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Aerospace Technology

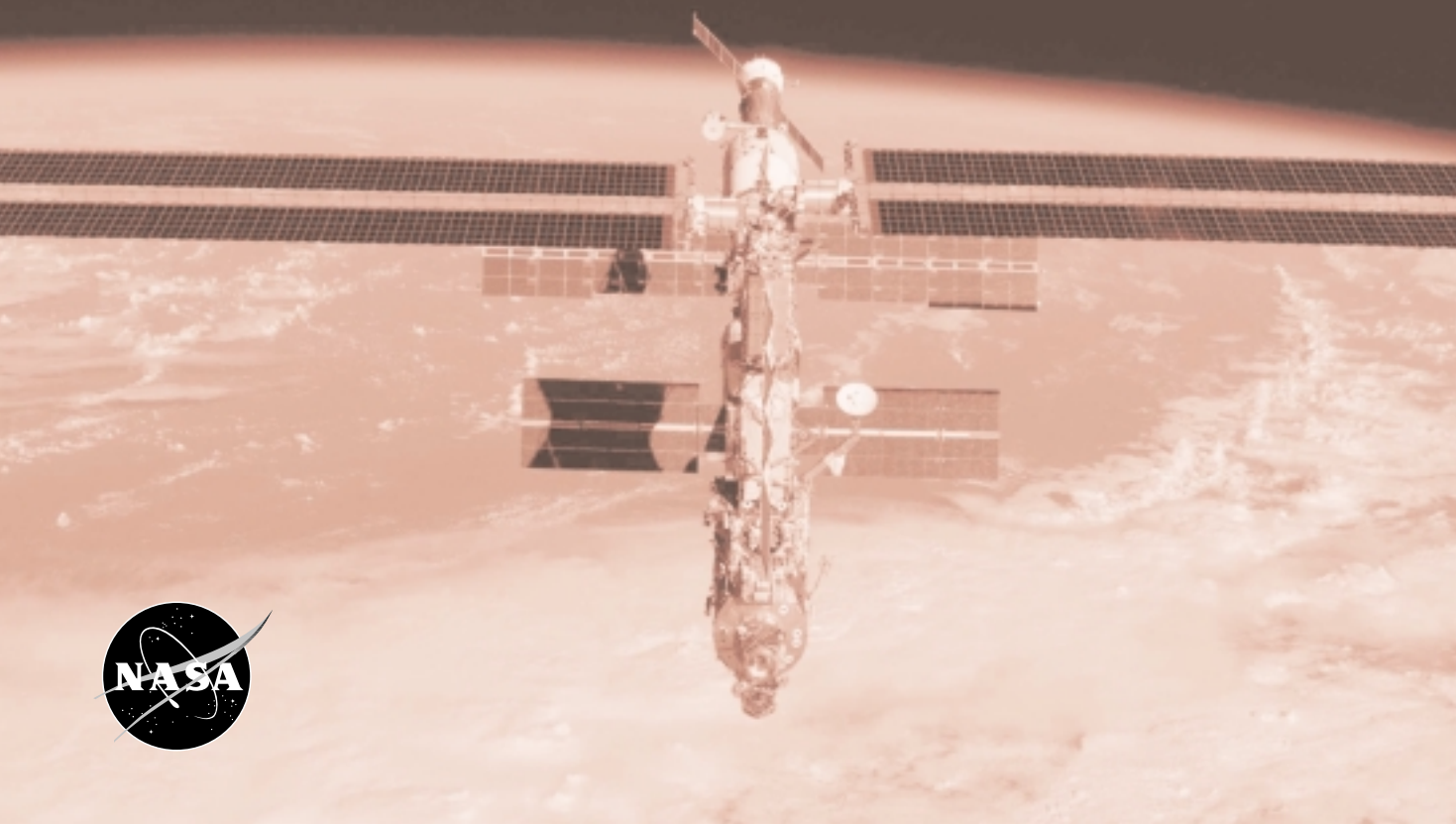
INNOVATION

Exploring the Capabilities of the International Space Station

Easing the Pain of Periodontal Disease

The "Eyes" Have It

NASA System Increases Runway Safety



NASA

Aerospace Technology
INNOVATION

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About the Cover:
A view of the International Space Station (ISS) during a fly-around by the Space Shuttle *Endeavour*. The 240-foot-long, 38-foot-wide solar array (spreading across the center of the frame) is the newest part and one of the most prominent components of the station.

Online 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
4/01	**STS-6A ISS Assembly Flight	Protein Crystal Growth (PCG) Generic Bioprocessing Apparatus (GBA) Advanced Astroculture	Center for Biophysical Sciences and Engineering Bioserve Space Technologies Wisconsin Center for Space Automation and Robotics
6/01	STS-107	Astroculture Water Mist Zeolite Crystal Growth (ZCG) Commercial Protein Crystal Growth/ Protein Crystallization Facility (CPCG/PCF) Commercial ITA Biomedical Experiment (CIBX)	Wisconsin Center for Space Automation and Robotics Center for Commercial Applications of Combustion in Space Center for Advanced Microgravity Materials Processing Center for Biophysical Sciences and Engineering Instrumentation Technology Associates

* As of October 2000.
** 4/01—STS Flight No. to be determined.
Key: STS—Space Transportation System
ISS—International Space Station

Commercial Opportunities Aboard the ISS

By Joseph Rothenberg
Associate Administrator for Space Flight
NASA Headquarters

WITH THE INTERNATIONAL SPACE STATION (ISS) now in orbit, new frontiers in human space exploration, technology and business have opened. The ISS is an unparalleled, international, scientific and technological cooperative venture that will usher in a new era of human space flight, with the promise of economic benefits to people on Earth.

The ISS will provide more room for research, with greater resources and flexibility than any spacecraft ever built. The ISS provides unprecedented, long-term access to the microgravity and ultra-vacuum environment of space, a flexible vantage point for observational research and a testbed for new technologies.

The ISS Commercial Opportunity, first and foremost, is about stimulating business investment in the development of new markets and industries in low-Earth orbit. The ISS has three broad categories of commercial opportunity: users, operations and new capability development. Within each area, NASA is using its position as both a customer and a service provider to stimulate new commercial space businesses. As the user base broadens, it is expected that NASA will become just one of the customers for commercial operations and new capabilities. To ensure that there will be adequate opportunities available for commercial uses, NASA is allotting approximately 30 percent of the U.S. share of the ISS's research capacity for economic development.

NASA provides resources geared toward the unique capabilities and vantage point of the Space Station. The ISS will be an orbiting laboratory that will provide an unprecedented facility for long-term scientific research, technology development and the achievement of commercial goals in space. To this end, there are a number of laboratory facilities available. These accommodations and services range from laboratory racks in pressurized modules with full utility and crew services, to externally mounted attached payload sites that are exposed to the near vacuum of space. Commercial organizations are encouraged to participate through NASA-industry partnerships in those research areas for which they anticipate future business potential.

Another potential commercial development of the ISS involves private industry providing the services necessary to maintain and continually improve ISS capabilities. Operating a space-based laboratory is different and far more complex than similar activities on Earth, but these are not insurmountable barriers for major U.S. service providers to overcome if they are to take their Earth-based services to space. The services needed for a research platform in low-Earth orbit are, in many cases, the same as are required anywhere on Earth or needed by the many satellites orbiting Earth. In the case of the Space Shuttle and the ISS-Mir programs, logistics support for both operations and the research community are already commercially provided. The growing base of users will shape the future of operational needs of the ISS. Commercial sources may provide and evolve these operational capabilities. NASA may become one of a number of paying customers for these augmented services.

The commercial sector can provide capital improvements to the ISS based on the demand of both public and private customers. Such development can be either enhancements to existing capabilities—for example, increasing the available power to ISS users with commercially supplied power—or it can be a new capability, such as a commercially provided module. Because of the large investment cost, this area represents the highest commitment of private funds. As with operations, new capability development will be market-driven by the profitability of the ISS uses and the increased demand. NASA may benefit from these new and improved capabilities without bearing the burden of the total operational cost.

NASA has supported scientific and commercial research in the life and microgravity sciences for approximately 15 years, beginning with the operation of the Space Shuttle fleet. However, the cumulative research time on board the 100 Space Shuttle missions has been only about six months. With the advent of the ISS, researchers will have access to a space laboratory for periods of years, with greater resources than any previous orbiting facility. The ISS will provide greater research flexibility, regular crew interaction with experiments and time for iterative or multigenerational research.

Exploring the Capabilities of the ISS

THE INTERNATIONAL SPACE STATION (ISS) provides a diverse range of possibilities for commercial research and development.

The 1998 Commercial Space Act promotes commercial space opportunities and established the construction of the ISS as a priority goal of national policy in the economic development of Earth orbital space. To this end, NASA has created a process for working with companies to make ISS economic opportunities available.

The strategy is for NASA, in partnership with the private sector, to initiate a set of pathfinder business ventures that can achieve profitable operations over the long run without public subsidies. These business pathfinders will break down public sector and market barriers in the near term and lead to economic expansion over the long run.

In a speech to the International Astronautical Foundation in October, NASA Administrator Daniel S. Goldin noted that NASA is willing to commit part of its share of the Space Station's resources to commercial undertakings because, "We believe that market-driven research is one of the best uses of the station.

"But I strongly believe that every nation—whether they are part of the Space Station or not—could benefit from developing space commercialization programs of their own."

With the signing of several commercial agreements, NASA and industry have opened a new era of space economic development. NASA and industry are forming partnerships to create new markets and provide economic benefits to people on Earth.

Dreamtime Holdings, Inc., is bringing high-definition television (HDTV) to the space program. HDTV will offer NASA engineers and scientists the most detailed look ever at scientific experiments conducted on the ISS. StelSys will use NASA's bioreactor technology on the ISS to conduct biomedical research. These commercial agreements illustrate the broad spectrum of opportunities available aboard the ISS.

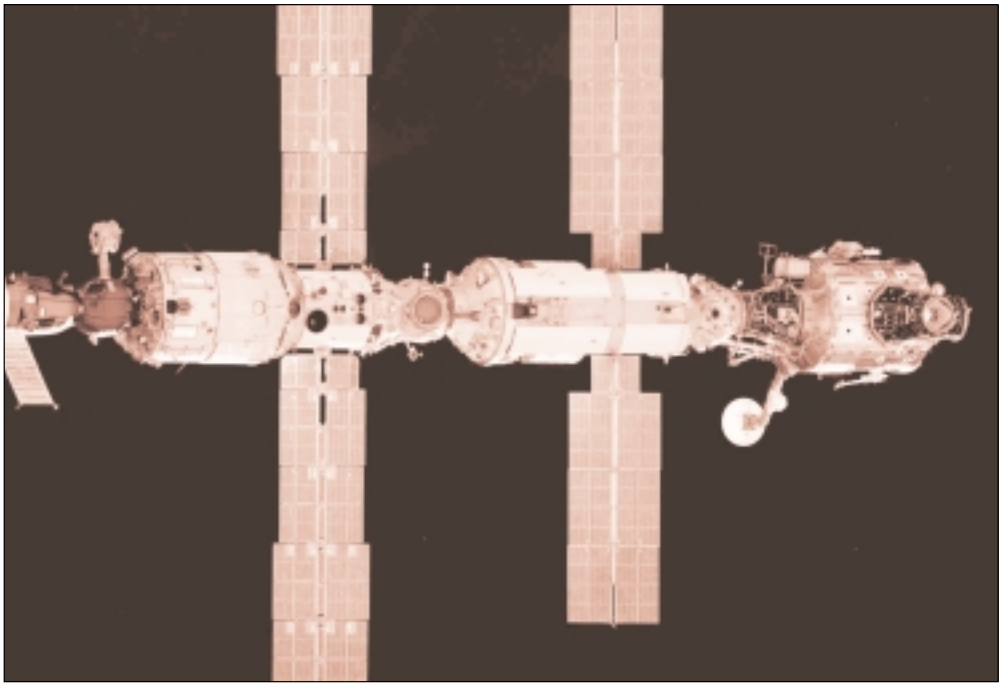
But commercialization is not the only foreseen use of the station. The ISS will serve as a testbed and springboard for further exploration of space. The station will provide an orbital laboratory for long-term research, where gravity, one of the fundamental forces of nature, is greatly reduced. Conducting research in microgravity, a state of very weak gravity one-millionth of what is felt on Earth, gives scientists a unique opportunity to study processes that are obscured by gravity on Earth, test existing theories and make new ones.

The STS-97 astronauts and the Expedition 1 crew members pose for a historic portrait onboard the International Space Station (ISS) shortly after hatches were opened between the Space Shuttle Endeavour *and the station. In front, from the left, are Sergei K. Krikalev, Brent W. Jett, Jr., William M. Shepherd and Joseph R. Tanner. In back, from the left, are Marc Garneau, Carlos I. Noriega, Yuri P. Gidzenko and Michael J. Bloomfield. A pre-set digital still camera was used to record the scene.*

In addition, world class research in biology, chemistry, physics, ecology and medicine can be conducted using the most modern tools available.

The medical benefits of conducting science in space could lead to new drugs and a new understanding of the building blocks of life. Researchers also expect a thorough understanding of the effects of long-term exposure on humans in microgravity.

"We are excited about the station," Administrator Goldin said, "because it will be our primary means for conducting the long-term space-based



The International Space Station (ISS), against darkness of space, photographed by STS-97 crew members onboard the approaching Space Shuttle Endeavour. *The Soyuz spacecraft, which taxied the Expedition 1 crew in late October, is partially out of the frame at left.*

research that will help us ensure the continued health and safety of our astronauts, so that they will be able to leave low-Earth orbit to travel to Mars or beyond."

"We hope to make great progress in astronaut health. The station will allow us to study the long-term debilitating effects of the space environment on human health and performance from the micro level of cells to the macro level of the entire human organism. As we learn more about the effects of radioactivity and weightlessness on the human body, we will be better able to develop effective countermeasures, which will enhance our ability to leave low-Earth orbit and improve live on Earth."

Industrial benefits may lead to stronger, lighter metals and more powerful computer chips. The absence of convection—the currents that cause warm air or fluid to rise and cool air or fluid to sink—in space will allow different materials to be studied more thoroughly in orbit than on Earth. Fluids and flames will behave differently in microgravity as well.

While some experiments will take place inside the Space Station, others will take place externally. These experiments will help reveal the effects of long-term exposure to the external space environment. Understanding phenomena such as extreme temperature and micrometeorites will guide engineers toward enhancing spacecraft design. Earth observations will allow researchers to study changes to the environment, both natural and human-caused. Other benefits may lead to advanced weather forecasting systems and the most accurate atomic clocks.

The term "microgravity" will become more commonplace in the era of the ISS. The specific disciplines of microgravity science that will be studied aboard the station include biotechnology, combustion science, fluid physics, fundamental physics and materials science.

The station also offers possibilities in the development of advanced robotics and in studying the complex interactions of the space environment with materials and protective coatings. Additional research topics will include advanced power generation, thermal management and advanced communications concepts.

Commercialization of space research will allow industries to explore new products and services. Finally, the result of such innovation will create new jobs here on Earth and in space.

For more information, visit the International Space Station web site at *http://commercial.hq.nasa.gov/*

KSC Innovation Transferred to U.S. Air Force

THE MEDEVAC OXYGEN SYSTEM (MOS), currently deployed aboard U.S. military aircraft at the Space Shuttle Transatlantic Abort Landing sites, is now an emergency tool for the U.S. Air Force.

The MOS, developed by NASA Kennedy Space Center (KSC) Biomedical Office, is now being used by the U.S. Air Force Air Mobility Command through an intergovernmental technology transfer. The transfer was completed due to the work of the KSC Technology Counselor, working with the KSC Technology Programs and Commercialization Office.

Lew Parrish, KSC's technology counselor with the Southern Technology Applications Center (STAC), started working on the transfer in September 1998, after receiving an inquiry from the Chief, In-Flight Medical Equipment, 86th Aeromedical Evacuation Squadron, Ramstein Air Base in Germany, regarding the MOS technology.

The MOS sounded similar to the Therapeutic Oxygen Manifold System (TOMS) currently used on USAF C-141 aeromedical evacuation missions. Parrish was told the supplier of the TOMS units had gone out of business, making the purchase of new TOMS units or replacement parts impossible. Seeing a potential need for the MOS, Parrish initiated a chain of contacts within the Air Force that eventually led to Master Sergeant David C. Hudson, manager of aeromedical equipment research and acquisition in the Office of the Command Surgeon at Headquarters Air Mobility Command, Scott Air Force Base, Illinois.

Parrish worked closely with Barry Slack, the NASA/KSC innovator of this system, to obtain one of the MOS kits and all documentation needed to successfully transfer the system to the Air Force. Hudson visited KSC to see the system and meet the innovator. He was pleased with the kit, and advised it should indeed solve the problems the Air Force was having with the TOMS. He formally requested a transfer of the technology to the Air Force.

The Medevac Oxygen System developed by NASA Kennedy Space Center is now an emergency tool for the U.S. Air Force. Photo provided by Kennedy Space Center.

Slack, a member of the NASA Biomedical Engineering Office at KSC, designed the MOS after an inspection was conducted of the Space Shuttle Transatlantic Landing (TAL) site medical resources. Not all of the USAF C-130 astronaut medevac planes had the capacity to handle more than three patients. Shuttle crews are normally larger, so Slack decided a new system was needed. After research, and with expert advice from pararescuers from Patrick Air Force Base in Florida, the newly designed MOS was born.

The system is designed to provide a therapeutic oxygen supply to patients being flown aboard the C-130 aircraft during a long haul medevac scenario.

Each MOS can supply up to four patients and systems can be joined sequentially. The C-130 provides a source of gaseous oxygen at approximately 400 pounds per square inch (psi) from its onboard liquid oxygen supply. The pressure of the gaseous oxygen is reduced to 50 psi by a regulator for distribution to each patient station. A flow controller and humidifier are provided at each station. The assembly can be attached to the litter or other patient-carrying device. The output from the humidifier connects to a non-rebreathing mask. The entire system is packed and stored in a durable, plastic, waterproof case that is divided and padded to prevent damage during storage and transport.

Although originally designed to meet requirements of the Space Shuttle program, this Medevac Oxygen System can meet needs for patient oxygen delivery on a variety of airborne and surface platforms. A supply of gaseous oxygen at greater than 100 psi is required. On this system, a standard litter stanchion attachment fitting is used to secure the regulator, but other methods could be easily fitted. The most common application may be the Hercules C-130 aircraft, which is found in the inventory of 64 countries worldwide. Use aboard combat transport aircraft such as the C-141 and C-5 aircraft, as well as various helicopters, is envisioned.

Use aboard the C-130 aircraft, especially the new C-130 J and X models that will be incorporating a new liquid oxygen system capable of supporting 25 litter

patients, is also planned. The Air Force also intends to brief both the U.S. Coast Guard and the U.S. Navy on the MOS system for incorporation of the technology in their aircraft.

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

Easing the Pain of Periodontal Disease

WITH THE PATIENT RECLINING IN THE CHAIR, the dentist pokes a small metal probe into the space between the teeth and the gums, searching for evidence of periodontal disease. Conventional periodontal probing is invasive, very uncomfortable for the patient, and the results can vary greatly, both for different dentists and for repeated measurements by the same dentist. But this painful, archaic method may be destined for the archives of dental history, thanks to the development of an ultrasonagraphic probe (USProbe).

Periodontal disease is the most common dental disease, involving the loss of teeth by the gradual destruction of ligaments that hold teeth in their sockets in the jawbone. The disease usually results from an increased concentration of bacteria in the pocket, or sulcus, between the gums and teeth. These bacteria produce acids and other byproducts, which enlarge the sulcus by eroding the gums and the periodontal ligaments.

The sulcus normally has a depth of one to two millimeters, but in patients with early stages of periodontal disease, it will have a depth of three to five millimeters. By measuring the depth of the sulcus, periodontists can have a good measure of the disease's progress. Presently, there are no reliable clinical indicators of periodontal disease activity and the best available diagnostic aid, periodontal probing, is only an analysis of what attachment is already lost.

A method for detecting small increments of periodontal ligament breakdown would permit earlier diagnosis and intervention with less costly and time-consuming therapy, while overcoming the problems associated with conventional probing.

The Ultrasonagraphic Probe provides a mapping system for non-invasively making and recording differential measurements of the depth of any patient's periodontal ligaments, leading to earlier diagnoses of periodontal disease. Photo provided by NASA Langley Research Center.

The USProbe provides a mapping system for non-invasively making and recording differential measurements of the depth of any patient's periodontal ligaments relative to a fixed point, the boundary between the root's crown and its root (called the CEJ). The mapping system uses ultrasound to detect the top of the ligaments at various points around each tooth, and uses either ultrasound or an optical method to find the CEJ at the same points. The depth of the sulcus is calculated as the difference between these two points.

According to John Senn, co-owner of Visual Programs, Inc., the new device may some day be celebrated as one of the major steps forward in the battle against periodontal disease.

"The probe should be the next major piece of dental equipment. By using the new technology, dentists and hygienists will be able to perform exams earlier and may detect periodontal disease while the teeth can still be saved," he added.

The probe that is used in the mouth to send and receive ultrasound signals is very small. Additional instrumentation is contained within a standard personal computer, allowing the entire measurement to be computerized. In addition, manual charting of pocket depth will be eliminated since the data will be automatically transmitted to the computer.

In addition to solving the problems associated with conventional probing, USProbe may also provide information on the condition of the gum tissue and the quality and extent of the bond to the tooth surface.

The current method of diagnosing periodontal disease is invasive, uncomfortable and inexact, requiring that a small metal probe be poked into the space between the teeth and the gums. Photo provided by NASA Langley Research Center.

The roots for the ultrasound technology used in this innovation are in an ultrasound-based time-of-flight technique used routinely in NASA Langley Research Center's Non-Destructive Evaluation Sciences Laboratory to measure material thickness and, in some cases, length. The primary applications of that technology have been aircraft skin thickness for corrosion detection and bolt length for bolt tension measurements.

The Periodontal Structures Mapping System was invented at NASA Langley Research Center by John A. Companion under the supervision of Dr. Joseph S. Heyman. Support of the research and development that led to this invention was provided by NASA's Technology Applications Engineering Program and by the U.S. Navy's Dental School, Great Lakes, Illinois. This technology was patented in May 1998 and the patent was exclusively licensed to Visual Programs, Inc. of Richmond, Virginia, in January 2000. Under their sponsorship and a grant from the NIH Institute of Dental and Craniofacial Research, professors and graduate students in the College of William and Mary's Applied Sciences Department are developing a commercial product based on the NASA invention. This effort is being supported by hygienists at Old Dominion University's School of Dental Hygiene in Norfolk, Virginia.

For more information on the USProbe, please contact Mr. John Senn of Visual Programs, Inc., Richmond, Virginia. 804/553-3157, *jsenn@tooth.net* Please mention you read about it in *Innovation.*

Probe Could Perform Breast Biopsies without Surgery

BIOLUMINATE, INC., HAS OBTAINED A LICENSE to develop, produce and market an innovative diagnostic device for early breast cancer detection based on technology originally developed by NASA researchers.

The San Jose-based company plans to develop a commercial version of the "Smart Surgical Probe" originally developed at NASA Ames Research Center, Moffett Field, California. The probe is a small disposable needle with multiple sensors. It has the potential to enable physicians to diagnose tumors without surgery, thereby dramatically reducing the number of breast biopsies that women undergo annually.

"This device is being developed to make real-time, detailed interpretations of breast tissue at the tip of the needle," said Robert Mah, the Ames scientist who invented the technology. "The instrument may allow health care providers to make expert, accurate diagnoses as well as to suggest proper, individualized treatment, even in remote areas," he said.

"Every week in the United States, approximately 18,000 open surgical procedure breast biopsies are performed on women with suspicious breast lesions," explained BioLuminate Chief Executive Officer Richard Hular. "By taking the Ames Smart Probe and developing it further, BioLuminate hopes to be able to produce a real-time measurement instrument that will reduce the need for surgery. If we are successful, the probe will significantly improve women's health care, and could potentially reduce annual health care costs," said Hular.

Further development of the smart surgical probe is focused on distinguishing cancer tissue types and obtaining real-time measurements. "The probe uses special neural net software developed at Ames that learns from experience. The goal is to enable the instrument to detect the physiologic signs of cancer and may predict its progress," explained Mah.

The breast cancer tool is being developed in collaboration with Stanford University School of Medicine, Stanford, California. It is a spin-off from a computerized robotic brain surgery "assistant" previously developed by Mah and Stanford neurosurgeon

The Smart Surgical Probe could enable physicians to diagnose breast tumors without surgery, dramatically reducing the number of breast biopsies that women undergo annually. Photo by Dom Hart of NASA Ames Research Center.

Dr. Russell Andrews. The larger brain surgery device is a simple robot that can "learn" the physical characteristics of the brain. It soon may give surgeons finer control of surgical instruments during delicate brain operations.

The technology was originally developed by NASA to serve as a geologic probe to be used in a search for life on Mars.

For more information, contact Michael Braukus at NASA Headquarters. 202/358-1979, *mbraukus@mail.hq.nasa.gov* Please mention you read about it in *Innovation.*

TECHNOLOGY COULD HELP SAVE VANISHING LANGUAGES

The most up-to-the-minute language-instruction technology, used in the space program, may come to the rescue of some venerable old languages and cultures.

Native American educators are looking at technology from NASA Johnson Space Center (JSC), Houston, Texas, in their efforts to preserve and teach their peoples' languages. The JSC Language Education Center is used to help teach astronauts, Russian cosmonauts and others English, Russian and Japanese so they can better work together in the exploration and development of space. The facility is among the largest and most advanced of its kind in the nation.

Vernon Finley and Johnny Arlee, language instructors at Salish Kootenai College on the Flathead Indian Reservation at Pablo, in northwestern Montana, recently visited the language center.

Arlee teaches the Salish Cultural Leadership Program at the college. The program's goal is to pass cultural leadership on to future generations by developing leaders to replace the elders. "Most who still speak the Salish language are elders," said Arlee, who at 59 is among the youngest of the less than 100 who still speak their native Salish language.

Finley, 46, teaches Kootenai. "While there have been language preservation efforts, they have not produced many fluent speakers," said Finley. "Unfortunately, the Kootenai are even fewer in number than the Salish, with fewer elders to speak and teach the language." Both cultures view language fluency as a vital part of the development of future leaders.

The teachers' visit to JSC verified that they are moving in the right direction. Although they are concerned that they must produce many of their own materials, the center provides models that they can use in developing their tools.

The language instruction technologies involved are computer-based language learning. The technology is used to integrate the multimedia capabilities of the computer: audio, text and visual.

"I believe our visitors have seen language acquisition technologies and methodologies that will help them teach and preserve their languages. It was a very productive visit," said Tony Vanchu of TechTrans International, director of the Language Education Center.

For more information, contact Dr. Tony Vanchu, TechTrans International, 2200 Space Park Drive, Suite 410, Houston, TX 77058. 281/438-0644, 281/483-4050, *avanchu@ems.jsc.nasa.gov* Please mention you read about it in *Innovation.*

"Snaking" Around in Exploration

NASA ENGINEERS ARE DEVELOPING AN INTELligent robot snake that may help explore other planets and perform construction tasks in space.

The robot serpent, able to independently dig in loose extraterrestrial soil, smart enough to slither into cracks in a planet's surface and capable of planning routes over or around obstacles, could be ready for space travel in five years, NASA engineers predict.

"The snake will provide us with flexibility and robustness in space," said Gary Haith, lead "snakebot" engineer at NASA Ames Research Center at Moffett Field, California. "A snakebot could navigate over rough, steep terrain where a wheeled robotic rover would likely get stuck or topple over."

"One of our first steps was to make a simple mechanical test snake, and we constructed it in less than a day thanks to previous work at other labs," said Haith. "It is a direct model of a 'polybot' developed by Mark Yim of Xerox Palo Alto Research Center in Palo Alto, California, with whom we are cooperating. We have slightly different electronics in our version."

The test snake has a wire that carries communications and power to and from the computer brain. The several identical hinge-like modules are attached together in a chain, and off-the-shelf hobby motors in each of its hinged segments cause it to move. Each of

An intelligent robot snake is being developed that will be able to independently dig in loose extraterrestrial soil, is smart enough to slither into cracks in a planet's surface, and is capable of planning routes over or around obstacles. Photo provided by NASA Ames Research Center.

the motors takes a signal from the snake's main computer brain.

"Our first test robot does what we tell it to do, no matter what the results are. If it comes to an obstacle, the robot will continue to try to go over it, even if the task is impossible," he said. "We made the first, simple robot because we wanted a working snakebot in a day or two, a robot that would help us to think about how a snakebot could and should move."

"Robotic serpents can inch ahead, flip themselves backward over low obstacles, coil and side-wind," Haith said, "while future work could enable the snake to become a mast or a grasping arm. A rover would need to have a dedicated mast and arm that would cost extra weight, money and time," he said.

"ROBOTIC SERPENTS CAN INCH AHEAD, FLIP THEMSELVES BACKWARD OVER LOW OBSTACLES, COIL AND SIDE-WIND WHILE FUTURE WORK COULD ENABLE THE SNAKE TO BECOME A MAST OR A GRASPING ARM."

"A snakebot is not as good at some jobs as other robots, but you get a lot more robot for the weight and the money," he said. "But it's hard to tell the snakebot what to do. It is a complex robot that must operate independently, possibly far from Earth. Work on our second snakebot is aimed at making it capable of independent behavior."

"The key part of what we are striving for in the second snakebot version and beyond is sensor-based control in which the robot uses its sensors to decide what to do," Haith explained. "Each hinged section includes a microcontroller, a motor, electronics and gears to get the hinge to move to certain positions."

The snakebot will have a main computer that will tell the small computer in each segment what to do in a planning sense. The tiny computers in the segments could provide "reflexes" that take care of simple but important jobs.

"In the next couple of months, we hope to simulate the snakebot in a computer program so we can automatically develop computer routines that can control the robot," Haith said.

"We hope to write software that allows the snake to learn on its own by experience," he said. "Some lessons we hope it will learn are how to crawl from soft to hard surfaces, and how to go over rough surfaces that have rocks. We even hope to show that it can climb scaffolds and go into cracks. These abilities would help the robot look for fossils or water on another planet."

According to engineers, the snakebot can save spacecraft weight because the snake-like design enables the robot to do many tasks without much extra equipment. One advantage of the snake-based design is that the robot is field-repairable. "Other benefits could include: the snakebot can crawl off a spacecraft lander and doesn't need a ramp, its moving parts can be sealed inside artificial skin to avoid exposure to the outside environment and the robot can still function, even if one joint freezes," said Haith.

For more technical robotic snake information, please visit the NASA snakebot Internet site at: *http://ic-www.arc.nasa.gov/ic/snakebot/*

For more information, contact Gary Haith at NASA Ames Research Center. ✉ *haith@ptolemy.arc.nasa.gov* Please mention you read about it in *Innovation.*

Spacesuit Technology May Aid Firefighters

TECHNOLOGY USED TO PROTECT SPACE-walking astronauts may soon be available to firefighters through the development of an advanced suit offering better protection, endurance, mobility and communications.

NASA Johnson Space Center (JSC), working with the Houston Fire Department, the Department of Defense and Lockheed Martin, is developing the prototype suit that could double the time a firefighter can battle a blaze before having to rest and cool off.

Annually in the United States, approximately 100 firefighters are killed and 100,000 are injured fighting fires that kill more than 5,000 people each year and injure almost 30,000 others. Fires in the United States also cause more than $130 billion in economic losses. Greater firefighting efficiencies could reduce those losses.

The advanced firefighter's suit will use a number of state-of-the-art NASA technologies. Among them is

active cooling, protecting the firefighter from metabolic heat trapped in the suit. Combined with new fabrics on the outer garment, the liquid cooling inner garment can allow more lengthy exposure to temperatures of up to 500 degrees Fahrenheit, compared to a maximum of 300 degrees for current suits. It will be double sealed, exposing no skin areas and providing protection against hazardous materials. The suit also will offer greater impact protection.

The design is still evolving. The suit ultimately could have an integrated modern helmet with duplex radio, biodata and temperature sensors, infrared imaging to search for fire victims and readouts on the status of its life support system. Infrared imaging work at JSC is coupled with an effort to provide infrared victim-search capability for the International Space Station.

The next-generation suit is modular. Its ergonomic design allows more freedom of movement than present suits and it is light in weight.

WITH PROTECTION FROM BOTH INTERNAL AND EXTERNAL HEAT SOURCES, THE FIREFIGHTER WILL BE ABLE TO EXTEND THE TIME AVAILABLE TO PERFORM THE TASKS OF SAVING LIVES AND PROPERTY.

Kumar Krishen of JSC's Technology Transfer and Commercialization Office; Tico Foley, an aerospace engineer in the Crew Station Branch of JSC's Space and Life Sciences Directorate; along with firefighters have identified about 40 potential areas for high-tech improvements. One is the cooling capability. "With protection from both internal and external heat sources, the firefighter will be able to extend the time available to perform the tasks of saving lives and property," Foley said.

The Houston Fire Department set goals and requirements for the suit. JSC's Technology Transfer and Commercialization Office is responsible for coordinating the project and developing approaches for the design, integration and testing of the suit and its components. The Defense Department developed heat stress models and developed, tested and evaluated materials.

Such suits could be produced in large numbers for perhaps twice the cost of current suits. But predicted reduction in firefighter deaths and injuries,

PROPOSALS SELECTED FOR TECHNOLOGY DEVELOPMENT

A tiny spacecraft hurtling through the darkness of space "diagnoses" and repairs its own malfunctions without waiting for instructions from home. A rover-robot scuttling across the rocky surface of a far-away planet suddenly "decides" to swerve sharply left to avoid a boulder.

These scenarios could result from two of the 111 proposals NASA has selected as part of its Cross-Enterprise Technology Development Program. The agency will spend more than $120 million seeking high-payoff technologies to revolutionize future space flight systems.

Over the next one to three years, principal investigators in 30 states, chosen from a field of more than 1200 applicants, will explore promising new ideas that could lead to the agency's achieving many of its long-range goals in space science, Earth science and human exploration of space. Forty-nine percent of the selected proposals are from universities.

The broad range of studies, to be conducted by universities, industry, and private and government laboratories will address 10 general technology areas. For example, new sensors will be developed for the gathering of previously unavailable science data from remote sources. The automation of spacecraft functions will be studied to enable complex new missions with greatly reduced human intervention. New component technologies including advanced materials, micro-devices and support systems will be developed that can significantly reduce the mass, cost and onboard resource needs of future spacecraft.

The Cross-Enterprise Technology Development Program is a primary NASA vehicle for identifying and developing revolutionary space technologies to enable future missions and stimulate new concepts for missions not yet conceived.

For more information, contact Michael Braukus at NASA Headquarters. 202/358-1979, *mbraukus@mail.hq.nasa.gov* Please mention you read about it in *Innovation.*

greater efficiencies in rescuing victims and allowing firefighters more time and greater efficiencies in fighting fires could more than make up for the higher cost.

The project to develop the advanced suit began in 1997 when two Houston firefighters brought a badly damaged helmet to the Technology Transfer and Commercialization Office. They asked if NASA technology could offer something better and lighter than the leather design, which dates back to the 1800s. The project expanded to look at overall protection for firefighters and to development of the advanced suit.

For more information, contact Kumar Krishen at NASA Johnson Space Center. 281/483-0695, *kumar.krishen1@jsc.nasa.gov* Please mention you read about it in *Innovation.*

"Space-vision goggles" developed by Dr. Rafat Ansari could be used by doctors to remotely monitor the eye health of astronauts and cosmonauts in space for long periods of time. Photo provided by NASA Glenn Research Center.

The "Eyes" Have It

FROM THE WEIGHTLESSNESS OF SPACE TO NASA Glenn Research Center's National Center for Microgravity Research on Fluids and Combustion, Dr. Rafat Ansari has devoted himself to researching down-to-Earth applications of his dynamic light-scattering (DLS) technique.

His research has advanced the development of opthalmic instruments used to detect early signs of eye diseases such as uveitis (eye inflammation), cataracts, diabetic retinopathy and age-related macular degeneration (AMD). There is also a possibility that the instruments could be used to detect Alzheimer's disease. Since the eye is easily accessed by light, the optical technologies created by Ansari can also be used for the evaluation of structure and physiology in health, aging and disease.

As residents enter the International Space Station for the first time, the challenges to human health and safety are evident for astronauts and cosmonauts who may be exposed to the ionizing and ultraviolet radiation of outer space. "Surgeries in a space environment or on distant planets during an expedition phase may not be a viable option," Ansari explained. "With 'space-vision goggles,' doctors will not only be able to remotely monitor the astronauts and cosmonauts for the possibilities of radiation-induced cataracts, but also observe EEG and heart monitors and record body temperatures. Blood sugar and cholesterol levels could also be monitored without taking a blood sample."

Ansari's laboratory is in the process of designing and constructing space-vision goggles. The goggles include a compact device based on his technique of DLS and other optical techniques and sensors supported by an internet web system to monitor an astronaut's health during long-term space travel.

Until recently, Ansari's efforts have focused largely on four areas of research: cataracts, diabetes, AMD and Alzheimer's disease.

Cataracts, AMD and Alzheimer's disease primarily affect people throughout the world over the age of 60. Cataracts are the gradual formation of protein clumps that eventually cloud the lens of the eye. Protein deposits called amyloids are present in the brains of people with Alzheimer's disease. With the adaptation of DLS techniques, physicians will be able to look into the lens, cornea, aqueous, retina and vitreous of an eye for amyloid protein. Detecting the disease in its earlier stages may lead to treatment with anti-inflammatories, antioxidants or hormone replacement therapies.

Although there remains no cure for cataracts, ongoing clinical research conducted between NASA and the National Eye Institute/National Institutes of Health using Ansari's DLS Probe has led to successful clinical testing of this new optical technology. It has enhanced opthalmologists' ability to trace the beginning stages of eye disease painlessly, non-invasively and quantitatively in humans.

For more information, contact Laurel Stauber at NASA Glenn Research Center. 216/433-2820, *laurel.j.stauber@grc.nasa.gov* Please mention you read about it in *Innovation.*

Monitor Could Improve Air Safety

THE INNOVATOR OF THE PERSONAL CABIN Pressure Altitude Monitor and Warning System hopes the system will improve air safety.

NASA Kennedy Space Center's (KSC) Jan Zysko, the system's innovator, said, "If this technology can help to avoid even one incident or accident, it will have been worth all the effort put forth over this past year."

The device is a hand-held instrument that can warn the user of potentially dangerous or deteriorating cabin pressure altitude conditions. Zysko, chief of the Spaceport Engineering and Technology Directorate's Data and Electronic Systems Branch, said the monitor, which is about the size of a pager, operates independently of other aircraft systems. It monitors the pressure/time conditions when supplemental oxygen is to be used per applicable Federal Aviation Regulations (FAR). The monitor is user-programmable and incorporates a highly accurate pressure transducer. It warns the user of impending danger of hypoxia through simultaneous audio, vibratory and visual alarms. In addition, a lighted digital screen displays a text message of the warning and the condition causing the alarm.

The monitor was conceived to give Space Shuttle and Space Station crew members added independent protection from "an incipient depressurization event," Zysko explained. Two major incidents galvanized in Zysko's mind the need for such a device: the Mir/Progress collision in June 1997 and the Payne Stewart aircraft accident in October 1999.

Hypoxia, a state of oxygen deficiency in the blood, tissues and cells sufficient to impair functions of the brain and other organs, is a major concern to pilots. The symptoms of hypoxia often go unrecognized, since the brain is the first organ to be affected. Once hypoxia occurs it is difficult, and often impossible, for the person to acknowledge the situation or take corrective action. In the early stages, there is considerable loss of judgment and cognitive ability. The person may become euphoric or even belligerent, and in the later stages, suffer impaired visual, physical and motor skill functions before succumbing to unconsciousness and eventual death. The length of time required for a person to lose useful function after being exposed to reduced cabin pressure is based on the physiological condition of the person and the pressure altitude. At 35,000 feet, a common altitude of commercial air carriers, the time of useful consciousness (TUC) is 30 to 60 seconds. If the cabin pressure loss is sudden, the TUC is reduced to only 15 to 30 seconds.

A device about the size of a pager may save pilots' and astronauts' lives by alerting them to potentially dangerous or deteriorating cabin pressure altitude conditions. Photo provided by NASA Kennedy Space Center.

Zysko and the KSC team involved developed this technology from concept to prototype to commercialization in less than 12 months, at a total cost of less than $100,000. He emphasized the cooperation, collaboration and interest from multiple government agencies, including the National Transportation Safety Board (NTSB), the Federal Aviation Administration (FAA) and the U.S. Air Force. Dynacs, Inc., the KSC engineering development contractor, played an important role in the circuit design and fabrication of the prototype.

Licensing Manager Melanie Chan explained there are several potential NASA and aviation/aerospace applications. Pilots flying both pressurized and non-pressurized aircraft could benefit from the warning system. Human-tended space operations also could use the innovation. Low-Earth orbit (LEO) vehicles—the Space Shuttle, International Space Station and Mir—are markets, as are long-duration/interplanetary vehicles and future planetary habitats. Ground systems are also applications, including the Mars simulation chamber and pressure/vacuum test chambers.

Zysko added that applications beyond aviation and aerospace include scuba diving, skydiving, mountain

climbing, meteorology, underwater habitats, hyperbaric chambers, altitude chambers and positive/negative pressure vessels.

"For pressurized aircraft, the invention provides an independent warning of cabin pressure altitude where a cabin leak or other reason for pressurization loss might go undetected," he added. "For non-pressurized aircraft, the monitor tracks time and altitude profiles and warns when supplemental oxygen is needed per the applicable FAR."

During the next phase of development, Zysko would like to integrate carbon monoxide (CO) and carbon dioxide (CO_2) sensors into the unit for more complete aviation and aerospace environmental monitoring. The presence of CO in an aircraft environment due to engine exhaust gases entering the cockpit is a significant aviation hazard. The CO_2 sensor addition would be particularly helpful for independent monitoring of the CO_2 scrubber effectiveness on long-duration space vehicles and space habitats.

A private pilot, Zysko illustrated the need for his invention with a significant number of hypoxia and cabin pressure-related incidents contained in the NTSB and FAA accident and incident databases. He said the FAA and NTSB agree that there are probably many more hypoxia-related incidents and accidents, but there is insufficient evidence to list hypoxia as a probable or contributing cause.

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

NASA System Increases Runway Safety

ON-THE-GROUND COLLISIONS AT THE nation's overcrowded airports are occurring more frequently, but NASA engineers have developed a way to keep aircraft on track and away from dangerous encounters.

The Runway Incursion Prevention System (RIPS) is an advanced cockpit display system, developed at NASA Langley Research Center in Hampton, Virginia. It would provide pilots and air traffic controllers with an early warning if another plane or a ground vehicle is about to intrude onto the runway.

Close calls between aircraft and ground vehicles or other planes, often called runway incursions, have grown steadily during the past decade. In the last five years there has been a 60 percent increase in near-collisions, according to the National Transportation Safety Board, with 320 incidents reported in 1999 alone. Reducing runway incursions has become the Federal Aviation Administration's (FAA) number one safety priority.

Harry Verstynen, the chief pilot from Langley, said the RIPS display has multiple uses. "Even for the large percentage of the time that you are not having a runway incursion," he said, "the displays that are being developed as part of this project will give the pilot significant improvements in situational awareness on the airport and taxiing in low-visibility conditions."

Technicians equipped a NASA 757 aircraft with the experimental displays and computer systems. NASA and airline pilots made a number of overnight flight tests at Dallas-Fort Worth International Airport to evaluate the technologies. Their observations will be used to help refine the displays for possible use in airliners.

Airline pilots have given the system high marks. "We have made several recommendations on some changes, but overall it's a well thought-out system," said John Penney, Advanced Maneuvers Program manager and Standards Captain B-757/767 of United Airlines. "With a few minor adjustments, I think it's something commercial industry and aviation industry should take and grab hold of."

NASA's RIPS integrates several advanced technologies into a surface communication, navigation and surveillance system for flight crews and air traffic controllers. It combines a head-down display of an electronic moving map of airport runways and taxiways with a head-up screen that gives the pilot real-time guidance. The system shows and sounds alerts if another plane or vehicle is about to encroach onto the runway. RIPS also uses specially developed computer software, GPS signals and ground technologies developed by the FAA's Runway Incursion Reduction Program.

This research is part of the NASA Aviation Safety Program, which is a partnership with the FAA, the Department of Defense, aircraft manufacturers, airlines and universities. The partnership

supports a national goal to reduce the fatal aircraft accident rate by 80 percent in 10 years and by 90 percent in two and a half decades. Researchers at four NASA field installations are working with the FAA and industry to develop advanced, affordable technologies to make flying safer: Langley Research Center, Hampton, Virginia; Ames Research Center, Moffett Field, California; Dryden Flight Research Center, Edwards, California; and Glenn Research Center, Cleveland, Ohio.

For more information, contact contact Katherine Barnstorff at NASA Langley Research Center. 757/864-9886, *K.A.Barnstorff@larc.nasa.gov*
Please mention you read about it in *Innovation.*

Materials May Allow Spacecraft Design Change

NEW THERMAL PROTECTION MATERIALS THAT may radically change the design and performance of future aerospace vehicles were tested recently. The materials may also overturn an age-old tenet of aerodynamics: that only blunt-body aerospace vehicles can survive the searing temperatures created as the vehicles tear through the atmosphere.

"We believe these materials may lead to a radical new concept in aerospace vehicle design and performance —the use of sharp leading edges on hypersonic vehicles," said Joan Salute, project manager for the mission at NASA Ames Research Center at Moffett Field, California. "The potential increase in spacecraft maneuverability is like going from a semi-trailer to a Ferrari." Salute said the material showed exceptional performance during its first flight test in 1997 and during tests in Ames' arcjet facilities.

Sharp leading edges offer several advantages over the blunt-body design currently in use. They could allow a Space Shuttle or crew return vehicle to maneuver in space more like an airplane and potentially allow astronauts to return to Earth from anywhere in orbit. They also might eliminate the electromagnetic interference that causes the communications blackouts that plague reentering blunt-body space vehicles. Reducing the amount of drag could lead to a reduction in propulsion requirements. In addition, planetary probes could make use of sharp-body technology for aerobraking and to maximize their maneuvering capability.

This research is part of the SHARP (Slender Hypervelocity Aerothermodynamic Research Probes) program, a joint effort among NASA, Sandia National Laboratories and the U.S. Air Force. It is funded by the Pathfinder Program at Marshall.

"Our goal is ultimately to transfer this technology to the aerospace industry for use in next-generation reentry vehicles," said Jeff Bull, chief engineer for the project at Ames. "SHARP-B2 should prove to be a key step in enabling future sharp body aerospace vehicles."

"Sharp leading edge technology is one of several technologies NASA is developing to help achieve its aerospace goals," said Michael Phipps, project manager of the Pathfinder Experiments Project at NASA Marshall Space Flight Center in Huntsville, Alabama. Phipps cited several areas that may benefit from this

SHARP-B2 reentry vehicle before flight with two of the four UHTC strakes visible. Photo provided by NASA Ames Research Center.

new technology, including safer and more reliable aerospace vehicles. In the long term, the technology also may reduce the cost of putting payloads into space, from thousands of dollars per pound to a few hundred dollars per pound, making access to space more affordable to a variety of markets.

The test was conducted by launching an Mk12A reentry vehicle (RV) equipped with four 5.1-inch-long strakes, or sharp leading edges. Each contained three Ultra High Temperature Ceramics (UHTCs), materials designed to prevent spacecraft from burning up during reentry into Earth's atmosphere.

After reaching an altitude of about 400 nautical miles, the RV was returning through Earth's atmosphere at blistering speed. It was slowed by a parachute and landed in the Pacific Ocean. Sensors in the strakes measured how closely performance matched pre-flight calculations, and at what temperature the materials began to melt.

One pair of strakes was retracted just before reaching temperatures high enough to cause the material to begin ablating, or burning off. The other pair was retracted shortly after ablation began, at a temperature of nearly 5,100 degrees Fahrenheit. NASA engineers collected data throughout the 23-minute flight, up to the moment of splashdown.

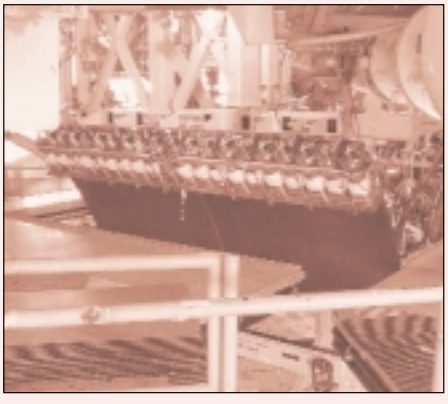
For more information, contact June E. Malone at Marshall Space Flight Center. 256/544-7061, *june.malone@msfc.nasa.gov* Please mention you read about it in *Innovation.*

FURTHER X-33 ENGINE TESTS PLANNED

Two engines designed to propel America's X-33 into high-speed, suborbital flight in 2003 have been mounted side by side in a Mississippi test stand for qualification firings, slated for the end of the year.

At NASA Stennis Space Center in Mississippi, tandem test firings of X-33's Linear Aerospike XRS-2200 engines will begin with short bursts and will eventually lead to full firings for the durations needed to send the unpiloted vehicle from a launch pad in California to landings in either Utah or Montana.

X-33, being developed under a cooperative agreement between NASA and Lockheed Martin, is a half-scale prototype of a commercially developed and operated, reusable launch vehicle of the future. It is designed to demonstrate new, reusable, single stage-to-orbit technologies. One goal of the project is to provide safe, reliable and affordable access to space.



Engines on stand, awaiting testing. Photo provided by NASA Marshall Space Flight Center.

Fourteen single-engine test firings of an earlier version the unique Aerospike engine developed by the Rocketdyne Propulsion and Power Unit of the Boeing Company were successfully completed earlier this year.

The difference between the linear Aerospike engine and conventional rocket engines is the shape of the nozzle. Unlike conventional rocket engines that use a bell nozzle to constrict expanding gases, the Aerospike nozzle is V-shaped and called a ramp.

The hot gases are shot from chambers along the outside of the ramp's surface. This unusual design allows the engine to be more efficient and effective than today's rocket engines.

At least nine test firings of the twin flight engines are planned at Stennis before they are delivered to Lockheed Martin's X-33 assembly facility in Palmdale, California.

The X-33 Program is managed by NASA Marshall Space Flight Center in Huntsville, Alabama.

For more information, contact Dr. Donald J. Chenevert, P.E., X-33 Project Manager, at NASA Stennis Space Center. 228/688-3126, 228/688-7885, *Don.Chenevert@ssc.nasa.gov* Please mention you read about it in *Innovation.*

SBIR Programs Win R&D Award

HIGH-TECHNOLOGY INVENTIONS DEVELOPED through Phase II Small Business Innovation Research (SBIR) contracts at NASA Dryden Flight Research Center in Edwards, California, and NASA Langley Research Center in Hampton, Virginia, were recently named to *Research and Development Magazine*'s R&D 100 for 2000.

Langley's innovation, developed with Triton Systems, Inc., of Chelmsford, Massachusetts is a class of aerospace materials that is highly resistant to the harsh extremes of low-Earth orbit, where an increasing number of satellites are being placed. These polymers, called TOR polymers, will provide an effective coating when applied to spacecraft surfaces, protecting against erosion by atomic oxygen and damage from space radiation. Some organic polymers in low-Earth orbit, such as Kapton™ and Teflon™, typically experience degradation over time due to attack by atomic oxygen (AO) and ultraviolet radiation. TOR polymers are designed with phosphorous in the polymer backbone to provide resistance to those effects. The AO and phosphorous react to produce a protective phosphate layer. The layer then works to reduce AO erosion by 15 to 100 times relative to Teflon™ or Kapton™, without sacrificing the polymer's chemical properties. This resistance translates to spacecraft components with longer lifetimes and reduced costs.

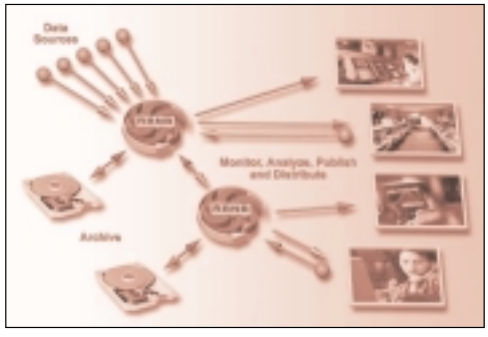
LANGLEY'S INNOVATION, DEVELOPED WITH TRITON SYSTEMS, INC., IS A CLASS OF AEROSPACE MATERIALS THAT IS HIGHLY RESISTANT TO THE HARSH EXTREMES OF LOW-EARTH ORBIT, WHERE AN INCREASING NUMBER OF SATELLITES ARE BEING PLACED.

Triton has developed processing and fabrication techniques for the materials and manufactures them in the form of powder, adhesive tape, solution, fiber, thread, fabric and film. The fibers are twisted into thread that can be used to sew multi-layer thermal insulation blankets, woven into fabric and braided to make tethers. Large films can be metallized and used for solar arrays or inflatable space structures.

The materials have been selected for use on two NASA space missions scheduled for launch in the winter of 2000. They are presently under evaluation for several electronic applications because of inherent resistance to high voltage and arcing. Applications for the TOR plastic material include upcoming satellites which will use TOR insulation blankets.

Dryden's innovation, developed with Creare, Inc., of Hanover, New Hampshire, is software that is helping to tame the vast amount of information flowing through the Internet. The patent-pending Ring Buffered Network Bus (RBNB) DataTurbine® provides multi-site streaming data access, both real-time and historical, with collaborative processing. The software adds memory to network communications and facilitates time correlation of distributed data sources. It also enables and facilitates remote monitoring, data distribution, application integration and collaborative processing between multiple data sources and sinks.

Intended for creating networks of measurements and distributed measurement processing, DataTurbine is a software server that provides a buffered network path between suppliers and consumers of information. Diverse distributed applications pool and share data using DataTurbine as a common intermediate point of contact. The server enables



Top: a polymer developed by (left to right) Joseph Smith, John Connell and Paul Hergenrother of NASA Langley Research Center, was recently named to Research and Development Magazine*'s R&D 100 for 2000. Bottom: Ring Buffered Network Bus DataTurbine® provides multi-site streaming data access, both real-time and historical, with collaborative processing; Photos provided by NASA Dryden Flight Research Center.*

remote monitoring using Web browsers and other utilities, synchronized data distribution from multiple sources to multiple sinks, application integration of diverse software using standard networks, and collaborative processing between distributed on-line users.

The applications of an Internet-based management tool such as DataTurbine are numerous. It can be used for manufacturing process control, medical and physiological management, business and commercial multimedia data streaming, scientific data processing and enterprise management. Dryden is using the DataTurbine to support existing flight research activities and to support NASA's efforts in developing advanced broadband wireless communication strategies for the future air transportation system. The tool is also being leveraged by Department of Energy and U.S. Air Force researchers for integrating distributed data sources into new data acquisition solutions and decision-support systems.

The 2000 R&D 100 Awards mark the 38th consecutive year that the editors of *R&D* magazine and a select group of technology specialists have chosen the top 100 products introduced into the marketplace over the previous year. The winners are chosen for their "technological significance" over competing products and technologies.

For more information about TOR polymers, contact Bob Mojazza at Triton Systems. 978/250-4200 ext. 148. For more information about DataTurbine, contact Larry Freudinger at NASA Dryden Flight Research Center. 661/276-3542, larry.freudinger@mail.dfrc.nasa.gov Please mention you read about it in *Innovation.*

Plant Growth System Ready for Space

ORBITAL TECHNOLOGIES CORPORATION (ORBITEC) of Madison, Wisconsin, has developed the Biomass Production System (BPS) under a Small Business Innovation Research (SBIR) contract with NASA Kennedy Space Center. The BPS is an innovative plant growth chamber that provides the precise environmental control required to perform meaningful plant research in microgravity.

The BPS is designed and manifested to fly on the Space Shuttle and International Space Station (ISS) to support scientific and commercial plant growth and biotechnology investigations in space. Projected research areas include reproduction and development biology, gravitational biology, environmental biology, radiobiology, bioregenerative life support and technology validation.

The Biomass Production System is designed and manifested to fly on the Space Shuttle and International Space Station (ISS) to support scientific and commercial plant growth and biotechnology investigations in space. Photo provided by NASA Kennedy Space Center.

The BPS has been developed to closely meet or exceed science requirements for plant growth in the Space Station era as a precursor to the Plant Research Unit within the Space Station Biological Research Program. Important features of the BPS include independent control of temperature, humidity, lighting, carbon dioxide levels and nutrient delivery for up to four different chambers; easy access to plant biomass through all phases of ground and orbital operations; enhanced data and video acquisition; sealed chambers for gas and water vapor exchange measurements; modular design of all subsystems; and an advanced control system integrating automated diagnostics.

Both space and terrestrial applications exist for the Biomass Production System, explained Thomas Crabb, ORBITEC's vice president. The environmental control technologies can apply to the Space

Shuttle, ISS, Spacehab, plant and animal habitats and other centrifuge facilities. Ground-based applications can extend into growth chambers; greenhouses; controlled environment agricultural systems; humidity control in homes, offices and other facilities; automated maintenance for large and small plantscapes; and specialized potting and planting systems for homes, offices, hotels and public buildings.

Significant commercial markets also exist for BPS technologies. Subsystem components and spinoffs will be commercialized for terrestrial markets. PLANET Products Corp., a sister company of ORBITEC, transitions valuable technologies from initial development stages into viable commercial markets via production and sales, equity or market partnerships, and technology or product licenses. The company has been formed to work in a strategic alliance with ORBITEC, with ORBITEC maintaining a research and development focus and PLANET leading the commercialization and market implementation.

The Photosynthesis and Assimilation System Testing and Analysis (PASTA) experiment was funded for development by NASA's Office of Life and Microgravity Sciences and Applications, Life Sciences Division, as the science payload during technology verification testing of the Biomass Production System (BPS). The objective of the PASTA experiment is to determine the effect of the space environment, specifically microgravity (μG), on photosynthesis and metabolism of wheat. The PASTA experiment will be integrated into the hardware verification flight of the BPS.

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

ALTERNATIVE ACCESS SOUGHT FOR SPACE STATION

NASA has awarded four small businesses contracts to develop concepts and requirements to provide access to the International Space Station on emerging launch systems.

These studies could uncover a potential backup capability, augmenting the Space Station's primary resupply vehicles: the U.S. Space Shuttle, Russian Progress, European Space Agency Automated Transfer Vehicle and the Japanese H-II Transfer Vehicles.

"Alternate access to the Space Station is a potential market opportunity for emerging or established U.S. launch companies," said Dan Dumbacher, manager of the Second Generation Reusable Launch Vehicle Program Office at NASA Marshall Space Flight Center, Huntsville, Alabama. "These companies will develop concepts for alternate access to the Space Station, determine what a launch service needs to do to meet the requirements and offer suggestions on specific development risk-reduction activities, such as technology development or business planning, that we need to perform."

Companies selected were:

- Andrews Space and Technology of El Segundo, California
- Microcosm, Inc., of El Segundo, California
- HMX Ltd. of Reno, Nevada
- Kistler Aerospace Corporation of Kirkland, Washington

The contingency resupply service understudy would seek to be capable of launching within a week if necessary and could enhance the Space Station's operational flexibility if primary delivery methods were unavailable. Established launch services companies are studying the same idea under existing contracts managed by NASA Kennedy Space Center, Florida.

"This potential alternate means of transportation could help us meet our commitments to the Station," Dumbacher said.

The study contracts, set aside for small business, are managed by Marshall under the Alternate Access Project of the Space Launch Initiative. Marshall is NASA's lead center for space transportation systems development.

For more information, contact Rosalie Allen, manager of Program and Business Development for Space Transportation at NASA Marshall Space Flight Center. 256/544-0117, *Rosalie.W.Allen@msfc.nasa.gov* Please mention you read about it in *Innovation.*

Innovation Contributes to Future Interferometry Mission

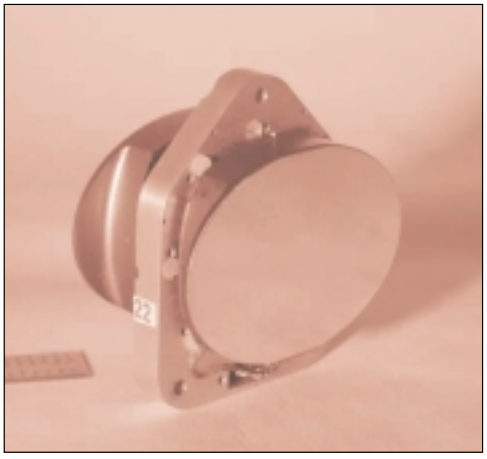
SPACE INTERFEROMETRY IS A KEY TECHNOLogy in NASA's Origins Program for viewing the distant universe. Space interferometers will take the images from two or more separate telescopes and bring them precisely together at a central observation point. Light rays are waves, so through careful alignment, the images either reinforce or null each other, like merging waves on the ocean. Scientists will make use of these phenomena to enhance the image collected by the telescopes, to measure the distance and location of stars, and to null the light of stars to observe nearby objects such as planets.

A number of technology innovations have been required to make the prospect of space interferometry a reality, including one by Left Hand Design Corporation. With NASA Small Business Innovation Research Program (SBIR) support through NASA Jet Propulsion Laboratory (JPL), Left Hand Design has constructed a combined fast steering and alignment mirror. These mirrors are able to correct for distortions in the structure of the interferometer as a result of structural distortions during launch and temperature changes, for example. Furthermore, these mirrors can move at high frequencies to offset jitters in the structure that can result from such things as reaction wheels used to maintain the overall alignment of the space interferometer. This capability enables the high degree of precision required for interferometry.

COMBINED FAST STEERING AND ALIGNMENT MIRRORS FROM LEFT HAND DESIGN HAVE BEEN USED IN TESTBEDS AT JPL TO ASSIST IN THE DESIGN OF THE SPACE INTERFEROMETRY MISSION (SIM) SCHEDULED FOR LAUNCH IN 2006.

Combined fast steering and alignment mirrors from Left Hand Design have been used in testbeds at JPL to assist in the design of the Space Interferometry Mission (SIM) scheduled for launch in 2006. Testbeds are used to establish that the demanding requirements of space interferometry can be met with available technology, and to qualify the hardware for a future space mission. Left Hand Design has sold several of these combined fast steering and alignment mirrors to NASA, the Department of Defense and aerospace companies for similar projects. This technology is also expected to have application in space optical communication systems.

SIM will be able to measure the position and distances of stars several hundred times more accurately than in any previous mission. This information will greatly enhance our understanding of the size and age of our universe. SIM will also be used to probe nearby stars for planets similar in size to Earth. Technology innovations through NASA's SBIR Program are helping to make this possible.

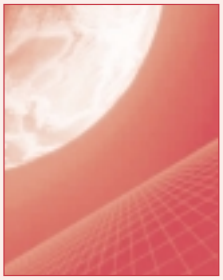


Combined Fast Steering and Alignment Mirror. Photo provided by NASA Jet Propulsion Laboratory.

For more information, contact Byron Jackson at NASA Jet Propulsion Laboratory. 818/354-1246, *Byron.L.Jackson@jpl.nasa.gov* Please mention you read about it in *Innovation.*

TECHNOLOGY OPPORTUNITY SHOWCASE

Moving Forward



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

Neural Net Navigation Tool

NASA is seeking industrial partners to continue the testing effort and license for commercialization of a neural net navigation tool, a self-contained onboard mobile vehicle navigation system. The system was developed to guide a robot through constrained pathways, but could potentially be used in a much broader range of applications. It allows for the autonomous navigation of virtually any mobile vehicle (such as a robot, truck, automobile, boat or airplane) that moves in an environment that is delimited by a boundary.

Unlike other mobile vehicle navigation systems, this invention utilizes neural network technology to determine the position and angular orientation of the vehicle without the need for large software programs and costly computing platforms required by conventional navigation systems. Neural networks are high-speed parallel processing electronic circuits modeled after the way neurons are connected in the human brain.

The mobile vehicle is first placed in a localized area where it collects position information using range sensors. This process is repeated for several localized areas, until the vehicle's entire operating range has been mapped.

The system is cost-effective, autonomous, continuously calibrated and easily adaptable. Potential commercial uses include use as industrial surveillance robots, material storage and handling robots, hospital delivery robots, entertainment robots, autonomous navigation of automobiles and augmentation of GPS navigation systems.

For more information, contact James Cameron, NASA Johnson Space Center. 281/483-1749, *james.l.cameron1@jsc.nasa.gov* Please mention you read about it in *Innovation.*

UV/IR Hydrogen Flame Detector

NASA Kennedy Space Center is seeking companies to license a new ultraviolet/infrared (UV/IR) hydrogen flame detector for commercial use. This development is a multispectral, digital signal-processing driven flame detector capable of sensing a flame from many sources caused by the ignition of hydrogen gas, and potentially other compressed gases. Commercially available flame detectors are prone to troublesome false alarms from reflections of the large flare stack that is continuously lit during Space Shuttle external tank fueling operations.

This technology was developed to produce a device immune to false alarms and capable of reliably detecting a small hydrogen flame. The detector unit's capabilities include interfacing with a computer to allow manual changes of the cross-correlation thresholds, sensor amplifier gains and sensitivity thresholds. The UV/IR flame detector is immune to false alarm situations by detecting attributes that are characteristic of an actual flame, while rejecting characteristics from flame reflections or scattered light.

Potential commercial uses include the petrochemical, power generation and aviation/aerospace industries, gas and electronic manufacturers, and research laboratories.

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

Microfabricated Gas Sensors

NASA Glenn Research Center (GRC) is actively seeking industrial partners to cooperatively further the development of high-temperature sensor technology and to develop applications for hydrogen sensor technology. The sensors allow in situ measurement of gases relevant to safety, emissions and chemical processing. They function in environments where conventional sensors are inoperable. They can be mass-produced through silicon-based device fabrication technology. Their minimal size, weight and power consumption give designers lots of flexibility.

Three types of the sensors are being developed: leak sensors (including hydrogen), emission sensors (including high temperature gas sensors) and fire detection sensors. GRC, in conjunction with Case Western Reserve University, is developing a family of microfabricated high-temperature gas sensors to provide accurate and reliable detection of hydrocarbons, nitrogen oxides, carbon monoxide, carbon dioxide and oxygen. Compared with conventional sensors, these devices often have superior high-temperature performance, chemical resistance and mechanical toughness. Silicon-processing technology reduces the cost of fabrication. Integration of these sensors into an array, effectively a high-temperature electronic nose, is an active project of the Glenn Micro-systems Initiative.

These sensors have been applied in a variety of environments, from the assembly line at Ford Motor Company to demonstration flights on the Space Shuttle.

For more information, contact Gary Hunter at NASA Glenn Research Center. 216/433-6459, *gary.w.hunter@grc.nasa.gov* Please mention you read about it in *Innovation.*

NCTN DIRECTORY

Moving Forward

NASA Field Centers

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

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

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

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

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

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

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

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.

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

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

Jim Aliberti
Kennedy Space Center
Kennedy Space Center,
Florida 32899
407/867-6224
jim.aliberti-1@kmail.ksc.nasa.gov

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

Sam Morello
Langley Research Center
Hampton, Virginia 23681-0001
757/864-6005
s.a.morello@larc.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
228/688-1914
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

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

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
216/586-3888, 216/229-9445

Thomas G. Rainey
Florida/NASA Business Incubation Center
Titusville, FL
407/383-5200

Celeste Moore
University of Houston/NASA Technology Center
Houston, TX
713/743-0451

Joanne Randolph
Business Technology Development Center
Huntsville, AL
256/704-6000, ext. 202

Richard C. (Michael) Lewin
Department of Business and Economic Development
Greenbelt, MD
800/541-8549

Julie A. Holland
NASA Commercialization Center/California State Polytechnic University
Pomona, CA
909/869-4477

Martin Kaszubowski
Hampton Roads Technology Incubator
Hampton, VA
757/865-2140

Ann Lansinger
Merger Technology Center NASA Business Incubator
Baltimore, MD
410/327-9150

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 agencies 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
352/294-7822

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

Pierrette Woodford
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 ONLINE

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

Events

The ***2001 IEEE Aerospace Conference*** will be held March 10–17, 2001 in Big Sky, Montana. This is the twenty-first in a series of annual weeklong winter conferences designed for aerospace experts, academia, military personnel and industry leaders in a stimulating and thought-provoking environment. The Conference promotes interdisciplinary understanding of aerospace systems, their underlying science and technology and their applications to government and commercial endeavors. The program will survey and record key innovations and achievements in aerospace technologies and their applications to date, and will explore future possibilities. For more information or to register for the conference, visit the web site at *http://www.aeroconf.org/index.htm*

NASA Advanced Materials Symposium: New Directions in High Performance Polymers will be held March 21-22, 2001 in Virginia Beach, Virginia. For more information, contact Ray Turcotte, Technology Marketing Manager, at NASA Langley Research Center. ✆ 757-864-8881, ✉ *r.p.turcotte@larc.nasa.gov*

The Association for Computing Machinery's Special Interest Group on Computer-Human Interaction (ACM SIGCHI) is sponsoring the ***CHI 2001 Conference***, which will be held March 31–April 5, 2001 in Seattle, Washington. ACM is a major force in advancing the skills and knowledge of Information Technology (IT) professionals and students throughout the world. The keynote speaker for the conference will be Bill Gates, chairman of Microsoft Corporation. For more information or to register for the conference, visit the web site at *http://www.acm.org/sigchi/chi2001/*

International Space Development Conference 2001 (ISDC 2001), hosted by the American Institute of Aeronautics and Astronautics (AIAA), Albuquerque Section, and the New Mexico Space Society, a chapter of the National Space Society, will be held May 24–28, 2001 in Albuquerque, New Mexico. The International Space Development Conference is the annual meeting of the National Space Society (NSS). ISDC is co-sponsored by the American Institute of Aeronautics and Astronautics. The purpose of the conference is to provide updates of the latest space information and trends to members of the two organizations, as well as members of other space-related organizations. The conference is open to interested members of the public, as well as members of NSS, AIAA, or any other supporting organization. ISDC 2001 is intended to provide a wider level of exposure and appreciation of space issues and concerns, all presented by an outstanding array of scientists, astronauts, businesspeople and civic leaders. For more information or to register for the conference, visit the web site at *http://www.isdc2001.org/*

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