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Aerospace Technology

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INNOVATION

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This year marks the 30th Anniversary of Apollo 11. On July 20, 1969, the human race accomplished its single greatest technological achievement of all time when a human first set foot on the Moon.

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
12/99	STS-101	ASTROCULTURE™ Commercial Protein Crystal Growth	Wisconsin Center for Automation and Robotics Center for Macromolecular Crystallography

* As of August 1999.
Key STS—Space Transportation System

WELCOME TO INNOVATION

The Legacy of Project Apollo

by Roger D. Launius
NASA Chief Historian

JULY 1999 MARKED THE 30TH ANNIVERSARY OF the epochal lunar landing of Apollo 11 during the summer of 1969. Project Apollo took on a life of its own over the years and left an important legacy to both the nation and the proponents of space exploration. Its success was enormously significant.

At 4:18 p.m., EST, on July 20, 1969, the Lunar Module—with astronauts Neil A. Armstrong and Edwin E. "Buzz" Aldrin aboard—landed on the lunar surface while Michael Collins orbited overhead in the Apollo Command Module. Armstrong set foot on the surface with his famous words and Aldrin soon followed. They plodded around, collected soil and rock samples and set up scientific experiments before splashing down to Earth in the Pacific Ocean on July 24.

PROJECT APOLLO IN GENERAL, AND THE FLIGHT OF APOLLO 11 IN PARTICULAR, SHOULD BE VIEWED AS A WATERSHED IN THE NATION'S HISTORY.

Five more landing missions followed at approximately six-month intervals through December 1972, each of them increasing the time spent on the Moon. The scientific return was significant—instruments placed on the Moon by the American astronauts are still transmitting important data to scientists throughout the world. But none of the Apollo flights equaled the excitement of Apollo 11.

Project Apollo in general, and the flight of Apollo 11 in particular, should be viewed as a watershed in the nation's history. It was an endeavor that demonstrated both the technological and economic virtuosity of the United States.

There are several important legacies (or conclusions) about Project Apollo that need to be remembered at this anniversary of the Apollo 11 landing. Any assessment of Apollo that does not recognize the accomplishment of landing an American on the Moon and safely returning before the end of the 1960s is incomplete and inaccurate, for that was the primary goal of the undertaking.

Apollo was as much a triumph of organization and a triumph of management in meeting the enormously difficult systems engineering and technological integration requirements. It was essential that we had the support of the President and Congress, the participation of many accomplished scientists and engineers and the continuing interest of the public at large. No single government agency nor institution nor corporation can perform alone the tasks associated with reaching major national objectives. Apollo was an outstanding example of how government agencies, industrial firms and universities can work together to reach seemingly impossible goals.

From a technological perspective, and more to the point, management over design, engineering, procurement, testing, construction, manufacturing, spare parts, logistics, training and operations was recognized as critical to Apollo's success in November 1968. *Science* magazine, the publication of the American Association for the Advancement of Science, observed:

In terms of numbers of dollars or of men, NASA has not been our largest national undertaking, but in terms of complexity, rate of growth, and technological sophistication it has been unique. . . . It may turn out that [the space program's] most valuable spin-off of all will be human rather than technological: better knowledge of how to plan, coordinate, and monitor the multitudinous and varied activities of the organizations required to accomplish great social undertakings.

Something most NASA officials did not understand at the time of the Moon landing in 1969, however, was that Apollo had not been a normal situation and would not be repeated. The Apollo decision was, therefore, an anomaly in the national decision-making process. The dilemma of the "golden age" of Apollo has been difficult to overcome, but moving beyond the Apollo program to embrace future opportunities has been an important goal of NASA's leadership in the recent past.

A significant legacy, full of impact, was started and remains today for both the nation and space exploration proponents: the emergence of products and processes, both new and enhanced existing ones, which trace their origins to technology developed to meet the goals of Apollo.

Apollo's Contributions to America

That's one small step for [a] man . . . one giant leap for mankind.

IT'S BEEN 30 YEARS SINCE AMERICAN ASTRONAUT Neil Armstrong spoke those words as he became the first human to set foot on the surface of the Moon. No more flights to the Moon are scheduled now, and future ones will undoubtedly be made differently, but the Apollo program has not really ended.

Thirty years after the triumph of America's first lunar landing, the technologies developed to enable NASA to make manned space flights and explore the Moon continue to enhance our way of life in America. Transferring and commercializing Project Apollo's technologies have contributed to strengthening the U.S. economy and bolstering our country's global competitiveness.

Since 1976, about 1,300 documented NASA technologies have benefited U.S. industry, improved the quality of life and created jobs for Americans. These innovations have helped industry and manufacturing, agriculture and food, environment and resource management, recreation, health and medicine, transportation and public safety, and communications and computers. Without our nation's space program, some everyday products and processes we take for granted may not have been developed. The following are some of Apollo's contributions:

- Scratch-resistant sunglass lenses were derived from a highly abrasion-resistant coating developed to protect, from harsh environments, the plastic surfaces of such aerospace equipment as the helmet visors worn by moonwalking astronauts.
- Quartz watches and clocks became the new horizon for consumer time accuracy after adapting a quartz crystal NASA used to obtain a stable time base for all Apollo missions.
- Computer-aided tomography (CAT) scanners and magnetic resonance imaging (MRI) technology used in hospitals worldwide came from technology developed to computer-enhance pictures of the Moon for the Apollo program. The industrial version of the CAT scan inspects for imperfections in aerospace structures and components, such as castings, rocket motors and nozzles.
- Patient monitoring equipment, commonly used today at nurse's stations to monitor the heart rate and other physiological signs of hospital patients, employs the same technology developed to monitor astronaut vital signs during the Apollo missions.
- Personal and workplace computers have become smaller, lighter and more efficient as a result of Apollo's computer and technology requirements.
- Firefighters, racecar drivers and hazardous materials and shipyard workers wear cool suits, which kept Apollo astronauts comfortable during moonwalks. People with multiple sclerosis, cerebral palsy and spina bifida wear them to lower body temperature. Kids with congenital disorders that make their bodies intolerant of sunlight wear adapted suits.
- A cardiovascular conditioner developed for space conditioning studies for the Apollo program led to the development of a physical therapy and athletic development machine used by football teams, sports clinics and medical rehabilitation centers.
- Cordless power tools and appliances, such as drills and dust vacuums, respectively, are based on technology used to develop tools for the astronauts to drill below the Moon's surface to collect lunar core soil samples. 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.
- Athletic shoe design and manufacture also benefited from Apollo. Spacesuit technology was incorporated into a shoe's external shell. A stress-free "blow molding" process adapted from NASA spacesuit design was also used in the shoe's manufacture.
- The space shoes used on the Moon are 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 stress-free "blow-molding" process were incorporated into athletic shoe design and manufacture, and the design can also be configured for different sports.
- A special fabric developed for Apollo spacesuits is used in heavier material to construct shopping centers roofs, sports stadiums and airports. Fabric roofs are on the Silverdome in Pontiac, Michigan, the Georgia Dome in Atlanta, Olympic Stadium in Rome and airport terminals in Denver. The fabric is light, flexible, 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.
- Insulation barriers made of aluminum foil laid over a core of propylene or mylar were developed

to provide radiation protection and to maintain consistent spacecraft temperatures for Apollo and subsequent missions. The insulation is used to insulate cars and trucks; it also diminishes engine and exhaust noise.

- A unistix controller used by severely disabled people to operate a typical highway vehicle was developed from the Apollo lunar roving vehicle. The vehicle's rubber tires were the predecessor to all-weather winter radial tires for automobiles.
- Vacuum-metallizing techniques used for a variety of purposes on virtually all NASA spacecraft, including Apollo missions—mainly thermal radiation insulation—led to an extensive line of commercial products. These include insulated outer garments, packaging for foods, wall coverings, window shades, life rafts, candy wrappings, reflective blankets and photographic reflectors.
- Water purification technology used on the Apollo spacecraft is now employed in several spinoff applications to kill bacteria, viruses and algae in community water supply systems and cooling towers. Filters mounted on faucets can reduce lead in water supplies. Water-cleaning systems have been adapted for cleaning spas, hot tubs and pools.
- A hospital food service system employs a cook/chill concept for serving food. The integral heating system, developed for the Apollo program, allows staff to prepare food well in advance and maintain heat, visual appeal and nutritional value while reducing operating costs.
- A hollow retroreflector, a mirror-like instrument that reflects light and other radiations back to the source, was developed for the Apollo-Soyuz Test Project. It was further expanded for use as an instrument or component in a variety of sensor applications, including an efficient means of beam positioning in the laboratory. It also has been used in monitoring the presence of hazardous gases in oil fields, refineries, offshore platforms, chemical plants, waste storage sites and other locations where gases could be released into the environment.
- A process for bonding dry lubricant to space metals, necessary to accommodate lightweight Apollo components, led to the development of surface enhancement coatings or synergistic coatings, which are used in such applications as pizza making and laser manufacture. Each coating is designed to protect a specific metal group or a group of metals to solve problems encountered under operating conditions, such as resistance to corrosion and wear.

For more information on how Project Apollo and other missions have fundamentally changed our everyday lives for the better, visit *http://nctn.hq.nasa.gov/success/index.html* or *http://www.spacezone.com/stawoe/stawoe.htm*

License Spurs New Business

A TECHNOLOGY FROM NASA'S STENNIS Space Center has launched a small technology consortium that could gross approximately $20 million over the next five years by commercially developing several environmental uses of a plant stress imager prototype. Associated Technical Management Corporation of Texarkana, Texas, researches and develops applications of the portable video imager and multispectral imaging system. The consortium's Chief Executive Officer Don Sumner has signed an exclusive license agreement with Stennis.

Stennis researchers have filed a patent application through the NASA Technology Transfer Office for the portable video imager, which measures far-red and infrared light waves to detect "plant stress." Such stress indicators are signals of how plants are reacting to poor environmental conditions, such as insufficient nutrients, inadequate watering, disease or insect infestation.

"I can't express the excitement we feel and the possibilities that are before us," Sumner said. He envisions a system that could be placed on all-terrain vehicles for environmental use, on helicopters to cover vast expanses of timber and forests and eventually on aircraft to evaluate larger or more distant locations. He has thought about adding ground-penetrating radar to the device to sense underground leaks in gasoline storage tanks or in sewage lines. Additional lenses and filters could enable the device to detect gases or vapors.

Past attempts to detect plant stress had been too labor intensive for farmers to be cost-effective. Sumner believes a farmer or forester could efficiently and routinely analyze plant stress while working in the field. Savings in harvest time,

Stennis Space Center Director Roy Estess, left, and Technology Transfer Officer Kirk Sharp, right, accept a check from Don Sumner of Associated Technical Management Corporation for the exclusive licensing of the plant stress technology at Stennis, a dual-use project.

fertilization costs and crop losses could substantially increase profits. "Being able to expand the imager's flexibility would provide farmers with a two-week lead to respond to whatever the crops needed to increase yields," Sumner said.

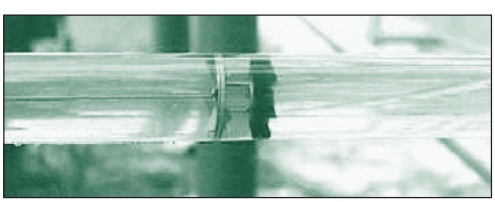
For more information, contact the Commercial Technology Office at Stennis Space Center. 228/688-1929. Please mention you read about it in *Innovation.*

Turbo Pipe Cleaner Licensed

TITUSVILLE INDUSTRIES, INC., OF TITUSVILLE, Florida, recently received a nonexclusive license from NASA's Kennedy Space Center to develop, design, market and sell a patented Turbine-Driven Brush Pipe Cleaner based on a NASA-developed innovation. Titusville Industries is designing a creative method for the internal cleaning of fluid pipe systems.

The pipe cleaner is designed to use hydraulic force to spin an internal turbine blade connected to a common brush assembly that rotates and cleans the inside of commercial and/or industrial pipes and tubes. Tom La Forge, Senior Vice President of Titusville Industries, states that the real innovation exists in its capacity to clean pipes and tubes at right angles and 45-degree turns while utilizing its own force generated by the natural physics of water. The technology was successfully demonstrated at Kennedy in a controlled test facility.

NASA engineering developed the pipe cleaner to provide a practical method to clean water lines and pipes that contain solvent residues compatible with water. It replaced existing costly and time-consuming pipe-cleaning processes. It is viable for cleaning processes in which chemicals and solvents are delivered through pipes to vats that contain flight hardware plumbing and fittings that need to be cleaned to stringent standards. The cleaner contains a small turbine and bearing assembly that uses upstream pressure of the water-cleaning solution to spin a standard circular brush to clean the inside of pipes. The turbine brush uses the fluid flow for power, and a thin cable held upstream in tension controls brush position, thus eliminating mechanical drive cables or pressure lines used to power previous systems. The brush is pulled upstream by the cable, enabling the same pipe surfaces to be repeatedly cleaned without changing the fluid flow direction.



A brush designed to clean pipes, which carried flight hardware cleaning solvent to vats, is the basis for a pipe cleaner using hydraulic force.

Titusville Industries is a tenant of the Florida/NASA Business Incubator Center, which facilitated the license agreement between NASA and Titusville Industries. The center is providing business development and a marketing strategy for commercializing the product.

Titusville Industries is developing a prototype two-inch turbine blade/brush assembly that is being evaluated by the Mechanical, Materials & Engineering Department at the University of Central Florida. The new design provides for a common shaft for mounting the turbine and brush as a complete assembly. According to La Forge, if proven successful, the assembly would complement the other design and could be used as an option.

The turbine blade has recently completed testing under the direction of NASA engineers and in coordination with the company. The turbine blade has exceeded design expectations and has performed exceptionally well under strict testing procedures. Titusville Industries is also in discussion with a corporation that will provide a special material to injection-mold the custom turbine impeller and brush assembly. The material is made from a mixture of recycled rubber tires and plastics, minimizing tooling, manufacturing and engineering costs.

The Turbine-Driven Brush Pipe Cleaner has the potential to be used in several markets involving commercial fluids processing, including soft drink manufacturers, milk processing companies, water bottling companies, breweries, alcoholic beverage–producing companies and soup manufacturers. Applications exist in the corrosion control of steam service lines, in the removal of marine organisms from seawater lines and in the post-construction cleanup of new pipelines. The product's main uses are primarily for preventive maintenance or light industrial cleaning.

NASA's prototype consisted of a closed loop system with a 150-gallon-per-minute maximum pump. Facility requirements to run the system are 220-volt, three-phase alternate current power. The system is transportable in a standard pickup truck bed. Also, a small demonstration system using a one-inch diameter turbine brush and clear tubing is available from Titusville Industries.

For more information, contact Lewis Parrish at Kennedy Space Center. 407/867-6373, ParriLM@kscgws00.ksc.nasa.gov Please mention you read about it in *Innovation.*

Underestimating the Power of Plants

BIOLOGISTS ARE STUDYING THE ENERGY conversion processes in photosynthesis by examining space-grown protein crystals from green plants. The goal is to obtain more information on possible alternative solar power sources.

A German research team presented the results of a Space Shuttle experiment designed to crystallize Photosystem I molecules, a protein in green plants that uses trapped energy in sunlight to convert carbon dioxide into carbon and oxygen. Photosystem II protein molecules use light energy to split water into hydrogen and oxygen for plant respiration.

Previous Space Shuttle missions have shown that some protein crystals grown in the microgravity conditions of space have better order and dimension. Microgravity can also affect the rate at which the proteins initiate new growth. This Space Shuttle photosynthesis investigation is trying to discover what features of Photosystem I protein molecules allow for solar energy conversion and produce results that can improve the protein's crystallization conditions on Earth. According to the researchers, this experiment has yielded the best data set thus far obtained from Photosystem I crystals.

Photosystem I and II molecules are significant because they underlie Earth's balance between water and heat, as well as between oxygen and carbon dioxide, the building blocks of life. Earth's environments—from forests to grasslands to the oceans—are direct products of these molecules. Without them, life as we know it would not exist.

Burning carbon fuel such as oil and coal now supplies much of the world's power needs and is suspected of producing most of the excess carbon dioxide greenhouse gasses implicated in the current global warming debate. Nonpolluting alternative fuel sources are being developed to take the place of rapidly depleting oil and coal reserves. Solar power, a clean and unlimited power source, may be the most promising alternative. However, to harness and generate the Sun's power, extremely large solar panels are needed, and there is no solution for power when the Sun sets.

By identifying and studying metabolism characteristics of Photosystem I, scientists hope to develop more systems that use light as a power source and apply this information to pollution prevention and environmental cleanups. Green plants use Photosystem proteins to capture and use energy from sunlight. In photosynthesis, there are many energy-producing conversion steps from sunlight to plant development and growth.

Ancient organisms called cyanobacteria—the first oxygenic organisms to convert light to energy on Earth—were used in the space experiment. Found abundantly today, the cyanobacterium protein represents more than half the total biomass productivity in all open ocean environments and may process up to 50 percent of the excess carbon dioxide greenhouse gases implicated in the current global warming debate.

The Photosystem I experiment used the European Space Agency's Advanced Protein Crystallization Facility and is among the results recently published by NASA from the 16-day Life and Microgravity Spacelab (LMS), which flew June 20 to July 7, 1996, aboard the Space Shuttle *Columbia.* Its record development and cost—each experiment cost about half of most Spacelab experiments—make LMS an example of how future space station missions can control experiments remotely from locations around the globe.

For more information, contact David Noever at Marshall Space Flight Center. 256/544-7783, 256/544-1777, *David.A.Noever.Dr@msfc.nasa.gov* Please mention you read about it in *Innovation.*

BETTER FOOD FOR SPACE AND EARTH

NASA has selected Iowa State University, Ames, Iowa, to head the National Food Technology Commercial Space Center, working to improve food for long-duration space missions and to enhance the packaging, preparation and storage of commercially produced food. Following a 60-day cooperative agreement for detailed definition, a five-year cooperative agreement with a possible five-year extension will be awarded in September 1999. Johnson Space Center, Houston, Texas, will sponsor the commercial space center. Commercial partners in the center will provide additional resources in a collaborative effort to develop the new technologies.

As space flight evolves from short-duration Space Shuttle missions to extended habitation aboard the International Space Station, NASA will be challenged to provide astronauts with more palatable and nutritious food. The agency must also find ways to decrease the weight of items to be carried to the station, reduce the on-board storage requirements and diminish the amount of waste produced. The development of advanced food technologies is essential for successful long-duration missions. Improvements in the shelf life and safety of food for space flight could lead to similar improvements in commercially produced and packaged food available to the public.

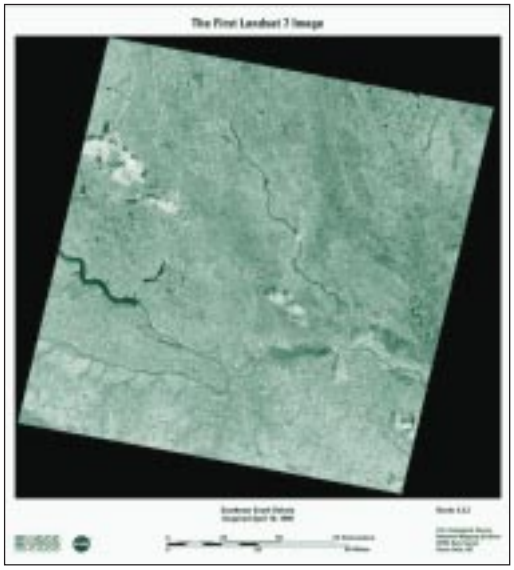
For more information, contact Renee Juhans at NASA Headquarters. 202/358-1712, *rjuhans@hq.nasa.gov* Please mention you read about it in *Innovation.*

USDA Partnership Cost-Effective

A NEW PARTNERSHIP BETWEEN NASA AND the U.S. Department of Agriculture (USDA) could result in updated maps of Yellowstone National Park, a better understanding of wildfires and improved management of California vineyards. Under the partnership, NASA has selected 13 research proposals that will apply remote-sensing data—images of Earth taken by satellites—to issues on the ground: forest mapping, soil studies, wildfires, range management, floodplain drainage and crop monitoring.

"This new partnership between NASA and USDA demonstrates the diverse and wide-ranging applications of NASA's Earth Science [Enterprise] research and its relevance to the American people," said Dr. Ghassem Asrar, Associate Administrator for Earth Science at NASA Headquarters, Washington, D.C. "The Office of Earth Science is eager to form new partnerships with other government agencies, industry and public groups to expand America's use of our Earth Science research."

"We in the Department of Agriculture, especially the Cooperative State Research, Education, and Extension Service, are very excited about partnering with NASA on these research projects," said I. Miley Gonzalez, Under Secretary for Research, Economics and Education. "We recognized that there were areas of research where images from space combined with ground surveys can greatly benefit our mapping efforts. We are looking forward to these pilot projects and hope they may lead to future partnerships between our organizations to explore land management and precision agriculture topics."



Photos such as this, one of the first from Landsat 7, will be used to create new maps for land management, forestry studies and improved understanding of wildfires and west coast vineyards.

From 180 proposals, the 13 projects involve 11 universities, 11 private companies, 17 federal agency facilities and four state and local governments. Researchers will use a variety of public and private spaceborne and aircraft-mounted Earth-observing instruments along with ground observations in their studies. For forestry studies, NASA, the USDA Forest Service and universities will use the recently launched Landsat 7 and other satellites to create valuable new maps of Yellowstone and other public lands.

Satellite imagery also can provide researchers at the Forest Service and universities with maps of vegetation in areas prone to wildfires. Firefighters can determine which types of plants are more likely to fuel wildfires and better predict what paths such fires may take.

Using airplanes and spacecraft that observe characteristics of grape vines invisible to the naked eye, researchers can "see" when vines are ill, allowing vintners to act before many vines are lost to disease. This research will allow America's billion-dollar wine industry to manage its vineyards more cost-effectively.

For more information, visit *http://earth.nasa.gov/nra/archive/nra98oes09/winners.html* or contact David Steitz at NASA Headquarters. 202/358-1730, *dsteit@hq.nasa.gov* Please mention you read about it in *Innovation.*

Faster "On-Ramp" to Info Highway

AN EDUCATIONAL PARTNERSHIP IS PROVIDING a faster on-ramp to the information highway for students using a reconfigured NASA antenna for radio astronomy Internet experiments. The Lewis Center for Educational Research in Apple Valley,

California, has partnered with LOMAC Information Systems and Mountain States Communication—both headquartered in Victorville, California—as well as Lucent Technologies of Murray Hill, New Jersey, to provide a high-speed wireless Internet link for the Goldstone-Apple Valley Radio Telescope program.

This telescope program is an educational partnership among the Lewis Center, NASA's Jet Propulsion Laboratory (JPL) and NASA's Deep Space Network (DSN). It enables middle school and high school students around the country to take control of a radio telescope at the DSN's Goldstone, California, facility.

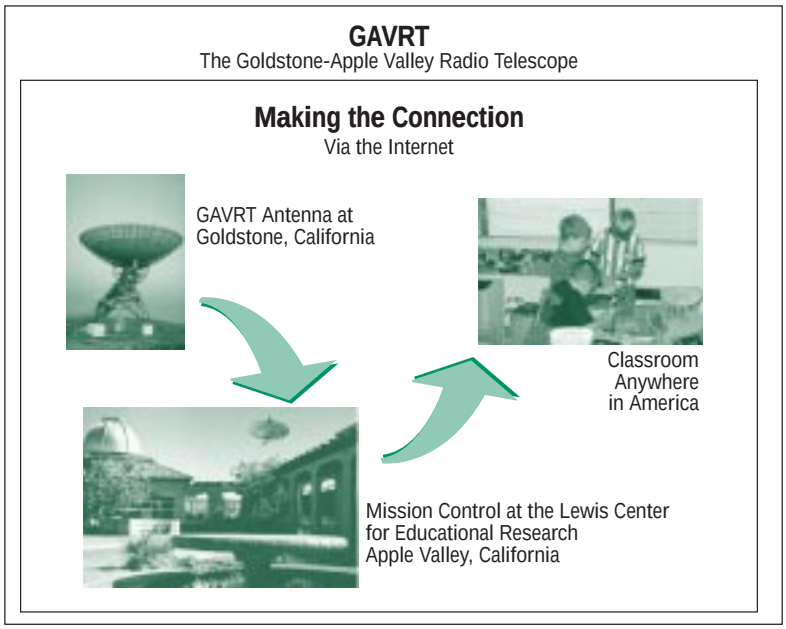
Students operate the antenna from classroom computers to perform real scientific research, using curriculum developed by Lewis Center staff and JPL scientists and engineers. The DSN is a worldwide system of ground stations used to communicate with spacecraft and conduct radar and radio astronomy studies.

"We have developed a sophisticated educational tool that gives students everywhere the chance to participate in real science," said Lewis Center Director of Technology Jim Roller. "Until now, we've had to share access to the Internet with many other schools in the county and faced slowdowns that stalled our system. We're extremely pleased with this solution."

Lucent will provide new hardware for a ten-megabit-per-second microwave connection between the Lewis Center and Mountain States Communication. Mountain States will provide dedicated Internet connectivity for clear access to the Internet. LOMAC Information Systems will provide all installation and system maintenance services for the new connection.

"As a NASA laboratory, JPL is committed to giving students the opportunity to experience the real world of science and the thrill of discovery," explained Dr. Michael Klein, manager of the DSN Science Office at JPL. "It's very gratifying to have local and national businesses join us to promote scientific literacy in American schoolchildren. We hope that all the students gain a real appreciation for what science is and an understanding that everyone can participate."

The Goldstone-Apple Valley Radio Telescope program was founded in 1996, when JPL, the Lewis Center and the Apple Valley Unified School District agreed to work together to develop a curriculum-based educational program that uses a radio telescope at Goldstone. Since the program began, 24 teachers and more than 2,000 students in six states have participated. Middle and high school teachers train at the Lewis Center and during a week-long course at Auburn University in Alabama. The Lewis Center is a science and educational resource for students, teachers and community members throughout the region.



A NASA radio astronomy antenna has been reconfigured to allow students, nationwide, to participate in real science via their own microwave and Internet connections, made possible through an educational partnership.

For more information, contact Jim Roller at the Lewis Center for Educational Research. 760/242-3514, 760/242-3783, *jim@avstc.org* Or contact John G. Watson at the Jet Propulsion Laboratory. 818/354-5011, *John.G.Watson@jpl.nasa.gov* Please mention you read about it in *Innovation.*

Video Clarification Better Than Ever

A NEW TECHNIQUE THAT MAKES EXISTING video images clearer and steadier than anything in current use has several uses in the law enforcement, medical and meteorology fields. However, it could be most cost-effective for the consumer home video market.

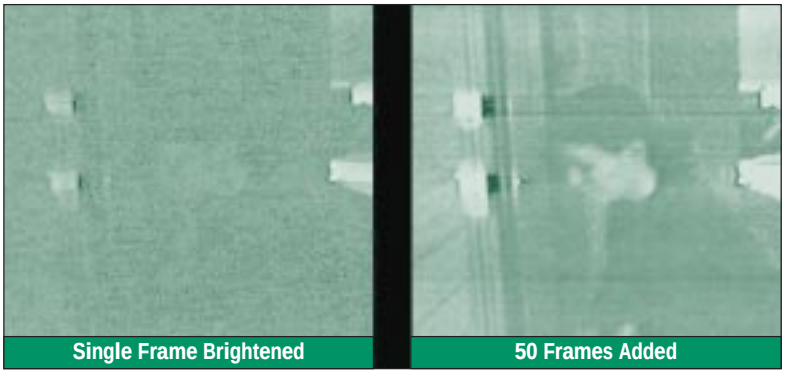
Two scientists at NASA's Marshall Space Flight Center—Dr. David Hathaway of the Space Sciences Laboratory and Paul Meyer of the Global Hydrology and Climate Center (GHCC) in the computer laboratory—have developed the Video Image Stabilization

and Registration (VISAR) technique, a computer algorithm that corrects existing images for zoom, tilt and jitter. Reviews by the Los Alamos National Laboratory concluded that VISAR was unsurpassed in its clarification of distorted video images.

"With VISAR," said Hathaway, "a sequence of video images won't move around, zoom in and out, or rotate." VISAR's corrective power depends on how many video frames are available to be blended together, but generally VISAR can correct image jitter to about one-tenth of a pixel, a tiny square of color that makes up an image. It can correct magnification and zoom to 0.1 percent and angles to within 0.03 degrees.

When the FBI's Southeast Bomb Task Force asked if anyone at Marshall Space Flight Center could help improve the clarity of poor quality video from the 1996 Atlanta Olympic Games bombing, both Hathaway and Meyer believed they might be able to help. Two years of trial and error resulted in the ability to stabilize, sharpen and brighten the images. The process also took them from using a $30,000 "QuBit" video-capturing device to using devices as low as $200, and a change in Windows version software reduced processing speed from five minutes to 15 seconds.

"Telescopes are always shaky," said Hathaway, a solar physicist who uses video stabilization techniques to enhance pictures of the Sun. Measurements of the Sun's position or features on the solar surface can be affected by this jittery affect. Meyer, a meteorologist and computer scientist working in the GHCC, processes weather satellite images.



The NASA software, VISAR, can overcome video defects in one frame by adding information from multi-frames to reveal a person. The clarified image on the right reveals a person after 50 frames of video are added to the single frame image on the left.

The key to clarifying a video sequence is to stabilize the image, according to Hathaway. VISAR allows you to combine several video images together, and noise can be averaged out among the frames. The more images you can combine, the greater the corrective power of VISAR.

In the past, video stabilization has been limited to registering horizontal and vertical image movements. These methods do not account for rotational or zooming effects in video data sequences, and they are sensitive to the effects of parallax when items in the background and foreground move at different rates and/or different directions. VISAR can correct images when of all of these adverse effects are present.

Current techniques do not take into account how the clarity problem occurred in the first place. Today's techniques are unable to combine images and thus only work on a frame of video at a time. The more a camera operator zooms in, an image becomes larger and more spread out. Because today's techniques can only sharpen the edges of an image, noise and distortion in the image increase.

As mentioned above, computer and video images are made up of tiny squares of color, called pixels. By registering VISAR on an object in the image, the pixels from several video frames can be lined up together. The result is a steadier video.

VISAR surpasses existing image-correction technology, which cannot compensate for the effects of zoom or tilt, but the VISAR algorithm did. By steadying and reducing the noise in the FBI video images, Hathaway and Meyer brought out a wealth of information, revealing new, previously obscured details.

In terms of law enforcement use, the police often use video to identify suspects by recognizing faces in a crowd or repeat crime scene visitors, to investigate a crime scene or to spot identifying characteristics. VISAR could be used to steady images of car chases shot from inside a moving police car, enabling the police to focus on a license plate number or an image of the driver's face reflected in the rear-view mirror.

In medical imaging, VISAR could help clarify ultrasound images, infamous for their grainy, blurred quality. More importantly, with VISAR, doctors could make better medical diagnoses, and medical students would train better with steadier, clearer images.

Applied to meteorology, VISAR could track cloud formations and storms and be used to determine any changes in the images of a hurricane's eye. Determining

During car chases, police can use VISAR to focus on a license plate number.

a tornado's wind speed may be possible using VISAR to steady a home video camera image to track objects whirling on the outside of the tornado.

The home consumer could benefit the most. Although many consumer camcorder devices currently have built-in anti-jitter devices, no devices are available to fix zoom and tilt problems that occur during videotaping. "VISAR can be used to correct these mistakes afterward," Hathaway said.

VISAR is currently covered under a provisional patent, and it will soon be available for licensing. The pair hopes to develop real-time stabilization in the future to actually correct footage as it is being videotaped.

For more information, contact David Harris at Marshall Space Flight Center. 256/544-0057, 256/544-2669, *David.C.Harris@msfc.nasa.gov* Please mention you read about in *Innovation.*

JOINT EFFORTS IN DEEP SPACE PROPULSION

MSE Technology Applications, Inc., of Butte, Montana, recently signed an agreement with the Jet Propulsion Laboratory (JPL) in Pasadena, California, for advanced research on deep space propulsion systems. The new agreement, brokered by the MSU TechLink Center in Bozeman, Montana, enables MSE and JPL to collaborate on space-related research and development activities.

MSE's computational fluid dynamic (CFD) modeling capabilities will contribute to JPL's development of new propulsion technologies for deep space exploration, including pulsed plasma thrusters and fusion propulsion devices. Under the agreement, other MSE aerospace technologies, such as its magnetic nozzle technology, will also be evaluated for use in JPL's deep space propulsion systems. This project is expected to help MSE successfully develop and commercialize its advanced propulsion technologies.

As one of Montana's largest research and development companies, MSE is well known nationally for its research on energy-related and environmental technologies. It has been conducting research in the advanced propulsion area for NASA for the past several years and currently has contracts with four other NASA centers. MSE has developed ways to test new space engine designs using high-performance computers—in effect, creating a virtual environment that simulates these engine designs operating in deep space conditions. These tests allow existing engine designs to be improved and theoretical designs to be evaluated. Within this virtual environment, engine thrust and efficiency can be measured along with other performance characteristics. MSE's CFD modeling capabilities will specifically support JPL's development of the Mars Cargo Vehicle.

This agreement is the second joint research project that the MSU TechLink Center has established between Montana companies and JPL during the last year. NASA funds TechLink to link companies in Montana and the surrounding region with NASA centers for joint research and technology transfer. TechLink's overriding purpose is to contribute to the success of both high-tech companies and traditional resource-based industries in the state and region.

For more information, contact Dr. Will Swearingen at the MSU TechLink Center. 406/994-7704, *wds@montana.edu* Please mention you read about it in *Innovation.*

Riding the Highways of Light

A PROTOTYPE OF AN INNOVATIVE LASER-propelled transportation concept could someday result in space travel that is better, faster and cheaper for both Earth-bound transportation as well as space-bound flights. The Lightcraft—a small, disk-shaped, laser-propelled aircraft—virtually eliminates an on-board propellant. The absence of a propellant will allow the Lightcraft, whose revolutionary potential could parallel that of the Apollo program, to quickly and cheaply reach the speeds necessary for modern space travel. During the recent Advanced Propulsion Research Workshop held in Huntsville, Alabama, it was noted that a sophisticated descendant of Dr. Robert Goddard's first liquid propellant rocket—the Saturn V of Project Apollo—sent the first humans to the Moon just 43 years after Goddard's March 1926 launch.

Low cost, simplicity and responsiveness upon demand are the predominant reasons the Air Force Research Laboratory and NASA's Marshall Space Flight Center have joined together to research an innovative and promising method for reaching space. The evolution of ultra-lightweight high-temperature materials, dual-mode laser propulsion engines, powerful lasers and the opportunity to change science fiction into scientific fact are also driving forces in this effort.

Laser Lightcraft and their propulsion modes are a radical departure from current methods. If successful, this new energy beam propulsion technology will supplement rather than replace current manned and unmanned launch systems. "My goal has been to cut the cost of getting to space by a factor of 1,000 using a system that is completely green," explained Professor Leik Myrabo of Rensselaer Polytechnic Institute (RPI) in Troy, New York. Myrabo is the first under the sponsorship of the Laser Propulsion Program of the former Strategic Defense Initiative Organization to propose and develop the laser Lightcraft.

Leik Myrabo (right) watches as students at Rensselaer run a computer simulation for an air spike wind tunnel test on the Lightcraft model held by the student at left. (RPI photo)

Called "Lightcraft" because it flies on a beam of light, the vehicle harnesses the energy of a laser beam and converts it into propulsive thrust. A parabolic mirror focuses the pulsed laser energy into a ring-shaped "absorption/propulsion" chamber. The atmosphere acts as a propellant as the focused laser light superheats the air to become a jet exhaust that pushes the craft up. With higher altitude, thinning air and a speed 5.5 times the speed of sound, the craft would use a small on-board supply of hydrogen heated by the remote laser beam.

Since 1972, Myrabo has been further developing a variation of an Arthur Kantrowitz idea: using lasers to launch satellites. The approach holds great promise for significantly reducing the launch costs of microsatellites that use today's chemical-fueled, combustion-powered rocket technology. Myrabo tried a few initial designs for NASA and then came up with the "toy top" design for ground-based lasers by reversing the laser optics of space-based lasers. With continued Air Force and NASA sponsorship, Myrabo has developed and test-flown a 15-centimeter (6-inch) diameter model of the toy top Lightcraft. In testing, a light shield erected by a crane is used to eliminate the chance of blinding an orbiting satellite's sensor.

Myrabo is now collaborating with Dr. Franklin Mead, of the Air Force Research Laboratory's advanced propulsion group, to conduct field tests to demonstrate how the craft can be propelled using available high-powered lasers. Further research may use a 100-kilowatt laser to boost a larger model and, eventually, a 1-gigawatt laser necessary to orbit satellites.

The giant leap could happen by the mid-21st century with another propellant concept. Requested by the Space Studies Institute in Princeton, New Jersey, Myrabo and his students are designing a similar craft using microwaves beamed from space. He and his students are also studying a microwave Lightcraft—an advanced derivative of a tiny, 25-gram craft that he is pushing around on a 10-kilowatt beam of infrared laser light in tests at White Sands Missile Range, New Mexico.

The concept is part airship, part microwave receiver and (smallest) part jet and rocket engine. It is powered from Earth by sunlight captured by an orbiting power station and the atmosphere heated by a laser as a propellant. Switching on the microwave transmitter would make the Lightcraft disappear in less than an eye blink. The microwaves would be focused by the internal reflector to heat the air on one side or the other of the craft and push it in the opposite direction.

Climbing a good altitude, beyond the speed of sound, where you use the magnetohydrodynamic drive, the craft tilts from flying edgewise to flying flat into the air stream, but for a reason. The microwaves are reflected forward to create a superhot bubble of air above the craft and form an air spike that acts as the nose cone as the Lightcraft accelerates to 25 times the speed of sound.

"This cleans up the aerodynamics of a vehicle that does not look like it should fly in that direction," Myrabo said. Even better, when the load is properly balanced, the craft sails through the air without leaving a shock wave and virtually no supersonic wake. Water is used by the craft to cool the rectennas and as a propellant in the last stages of ascent.

Myrabo points out that most of the technologies or principles have been demonstrated. "If successful, this will cut the cost of getting to space to whatever someone wants to charge for electricity from the orbiting power station," Myrabo said. "You could go halfway around the world in 45 minutes, or from the Earth to the Moon in about 5 1/2 hours." At the Moon, the Lightcraft would zoom down a series of ring-shaped electromagnets that would slow the craft, or it could accelerate another Lightcraft for the return to Earth.

For more information, contact David Harris at Marshall Space Flight Center. 256/544-0057, 256/544-2669, *David.C.Harris@msfc.nasa.gov* Please mention you read about it in *Innovation.*

The X-34's First Captive Test Flight

A TEST VERSION OF AN X-34 DEMONSTRATOR vehicle recently made its first captive-carry test flight. The vehicle is designed to test new technologies and methods of operations needed to develop low-cost reusable space vehicles.

The first of several captive-carry flights between the X-34 technology testbed demonstrator and its L-1011 carrier aircraft was conducted in June at NASA's Dryden Flight Research Center at Edwards, California. The purpose of this test was to verify the safety of the combined vehicles for Federal Aviation Administration (FAA) certification purposes because of modifications to the L-1011 carrier vehicle.

Initial data indicate that no major problems occurred in the 1 hour, 50 minute flight. Additional flights will be required, however, to examine the entire flight profile for the X-34 and its carrier before subsequent air-launched and unpowered approach and landing flights later in the year.

Several planned test objectives were accomplished during the flight. The operational program is designed to demonstrate that reusable launch vehicles can be more reliable, fly more often and fly in worse conditions than current vehicles using a smaller operations team. The performance of the aircraft was evaluated during several scheduled maneuvers at various speeds and altitudes. The L-1011 crew conducted a simulated rocket engine propellant release from the X-34 using fluorescent dye. The electronic connections among the mated aircraft, data collection systems and the video camera system on the L-1011 were also checked.

A modified L-1011 takes off with the X-34 on its first captive flight.

When a commercial airplane such as the L-1011 is altered, the FAA must certify that the changes have not adversely affected the plane's safe operation. The planned 2.5-hour test was shortened after a safety observer aboard a NASA F-18 chase plane noticed a fuselage panel on the L-1011 seemed to be vibrating. The panel was located on the bottom aft fuselage of the carrier aircraft behind the X-34. Based on video from the

NASA AWARDS HIGHEST HONORS

Four U.S. companies committed to innovative management, quality and customer service have received the George M. Low Award, NASA's highest honor for quality and technical performance and the nation's oldest award for organizational quality. Barrios Technology, Inc., Houston, Texas, received the award for small business product, and Kay and Associates, Edwards, California, won for small business service. Raytheon Support Services Company, Annapolis Junction, Maryland, won large business service, and Thiokol Space Operations, Brigham City, Utah, took large business product. Each was evaluated according to seven criteria: performance, cost and schedule, innovation, management leadership, alignment of organizational goals with NASA's strategic plans, customer orientation and adherence to the Total Quality Management philosophy. The award demonstrates outstanding management and customer service and encourages contractors to implement quality principles that prove profitable for the companies awarded and NASA.

Barrios Technology is a small female-owned business providing information technology, space operations, expertise and training to the aerospace industry. Kay and Associates is a family-owned contract engineering firm that provides specialized engineering, logistical and technical services at NASA's Dryden Flight Research Center, saving NASA $800,000. Raytheon Support Services Company provides logistics support, warehousing and distribution of equipment and material at NASA's Goddard Space Flight Center. Thiokol is the NASA contractor responsible for the manufacture, launch support and refurbishment of the Shuttle's reusable solid rocket motor, delivering 100 percent on time for seven years and whose cost reduction efforts have saved NASA $152 million.

For more information, contact Sonja Alexander at NASA Headquarters. 202/358-1761, *salexand@hq.nasa.gov* Please mention you read about it in *Innovation.*

chase plane, test officials decided to end the flight. No further details were available pending a close inspection of the aircraft and extensive flight test data.

Eventually, the X-34 will perform high-speed suborbital free flights to demonstrate such technologies as an advanced thermal protection system, composite structural components and autonomous landing. The unpiloted X-34 is a single-engine rocket plane that will fly itself with onboard computers. It will be powered by the new Fastrac engine, designed by NASA's Marshall Space Flight Center in Huntsville, Alabama, which also manages the X-34 program for NASA. Dryden is supporting the captive-carry part of the program with flight testing and ground vibration tests.

In 1996, NASA awarded Orbital Sciences Corporation of Dulles, Virginia, a contract to design, build and test-fly the X-34. The contract includes a structural test vehicle for vibration and captive-carry flights and two flight vehicles. Orbital Sciences owns the L-1011, which also launches the company's Pegasus launch vehicle. X-34 engineers are in the process of strengthening the L-1011 panel and support structure for the second flight, which is scheduled sometime in August.

For more information, contact Leslie Mathews at Dryden Flight Research Center. 661/258-3458, *leslie.mathews@mail.dfrc.nasa.gov* Please mention you read about it in *Innovation.*

The World's Fastest Aircraft Flies Again

NASA'S DRYDEN FLIGHT RESEARCH CENTER at Edwards, California, flew its fastest and highest flying airplane, the SR-71A, to evaluate the SR-71's performance, handling and flying qualities with a test fixture mounted atop the aft section of the aircraft. This test fixture was originally used for the Linear Aerospike SR-71 Experiment (LASRE), supporting research for the X-33 program.

Further research for the SR-71 to evaluate its performance, handling and flying qualities included mounting a fixture atop the aft section.

The flight of the SR-71 "A" model took place on June 30, 1999, the first flight of this aircraft since October 29, 1998. The aircraft reached a maximum speed of Mach 2.25, about 1,450 mph, at 55,000 feet. Three more flights are scheduled in the next few months.

"The long-anticipated prospect of getting the SR-71 aircraft back in the air is exhilarating," said Dryden's SR-71 Project Manager Steve Schmidt. "This phase of the flight research program has gotten off to a great start. The aircraft and project team performed flawlessly, which is further testament of the cooperative 'teamwork' that has been a sustaining hallmark of the SR-71 programs."

NASA's "B" model is used for proficiency training for pilots and the flight test engineers. Recently, the "B" model completed its planned 200-hour phase inspection and has been put into flyable storage. These two SR-71s have been on loan to NASA from the U.S. Air Force, which just transferred ownership to NASA.

In addition to these two SR-71s, the Air Force turned over possession of its two other flyable SR-71s, which will complement the other two NASA planes in future flight research programs. These will provide unsurpassed flexibility as well as additional capabilities to perform multiple high-speed research experiments.

The SR-71 can fly more than 2,200 mph (Mach 3 plus)—or three times the speed of sound—and at altitudes of more than 85,000 feet. Data from the SR-71's high-speed research program will be used to aid designers of future supersonic and hypersonic aircraft and propulsion systems, including a high-speed civil transport. SR-71 flights have also provided information on the presence of atmospheric particles at extremely high altitudes, where future hypersonic aircraft will be operating.

As research platforms, the SR-71s carry out research and experiments in aerodynamics, propulsion, structures, thermal protection materials, high-speed and high-temperature instrumentation, atmospheric studies and sonic boom characteristics. The LASRE project was a small, half-span model of a lifting body positioned on the rear of the SR-71 aircraft, which operated like an "airborne wind tunnel." The SR-71 has also acted as a surrogate satellite for transmitters and receivers on the ground, assisting in the development of a commercial satellite-based, instant and wireless, personal communications network, called Iridium. Another project joined NASA and the University of California at Los Angeles (UCLA) in investigating the use of charged chlorine atoms to protect and rebuild the ozone layer. Ongoing research in high-speed, high-altitude flight continues to gain interest among the scientific community, industry and other government agencies.

For more information, contact Leslie Mathews at Dryden Flight Research Center. 661/258-3458, *leslie.mathews@mail.dfrc.nasa.gov* Please mention you read about it in *Innovation.*

Contract Creates Communications Company

TELENEXUS, INC., OF RICHARDSON, TEXAS, has established itself in wired/wireless telephony and Radio Frequency Identification (RFID) system development. It has established a sister company, based on technologies developed during a Small Business Innovation Research (SBIR) project with NASA's Kennedy Space Center.

The company developed and commercialized the Digital Wireless Voice Network, based on a wireless headset design that NASA wanted for use in Kennedy's Operational Intercommunications System (OIS). Company President Chuck Lau said that Telenexus marketed the innovation as the TNEX-2000—a flexible, wireless communications system that provides local voice communications for virtually any work group and requires no Federal Communications Commission (FCC) site license to operate.

Since that time, Telenexus has grown into a major technology partner with Texas Instruments, Sirit Corporation and Mobil Oil. The company developed and manufactured transceivers for toll collection systems, the Mobil Speedpass and the Texas Instruments Registration and Identification System (TIRIS)—the Tag-It low-cost tags. Telenexus is now developing parking lot and airport hands-free collection systems.

The company is also marketing a telephone/voice mail system under the Voice Logic name, a sister company it formed. Trademarks include DVO, Amigo, Voice Express, Clarity and Encore. Voice Logic is focusing on the rapidly growing small office/home office telephony market.

In addition, Telenexus has a joint venture partnership to develop a wireless Private Branch Exchange (PBX) system. The company believes that a 2.4-gigahertz PBX system based on its own Application Specific Integrated Circuit (ASIC) will be a successful commercial product beyond the NASA-developed system. NASA's need for this innovation was to enhance Kennedy Space Center's Digital Operational Intercommunications System (OIS-D) by providing it with a wireless headset link capable of supporting all Space Shuttle and payload launch and test activities at the center, including their interfaces to communications systems at other NASA centers.

The Telenexus TNEX-2000 wireless communications system uses digital modulation on a spread spectrum. It consists of a base station, four radio/antenna modules and as many as 16 remote units with headsets. The base station serves as a network controller, audio-mixing network and interface to such outside services as computers, telephone networks and other base stations. The system is useful in industrial maintenance, emergency operations, construction and airport operations. Also, digital capabilities can be utilized by adding barcode readers for taking inventories.

This flexible, wireless communications system provides local voice communications without an FCC site operation license. It is based on a digital ground communications system capable of supporting all Space Shuttle and payload launch and test activities at Kennedy Space Center and interfacing with other NASA centers.

For more information, contact Lewis Parrish at Kennedy Space Center. 407/867-6373, *ParriLM@kscgws00.ksc.nasa.gov* Please mention you read about it in *Innovation.*

SBIR Success at Marshall

Company Formed: Two Products Commercialized

A SMALL BUSINESS INNOVATION RESEARCH (SBIR) agreement with Marshall Space Flight Center and Integrated Systems, Inc. (ISI), of Utica, New York, has resulted in the commercialization of two products. One of the products has led to forming a new company.

A unique Kalman filter that enhances the ability to perform the proximity-sensing phase of the Automated Rendezvous and Capture (AR&C) mission was developed under an SBIR contract. This technology enables a robot supply vehicle to automatically dock with and service Earth-orbiting satellites or the International Space Station.

In the foreground is a sample of Microlith's catalyst-coated metal substrate. Behind it is an automotive Microlith light-off converter and main converter in an integrated car. To the right is a stand-alone Microlith automotive preconverter.

The company used the technology as the basis of a commercial object position and attitude determination system that simultaneously tracks an object's linear and angular movement in all six degrees of freedom. ISI further extended the technology to develop the ImageExpress™ workstation, ultimately forming a separate company, Sensory Applications, Inc. (SAI), to specifically market the system and related technologies. ImageExpress provides a simple-to-use digital mainframe motion analysis workstation for streamlining design and production processes. Governmental and scientific applications include automatic collision avoidance, automated supertanker docking, automated aircraft landing, robot control and machine vision.

Essentially, the filter can be used for any application that measures resolvable angle data from known targets that must estimate relative position and attitude. Viable utilizations also include limb motion analysis, as well as assembly line position and crash dummy motion analyses.

Technology Expected to Save Millions

An SBIR technology being evaluated by the automotive industry could save NASA millions of dollars in air-cleaning space flight life support. Marshall Space Flight Center is field-testing the use of a small, metal monolith as a potential component of the International Space Station's Trace Contaminant Control System. The monolith, a catalyst-coated metal honeycomb of unique geometry that enables more efficient direct electrical heating and enhanced catalytic activity over conventional catalyst substrate technology, will result in energy and mass savings for the International Space Station.

Termed as Microlith®, the technology could save NASA an estimated $31 million over a 15-year period. More than a dozen Microlith-related U.S. patents have been issued, while a number of foreign and other U.S. patents are pending.

Precision Combustion, Inc., of New Haven, Connecticut, is employing a small amount of electrical heating of this novel, ultra-lightweight metal catalyst substrate to achieve more than 99-percent destruction of difficult-to-remove trace organic contaminants at low air inlet temperatures. Current research and development is also under way with NASA on producing a high specific surface area washcoat that would extend the operation of the technology to much lower light-off temperature applications. The washcoat is a specially formulated chemical coating that permits an increased amount of a reactive catalyst to be more evenly and more durably applied to the metal monolith.

Nonheated versions of the technology are being evaluated by major auto makers for automotive emission concerns. For the air-cleaning systems designer, the Microlith enables the use of sophisticated catalysts, while ensuring safe, relatively low-cost, low-temperature operation. A number of major corporations are conducting joint development programs with Precision Combustion on customer-specific applications.

Oxidation System Marketed to Private Sector

An effective catalytic oxidation system to remove contaminants during long-term manned space missions has reached its primary SBIR Phase II goal and is being marketed to the private sector. A contract between Marshall Space Flight Center and Umpqua Research Company in Myrtle Creek, Oregon, originally focused on the stringent water quality requirements of long-term manned space flight, with the manufacture of light hardware as the primary Phase II goal. The main focus for near-term commercialization is the International Space Station. Continued sales are expected for long-term missions to the Moon and Mars.

The U.S. Air Force has also funded the technology for the destruction of environmental contaminants associated with aviation fuel, solvents, soluble propellant and munitions byproducts. The National Science Foundation has supported the effort for phenol, trichlorethylene, methylene blue and benzene contaminants.

The energy-efficient operation of the catalytic oxidation system offers excellent heat recovery, with contaminant destruction depending primarily on operation temperature and catalyst contact time. It destroys most waterborne organic compounds. Soluble alcohols, ketones, amides, amines, aromatics and halocarbon levels have been oxidized using dissolved elemental oxygen to form carbon dioxide, water and constituent inorganic species. At the same time, the system has the capability to eliminate such inorganic contaminants as nitrite.

Umpqua's most recent efforts have been applied to the remediation of ammonium perchlorate–contaminated groundwaters associated with the manufacture of solid rocket fuels, munitions and fireworks. Calgon Carbon Corporation has signed an exclusive license for use of the technology in treating perchlorate-containing brines that have resulted from the regeneration of ion-exchange beds used to remove perchlorate from groundwater. An initial pilot scale test is in progress at NASA's Jet Propulsion Laboratory. Additional Phase III development work will be funded by Calgon to reduce catalysts' costs and to minimize the formation of unwanted reaction byproducts.

Company Becomes World-Class Developer

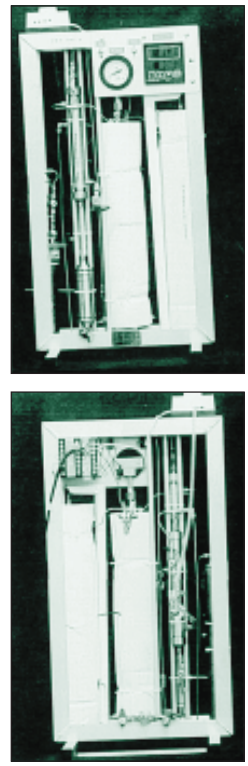
In an SBIR effort with Marshall Space Flight Center, Foster-Miller, Inc., of Waltham, Massachusetts, has established itself as a world-class developer of vapor compressor systems and equipment for novel applications. At the same time, the company has identified ways to utilize waste heat and to reduce thermal management system weight for manned space flight applications.

The contract has resulted in a list of accomplishments for Foster-Miller. Initially, the company constructed a heat pump heater for crew hygiene water. The pump, utilizing waste heat from the thermal bus, reduced water-heating power requirements by 4.9 kilowatts. Then the company developed a proprietary oil-refrigerant separator for use in microgravity, a key component for the use of heat pumps in space. Next came the design and testing of a two-phase spacecraft thermal bus that employed a binary refrigerant mixture. The unique control system developed for the thermal bus resulted in an 85-percent decrease in pumping water.

In addition, Foster-Miller's efforts have developed unique expertise in the fields of refrigerant chemistry and application engineering for the company. Commercial applications of the product include engineering and consultation for the electric utility and supermarket industries to develop and test replacements for ozone-depleting refrigerants for commercial refrigeration and the development of a refrigerant mixture replacement for R-12 in automotive air conditioning.

Research and development activities concern various government agencies. For NASA, efforts entail the design, fabrication and testing of a high-lift heat pump for future lunar and Martian explorations, along with the investigation of modular heat pumps for manned and unmanned space flights. Other government applications include multiple tasks for the Department of Defense. One is a refrigerant replacement for silo-based missile guidance systems, and another focuses on microclimate and human-portable personal cooling systems. The point of contact at Foster-Miller is David H. Walker at 781/684-4237.

For more information, contact Helen Stinson at Marshall Space Flight Center. 256/544-7239, 256/544-3151, *helen.stinson@msfc.nasa.gov*
Please mention you read about it in *Innovation.*



This shows a front view (top) and a rear view (bottom) of the catalytic oxidation test unit.

TECH 2009: EXPLORE THE CUTTING EDGE

The 10th Annual National Technology Transfer Conference is scheduled for November 1–3, 1999, at the Fontainebleau Hilton in Miami Beach, Florida. Tech 2009, considered America's premier showcase of new and next-generation technologies, is an unmatched opportunity to meet with and sell to top technology decision-makers from throughout industry and government who are looking for new product/business ideas, engineering solutions and ways to improve their manufacturing/production processes.

A wide range of industries will be represented by the hundreds of top technology managers from leading companies and research and development centers. More than 7,000 design and development engineers and technology and engineering managers from all 50 states and 46 countries are expected. Exhibitors will include federal laboratories and agencies, their contractors and research and development partners, leading-edge companies, universities and state organizations, with innovative technologies, products and services available for license or sale.

The conference is sponsored by NASA, NASA Tech Briefs and the International Society for Optical Engineering and is co-located with the Southeast Design & Manufacturing Expo, the Small Business Tech Expo and the Small Business Innovation Research (SBIR) program.

For more information, visit *http://www.techeast.net/2009exhibitor.html* or contact 212-490-3999, 212 986-7864, *Melissa@abpi.net*
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 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.

Hybrid Imaging Technology

The Jet Propulsion Laboratory (JPL) is looking for licensees for its Hybrid Imaging Technology (HIT), which merges the best features of the Charge Coupled Device (CCD) and Complementary Metal Oxide Semiconductor (CMOS). HIT uniquely couples CMOS circuitry to a CCD-based imaging array. The benefits include the imaging performance surpassing state-of-the-art CCDs, the power consumption of a CMOS imager, the capability to integrate camera electronics at the chip level, full compatibility with JPL's Delta Doping for High Quantum Efficiency and UV Detection, the ability of the imager format to be coupled with a variety of CMOS processor and controller chips, and the CCD and CMOS technologies merged without costly process development or performance degradation. The Parallel Hybrid Ultra-low-noise Detector (PHUD) combines HIT with a novel technique to achieve subelectron (rms) noise readout via simultaneous multiple sampling of many pixels. PHUD draws on the strengths of both the CCD and Active Pixel Sensor (APS) technologies to create a superior detector. A PHUD detector consists of a CCD imaging array hybridized to a multichannel CMOS signal detection and processing chip, resulting in the exceptional quantum efficiency, fill factor and broad spectral response of CCD imagers with the low-power operation and flexibility of integration found in CMOS devices.

For more information, contact Mark Wadsworth at the Jet Propulsion Laboratory. 818/354-7833, 818/393-0045, *Mark.Wadsworth@jpl.nasa.gov* Please mention you read about it in *Innovation.*

Novel Polymer Film Technologies

Langley Research Center is looking for companies interested in developing commercial products based on a family of materials and processing technologies for both the emerging conductive polymer market and the existing high-performance polymer market. These robust and easily processed materials offer various combinations of conductivity, reflectivity and dimensional stability, and they may enable advancements in electronics, space films for reflectors, concentrators, antennae and anti-microbial packaging. Characterized by various levels of reflectivity and thermal stability, the materials will support advancements in many applications. Using a one-step chemical process, self-metallizing film technology produces completely metallized, highly reflective and conductive surfaces on a polymer film. The resulting metallized surface, because of its integration with the polymer, provides superior adhesion over commercially available deposited films from which the metal coating can easily be removed. Metal oxide–containing polymers create films and coatings that have an optically clear, semiconductive metal oxide surface. Metal ion–containing polymers enhance the thermal and dimensional stability of the base polymer. Incorporating metal ions lowers the coefficient of thermal expansion of base polyimides by as much as 30 percent; the materials are neither conducting nor light reflecting. Metallized films using supercritical-fluid infusion enable the production of polymer films and coatings with a reflective and conductive metallic surface. The material also has nanosized metallic particles dispersed throughout.

For more information, contact Sherry Sullivan at Langley Research Center. 757/864-2556, *s.l.sullivan@larc.nasa.gov* Please mention you read about it in *Innovation.*

Integrated Reaction Wheel Assembly

Goddard Space Flight Center seeks to transfer the Integrated Reaction Wheel Assembly (IRWA) technology to private industry. Developed for science missions, the IRWA offers companies an opportunity to virtually eliminate the technical risk and minimize the financial investment required to introduce a new spacecraft component. The technology was developed for NASA's Small Explorer Lite program—an initiative to provide small, low-cost, high-performance/reliability spacecraft. Designed primarily for small spacecraft launched from a Pegasus-class vehicle, the IRWA provides unique plug-and-play capabilities. The stand-alone assembly contains all the necessary power converter, commutation, control and telemetry electronics. It can be operated with a current (torque) or speed (momentum) controller. Modular interface electronics provide adaptability to any spacecraft computer interface via a standard serial communications interface. Mechanically, the unsealed design reduces the weight and cost associated with complex O-ring seal designs. The flywheel is cantilevered off the motor shaft, enabling the entire rotating assembly to be balanced while fully assembled. Potential commercial uses are spacecraft manufacturers and suppliers of spacecraft components. Other benefits include reduced weight, improved bearing performance, easy mounting, reduced electronics design cost and improved low-speed accuracy.

For more information, contact Adrienne Marble at Goddard Space Flight Center. 301/286-8175, 301/286-0301, *amarble@pop700.gsfc.nasa.gov* Please mention you read about it in *Innovation.*

NCTN DIRECTORY

Moving Forward

NASA Field Centers

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

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

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

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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.

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

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281/483-0474
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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.

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, 216/433-5300

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

Judy Johncox
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 (Michael) Lewin
Maryland Economic Development Corp.
Greenbelt, MD
800/541-8549

Van Garner
California State Polytechnic University–Pomona
Pomona, CA
909/869-2276

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

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
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

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 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 ***IDEAS (Innovations, Demonstrations, Exhibits, Applications, Spinoffs) Conference,*** focusing on microsystems, will be held November 17–18, 1999, at NASA's Glenn Research Center at Lewis Field in Cleveland, Ohio. This Microsystems Partnering Forum is designed to bring researchers and industry representatives together to stimulate partnering in this exciting and rapidly evolving arena. Technologies showcased will focus on health monitoring in harsh environments, including sensors, actuators, microelectronics, packaging, micromachining and other supporting topical areas. Keynote speakers are Dr. Al Pisano of the University of California at Berkeley and Dr. David E. Cole, Director of the Office for the Study of Automotive Transportation. The event is being sponsored by Glenn Research Center, the Great Lakes Industrial Technology Center, the Ohio Aerospace Institute and the Mid-Atlantic Technology Applications Center. For more information, visit *http://ideas.grc.nasa.gov* or contact *ideas@grc.nasa.gov*

Planetfest '99, December 3–5, 1999, is an international festival and exhibition, presented by The Planetary Society, at the Pasadena Convention Center in Pasadena, California, to celebrate and witness the arrival of the Mars Polar Lander on Mars with live images from its cameras of the never-before-explored domain near the Martian south pole. There will be special activities and interactive technological programs, including a children's "Mars Experience" hall, science fiction book signings, the sealing of a millennium time capsule, space art, NASA and JPL exhibits and science fiction films. A World Wide Web presence includes presentations, debates and discussions by renowned and popular science and science fiction authorities. For more information, visit *http://planetary.org/Pfest99/index.html*

The ***Next Generation Space Telescope (NGST) Science and Technology Exposition*** will be held September 13–16, 1999, at the Four Points Sheraton Hotel in Hyannis, Massachusetts. This meeting will acquaint the astronomical research community and industry with the instrument study results and early plans of the prime contractors. It is an opportunity for astronomers to learn about the technology challenges associated with various aspects of the NGST designs (such as large lightweight optics, advanced operations concepts and infrared detectors) and to examine research programs in the Design Reference Mission. Industry participants can learn how specific astronomical investigations drive design decisions for the observatory. They will also have the opportunity to present technologies to the NGST Phase A prime contractors and science instrument teams. For more information, contact Debora Miller at Goddard Space Flight Center. 301/286-5265, *Debora.A.Miller@gsfc.nasa.gov*

National Aeronautics and
Space Administration

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