plants. Many vegetable farmers around the world are learning how to grow crops without soil—a method known as hydroponics, which also has promise for long space flights during which astronauts will grow their own food without carrying heavy soil into space.

***Buyers or sellers—***NASA's Landsat satellites are helping determine potato pricing in the Pacific Northwest. A company is using data from a Landsat satellite passing over Oregon and Washington to calculate just how well potato crops are doing. The more potatoes there are, the less money farmers will get for their crop. The fewer potatoes growing in the area helps a farmer decide to harvest early and get a higher price.

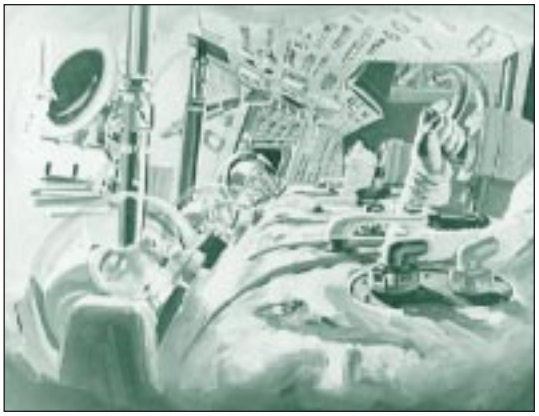
## Life, Health and the Moonsuit of Happiness

***Cooling systems for health and occupational comfort—***A channeled cooling garment for space wear has resulted in personal medical cooling systems worn by patients with multiple sclerosis, cerebral palsy and spina bifida, among others, to lower their body temperatures. "Cool Suits" are used by hazardous materials workers, armored vehicle crews, firefighters, crop dusting pilots, heavy equipment operators, auto racing drivers and surgical personnel in hot operating room environments.

***Spacesuits are everywhere—***Spacesuit material is used in construction of shopping centers, sports stadiums, airports and many other places. Lightweight fabric used in the Mercury and Gemini programs—and improved on during the Apollo era—was used to build Atlanta's Georgia Dome, Rome's Olympic Stadium, a Vancouver stadium, and airport terminals in Denver and Saudi Arabia. This flexible, stronger-than-steel "moonsuit" fabric developed by Owens-Corning is being used by more architects, engineers and building owners because it is durable, fire resistant and moisture repellent. It expands and contracts with temperature changes, lets in light and reflects heat, thus reducing cooling and lighting costs.

***These shoes were made for moonwalking—***The space shoes used on the Moon were also perfect for retaining shock absorption, stability and flexibility in the athletic arena. The midsole, similar to the rigid/flexible system in spacesuits, and NASA's "blow-molding" process for stress-free durability were incorporated into athletic shoes and showed no visible signs of wear or structural fatigue after testing equivalent to 400 miles. They can also be configured for different sports.

***Lifesaving "jaws"—***Firefighters and rescue workers use lifesaving "jaws" tools to help injured accident victims. The tools are powered by the same small explosive charges that release the Space Shuttle's solid rocket boosters. The boosters are held together by explosive bolts that burst for release from the rest of the vehicle. A company has been supplying NASA with explosive nuts and bolts and related equipment



*"Moonsuit" fabric worn by the Apollo astronauts is now used by architects, engineers and building owners.*

*Technology used in the Space Shuttle's external tank is now being applied to golf ball manufacturing.*

since the Apollo days. The rescue tools can be set up quickly, are lightweight and cost less; they were used in the Oklahoma City bombing rescue efforts.

***Less firefighters' lives are being lost—***Firefighters die often from smoke fumes and inhalation. Breathing equipment for astronauts is universal in firefighting because its light weight is an advantage over the old heavy equipment often left behind. The system is more evenly distributed on the hips and has better visibility with a low oxygen warning device.

***Skylab helps sniff out killer vapors—***Detectors on Skylab helped eliminate killer vapors by identifying carbon monoxide and smoke. This sensitive instrument immune to vibration distinguished carbon monoxide from water vapor by removing the water vapor before measurement. Smoke or fire triggers an alarm with an ionization chamber that acts as a sensor. This technology can be found in some of the smoke and carbon dioxide detectors available today.

***Space in the lives of women—***Space is saving their lives with the help of Hubble Space Telescope technology. Breast biopsies can be performed with a needle instead of a scalpel using supersensitive charged coupled devices (CCDs), which are silicon chips that convert light directly into electronic or digital images. A company adopted the new CCD for its breast biopsy system to obtain clearer images than conventional x-rays offer.

***Beam me up—***Lasers are used to transmit communications signals, to drill, cut or melt hard materials and to carry out various medical applications and treatments. Lasers have given heart patients a nonsurgical alternative to open up clogged arteries after the Food and Drug Administration approved a new surgical method derived from laser technology pioneered by the Jet Propulsion Laboratory for remote sensing. A small catheter is threaded through coronary arteries, and the laser light is carried through fiber optic bundles within the catheter. Another group of fibers shines a light at the tip to provide video pictures of the inside of the artery.

***Better body imaging—***Such imaging is acquired through digital image processing through two of the most widely used body imaging techniques: computer-aided tomography and magnetic resonance imaging. These two methods were developed from digital image processing technology that enhanced pictures of the Moon and later became the basis for the NASA Landsat satellites.

## Home and Leisure

***Home improvement power tool is born—***Apollo astronauts needed a way to drill as much as 10 feet beneath the Moon's surface to collect core samples. As with everything else that went to the Moon, the drill had to be small, lightweight and battery powered. A company designed a computer program so the drill's motor could use as little power as possible, which has provided a strong technology base for developing battery-powered tools and appliances.

***What has golf got to do with space?—***How is golf connected to Space Shuttle technology? Companies have worked with the airload and slosh control used in the Space Shuttle's external tank to provide "unmatched accuracy and distance" in its latest golf ball design. Similar to the liquid in the Shuttle tank, when flying through the air, the liquid inside the golf ball sloshes around unless it is controlled to keep it traveling in an efficient and predictable way. As an object moves through the air, its aerodynamic efficiency is also affected by the way the air passes across its surface. These "airloads" are important for a golf ball as well as the external tank.

NASA has a tradition of excellence extending back to the NACA established in 1915. Concerned with the problems of flight in the atmosphere and in space, NASA's partnerships with industry, universities and other government have helped make the United States the most scientifically and technically advanced civilization the world has ever known.

Our lives have fundamentally changed for the better in the 40 years since the dawn of the space age, and NASA's creation was a crucial part of it. The next 40 promise similar progress. Happy 40th, NASA!

For more information, contact Karen Kafton at the National Technology Transfer Center. 304/243-2415, 304/243-2457, *kkafton@nttc.edu* Please mention you read about it in *Innovation.*

# Technology Transfer: 1997 Year in Review

TECHNOLOGIES "TWICE USED"—ONCE FOR NASA's principal mission in space and aeronautics and again for other purposes in the form of products and services—directly affect and improve the quality of life on Earth. Featured in this issue of *Aerospace Technology Innovation* are 1997's highlights of the technologies in use today and being developed for tomorrow. These highlights include a wide range of technology transfer successes in partnering, information dissemination, technical assistance, licensing, cooperative research and development, collaboration, commercialization, telemedicine, the Mars Pathfinder mission and NASA's Crusade for Women's Health. The following is a synopsis of 1997 *Innovation* featured highlights:

## NASA and Red Pepper Launch Hot Item

Space Shuttle launch software allowed the market value of Red Pepper Software, a San Mateo, California, company, to grow to $225 million in just three years. The company adapted NASA's Ground Processing Scheduling System (GPSS) for some of America's Fortune 500 companies to help manage worldwide business transactions from one location. The commercial software systems inspired by GPSS supplement existing transactional and shop control systems, helping production and distribution centers satisfy customer demands by optimizing materials, capacity and labor in real time. At Kennedy Space Center, GPSS schedules the thousands of activities that simultaneously prepare the four Space Shuttle orbiters.

## NASA Recycles Milk Bottles

Rescue blankets made of recycled plastic milk bottles are a recent spinoff from the NASA Small Business Innovative Research (SBIR) program's research and development of lightweight metal insulation for spacecraft. Using the "honeycomb concept," researchers, in collaboration with NASA scientists at Ames Research Center, created a lightweight plastic insulation for blankets and clothing that is comparable to, yet better than, wool. This new material can keep a person warm even when it is wet. The rescue blanket is expected to be used primarily by disaster assistance and emergency rescue teams.

## Telemedicine Space and Earth Programs

Several NASA Centers of Excellence are investigating and implementing ways to bring telecommunications information technologies and medicine together to deliver health care, not only to astronauts but to citizens of Earth who live in remote locations and have limited access to medical care. A major focus of 1997 was NASA's progressive telemedicine programs and initiatives, which began nearly 40 years ago as a solution to a problem; NASA needed to be able to monitor astronauts' biomedical responses because they were in extreme and remote environments. NASA released an Integrated Strategic Program Plan (ISPP) for Telemedicine that outlined the Agency's commitment to enhancing its capability to provide medical care in support of human space flight and the Human Exploration and Development of Space (HEDS) Enterprise. Humans living in remote locations on Earth who need medical care will benefit from these new advances, as they already do from current NASA telemedicine technologies. NASA continues efforts to meet the challenge of delivering health care to astronauts in space as well as people in remote areas of the world, working toward telemedicine applications and collaboration with academia, industry and other government agencies.

## NASA Feeds the Hungry

East Africans learned to cook with solar energy and the help of a nonprofit California group promoting solar cooking technology, using data generated by NASA's Mission to Planet Earth program and the NASA Surface Solar Energy data set created by Langley Research Center and Analytical Services and Materials, Inc., of Hampton Virginia. Solar cooking—a clean, safe, convenient, relatively cheap heat source that reduces smoke, air pollution and deforestation—also may be used to pasteurize drinking water to help prevent disease. It will reduce time and money spent for firewood and cooking fuel.

## Emerging Technologies From Mars Missions

The Mars Exploration program as a whole plans a decade of inexpensive, innovative missions, but in 1997 the Mars Pathfinder embraced the basic Discovery program charter that encourages the use of available hardware. It also tested a number of novel systems, components and software, some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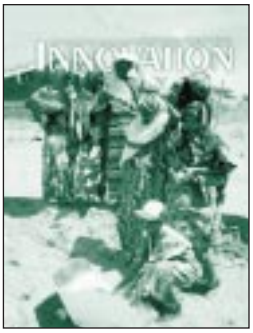


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showing great commercial promise, including a partnership with Mattel Inc., that renewed public interest in the space program. Some of the most interesting technologies emerged from the Mars Pathfinder mission, including: rocker-bogie suspension, silica aerogel insulation, Dynamics Algorithms for Real-Time Simulation (DARTS) software, the piezoelectric ultrasonic motor, the surface acoustic wave microhygrometer and a newly developed lightweight carbon fiber composite. The Mars Pathfinder has emerged as the quintessential model for NASA's faster, cheaper, better paradigm.

### Crusade for Women's Health

"There's Space in My Life" is an innovative, two year initiative to reach women, men and their families to share information about how NASA science, research and technologies improve their lives. The initiative originated with NASA Administrator Daniel S. Goldin, who wants to share information about how aerospace is an investment in our current standard of living, our knowledge of our place in the universe and our children's future. The commitment is to identify, develop and transfer NASA technologies to benefit women's health. Major areas of concern are cancer, reproductive health, pregnancy, osteoporosis and education. Teaming with industry, academia and government, several NASA biomedical experiments have resulted in successful new technology programs among NASA, the National Institutes of Health, the National Cancer Institute and the U.S. Department of Health and Human Services' Office of Women's Health. *Innovation* featured highlights of the technologies in use today and being developed for tomorrow that help doctors find and treat breast cancer. The experiments included: silicon chips, next-generation digital mammography, advanced ultrasound, smart robot probe, telemammography and tissue growth.

As we progress into 1998, *Aerospace Technology Innovation* will continue to report updates of past highlights, as well as feature new and exciting stories about NASA's technology transfer and commercialization program results.

For more information, you may access 1997 issues of *Innovation* at NASA's Commercial Technology web site at *http://nctn.hq.nasa.gov* or contact Karen Kafton at the National Technology Transfer Center. 304/243-2415, 304/243-2457, *kkafton@nttc.edu* Please mention you read about it in *Innovation*.

# Optical Supplier Benefits From NASA Technology

A NASA CLEAN-ROOM TECHNOLOGY AND THE National Technology Transfer Center (NTTC) are helping a supplier to one of the world's largest optical companies explore new markets and products. CleenEzy™ Inc. is investigating a much larger market potential after taking over an optical lens cloth supply business and later discovering its product was based on a NASA technology.

Owners Mike and Tina Simpson had no idea what landed in their laps when they acquired the established optical lens cloth supply business as an addition to the cleaning supply business they manage. A multi-use technology, which for years has shielded space missions from devastating effects that the tiniest particles can make, produces scratch- and lint-free results in CleenEzy™'s lens wipes. A tiny speck of dust could trigger a malfunction in a sensitive spacecraft system, so NASA developed contamination control technology in the 1960s to prevent particle contamination during production and assembly of flight equipment in hospital-like "clean rooms." This technology has produced several offshoots, such as a line of contamination control garments used by hospitals, pharmaceutical and medical equipment manufacturers, aerospace and electronic plants, and other industrial facilities where extreme cleanliness is vital.

"We're working with CleenEzy™ in researching several new products by making prototypes that will be

*Multiple market potential looks promising for a lens wiping cloth based on NASA's clean-room technology with the joint development efforts of the National Technology Transfer Center and Lewis Research Center.*

taken to mass production," Jack Williams of NTTC's Commercialization Center said.

CleenEzy™'s hypo-allergenic optical cloth is soft but durable enough to be effective on coated and uncoated surfaces, wet or dry, without streaking or smudging. It is reusable and disposable, making it more cost-effective than microweave cloths, and it has a four-micron porosity that entraps particles, preventing them from passing through or being released. In laboratories where lenses are manufactured, it significantly reduces the percentage of scratched lenses.

Research has found that the greatest sources of clean-room contamination are the people who work in such facilities. They can generate microscopic body particles that escape through tiny "windows" in the woven garments they wear.

CleenEzy™, located in West Virginia's northern panhandle, services many of the country's top 25 optical companies and is the only supplier of lens wipes recommended by the Opticians Association of America.

For more information, contact Matt Moran at Lewis Research Center. 216/433-8324, *mmoran@lerc.nasa.gov* Or contact Jack Williams at NTTC. 800/678-6882, *jwilliam@nttc.edu* Please mention you read about it in *Innovation.*

## GAMMA ARRAY BURSTS WITH APPLICATIONS

A gamma ray detector array developed by a Goddard Space Flight Center research team promises unprecedented accuracy in locating gamma ray bursts and a wide range of potential commercial applications, including medical imaging, environmental monitoring and nondestructive evaluation. Goddard is collaborating with the University of Arizona in Tucson and the National Institutes of Health to use a pixel array, another type of cadmium zinc telluride (CZT) array, in a brain imaging instrument.

Many areas of brain activity are smaller than 1 millimeter, and no prior instrument existed that could image activity in areas this small, researchers say. Nuclear medicine techniques for precise imaging are used to identify and locate gamma array activity in the brain. As a result, researchers expect the development of an entirely new class of high-resolution nuclear medicine scanners for improved detection of breast cancer, post–heart attack tissue damage assessment and more accurate epilepsy and stroke diagnoses.

A gamma ray strikes the CZT chip and produces an electric charge in a tightly packed electrode strip that makes very accurate determinations of a gamma ray's origin in such a small area. This portable detector could be commercially applied to many industrial situations, including monitoring radioactive waste storage sites, verifying nuclear treaties and probing interiors of structures and equipment to identify faults. A soda company is exploring the possibility of using gamma rays to determine whether bottles are filled to the correct level.

For more information, contact Bill Steigerwald at Goddard Space Flight Center. 301/ 286-5017, 301/286-1629, *wsteiger@pop100.gsfc.nasa.gov* Please mention you read about it in *Innovation.*

# KSC's Fruitful Hopes for Georgia

THE STATE OF GEORGIA AND NASA'S KENNEDY Space Center (KSC) recently signed an Interagency Agreement for Technology Transfer to establish a more proactive working relationship, according to the KSC Technology Programs and Commercialization Office. NASA has a responsibility to transfer space program technology and information to private industry, and KSC believes this agreement will provide "the widest practicable and appropriate dissemination of information concerning its activities, and consequentially, benefit the general public and the national economy," according to the agreement.

This cooperative relationship is similar to one KSC already has with the State of Florida, Kathleen Harer of KSC explained. It is to include joint projects, which will provide, as efficiently and effectively as possible, the necessary education, transfer of technology and utilization of information to fulfill the common goal of helping the private sector and industry readily benefit from the space program. The Interagency Agreement was signed jointly by KSC Director Roy D. Bridges, Jr., and Georgia Governor Zell Miller.

Both Georgia and KSC have responsibilities spelled out in the agreement. Georgia will identify state university system resources that can assist NASA in meeting its technology development and commercialization needs. The state must also provide resources and support for promoting the transfer of NASA technology to the private sector in Georgia, as well as identify viable markets and industries that are most likely to benefit from the technology transfer.

KSC must identify NASA technologies that have a potential for commercialization by the private sector in Georgia, provide the state with access to KSC for technology demonstrations and consultations and provide the personnel and resources necessary for the transfer of technology. KSC must also identify its own specific technologies and projects having technical transfer potential and co-sponsor and support workshops, symposiums and technical projects.

For more information, contact Gale J. Allen at Kennedy Space Center. 407/867-6226, 407/867-2050, *gale.allen-1@kmail.ksc.nasa.gov* Or contact Jeff Labow at Georgia Institute of Technology. 404/894-2272. Please mention you read about it in *Innovation.*

# Advanced Technologies: 1997 Year in Review

IN 1997, *AEROSPACE TECHNOLOGY INNOVATION* presented stories demonstrating NASA's continuing efforts and success in finding applications for existing technologies that have been used in other ways. Many technologies have more than one market, and *Innovation* reports the continual transfer and commercialization of valuable and beneficial technologies to the nation's businesses and citizens. The following are examples of 1997 advanced technology highlights:

***Marshall Space Flight Center*** signed an agreement with Horton's Orthotic Lab, Inc., of Little Rock, Arkansas, to license an innovative knee brace developed as a spinoff of space propulsion system mechanisms and material by a group of Marshall propulsion engineers. The brace allows knee function with support for recovery, and it provides quicker and less painful rehabilitation for patients who use it.

***Significant scientific discoveries*** from experiments conducted on two recent Space Shuttle missions could greatly improve life on Earth. NASA researchers, astronauts and university scientists responsible for the space-based experiments outlined their discoveries at a conference at the National Academy of Sciences in Washington, D.C. Their discoveries are expected to lead to better synthetic drugs, less expensive alloys and metal products, improved environmental cleanup, a greater understanding of weather and climate and a greater knowledge of how blood clots in the human body.

*Special brown sunglass filters, developed by Dr. Leonard Haslim of NASA's Ames Research Center for agricultural use, helps agricultural workers spot plant stress and disease.*


***"Virtual reality*** in medical practice using computer technology" was the goal announced in late 1997 by NASA and the National Center for Biocomputation. This is soon to be established by NASA and Stanford University in Palo Alto, California, as stated in a letter of intent signed in 1997. The center will be located at Stanford to develop new medical technologies to improve the ability of patients and surgeons to see outcomes before surgery is done, create a digital library of computerized "virtual patients" to be used to teach medical students and help physicians share information on uncommon surgeries.

***Future scientific space exploration*** missions to Antarctica, the Moon and Mars look promising after a four-wheel-drive roving robot explored the terrain of Chile's rugged Atacama Desert for 45 days. The rover, named Nomad, set travel records and exceeded expectations of scientists at Ames Research Center, Moffett Field, California, and at Carnegie Mellon University in Pittsburgh. Nomad traveled 133 miles, more than any remotely controlled robot has ever done over rough territory, driving 12 of those miles totally on its own—an important objective called autonomous driving. NASA and Carnegie Mellon are formulating plans to use Nomad to look for meteorites in Antarctica in 1998 and 1999.

***Spacesuits specially designed*** using technology that protects astronauts in space helped two British youngsters enjoy a more normal life. A team at NASA's Johnson Space Center in Houston provided "suits" to 4-year-old Kyle and 2-year-old Ryan of Shotton Colliery, England, after being contacted by an English newspaper. The brothers suffer from Polymorphic Light Reaction Syndrome, an extreme allergy to light caused by a very rare genetic defect. Without the suits, the boys could venture outside only at night, avoiding bright light.

***The frontiers of space exploration*** were brought to 15 U.S. middle school classrooms via the World Wide Web. KidSat is a 3-year pilot education program that uses an electronic still camera aboard the Space Shuttle. The program, a partnership among the Jet Propulsion Laboratory, the University of California at San Diego and the Johns Hopkins University's Institute for the Advancement of Youth, was launched for the second time on an *Atlantis* mission.

***Skies and roads may be safer*** with a modification to a filter NASA engineers already developed for current use with agricultural goggles to help pilots and drivers see better during daytime hours. A new sunglass filter, designed by Optical Sales Corporation in Portland, Oregon, was adapted from a filter originally developed to help farmers identify diseased plants by enhancing the human eye's capacity to detect other colors in the visible spectrum. The original filter, a low-cost, brownish, plastic material called the passive

*"Nomad" the rover created a new standard for robotic travel and paved the way for future space exploration to Antarctica, the Moon and Mars after traveling 133 miles, more than any other remote-controlled robot, in recent rough tests.*

chlorophyll detector, was developed in 1991 by Dr. Leonard Haslim of NASA's Ames Research Center.

NASA is preparing the most ***advanced spacecraft artificial intelligence software*** for launch aboard the New Millennium program's Deep Space One (DS1) spacecraft. The basic goal of DS1's computer artificial intelligence program, known as the "Remote Agent," is to operate and control a spacecraft with minimal human assistance that will logically address the state of the spacecraft and the consequences of its actions. DS1 is scheduled for launch in 1998. Remote DS1 is the first scheduled mission in NASA's New Millennium program, which is designed to test and validate cutting-edge technology for the systems and instruments aboard future NASA science spacecraft. The Remote Agent's development is a collaborative effort of the Ames Research Center and the Jet Propulsion Laboratory.

A newly developed ***remote-controlled helicopter*** will be able to perform precision crop spraying, border patrols, hazardous spill inspection, fire surveillance, crowd security and emergency medical delivery more safely and cost-effectively. NASA's Langley Research Center in Hampton, Virginia, and the U.S. Army have developed the Free Flight Rotorcraft Research Vehicle, a robotic helicopter that can carry a movie camera, still camera, video downlinks, night vision cameras or infrared cameras. Artificial intelligence techniques keep the chopper stable in flight and allow it to be remotely controlled from the ground.

***Design improvements*** for a new, more fuel-efficient Boeing 777 jet engine resulted from tests to improve NASA Space Shuttle engine performance. The new design gained a full half-percent in energy efficiency—meaning a savings of hundreds of gallons of fuel per flight, an annual savings of millions of dollars for the airline industry and a competitive edge in world markets. Researchers also are using the test results to fine-tune the large, electricity-generating turbines used by U.S. electric companies to save fuel. NASA and Pratt & Whitney, a commercial and military aircraft engine design and manufacturing leader, conducted the tests at Marshall Space Flight Center in 1992.

As we progress into 1998, *Aerospace Technology Innovation* will continue to report updates of past highlights, as well as feature new and exciting stories about NASA's advanced technologies.

For more information, you may access 1997 issues of *Innovation* at NASA's Commercial Technology web site at *http://nctn.hq.nasa.gov* or contact Karen Kafton at the National Technology Transfer Center. 304/243-2415, 304/243-2457, *kkafton@nttc.edu* Please mention you read about it in *Innovation.*

# Internet Solution Beyond Real Time

A SOLUTION FOR SOFTWARE TO MONITOR AND control numerous experiments onboard the International Space Station (ISS) and from several locations on Earth has led to the first real-time embedded hypertext transfer protocol server designed for space flight. Using a commercially available

*With a miniature wind tunnel, NASA Lewis software engineers created Internet interface software for future use with the International Space Station, keeping costs down and adding applications.*

technology, the solution was cost-efficient and brought forth some revolutionary commercial applications.

Engineers at NASA's Lewis Research Center in Cleveland developed the Embedded Web Technology (EWT) program to bridge the gap between traditional non–real-time Internet technology and the real-time embedded controls environment. This solved a cost-prohibitive problem: writing a specific graphical user interface (GUI) for each of the numerous individual experiments and then modifying the GUI to accommodate every user platform.

GUIs and custom platform interfaces offer a solution that works for single-user environments, but the development of the interface for the ISS requires that scientists throughout the world and astronauts aboard the ISS, using different computer platforms (personal computers, Macintoshes, UNIX workstations, and so on), be able to interact with their experiments.

To leverage the expanding technology in the ISS, Lewis engineers developed the EWT program, which has the potential for significant software development cost savings for both flight and ground software. For commercial applications, EWT can save product developers and their customers money by eliminating the need for custom user interface hardware and by simplifying the interface between the embedded software and the GUI. By following publicly available standards, hardware changes and upgrades have less of an impact on the software.

The Lewis software team developed Tempest, a web server that provides a real-time application over a separate port. It is the first real-time hypertext transfer protocol server designed for space flight. Tempest, when loaded into a control processor, allows the processor to act as a "remote web site." Authorized users, using a browser, could interact with the control processor to retrieve an applet, which will be the GUI through which the user views data and controls the experiment.

Another innovative concept is to serve Java applets from an embedded web server. The user could download the desired applets through a browser to a local computer, whatever it may be, and use Java's portability to run the same GUI as someone on a different platform. This alone has the potential for enormous cost savings over developing many specific GUIs and is directly applicable to the original "problem" of support for many undefined users on multiple platforms.

EWT offers unlimited product opportunities by enabling embedded devices to be linked, then connected to a higher order, multipurpose processor and plugged into the Internet. EWT puts expertise and equipment in one location and performs over the Internet real-time solutions, adjustments, maintenance and product upgrades to machines located anywhere. This technology has already spun off additional NASA applications, such as the Virtual Interactive Classroom, which enables students to interact with scientific equipment over the Internet.

EWT also has many commercial and nonspace applications in terms of products in which a microprocessor is used for control. The developed software has been loaded into a control computer for a small wind tunnel. The wind tunnel, controlled via the Internet, will demonstrate the technology at an EWT workshop at Lewis Research Center, sponsored by the Great Lakes Industrial Technology Center, a NASA technology center managed by Battelle. The May 5, 1998, workshop fostered technology transfer to commercial businesses.

For more information on EWT, contact David York at Lewis Research Center. 216/433-3162, *David.W.York@lerc.nasa.gov* For more information on the EWT workshop, contact Priscilla Diem at the Great Lakes Industrial Technology Center. 440/734-1186. Or visit the Great Lakes web site at *http://fcfsrvl.lerc.nasa.gov/public/techxfer/wkshop9805.html* Please mention you read about it in *Innovation*.

## NASA PILOT PROJECT NAMES EARTH SCIENCE PARTNERS

Two categories of 12 proposals, Types 2 and 3, have been selected from all sources, including industry and academia, as part of NASA's Earth Science Information Partners (ESIPs) pilot project, to develop working prototypes of innovative uses and applications of its Earth science data and related research. Type 3 ESIPs, expected to be financially self-sustaining at the pilot project's end, are responsible for developing the information for a broader user community. Type 2 ESIPs focus on data and information products in support of global change research that are developmental or research oriented, with an emphasis on flexibility and creativity in meeting advanced scientific applications.

From 50 Type 2 proposals submitted, NASA has selected proposals focusing on land-cover and land-use change issues, oceanography or hydrology, atmospheric research data and integration of interdisciplinary issues, including environmental factors in public health. From 65 Type 3 proposals submitted, NASA has selected proposals in nearly 15 scientific disciplines: regional applications, agriculture, coastal and marine applications, education and public outreach, and special applications to extend Earth Science Enterprise data to non-Earth science research communities. NASA's Earth Science Enterprise (formerly called Mission to Planet Earth) is a long-term research program designed to study Earth's land, oceans, air, ice and life as a total environmental system.

For more information, contact Michael Mewhinney at Ames Research Center. 650/604-3937, 650/604-3953, *mmewhinney@mail.arc.nasa.gov* Please mention you read about it in *Innovation*.

# Aerospace Technology Development: 1997 Year in Review

NASA'S 1997 AEROSPACE RESEARCH WAS NOT only successful in putting to use valuable technologies in space, but it also resulted in the discovery of numerous applications on Earth. The following is a summary of 1997 highlights featured in *Aerospace Technology Innovation*.

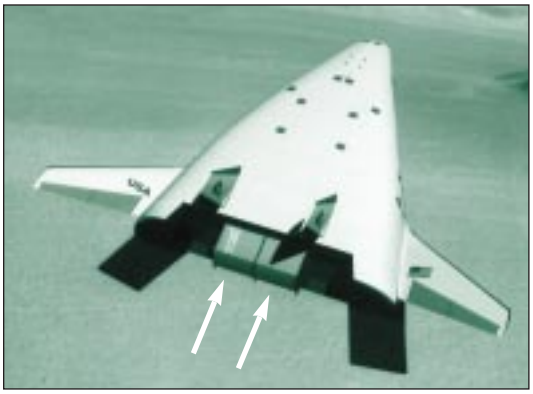
***Damage from earthquakes*** and high winds could be reduced by applying technologies developed to protect delicate experiments from minor vibrations and movements aboard the Space Shuttle in orbit. The active control technology for vibration isolation is mature and has a great potential market. Of the actively controlled buildings in operation today, all are in Japan with the exception of one in Taiwan. Other new construction will incorporate the technology, particularly in seismically active regions; it may be possible to retrofit the technology to other existing structures.

The ***NASA/Boeing X-36 Tailless Fighter*** Agility Research Aircraft successfully completed its flight research program in 1997 at NASA's Dryden Flight Research Center, Edwards, California. Engineers demonstrated the feasibility of future tailless fighters, achieving agility levels superior to today's best military fighter aircraft and the development of a low-cost alternative to full-size prototype aircraft.

***Satellite telemetry systems,*** created in the 1980s, found a market in the commercial communications field in 1997 for quick processing of voice, imagery and text data. Jim Chesney, founder of Goddard's Microelectric Systems Branch, discovered commercial applications for the technologies from the new telemetry system he was building and started his own company (1994), TSI Telsys. TSI Telsys' products and technology were developed for satellite telemetry applications.

***Space launch vehicles,*** the next generation, are a step closer after the successful completion of a critical series of tests on a rocket engine that could power these future vehicles. Tested at Marshall Space Flight Center in Huntsville, Alabama, the Fastrac engine—only the second American-made engine developed in the last 25 years—will be the primary propulsion system for the X-34 technology demonstration vehicle scheduled to begin flight tests in late 1998.

***Lower costs for space access,*** the creation of new space services and activities and the achievement of optimum performance and efficiency could result from the completion of the first in a series of in-flight qualification tests of a linear aerospike engine in 1997 at NASA's Dryden Flight Research Center. The NASA/Rocketdyne/ Lockheed Martin Linear Aerospike SR-71 Experiment (LASRE), includes a half-span, one-tenth-scale model of the X-33 being tested to power in 1999.



*Arrows indicate the linear aerospike engines on Lockheed Martin's X-33 Advanced Technology Demonstrator.*

***New Millennium program microprobes,*** hitchhiking to Mars aboard NASA's 1998 Mars Surveyor Lander, are charting the course for science in the 21st century after being the first technology validated in 1997 in NASA's new network approach to planetary science. The 1998 Mars Surveyor Lander mission is carrying two highly advanced microprobes, which will demonstrate an advanced microlaser system for detecting subsurface water on the Red Planet.

***Improving airplane traffic safety*** in low visibility, with reductions in ground accidents, close calls and miscommunication, looks promising following tests and technology demonstrations during 1997 in the eastern United States. Demonstrations of NASA and Federal Aviation Administration (FAA) aircraft technology on the runways and taxiways of Hartsfield International Airport in Atlanta concluded that reductions were possible by increasing situational awareness of pilots and controllers using a combined ground and airborne system with computer-generated graphics. The overall system integrates many technologies, including ground surveillance sensors and other equipment developed by the FAA aboard NASA's Boeing 757 research aircraft.

Astronauts and engineers have successfully concluded tests on a ***computer-generated virtual laboratory*** that will allow researchers—located anywhere in the world—to study potentially dangerous aircraft and spacecraft situations without risking human life. The world's largest flight simulator, located at NASA's Ames Research Center at Moffett Field, California, is able to move airplane and spaceship cockpits in all directions, including 60 feet vertically and 40 feet horizontally. There are five interchangeable cockpits that are used to simulate the Space Shuttle, helicopters, airplanes and other aerospace vehicles.

*A NASA researcher checks out a research pallet in a NASA Boeing 757 research aircraft before sending it to Atlanta's Hartsfield International Airport.*

***Measurements at higher altitudes*** and durations may be possible with the recent unofficial world record for high-altitude flight set by a solar-powered aircraft. A sleek, solar-powered, remotely piloted vehicle named Pathfinder has moved NASA closer to fulfilling growing scientific requirements for measurements at higher altitudes and durations than the current fleet of scientific platforms permits.

NASA has partnered with the general aviation industry in introducing the V-JET II, a ***turbofan-powered light aircraft*** designed for future flight testing and aimed at revolutionizing and revitalizing general aviation with a safer, smoother, quieter and more affordable light aircraft. The aircraft demonstrates breakthrough, low-cost turbine-engine propulsion systems for light, general aviation aircraft with cruising airspeeds greater than 200 knots.

A ***NASA computer network*** tool being tested at Ames Research Center could revolutionize the design, testing and construction of airplanes, shortening the process by 25 percent and eliminating retesting by providing more accurate and readily accessible information. The tool, called "Darwin," funnels wind tunnel data into a server computer and sends knowledge back in "near real time"—within about 30 seconds to 5 minutes—to researchers at NASA, at academic centers and in the aerospace industry, all located hundreds or thousands of miles from one another but linked to the computer system.

## PUBLIC TRANSPORTATION: THE NEXT GENERATION

Lewis Research Center is applying its experience with the International Space Station (ISS) to create the next generation of buses to increase efficiency, reduce emissions and operating costs, and lower manufacturing costs by opening up additional markets for turbine and power components. Lewis' concept of a hybrid system of electric power trains and gas turbines for buses could, by 1999, create an industry that can deliver 40-foot buses, advanced power train components and a low-cost turbine engine for small aircraft that could revitalize the general aviation market.

*The ISS has not even been assembled yet, but its technology is already revolutionizing the bus manufacturing industry.*

In such a hybrid system, electrical power is generated, stored and distributed throughout the vehicle, very similar to space power systems. Unlike conventional buses that waste much of their fuel while stopped in traffic or at bus stops, the engine of the Lewis-developed vehicle continues running at near-peak efficiency. This resultant excess energy is then stored and later used to accelerate the bus or provide additional power while going uphill. Lewis engineers designed the vehicle's unique energy storage system using supercapacitors, offering longer life than conventional batteries and providing exceptional capability to recover energy that would otherwise be lost during braking.

As pressure increases to reduce emissions and operating costs in public transportation systems, new technologies will be needed to replace the current diesel engines and mechanical drive trains. According to Dr. Larry Viterna at the Lewis Research Center, the power systems in the next generation of buses will look much like the power system being built for the ISS.

Lewis and its consortium of state and local government agencies, industry and academia worked with Teledyne Ryan Aeronautical of Toledo, Ohio, the developer of the turbine engine.

For more information, contact Jeff Brown at Lewis Research Center. 216/433-3888, *jeffrey.c.brown@lerc.nasa.gov* Please mention you read about it in *Innovation.*

Finally, in 1997, *Innovation* reported that NASA researchers have begun tests they hope will lead to improved commercial aircraft efficiency and $140 million in annual fuel cost savings by ***minimizing aerodynamic drag,*** the aerodynamic force from air pressure and friction that resists passage of an aircraft as it flies through the air. Adaptive Performance Optimization experiment tests will obtain data on putting an aircraft's control surfaces in the best position to reduce drag. Dryden Flight Research Center began tests in May 1997 using a modified Lockheed L-1011 TriStar operated by Orbital Sciences Corporation of Dulles, Virginia.

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# Future Fighter Technology Tests Completed

THE NASA/BOEING X-36 TAILLESS FIGHTER Agility Research Aircraft has successfully completed its flight research program and demonstrated the feasibility of future tailless fighters achieving agility levels superior to today's best military fighter aircraft. All project goals were met and exceeded—to develop and demonstrate enhanced technologies to improve the maneuverability and survivability of future fighter aircraft, according to Mark Sumich, X-36 project manager at NASA's Ames Research Center, Moffett Field, California.

"We also achieved the final flight's goal to expand the X-36's speed envelope up to 206 knots (234 miles per hour)," Sumich said. The aircraft's stability, handling and agility qualities were excellent at both ends of the speed envelope, after being examined at low speed/high angles of attack and high speed/low angles of attack.

Thirty-one flights were completed in only 25 weeks, an unparalleled accomplishment for a remotely piloted aircraft, according to Sumich. The third phase of the program was completed in mid-November 1997 at NASA's Dryden Flight Research Center, Edwards, California. The X-36 flew a total of 15 hours, 38 minutes and used four different versions of flight control software. The aircraft reached an altitude of 20,200 feet and a maximum angle of attack of 40 degrees.

*The X-36 is a subscale prototype jet built by McDonnell Douglas that is designed to fly without the traditional tail surfaces common on most aircraft.*

The 28-percent-scale X-36, built by the Boeing Phantom Works in St. Louis, Missouri, is designed to fly without the traditional tail surfaces common on most aircraft. The X-36 is 18 feet long with a 10-foot wingspan, stands 3 feet high and weighs 1,270 pounds. The aircraft is powered by a Williams Research F112 turbofan engine that provides 700 pounds of thrust. The aircraft is remotely controlled by a pilot in a ground station cockpit, complete with a headup display, eliminating the need for expensive and complex autonomous flight control systems.

"We now have a proven research aircraft that can be used for future tests. As people become aware of the aircraft's capabilities, interest is increasing in using it for future flight tests," said Gary Jennings, X-36 program manager for Boeing Phantom Works.

With the flight test program completed, the X-36 has been placed in flyable storage condition in a hangar at Dryden. "Discussions are under way about what to do next with both of the X-36 aircraft," said Gary Cosentino, X-36 deputy project manager at Ames. "There is potential for other technologies, such as a highly advanced reconfigurable flight control system, to be incorporated on the aircraft and possibly flight tested in the future."

The X-36 flight test program team consisted of employees from Boeing, Ames and Dryden. "The Dryden flight test infrastructure played a major role in supporting our operation and helped make us a success. The streamlined process of approval cycles allowed us to operate in a very efficient manner," Sumich said. NASA and Boeing are full partners in the project, which was jointly funded under a cost-sharing arrangement.

For more information, contact Michael Mewhinney at Ames Research Center. 650/604-3937, 650/604-3953, *mmewhinney@mail.arc.nasa.gov* Please mention you read about it in *Innovation.*

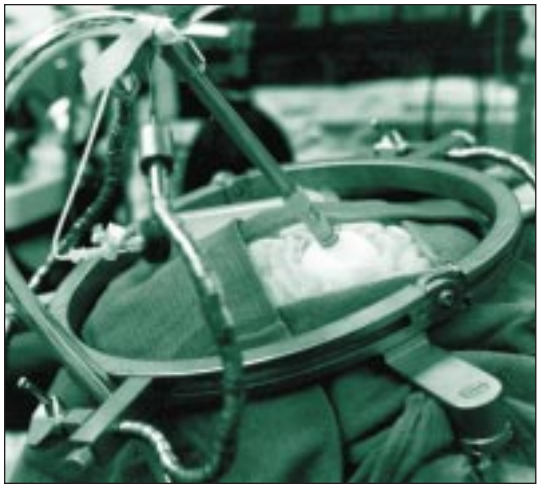
# Small Business/SBIR: 1997 Year in Review

A NEW SECTION FOCUSING ON SMALL BUSINESS research and commercialization was introduced in early 1997 as a regular section of *Innovation,* featuring NASA's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs.

The SBIR program increases opportunities for small businesses to participate in federal research and development, foster and encourage socially and economically disadvantaged persons to participate in technological innovation, increase employment, improve overall U.S. competitiveness and stimulate U.S. technological innovation. The year 1997 gave SBIR Phase II awardees the opportunity to increase their chances of commercializing their SBIR-funded research with the first SBIR technology commercialization review.

The STTR program requires cooperative research between a small business concern and a nonprofit research institution and awards STTR contracts to small businesses for cooperative research and development through a uniform, three-phase process. Although it is similar to the SBIR program, STTR is a separately funded activity.

The pace of change in the programs was rapid in 1997. SBIR and STTR piloted many projects and research that affected lives globally. For example, ***children with cancer now have hope*** through a new treatment technique, called photodynamic therapy, that uses tiny pinhead-size light emitting diodes (LEDs) to activate light-sensitive, tumor-treating drugs. Experiments of a NASA plant growth light probe were conducted under the SBIR program grant managed by the Technology Transfer Office at Marshall Space Flight Center in Huntsville, Alabama, and indicate that when special tumor-fighting drugs are illuminated with LEDs, the tumors are more effectively destroyed than with conventional surgery.



*This is a simulation of surgical implantation of the light emitting diode (LED) probe at the Children's Hospital of Wisconsin. The probe was developed for photodynamic cancer therapy under a NASA SBIR program grant.*

***Surgery in the dark*** can be done with a new battlefield care system, allowing doctors to be able to see patients in the dark using body-generated heat via a head-mounted infrared camera and monitor. It was developed by former Stennis Space Center employee, Jim Davidson, who received his initial education in thermal infrared image analysis while working with Stennis in 1995 on an SBIR contract to develop a pavement survey and management system.

Work through ***Stennis and the SBIR program*** continued to result in positive developments, such as the revolutionary system that provides color images of invisible hydrogen fires, making it easier to detect, locate and extinguish. Duncan Technologies, Inc., of Auburn, California, conducted this research.

Another SBIR company, Accurate Automation Corporation of Chattanooga, Tennessee, is a member of the team selected by NASA to design and construct four ***Hyper-X research vehicles*** under a $33.4 million performance-based contract. In 1997, the vehicles were tested at Mach 5, 7 and 10 at 100,000 feet altitude to validate airframe-integrated, dual-mode scramjet performance in flight. The Hyper-X program is being conducted by Langley Research Center and Dryden Flight Research Center. Accurate Automation's expertise in sensor technology is a result of ongoing NASA and Air Force SBIR programs.

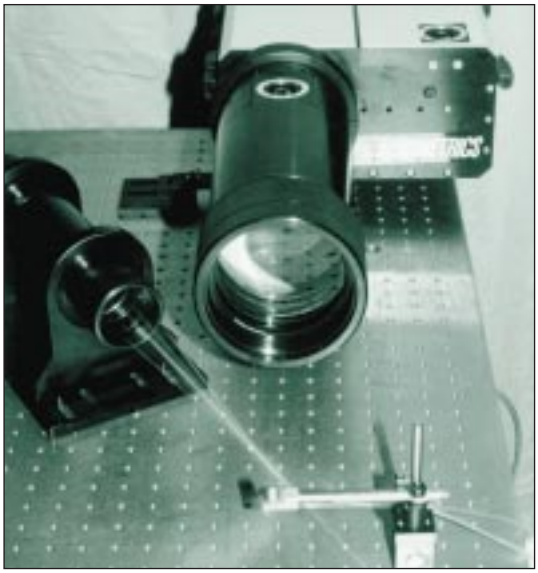
***Safety*** was another focus area for the SBIR program in 1997. An SBIR contractor successfully crash-tested a small airplane, designed to protect occupants against fatal injuries using airbags and energy-absorbing composite structures. All of the crash dummies on board during the final test "survived" the crash—a first for general aviation crash tests.

***A new insulation technology,*** developed through the SBIR program by Steve Miller of S.D. Miller & Associates in Flagstaff, Arizona, uses a honeycomb concept to convert plastic milk bottles into an effective material that is better than wool or fleece. This material is nonallergenic, dries five times faster and is four times warmer than wool in cold and damp

conditions. This is a spinoff from NASA's research into the development of lightweight metal insulation for future spacecraft, which could significantly reduce launch weight and costs. It is estimated that 70 jobs to make spacecraft insulation would be created, and the production of rescue blankets might result in 15 jobs.

The first tests of an SBIR project to ***make aircraft easier to operate*** and reduce pilot workload were completed by Aurora Flight Sciences of Manassas, Virginia, using single-lever control in a modified Cessna 02-A. The company's device took the three standard engine control levers—throttle, fuel-air mixture and propeller pitch angle—and had them computerized to make an air-cooled aircraft engine work much like the accelerator pedal in an automobile, similar to a car with automatic transmission.

A new measuring device at NASA's Lewis Research Center developed ***environmentally friendly engines*** that give off fewer emissions. The Phase Doppler Particle Analyzer (PDPA) was developed by Aerometrics Inc. of Sunnyvale, California, through an SBIR contract with Lewis. PDPA can optically determine the size and velocity of spherical particles, such as fuel and water, without interfering with the flow. Older measurement techniques required intrusive probes that changed the environment.



*Aerometrics Inc. developed the Phase Doppler Particle Analyzer via a contract with Lewis Research Center. The system consists of a laser and an optical system.*

*The use of a single lever for power control in retrofitted and future aircraft reduces the number of flight-related displays in the instrument panel, thus increasing pilot awareness.*

A portable and self-contained ***reflectance spectral radiometer,*** developed under an SBIR contract managed by the Jet Propulsion Laboratory, is expected to surge as researchers continue to recognize the importance of oceans in determining weather patterns and atmospheric composition around the world. This natural fluorometer radiometer calibrates satellite ocean color data to measure the concentration of microscopic marine plants or phytoplankton, the primary food source for sea animals and an important factor in the exchange of gases between the atmosphere and the world's oceans. More costly, earlier methods required sample collection for laboratory study.

***NASA received 215 STTR program proposals*** during the 1997 solicitation. Research topics include Earth remote sensing, advanced technology for space science, human exploration and development of space, general aviation, advanced space transportation and nondestructive evaluation of material properties and structural integrity.

SBIR/STTR program activities continue to seek ways to provide the small business community opportunities to develop technology that meets NASA's needs and commercial applications. As we progress into 1998, *Aerospace Technology Innovation* will continue to report updates of past highlights, as well as feature new and exciting stories about NASA's SBIR and STTR programs.

For more information, you may access 1997 issues of *Innovation* at NASA's Commercial Technology web site at *http://nctn.hq.nasa.gov* or contact Carl Ray at NASA Headquarters. 202/358-4652, 202/358-3878, *cray@hq.nasa.gov* Please mention you read about it in *Innovation.*

# NASA Technology Commercialization Review

IN ITS EFFORTS TO GUIDE SMALL BUSINESS Innovation Research (SBIR) Phase II winners toward successful commercialization, NASA assigned the National Technology Transfer Center (NTTC) with the task of technology commercialization review, to be performed by their expert review board. The purpose of the review is to help SBIR Phase I and II winners reach Phase III, a stage of further development of research from technology product to commercial product.

NASA's SBIR winners had presented innovative biomedical technologies to an expert review board in Houston on November 10 and 11, 1997. A recent review held in Del Mar, California, in March 1998 focused on advanced composite materials technologies. At the first review in Houston, the expert review board made comments and recommendations for each company presenting its biomedical technology fully developed, tested and readied for commercialization under SBIR Phase II. The most common recommendations made to the four companies demonstrating the technologies summarized below were: to clarify their goals or vision; to complete or improve on their business development plans; to partner with a knowledgeable expert or established company to overcome initial significant hurdles; to pursue patent protection; and to explore other potential applications for their technology to counter competing technologies.

The following is a summary of the technology partnership opportunities for new product development and commercialization of the technologies that were developed through NASA SBIR:

## Neuroskill Biomedical Instrument

*(Presented by VeriFax Corporation, Boulder, Colorado)*

A NASA SBIR-developed patented device ready for commercialization is a new twist to handwriting analysis that could help shed light on a number of causes, cures and preventions for cognitive decline and be highly beneficial in the health and security industries. Instead of studying how the handwriting appears, the designers focused on how a person writes. The device translates the writing dynamics of acceleration and pressure into complex signals. Each dynamic is represented by 1,000 data points on a millisecond time scale, giving as output very precise measurements of deterioration in stability, smoothness and synchronization of an individual's motor skill control level.

Neuromuscular diseases, toxic inhalation, drug or alcohol abuse, brain cell oxygen depletion, and sustained and intense stress all can be the cause of handwriting deterioration, and the diagnosis or early detection of any of these can be a result of human motor system handwriting dynamics analysis. Relevant benefits also include decreased doctor's visits, the avoidance of unnecessary hospitalization, patient complication monitoring, telemedicine applications and proper balance in prescriptions.

This technology could be useful in quantifying change in motor skill before and after medication is given—and also at different times of day and in different activities and locations. Integrating it could diminish the number of doctor's visits and avoid unnecessary hospitalization for monitoring patients in the case of complications.

Telemedicine applications of great value are a capability to electronically transfer information about neuromuscular performance to a neurologist or a medical specialist at any location, giving access to specialized neurological care for both the patient and doctor. Remote rural areas could be particularly affected, reducing costs while bringing medical care to those who might not otherwise receive it.

By studying handwriting deterioration to reflect motor skill control levels, other applications could include substance abuse screening and detection, monitoring for toxic inhalants and environmental distress, and accurate signature identification for security/privacy protection and forgery detection. Target markets could include neuromuscular disease centers, drug and alcohol abuse clinics, occupational health centers and the security industry.

## Miniaturized Biochemical Assays Using Novel Surface Plasmon Resonance Detection

*(Presented by Physical Optics Corporation, Torrance, California)*

The transformation of chemical concentration changes into optical signals will make it possible to observe shifts in surface plasmon polariton (SPP) resonances caused by the analysis of plasma-

deposited polymer films. A proposal to investigate the feasibility of a novel biochemical optical sensor concept could result in a new approach to the detection of surface plasmon-induced optical changes that could be applied in a broad spectrum of online chemical analysis instrumentation, from immunosensors to hydrocarbon detectors, with the potential to dramatically increase the sensitivity and range of such sensors.

Physical Optics Corporation proposed to incorporate its Optical Multilexor, a technology developed through NASA SBIR work, on a computer for low cost and customer convenience. One part of the system would not do everything, but task-specific add-ons could be purchased. Instead of the current practice of taking the instrument to the client, the instrument would already be in place; therefore, only the part itself would be taken to the instrument, and there would be more unity within the client company.

In-house software would be used to design Prism-based SPP devices to conclusively demonstrate the feasibility of the proprietary plasmon approach. These devices would help accomplish molecular recognition by means of the immunoglobin G(IgG)/anti-IgG immunochemical system. The next phase would upgrade and conduct practical testing of Prism-based multi-analyte devices, using optical wave guides to achieve full optical integration in plasmon/polymer sensors and constructing multiplexed multi-analyte versions of the proposed device.

The technology started by looking at the chemical structure of oxygen, and the company developed it to other capabilities. Physical Optics wants to take the working prototype into production.

## NASA LICENSES TO INCUBATION CENTER TENANT

A Brevard County corporation, a tenant of the Florida/NASA Business Incubation Center in Titusville, has signed a license agreement with NASA to commercialize the Particle Fallout/Activity Sensor, developed at NASA's Kennedy Space Center to detect the accumulation of potentially damaging dust and fibers on sensitive payload components. The agreement, arranged by Kennedy's Technology Programs and Commercialization Office, grants Technical Applications Unlimited (TAU), Inc., a patent license for the Particle Fallout/Activity Sensor. The agreement was signed by NASA General Counsel Edward A. Frankle and TAU Research Director Clyde F. Parrish.

TAU was incorporated about a year ago as a tenant of the Florida/NASA Business Incubator Center, which was created in 1996 to assist entrepreneurs and small businesses by offering office space at a reduced cost and providing technical assistance to tenants. The center is located at the Titusville campus of Brevard Community College.

Parrish said his company was formed as an opportunity to further develop new technology coming from Kennedy Space Center. His client list is growing for the Real Time Optical Fallout Monitor, which is selling in the price range of $4,000 to $5,000 a unit. Contract employees are using the Business Incubator Center facility to hand-assemble the units, with parts custom-made in Brevard County. Parrish is continuing to refine the monitor, he explained, and most of his marketing is done at trade shows across the country. He envisions adding full-time employees as business picks up.

Potential commercial uses are many, Parrish pointed out. The sensor can be applied to contamination monitoring in clean rooms and industrial applications, such as pharmaceutical or semiconductor manufacturing. The sensor can also be used in activity monitoring, such as medical patient monitoring and security systems, and in air handling assessment.

The inventors are Kennedy employees Curtis M. Ihlefeld, Dr. Robert C. Youngquist, John S. Moerk and Kenneth A. Rose III. The sensor works by measuring relative amounts of dust or other particles, which collect on a mirror in an area to be monitored. The prototype sensor included a sensor module and a data acquisition module, both of which could be operated independently of one another or in combination with one another. Parrish said the new product comes as a single unit.

The sensor includes a microprocessor-controlled module that detects a particle accumulation on a sensor surface and converts this information into digital data. The invention monitors particle fallout over a period of time at specified intervals, and it can store both the magnitude and time of occurrence of the sensed particle fallout in memory.

For more information, contact Gale Allen at Kennedy Space Center. 407/867-6226, 407/867-2050, *gale.allen-1@kmail.ksc.nasa.gov*
Please mention you read about it in *Innovation*.

## Liquid Dispersion and Encapsulation of Drugs

*(Presented by Institute for Research, Inc., Houston)*

The commercialization of a new drug delivery process could provide new treatment media and drug therapies that, up to this point, never existed or could not be administered because they were drugs that could not be combined for delivery or were considered ineffective and undeliverable. Encapsulation technology is the key to this enhanced delivery method for existing drugs and therapeutics. The enhancement is forming unique bioactive drug-filled microcapsules that, by way of diffusion, are delivered to a targeted organ or body tissue where only the targeted area is treated, leaving untouched the areas surrounding the targeted treatment area. It also promotes the use of insoluble drugs in liquid.

The production of multilayered microspheres with alternate hydrophobic and hydrophilic compartments opens up the possibility of developing multiple-therapy microcapsules that can allow sequential diffusion of two or more drugs from the same microcapsules once they arrive at the target tissue. Multiple-drug microcapsules could be used to deliver a chemotherapeutic drug to kill tumor cells and then deliver a substance to aid or stimulate the immune system's response to the tumor.

Larger, more uniform microcapsules open up more possibilities to treat highly vascular tumors (liver and kidney) with chemo-embolization, which would involve the injection of these microcapsules into an artery catheter, forming an artificial emboli, or blockage, cutting off the blood supply to the tumor. The reduced blood volume that flows past the tumor becomes loaded with the anti-tumor drug that scatters out of the microcapsules, thus increasing the chemotherapeutic dose to the tumor cells.

Microgravity experiments lead to the development of this microcapsule technology by eliminating the density problems that occur with phase separations of nonmixable liquids having different densities. Many cytotoxic or bioactive drugs cannot be injected intravenously. Others can, but they quickly degrade before reaching the target tissue or are cleared from the blood too quickly to allow a useful biological half-life. Properly designed microcapsules can provide unique methods of direct delivery by parenteral injection, nasal inhalation and dermal administration for sustained release of important bioactive drugs.

This technology allows for the co-encapsulation of liquids and mediums that previously could not be mixed, enabling a far more effective treatment—one that may not even have existed before this. A unique drug delivery system could be visualized by radiological or computerized tomography scanning to ensure that the cytotoxic drug is delivered directly to the target tumor.

## Use of Interactive Physician's Notes to Support Medical Diagnosis and Recovery Management

*(Presented by Seers Systems Inc., Pittsburgh)*

Epistemic Abductive Goal Oriented Language (EAGOL) is a decision support software tool based on a NASA SBIR Phase I contract that provides online, real-time diagnosis and recovery management. This tool permits a more ad hoc, goal-oriented style of decisionmaking and closes the loop in health care records, recognizing actions taken and allowing feedback to establish communication between the physician and the patient record. It is intended to provide an infrastructure that combines an electronic patient record with dynamic health care goals, methods and responsibilities of the various participants in the health care enterprise: physicians and supporting medical staff, hospital and health maintenance organization (HMO) administrations, insurance companies, and public health and other health care policy interests.

An application of EAGOL, called MEDEAGOL, is a reasoning engine that can maintain the rationalization process over the extended period of a patient's illness and can fit the temporal architecture of the patient record. MEDEAGOL combines a capability for real-time process diagnosis and recovery management with goal-oriented protocol generation and interpretation.

EAGOL's benefits and potential markets include increased consistency and quality of care, serving as a decision and information support framework for health care professionals, teaching hospitals and remote medical facilities to better manage patients and more effectively adhere to hospital and HMO policies. EAGOL provides protection against inaccurate documentation and satisfies the justification demands from insurance companies, physicians and hospital administrators or others

concerned with payment and cost containment. The software will be ready for commercialization in November 1998.

For information about these technologies, contact Shaik Mazharullah at the National Technology Transfer Center (NTTC). 800/678-6882, *smazharullah@nttc.edu* For information about the commercialization reviews, contact Sunni Richmond at NTTC. 800/678-6882, *srichmond@nttc.edu* Please mention you read about it in *Innovation.*

# Materials Method an SBIR Success

A NONDESTRUCTIVE THERMAL SPRAY COATING porosity and thickness measurement method was dubbed a success and gained notoriety before its development was complete under the Small Business Innovation Research (SBIR) program. JENTEK Sensors Inc. of Watertown, Massachusetts, has sold several GridStation™ Measurement Systems, developed as part of its Phase II SBIR contract with Goddard Space Flight Center, to both government users as well as commercial entities, before completing its SBIR work.

The system includes the JENTEK MWM™, an advanced conformable eddy current sensor, JENTEK's impedance instrument board and JENTEK's GridStation™ software environment. Also, JENTEK has developed dielectric sensors for ceramic porosity measurement.

JENTEK developed the GridStation™ Measurement System based in part on a NASA need to develop a method of performing nondestructive characterization of thermal spray coating porosity and thickness. The GridStation™ Measurement System solves this problem as well as provides a method for measuring coating thickness and other properties of numerous materials—ceramics, metals and composites. It can also provide age degradation monitoring, including fatigue, corrosion and thermal aging.

The approach developed by JENTEK for this process differs from conventional methods. The sensor signals are induced by specially configured, conformable arrays, minimizing the requirement for precise positioning of the sensors. Quantitative results can be provided in real-time without user interpretation. In addition, JENTEK's proprietary model-based approach uses "measurement grids" to reduce calibration requirements and increase repeatability, reproducibility and robustness.

*A JENTEK GridStation™ Measurement System at NASA's Lewis Research Center helped characterize ceramic thermal barrier coatings for turbine blade applications.*

The sensors are thin and conformable and can provide measurements on flat, convex, concave and conical surfaces. Accurate property determinations can be obtained—regardless of the shape of the part being tested—without recalibration for variations in curvature and without extensive special training or education.

While Goddard intended to use this innovation to characterize anodizing thickness, spacecraft contamination and thermal protection coatings, NASA's Lewis Research Center purchased the system to aid in the characterization of ceramic thermal barrier coatings for turbine blade applications. JENTEK has also tested the system for performing very early stage crack detection in stainless steel, aluminum and other metals. This early stage fatigue detection capability provides a new tool for monitoring fatigue life and detecting the onset of widespread fatigue damage. This is a capability on which JENTEK hopes to expand. JENTEK has worked with several companies, including Raytheon/E-Systems and Alcoa, in testing this capability.

JENTEK was a Spinoff Achievement Award winner at the 1997 Technology 2007/New England Showcase for "demonstration of the most innovative and commercially-significant product applying technology developed by, for, or with the federal laboratory and university R&D community."

For more information, contact Neil Goldfine at JENTEK Sensors. 617/926-8422, 617/926-8744, *jentek@shore.net* Please mention you read about it in *Innovation.*

***Technology Opportunity Showcase*** *highlights some unique technologies that NASA has developed and which 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.*

# Real-Time Monitoring

## Nonvolatile Residue Monitor

To measure nonvolatile residues in clean-room environments for the protection of sensitive payloads during launch preparations, Femtometrics, Inc., of Costa Mesa, California, has developed a Real-Time Nonvolatile Residue Monitor under a NASA Small Business Innovation Research (SBIR) contract with Kennedy Space Center. A prototype instrument has been fabricated and field-tested at Kennedy. Tests have demonstrated the monitor's capability to accurately detect and quantitatively measure nonvolatile residue in real-time. This monitor is a completely self-contained, single unit that is designed for onsite or remote operation. It is based on a surface acoustic wave microbalance, which operates similarly to a piezoelectric crystal microbalance but has much greater sensitivity. The crystal is held at a constant temperature just below room temperature and thus accurately reflects conditions on the payload.

This system has potential for use in the airline, aircraft, and shipbuilding industries, by law enforcement agencies, by public utilities or in any repeatable process where data are collected, transferred and analyzed. Its benefits include real-time monitoring, improved data availability, the elimination of latency, paper-intensive inspection processes and the need to rekey data. Future research will involve calibration methods and instrument repackaging.

## Surface Defect Monitoring

Kennedy Space Center also seeks a private industry commercial partner to transfer the NASA-developed Surface Defect Analyzer (SURDA) technology. The system, which has an industrial application, is being developed to provide an accurate method of evaluating the physical dimensions of surface flaws, defects and damage on critical surfaces of the Space Shuttle and related ground support equipment. SURDA will provide an alternative to the mold impression optical comparator or optical micrometry processes currently being used. Potential commercial applications include medical and dental measurements, materials analysis laboratories, aircraft, automobiles, precision tooling and appliance manufacturing.

SURDA uses the structured light microscopy technique as its basis and offers the benefits of real-time analysis and a permanent record of defect images, and it eliminates many labor-intensive functions required by other methods. The system consists of a 386-image acquisition and processing computer with a color display housed in a portable case. A 25-foot cable connects a handheld optical head containing the optics, television camera and line projector to the computer. The operator carries the unit to the vicinity of the test article and positions the optical head over the defect, using the small liquid crystal display "finder" screen provided at the optical head. Defects that need to be permanently recorded or analyzed in greater detail than possible with the relatively low-resolution liquid crystal display can be digitized and stored in the main computer. When digitized, defect images can be used to produce detailed, application-specific documentation of the defect using a built-in bubble jet printer. The overall field of view of the instrument in its present version is about 0.06 inch square. Its measurement resolution is better than 0.001 inch.

## Remote Alarm Monitoring

NASA seeks to transfer the Remote Monitoring and Alarm System (RMAS) technology it is developing to private industry for use in industrial applications. The system is a diagnostic system for monitoring the health and status of wideband fiber-optic transmission equipment at the Kennedy Space Center and Cape Canaveral Air Station. It is designed to monitor the alarms and power supplies of the remotely located terminal equipment and provide the status to a display system for monitoring at a central site. The RMAS is unique in that no other known system provides for monitoring both power supply voltages and alarms specifically for fiber-optic transmission equipment. The system also allows for the reprogramming of the remote unit's nonvolatile memory from a central monitoring site. The Central Monitoring Unit provides the user with graphical and audio alarms when a fiber optic-based circuit problem occurs.

Potential industrial applications include telephone companies for monitoring remotely located switching equipment, the fiber-optic equipment manufacturing industry for monitoring production lines and automated equipment from remote locations, and conventional and nuclear power systems for monitoring the status of remote sensors, pumps, actuators and motors. The alarm offers such benefits as real-time status of all system power supplies, alarms and displays. It also provides hard-disk and time-dated, hard-copy records of alarm status, allows for an easy reconfiguration of the system from a central location and eliminates the time-consuming troubleshooting process.

For information on any or all of the above technologies, contact the Technology Programs and Commercialization Office at Kennedy Space Center. 407/867-6226. 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.

**Bruce Webbon**
Ames Research Center
Moffett Field, California 94035-1000
650/604-6646
*bwebbon@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.

**Eugene (Lee) Duke**
Dryden Flight Research Center
Edwards, California 93523-0273
805/258-3802
*lee.duke@dfrc.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.

**George Alcorn**
Goddard Space Flight Center
Greenbelt, Maryland 20771
301/286-5810
*george.e.alcorn.1@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.

**Merle McKenzie**
Jet Propulsion Laboratory
Pasadena, California 91109
818/354-2577
*merle.mckenzie@jpl.nasa.gov*

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

**Henry (Hank) Davis**
Johnson Space Center
Houston, Texas 77058
281/483-0474
*henry.l.davis@jsc.nasa.gov*

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

**Gale Allen**
Kennedy Space Center
Kennedy Space Center,
Florida 32899
407/867-6226
*gale.allen-1@kmail.ksc.nasa.gov*

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

**Joe Heyman**
Langley Research Center
Hampton, Virginia 23681-0001
757/864-6005
*j.s.heyman@larc.nasa.gov*

**Lewis 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**
Lewis Research Center
Cleveland, Ohio 44135
216/433-3484
*Larry.A.Viterna@lerc.nasa.gov*

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

**Sally Little**
Marshall Space Flight Center
Huntsville, Alabama 35812
256/544-4266
*sally.little@msfc.nasa.gov*

**Stennis Space Center**
Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Nonintrusive Instrumentation.

**Kirk Sharp**
Stennis Space Center
Stennis Space Center, Mississippi
39529-6000
601/688-1914
*kirk.sharp@ssc.nasa.gov*

## 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.

Joseph C. Boeddeker
**Ames Technology Commercialization Center**
San Jose, CA
408/557-6789

Lyn Stabler (Acting)
**Mississippi Enterprise for Technology**
Stennis Space Center, MS
601/688-3144

Wayne P. Zeman
**Lewis Incubator for Technology**
Cleveland, OH
216/586-3888

Maria Clark
**Florida/NASA Business Incubation Center**
Titusville, FL
407/383-5200

## Small Business Programs

Carl Ray
NASA Headquarters
**Small Business Innovation Research Program (SBIR/STTR)**
202/358-4652
*cray@hq. nasa.gov*

Paul Mexcur
Goddard Space Flight Center
**Small Business Technology Transfer (SBIR/STTR)**
301/286-8888
*paul.mexcur@pop700.gsfc.nasa.gov*

## NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and 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
213/743-2353

Dr. William Gasko
**Center for Technology Commercialization**
508/870-0042

J. Ronald Thornton
**Southern Technology Applications Center**
University of Florida
904/462-3913

Gary F. Sera
**Mid-Continent Technology Transfer Center**
Texas A&M University
409/845-8762

Lani S. Hummel
**Mid-Atlantic Technology Applications Center**
University of Pittsburgh
412/383-2500

Christopher Coburn
**Great Lakes Industrial Technology Center**
Battelle Memorial Institute
440/734-0094

Joseph P. Allen
**National Technology Transfer Center**
Wheeling Jesuit University
800/678-6882

Doris Rouse
**Research Triangle Institute Technology Applications Team**
Research Triangle Park, NC
919/541-6980

### NASA ON-LINE

Go to **NASA's Commercial Technology Network (CTN)** 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 its latest innovations in materials technology at the ***SAMPE trade show,*** June 1–3, 1998, at the Anaheim Convention Center, Anaheim, California. Companies will have the opportunity to meet with NASA's inventors and explore opportunities to bring this technology to market. For more information, contact Michael Weingarten at 202/358-1680.

***Technoventions '98',*** a technology conference for environmental characterization, monitoring and surveillance, will be held at the Coronado Springs Hotel in Lake Buena Vista, Florida, on December 9–12, 1998. Laboratories and companies are invited to display their technologies. Call for papers abstract submission deadline is May 15. For more information, contact the Technoventions '98' Conference Manager at 407/207-4923 or e-mail conted@pegasus.cc.ucf.edu

***Technology 2008,*** the Ninth Annual National Technology Transfer Conference, will be held November 3–5, 1998, at the Hynes Convention Center, Boston. For more information, call 212/490-3999.

***Investment Seminar—***Looking for capital? The National Technology Transfer Center, the UNISPHERE Institute, and the Research Triangle Institute will present a one-day seminar on financing technology-oriented businesses on June 17, 1998, in Chapel Hill, North Carolina. The seminar will address business planning for technology firms, how to find capital, financing and investment opportunities, and strategic partnering. The event also includes side-meetings with venture capital firms and angel investors. For details and registration information, contact UNISPHERE Institute, 1625 Massachusetts Avenue, NW, Washington, DC 20036, call 202/588-9000, fax 202/588-9200, e-mail unireg@unisphere.com, or visit the web site at http:// www.unisphere.com



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