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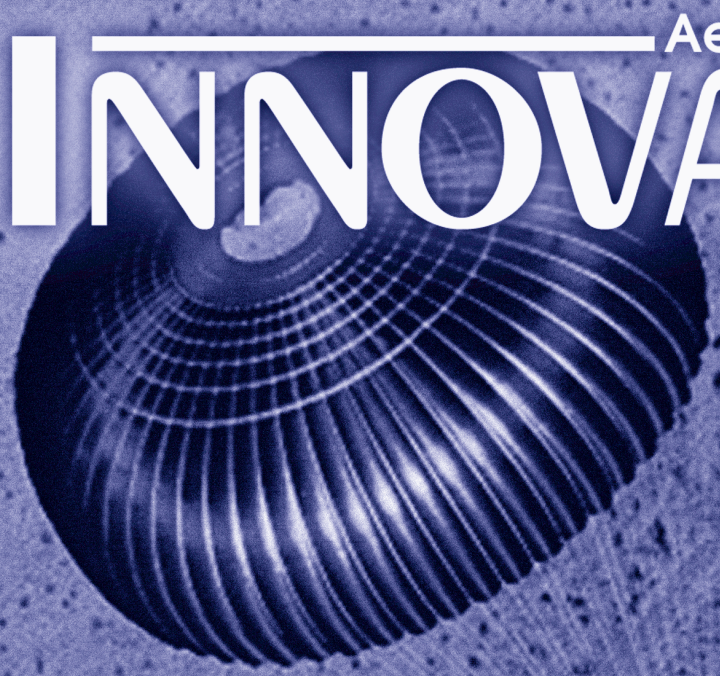
INNOVATION



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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

WELCOME TO INNOVATION

Small Business Innovation Research/Small Business Technology Transfer Provide Leverage for NASA

By Carl Ray
NASA SBIR Executive Director

"LEVERAGE" IS A COMMON BUZZWORD around NASA these days; it stems from the tighter budgetary atmosphere of the last few years. When people talk about leveraging, they generally are trying to utilize resources (funds or equipment, for example) from sources outside their particular programs.

Historically, the Small Business Innovation Research (SBIR) program, and later the Small Business Technology Transfer (STTR) program, have provided tactical leverage for NASA mission programs that have been able to understand and utilize them to their best advantage. The usage is tactical in the sense that the potential utility was seen as an unscheduled, unplanned, and often unlikely opportunity.

Today, the SBIR/STTR programs, with their recent realignments to NASA enterprise priorities, have matured, and it has become apparent that NASA mission programs are beginning to look to the SBIR/STTR programs for more than their tactical problem solving value. One program in particular has very successfully leveraged the SBIR/STTR programs in a broader strategic manner.

The general aviation (GA) revitalization, embodied in 1994 with the AGATE (Advanced General Aviation Transport Experiments) consortium, has strategically leveraged the SBIR and STTR programs to support its efforts. SBIR/STTR funding for GA projects has been more than $34 million between 1993 and 1998. The funds went directly to award winners—small businesses working on problems specified by the NASA GA community as subtopics in the SBIR and STTR solicitations. The results have been substantial.

The AGATE program was designed as a government-industry-university consortium and consists of more than 70 members. Its goals were to help revitalize the ailing industry by developing affordable new technologies and advocating for new standards and certification methods for next-generation single-pilot and near all-weather light aircraft.

It has been almost eight years since the NASA GA effort embarked on its strategic partnership with the SBIR/STTR programs. In the continuing success of this effort, NASA SBIR Phase II contracts have contributed to 14 marketable commercial successes as well as 14 technology developments. Now as their successes become visible, other NASA mission programs are actively seeking advice from the GA and AGATE teams on how to best use SBIR/STTR to help achieve their goals.

There is still a large portion of the total general aviation revitalization equation yet to be solved. For example, there are more than 5,000 public-use aviation landing facilities within the United States, and most are underused because of limited systems capabilities. The Small Aircraft Transportation System (SATS) is an initiative to focus on these challenges, with a goal of increasing personal mobility by providing affordable all-weather use of the nation's public-use landing facilities and better integration of small aircraft into our air transportation system. Technology areas include the integration of safe, low-cost and easy-to-fly aircraft with smart, small airports. The SATS team, already knowledgeable in the GA/SBIR partnership, is putting the successful momentum of that experience to good use in continuing to form future pathways of partnering with the SBIR program with a focus on the SATS initiative.

In another instance, the Kennedy Space Center has, over the past few years, initiated an extensive effort to develop its Spaceport Technology Center. The Center is seen as becoming a world class resource for the emerging space transportation industry. It is dedicated to furthering the visionary approaches for developing technologies for the spaceports of the future: a future in which spaceflight will become so affordable that industry will be able to take advantage of it for research, manufacturing and human exploration.

Clearly, the NASA SBIR/STTR program sees both SATS and the Spaceport Technology Center as viable sources for subtopics, as well as for exploring strategic partnering opportunities. The inclusion of SBIR in their strategic, programmatic planning is another way in which both can provide greater benefit to NASA, as well as to the country, in two ways: first, as a value-added technology development resource providing contribution to mission thrusts of the agency, and second, as a national resource providing R&D opportunities for the small business community, benefiting NASA, the company, the industry, and ultimately the nation's people. Just another way NASA SBIR/STTR is "helping small business make a big difference."

NASA Benefits from Small Business Programs

NASA MISSION PROGRAMS HAVE BENEFITED greatly from the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs since they were founded. Designed to provide increased opportunities for small businesses, the programs are also providing extensive opportunities for NASA. As the SBIR/STTR programs have matured, NASA programs have begun to take advantage of the benefits provided by SBIR/STTR.

The General Aviation (GA) revitalization, embodied with the Advanced General Aviation Transport Experiments (AGATE) consortium, is one of the programs that has used SBIR/STTR successfully. SBIR/STTR funding for GA projects has exceeded $30 million since 1993, with funds going directly to small businesses working on GA-specified problems, subtopics in the SBIR and STTR solicitations. Results for NASA, small business and general aviation have been substantial.

The AGATE program is made up of more than 70 members from industry, universities, the Federal Aviation Administration and other government agencies. It was founded to help revitalize the troubled aviation industry by developing affordable new technologies and advocating new standards and certification methods for next-generation, single-pilot, and near all-weather, light aircraft.

Companies that won Phase II SBIR contracts working toward the revitalization effort automatically became part of AGATE, leading to easier paths to developing business relationships. The GA/AGATE programs' use of SBIR/STTR has led to impressive results. One of the clearest examples of both the benefits of SBIR/STTR and the AGATE consortium is Cirrus Design's SR20 aircraft.

The SR20 is a four-seat single-engine airplane designed with speed, innovation, comfort and safety in mind. The company currently has over 500 confirmed orders for the SR20 plane and production has been consistently ramping up over the last year.

The SR20 is not just an example of AGATE benefits, but also the SBIR/STTR program's contribution to AGATE's evolving success in reviving general aviation as a viable industry in the United States. Cirrus Design Corp. itself was awarded two SBIR phase II contracts that played into the development of this plane, particularly with respect to innovative manufacturing techniques. In addition, the innovations of several other SBIR companies are integral parts of the plane, included in the impressive list of new technologies.

The SR20 includes as standard equipment an airplane emergency recovery parachute that was developed by Ballistic Recovery System (BRS) in part through an SBIR contract BRS had with the Langley Research Center. The SR20 parachute is known as CAPS–the Cirrus Airframe Parachute System. BRS has a million-dollar contract with Cirrus to supply the parachutes for the SR20.

The BRS parachute is also used in over 25 experimental category small airplanes, providing BRS with approximately $1 million in revenue per year. More importantly, the BRS system is a proven lifesaver. BRS has over 100 stories from pilots who have survived crashes because they had a BRS parachute system in their aircraft.

ARNAV is another NASA SBIR company that has its technology incorporated into the SR20 plane. Through its SBIR project, entitled "Affordable Electronic Weather Reporting System for General Aviation Pilots," ARNAV developed an innovative "weather in the cockpit" technology. This is a low-cost data link that provides weather information graphically to the cockpit. ARNAV has since expanded the application and has developed a cockpit multi-function display (MFD) which includes the "weather in the cockpit" function.

AGATE concept cockpit for future small aircraft.

ARNAV's MFD has been incorporated into the SR20 avionics system.

ARNAV has also applied this technology to other high profile efforts. For the 1996 Summer Olympics in Atlanta, Operation Helistar, an AGATE-based effort, required that all aircraft flying over the Games be equipped with ARNAV's data link. The link provided both weather and traffic information graphically to each cockpit. The AGATE ground control station had two-way text messaging capability with the aircraft as well, thus further increasing the safety of the many planes and helicopters over Atlanta.

In 1999, ARNAV continued to expand the availability of up-to-the-minute weather data to the general aviation community when it was awarded a five-year Flight Information System (FIS) contract with the Federal Aviation Administration (FAA). Under the contract, ARNAV will receive two nationwide data link frequencies on which to broadcast basic aviation weather reports. FIS is considered fundamental to the National Airspace System architecture modernization program.

The GA/AGATE program's success is not limited to technologies incorporated into the Cirrus SR20, nor has the SR20 been the only example of SBIR companies partnering (and thus increasing the success of both). Other innovations that are improving the safety, reliability and cost effectiveness of small aircraft include ModWorks' Human Factors Engineered Ergonomic instrument panel created by the joint forces of ModWorks and Vision Micro Systems. This panel includes Vision Micro System's Intelligent Digital Engine Monitoring System for small airplanes. This low-cost system reduces pilot's engine management workload and improves operation safety and reliability. Mod Works' manufacturing technology, which was developed under the STTR program, is key to the company's ability to produce the instrument panel at a lower cost.

The instrument panel has received FAA certification and has found a market in the retrofitting of older planes. In addition, Mod Works spun the technology into a different arena when it developed an FAA certified training simulator. The simulator is built with the same type of ergonomic instrument panel that goes into the airplanes—hence its market appeal. Over 250 simulators have been built and shipped in the last couple of years.

Innovative Dynamics Inc. (IDI) has been working on ice protection technology through the SBIR program for several years. IDI has developed a sensor system that assists in the detection of ice build-up as well as in determining if the accreted ice has been shed after system operation. The technology has been licensed to B.F. Goodrich and integrated into its pneumatic de-icers bringing ice detection technology to the general aviation market at an affordable price.

ARNAV's "weather in the cockpit" technology provides weather information graphically to the cockpit of general aviation aircraft.

Kennedy Space Center (KSC) is also beginning to look to the SBIR/STTR programs to support efforts to develop a Spaceport Technology Center. The Center is seen as becoming a world class resource for the emerging space transportation industry, and is dedicated to developing the necessary technologies that will lay the groundwork for the spaceports of the future.

Spaceport technologies require new techniques, methods, mechanisms and machinery used to process space cargo as well as space vehicles, and technologies to launch and land space vehicles. Discussions and lessons learned from the GA/AGATE team have been assessed and careful consideration has been given to areas best suited to the small business community and the SBIR/STTR programs. KSC is including the SBIR program as one of the strategic resources in its plan for acquiring technologies in support of the Spaceport Technology Center.

Other NASA programs, including the Office of Aerospace Technology's new Revolutionary Concepts (RevCon) program, are also looking at how they can best utilize the SBIR program to help advance their goals.

The SBIR/STTR program was designed primarily to give opportunities to small businesses to get involved with federal research and development activities. NASA has found that the program also contains opportunities for it as well, and now NASA, and the small businesses involved in its SBIR/STTR program, are reaping the benefits generated by those who took advantage of the opportunities.

For more information, contact Mike Durham at NASA Langley Research Center 757/864-3863 *m.h.durham@larc.nasa.gov* Please mention you read about it in *Innovation.*

Glenn Research Center Innovators Recognized

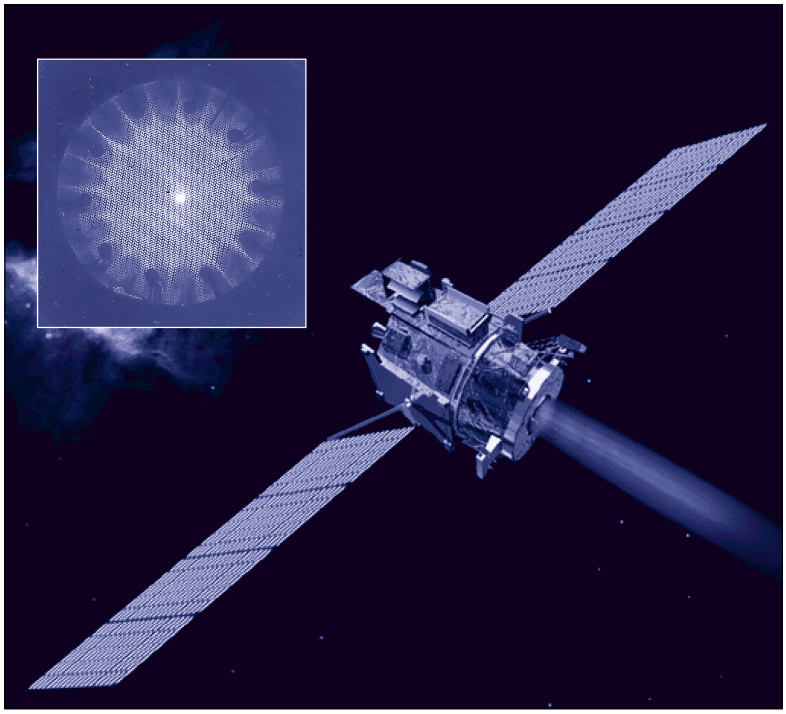
ENTERPRISE DEVELOPMENT, INC. (EDI) HAS named two project teams from NASA Glenn Research Center (GRC) as winners of the annual EDI Innovation Award. EDI recognizes individuals who develop practical and creative ideas that allow an organization to carry out its mission with an innovative product, a creative concept or a new procedure improving productivity.

James Sovey and Vincent Rawlin, aerospace engineers from the On-Board Propulsion Branch of the Power and On-Board Propulsion Technology Division, and Robert Roman, an aerospace technician from the Materials, Power and Propulsion Area, Test Installations Division, received the award for their work on the ring-cusp ion engine. Ion engines were developed to provide station keeping and orbit raising of communications satellites and are also used for primary propulsion for deep-space spacecraft.

Ion engines were first developed in the 1960s. The innovators patented the ring-cusp ion engine in 1984. Since then, NASA and Hughes Electronics have developed the engine to flight status. From 1997 to the present, Hughes has launched ten communications satellites using the ring-cusp engine for station keeping. In October 1998, NASA launched a ring-cusp ion engine aboard the Deep Space 1 spacecraft to validate ion propulsion and other spacecraft technologies, as well as encounter an asteroid and a comet.

The engine has accumulated more than 5,000 hours of thrust. Since June of this year, and until September 2001, prior to encountering the comet Borrelly, additional hours of thrusting time will be accumulated. The ring-cusp ion engine provides long-life devices that can significantly reduce costs to spacecraft customers. According to Hughes, "The dollar savings may be $7 million to $8 million per launch, so launch costs can go down, or we can increase the payload, or increase [spacecraft] lifetime. A sizable competitive margin is produced."

Dr. Mrityunjay Singh, chief scientist, and Richard Dacek, research technician, are employees of Dynacs Engineering Inc., located on-site at GRC. Their winning project is the Affordable Robust Ceramic Joining Technology (ARCJoinT), used for manufacturing and repair of high-temperature ceramics and fiber reinforced composite components.



The ring cusp ion engine was used to power NASA's Deep Space 1 spacecraft.

This technology has been used to produce dense, strong joints for silicon carbide-based ceramics and composite materials, as well as structures in complex shapes. The thermomechanical properties can be tailored according to component design and application requirements. The ARCJoinT process involves producing a carbonaceous paste that is applied in the joint area between the parts. The joint area is then heated to give strength to the joint to allow handling without fixturing. A silicon or silicon-refractory metal alloy is applied locally in

the joint regions and heated at a much higher temperature. These joints maintain their integrity at high temperatures and exhibit mechanical properties and environmental resistance. The formation of joints by this technology is attractive since the thermomechanical properties of the joint interlayer can be tailored to be very close to those of the base materials.

The ARCJoinT technology is robust and affordable because no machining is needed for the mating surfaces. It provides a low-cost manufacturing approach and is practical, reliable and affordable. A wide variety of silicon carbide-based ceramics and fiber reinforced ceramic matrix composite components have been joined using this method. A patent on the technology is in process.

Enterprise Development, Inc. is a not-for-profit subsidiary of Case Western Reserve University and a cooperative venture with the Weatherhead School of Management. EDI manages three business incubators: the Edison Technology Incubator; the Lewis Incubator for Technology, including its software, electronics and communications site at GRC; and BioEnterprise.

EDI RECOGNIZES INDIVIDUALS WHO DEVELOP PRACTICAL AND CREATIVE IDEAS THAT ALLOW AN ORGANIZATION TO CARRY OUT ITS MISSION WITH AN INNOVATIVE PRODUCT, A CREATIVE CONCEPT OR A NEW PROCEDURE IMPROVING PRODUCTIVITY.

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

Commercial Agreement to Explore New Frontier

TECHNOLOGY ORIGINALLY DEVELOPED TO study the effects of microgravity on cell tissue holds renewed promise for improving life on Earth following the announcement of an unprecedented private sector investment in the technology by Fisk Ventures, Inc. of Wisconsin. StelSys. LLC, a Baltimore-based joint venture between Fisk Ventures and In Vitro Technologies, Inc., will be working on the development and commercialization of real-world applications of the Bioreactor technology. The announcement was made during a Washington, DC ceremony in mid-September by NASA Administrator Daniel S. Goldin.

A rotating cell culture apparatus—known as the Bioreactor—is the centerpiece of a groundbreaking agreement with the private sector to explore a new frontier in biotechnology, focusing on infectious disease research and developing a liver-assist device for patients in need of transplant surgery. Developed by NASA Johnson Space Center (JSC) researchers, the Bioreactor makes it possible to grow three-dimensional tissue cultures and cells that permit researchers to study their structure and develop new ways to treat disease.

"This is a great deal for the American people," Goldin said. "It's a symbol of the success that can be achieved when government, private industry and academia work together on the exploration of new frontiers for scientific, technological and economic growth."

JSC researchers invented the rotating Bioreactor as a way to study the impact of microgravity on cellular growth on Earth and in space. Typically, cells grown in petri dishes on Earth are flat and form two-dimensional sheets. The rotating bioreactor allows cells to arrange themselves and grow into three-dimensional segments of functional tissue—more like living cells. These cells can then be used by researchers to test new medical treatments without the risk of harming their patients.

During several Space Shuttle flights, the Bioreactor successfully demonstrated its ability to grow three-dimensional human cells. The promise of the Bioreactor's capabilities was dramatically illustrated when it was carried on board Russia's Mir Space Station as part of the sixth joint Shuttle/Mir flight from September 1997 to January 1998.

For more information, please contact Dr. Neal R. Pellis, lead scientist of the Biological Systems Office at Johnson Space Center 281-483-2357 *npellis@ems.jsc.nasa.gov* Please mention you read about it in *Innovation.*

Software System Manages Computer Workload

MOST COMPANIES FACE A SIMILAR COMPUTER-related problem. Hundreds of users and thousands of jobs require computation. The companies own vast amounts of computing power in heterogeneous and distributed environments. While demand on some systems exceeds supply, other resources are underutilized. Management finds that establishing enterprise-wide priorities are impossible to dictate and little data can be gathered on actual system usage.

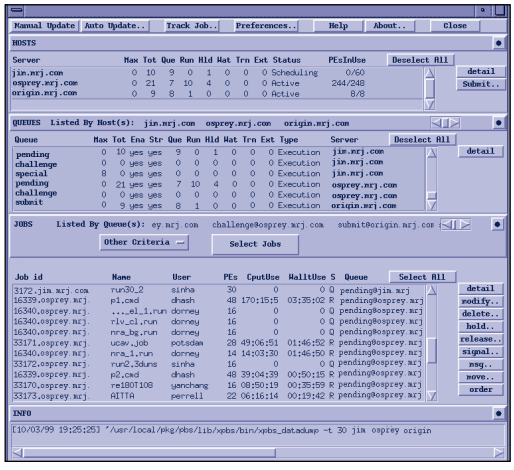
The solution, developed at NASA Ames Research Center at Moffett Field, California, is the Portable Batch System (PBS). PBS is a flexible workload management system that operates on networked, multi-platform UNIX environments, including heterogeneous clusters of workstations, supercomputers and massively parallel systems. PBS provides users with a single coherent interface to all of their computing resources. Users package their work into "containers" while management is able to set enterprise-wide scheduling and use policies. PBS maximizes efficient use of these resources while enforcing policy and provides detailed usage data.

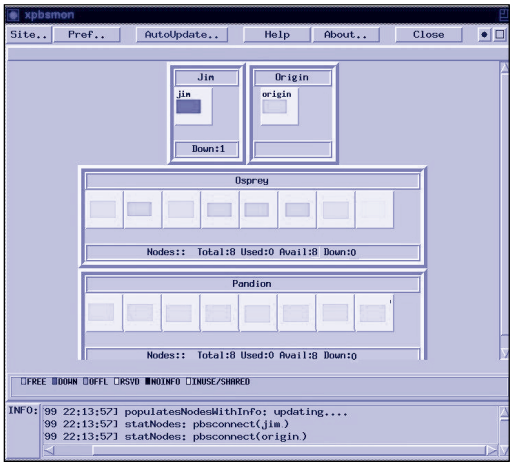
PBS PROVIDES USERS WITH A SINGLE COHERENT INTERFACE TO ALL OF THEIR COMPUTING RESOURCES. USERS PACKAGE THEIR WORK INTO "CONTAINERS" WHILE MANAGEMENT IS ABLE TO SET ENTERPRISE-WIDE SCHEDULING AND USE POLICIES.

Veridian-MRJ, then MRJ Technology Solutions, developed PBS for the Numerical Aerospace Simulation (NAS) Facility of NASA Ames from 1993 to 1997 to replace NASA's existing batch queuing system. In late-1997, Veridian-MRJ began full PBS development, support and distribution. More recently, PBS became an enabling technology of NASA's Information Power Grid (IPG).

In the four years that NASA was developing PBS, it was distributed to approximately 70 sites around the country. Since 1998, Veridian-MRJ has distributed PBS to more than 2,200 sites around the world. Of these, approximately 820 are actively using PBS. Veridian-MRJ achieved this by creating a Web site dedicated to PBS support and distribution.

The business model was to distribute PBS free and sell support services, including training, support contracts and software customizations. Sites around the world registered at the PBS Web site and, once authorized, freely downloaded PBS software source code.





Veridian-MRJ's Portable Batch System solves a problem faced by most companies – too much need for some computers, too little need for others. The system allows management to set enterprise-wide computer scheduling and use policies.

In addition, the Web site hosted an E-mail discussion list for the PBS user community, a frequently asked questions (FAQ) page, a change-request and problem-reporting interface, and both PBS administrator and support documentation.

The largest area of market growth for PBS has been from the Linux cluster community, rising from 10 percent of the overall customer base one year ago to more than 60 percent today. PBS is now recognized in the cluster community as the standard batch queuing system for Linux clusters.

In early 2000, the Veridian Corporation announced that it was moving all PBS activities from Veridian-MRJ into the commercial products company Veridian Systems. Veridian Systems committed funding to fully commercialize PBS, created the PBS Products Department, and doubled the staff to work commercialization. The first fruits of this effort are expected to be announced soon. In addition to the free version of PBS (OpenPBS™), Veridian will offer a binary "shrink-wrapped" version of PBS called PBS Pro™.

By proceeding with full commercialization of PBS, Veridian is completing the process of transforming NASA-funded software into a viable commercial product.

Veridian, a privately-held information technology company with 1999 annual revenues of $613 million, operates at more than 50 locations in the U.S. and overseas, and employs almost 5,000 people. The company is known for building strong, long-term relationships with a highly sophisticated customer base.

For more information about PBS, visit *www.pbspro.com* or contact James Patton Jones at 650/967-4675 *sales@pbspro.com* Please mention you read about it *in Innovation.*

NASA TELEMEDICINE TECHNOLOGY GATEWAY HONORED

A Web page that showcases telemedicine technologies developed for NASA has been honored by *Links2Go.com* as a "Key Resource" in the field of telemedicine—the use of electronic information and communications technologies to provide and support health care when distance separates the participants.

NASA's Telemedicine Technology Gateway (*www.nttc.edu/telemed.html*) is designed and maintained by the Robert C. Byrd National Technology Transfer Center at Wheeling Jesuit University. The site provides U.S. industry with access to NASA-developed telemedicine technologies that are ready for commercialization. NTTC's Market and Technology Assessment unit maintains the contents of the Web page, while the page itself was designed and is maintained by its Computer Information Services unit.

"The page is very focused, very specific, targeting telemedicine technologies from NASA," said Dr. Shaik Mazharullah, NTTC technology agent. "It is a one-stop shop for NASA telemedicine technologies and a central place for U.S. industry to find the technologies they are looking for."

"The page benefits NASA because it provides outreach to a targeted market. It benefits industry because it provides access to specific NASA technologies," Mazharullah said, adding that the site is both "unique and content-rich."

Each quarter, *Links2Go.com*, a Web site that provides online businesses and end-users with search and directory services, samples millions of Web pages. The most popular pages are downloaded and automatically categorized by topic. At most, 50 of the pages related to a particular topic are honored as a "Key Resource." Out of 50 pages selected as "Key Resources" in Telemedicine, the Telemedicine Technology Gateway was ranked ninth.

Earlier this year, Knowledge Systems International, Inc. (KSI) of Teaneck, New Jersey, signed a Memorandum of Agreement (MOA) with the Medical Informatics and Technology Applications Consortium (MedITAC), located at the Virginia Commonwealth University Medical College. KSI will work with MedITAC to develop an Internet telemedicine technology, a network that will essentially "bring the clinic to the patient" by allowing physicians to share complex patient data for remote consultation, diagnosis, treatment planning and simulation.

KSI learned of the technology, originally developed at NASA's Ames Research Center, through NTTC's NASA Telemedicine Technology Gateway.

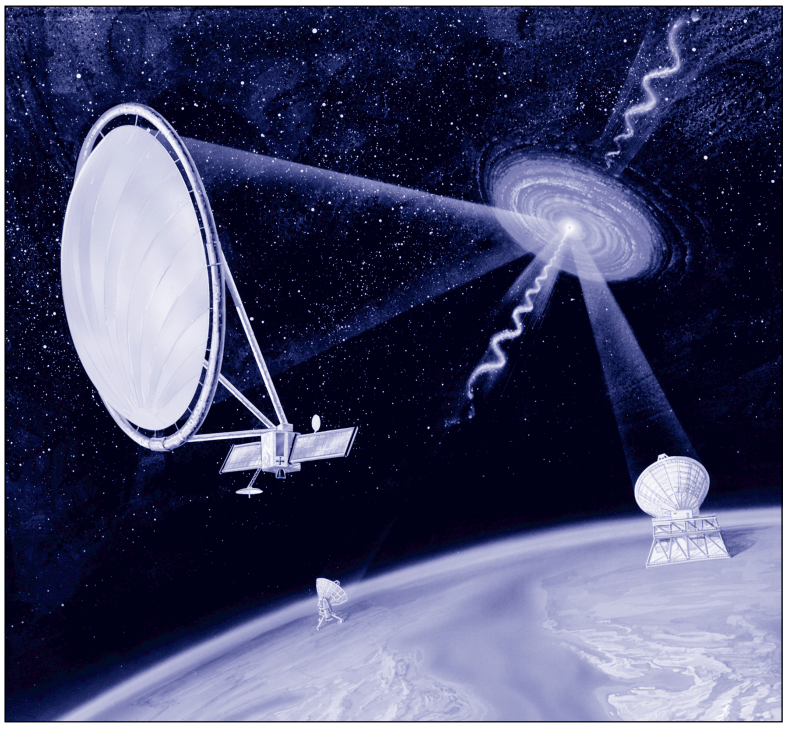
For more information about the NTTC's NASA Telemedicine Technology Gateway, visit *www.nttc.edu/telemed.html.* For more information about the NTTC, contact Dr. Shaik Mazharullah, NTTC technology agent at 304/243-2127 *smazharullah@nttc.edu.* Please mention you read about it in *Innovation.*

Space Inflatables on the Rise

LARGE TELESCOPES AND STRUCTURES 10 times the size of the Rose Bowl in Pasadena, California, that can be compacted and deployed in a single small launch vehicle and then inflated once they are in orbit, are a major part of the future of Earth and space exploration.

As part of the Gossamer Spacecraft Initiative, which is chartered with developing technology for large telescopes and space solar sails, scientists and engineers at NASA Jet Propulsion Laboratory (JPL) in Pasadena, California, are identifying and exploring new ways to put large structures in space.

The result is breakthroughs in ultra-light, inflatable materials that will substantially reduce mission costs and enable large, ultra-light objects to observe the Earth. These breakthroughs will aid NASA researchers in their quest to explore the farthest reaches of the universe.



The ARISE poster illustrates the research that will be possible when large, inflatable space antennas are launched into space. (Poster provided by NASA Jet Propulsion Laboratory.)

"Without new technology and new materials, we can't go forward. We need new materials, designs and solutions," said Artur Chmielewski, manager of JPL Space Inflatables Technology. "We need very light, powerful telescopes that can peer deep into the cosmos and look for Earth-like planets around other stars."

An important step in the technology development process is space testing of prototype inflatable systems. A past test program of inflatable technology, the Inflatable Antenna Experiment, deployed by the Space Shuttle *Endeavour* in 1996, provided significant data on the performance of inflatable systems. The 14-meter inflatable antenna was deployed and inflated for several hours in space. This successful demonstration of a tennis court-size inflatable structure in space has generated a lot of interest in the use of this promising new technology. Now, scientists are planning on-orbit tests to develop the technology further.

One of the first space applications of gossamer technology will be the Advanced Radio Interferometry between Space and Earth (ARISE) mission, which will use a high-resolution imaging technique called the space-based Very Long Baseline Interferometry (VLBI). An orbiting 25-meter (82-foot) inflatable radio telescope will be used in conjunction with ground telescopes to take pictures of space phenomena, such as neighborhoods around black holes, with a resolution 3,000 times better than that offered by the Hubble Space Telescope.

Innovators such as JPL's Dr. Mark Dragovan say that inflatable technology is the wave of the future. "Lightweight, flexible, inflatable materials will someday replace traditional steel and glass materials on space antennas and telescopes to the point that the whole telescope will consist of a reflector and detector as thin as plastic kitchen wrap," he said. "The challenge for NASA is to launch structures that are one hundred times lower density than the Hubble Space Telescope. If the telescope is extremely low-mass, then one can make it very large and inexpensive in our quest to put big eyes in the sky."

Inflatables have a major advantage over mechanical structures because even in the most modern telescopes, hundreds of pounds of steel and glass support a very thin reflecting surface that does all the work in collecting light from the cosmos. The alternative to these massive structures is inflatables, which are often 10 times less expensive, can be tightly packed

into small canisters, and are lower mass, allowing launches on smaller, cheaper rockets.

The space applications for antennas many times the size of today's mechanical orbiting antennas include satellites for deep space and mobile communications, Earth observations, astronomical observations, and space-based radar. Solar-powered sails thinner than human hair for propelling spacecraft to the stars, sunshades the size of a soccer field for space telescopes, inflatable habitats for the moon or Mars, and 24-meter antennas that can be held by one hand are all possible, according to scientists at JPL.

Future work on inflatables will concentrate on the areas of materials research, development of optical-quality telescopes, and huge solar sail structures.

The Gossamer Spacecraft Initiative is managed jointly by JPL and NASA Langley Research Center in Hampton, Virginia. NASA's Office of Space Science in Washington, DC, has overall program management responsibility.

For more information, contact Artur B. Chmielewski, manager of Jet Propulsion Laboratory Space Inflatables Technology 818/354-0255 *abc@jpl.nasa.gov* Please mention you read about it in *Innovation*.

Communications Satellite Serves Space Projects

NASA HAS LAUNCHED THE FIRST OF THREE OF the most advanced communications satellites ever designed to replenish the existing on-orbit fleet that has served the space community since 1983. The newest generation Tracking and Data Relay Satellites (TDRS) will provide vital communication links with the Space Shuttle, International Space Station, Hubble Space Telescope and other spacecraft and launch vehicles.

"The average age of the existing fleet is more than 10 years, which is beyond the mission design lifetime," said Anthony Comberiate, TDRS project manager at NASA Goddard Space Flight Center in Greenbelt, Maryland. "The new series will replenish our existing fleet and allow users to migrate to the new Ka-band," which will allow a threefold increase in data throughput.

The TDRS-H was launched June 30, 2000, aboard a Lockheed Martin Atlas IIA rocket from Cape Canaveral Air Force Station in Florida. The White Sands, New Mexico, ground terminal is the TDRS operational control center, which also provides customer telecommunications services. NASA plans to launch TDRS-I and TDRS-J in 2002 and 2003, respectively.

TDRS-H, with two additional satellites, will serve to replenish the existing on-orbit fleet of communications satellites. The three satellites are the most advanced communications satellites ever developed.

The TDRS-H spacecraft, having reached its geosynchronous on-orbit testing location of 150° West longitude, has assumed the operational name of TDRS-8. Maintaining its fixed position 22,300 miles above the Earth, TDRS-8 will provide nearly continuous communication links with controllers and researchers on the ground. After testing and acceptance of the spacecraft, TDRS-8 will be moved to its operational location of 171° West longitude. TDRS-8, when placed into operation, will relay enormous volumes of user data—voice, television and science—from various orbiting scientific and manned missions to ground control centers. The spacecraft also will track user satellites, determining their exact location in space.

TDRS-8 features the following new and improved services:

- S-band Single Access: Two 15-foot diameter steerable antennas used at the 2.0 to 2.3 GHz (gigahertz) band will supply robust communications to user satellites with smaller antennas and receive telemetry and range-safety data from expendable rockets during launch.
- Ku-band Single Access: The same two large antennas, operating at 13.7 to 15.0 GHz, will provide high data-rate support to the International Space Station with high-resolution digital television, and will dump large volumes of data at rates up to 300 Mbps (megabits per second). This rate is more than 5,000 times faster than the standard 56K (56 kilobytes per second) home-computer modem.
- Ka-band Single Access: A new higher-frequency (22.5 to 27.5 GHz) service that increases data rate capabilities to 800 Mbps will provide communications with missions like the International Space Station and future multi-spectral instruments for Earth science applications.
- Multiple Access: Using a phased array antenna and operating in the 2.0 to 2.3 GHz range, the system

receives and relays data simultaneously from five lower data-rate users and transmits commands to a single user.

Hughes Space and Communications of El Segundo, California, designed, built and tested the spacecraft under a fixed-price agreement with NASA. By specifying performance requirements, the new approach allowed the contractor to custom-design a spacecraft that met NASA's needs. Because it was allowed more latitude to use commercial practices, Hughes was able to reduce the costs associated with such a venture.

The Space Network Project at Goddard will manage TDRS-8 operations through NASA's Consolidated Space Operations contract.

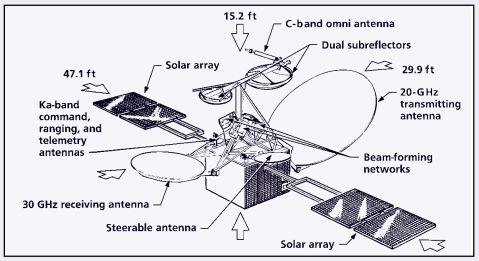
More information about the TDRS-H, -I and -J spacecraft can be found at *http://tdrs.gsfc.nasa.gov/tdrsproject/* or contact Marco Toral 301/286-9861 *Marco.A.Toral.1@gsfc.nasa.gov*

For more information about how to become a space network user, refer to *http://nmsp.gsfc.nasa.gov/tdrss* or contact Jon Walker 301/286-7795 *Jon.Z.Walker.1@gsfc.nasa.gov* Please mention you read about it in *Innovation*.

ACTS EXPERIMENTS COME TO AN END

After 81 months of operations, far exceeding its planned 24-month mission, NASA's Advanced Communications Technology Satellite (ACTS) concluded its extensive experiments program at the end of May 2000.

Launched in September 1993 as a partnership among NASA, industry and academia, ACTS opened the door for U.S. satellite communications technology in demonstrating the use of the high frequency Ka-band (30/20 GHz). Until ACTS, this frequency was virtually unused—the majority of communication satellites used lower frequency bands called C- and Ku-bands. Exploring Ka-band technology was designed to relieve orbital crowding and demonstrate the first band of frequency wide enough to carry simultaneous services ranging from multiple voice, video and data communications to computer connections at optical fiber data rates.



ACTS opened the door for U.S. satellite communications technology in demonstrating the use of high-frequency Ka-band. Exploring Ka-band technology was designed to ease orbital overcrowding. (Illustration provided by NASA Glenn Research Center.)

"The ACTS Experiments Program has been an outstanding research and development achievement that resulted in a unique operational capability for the center and the agency," said Donald J. Campbell, NASA Glenn Research Center director. "It was a bold step to put a new communication satellite into operation with minimal support, and based on program results, it was the right decision because it laid the foundation for advancements in communication satellites."

Throughout its lifetime, ACTS, which was managed by the NASA Glenn Research Center in Cleveland, Ohio, opened new frontiers by utilizing a unique hopping spot beam antenna system that generated 51 tightly focused signal beams. Each spot beam typically had a diameter of 150-200 miles and was able to "hop" from one location to the next, covering up to 40 locations in a millisecond. Concentrating satellite power in such a way permitted significantly smaller and less expensive Earth stations. In addition, the spot beam was better able to penetrate through rain and mitigate rain fade.

"The ACTS Experiments Program had the foresight to step beyond the conventional thinking and prove the technology needed for the future, as well as the present," said Joseph H. Rothenberg, NASA associate administrator for space flight.

The ACTS Experiments Program has achieved remarkable milestones with 103 experiments and numerous demonstrations involving more than 200 diverse partners, paving the way for the next generation of communications satellites. The experiments program succeeded in areas as diverse as advanced networking, medicine, education, defense, emergency response, maritime and aeronautical mobile communications, science and astronomy.

ACTS set the standard for next generation communications satellites. Its pioneering advanced technologies for space communications have shown the feasibility of the next generation communication satellites to meet ever-growing communications needs.

Its successes have been recognized through numerous awards, including induction into the U.S. Space Foundation's Space Technology Hall of Fame in 1997, an R&D 100 Award in Significant Technology in 1995 and the prestigious Federal Technology Leadership Award in 1995.

For more information on the ACTS Program, please visit: *http://acts.grc.nasa.gov,* or contact Robert Bauer, NASA Glenn Research Center 216/433-3431 *Robert.A.Bauer@lerc.nasa.gov* Please mention you read about it in *Innovation*.

NASA Scientists on "SAFARI"

AFRICAN SMOG AND ITS ROLE IN GLOBAL change are under study by NASA and international scientists who are now tracking the movement of air pollution in the southern part of the African continent.

The southern African atmosphere is particularly vulnerable to air pollution due to a persistent high-pressure system there. African smog is a "soup" of smokes from industry, mining, agricultural burning and other sources.

According to Philip Russell, who works at the Atmospheric Chemistry and Dynamics Branch, part of NASA Ames Research Center at Moffett Field, California, satellite measurements of airborne particles, including smoke and haze, as well as water vapor and ozone, were taken. Plans call for the results to be used for improving the measurement accuracy. "We want to better understand the effects that smoke, haze and trace gases have on the African and global climate. We also want to help improve remote measurements of the Earth's surface, for example, measurements of vegetation and ocean color," said Russell.

NASA researchers were among more than 100 scientists who conducted extensive and varied field studies as part of the Southern African Regional Science Initiative (SAFARI 2000) that has been underway for more than a year. Flights and science activities were based in Pietersburg, Republic of South Africa.

Russell's team measured and analyzed sunlight with an airborne sunphotometer carried on the University of Washington CV-580 aircraft. The sunphotometer measures the amount of sunlight that penetrates smoke and other aerosols in the atmosphere at different wavelengths, including ultraviolet, visible and infrared light.

Russell's researchers matched airplane flights with satellite overpasses, and sampled smokes from burning vegetation as well as industrial emissions. Other investigators on the CV-580 aircraft and on the ground simultaneously measured a variety of aerosol properties during data consistency tests.

In addition to Russell, Ames scientists on his team included Beat Schmid and Jens Redemann. A second Ames team, led by Peter Pilewskie, conducted other African field studies. His "radiation group" flew a solar spectral flux radiometer instrument on a NASA ER-2 airplane and on the University of Washington's CV-580 aircraft. Scientists used data from the instrument to find out how much solar energy is absorbed by particles of smoke and dust and other aerosols, and how much energy clouds reflect. In addition, the researchers tested the ability of satellites to make the same measurements from space.

Participants prepare a radiometer array in support of SAFARI 2000 studies of solar radiation and climate. (NASA photo.)

The NASA Ames studies were part of the larger SAFARI effort. It included analysis of terrestrial ecology and land processes, land cover and land use change, atmospheric aerosols and trace gases, clouds and radiation, hydrology and computer modeling. Researchers are studying these elements by using ground and airborne measurements complemented by remote sensing observations from older satellites, in addition to a new generation of Earth observation satellites. They include sensors on NASA's Terra, Landsat 7 and SEAWIFS satellites as well as the European ENVISAT and POLDER II spacecraft.

The study region for SAFARI 2000 includes Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. Scientists from the United States, Canada, the United Kingdom and Germany collaborated to conduct the science initiative. NASA's Earth Observing System project was the primary sponsor of U.S. participation in SAFARI 2000.

More SAFARI 2000 information, including listings of additional experiments and organizations, is on the Internet at: *http://safari.gecp.virginia.edu* and *http://eos.nasa.gov*

For more information, contact Philip Russell at NASA Ames Research Center 650/604-5405 *prussell@mail.arc.nasa.gov* Please mention you read about it in *Innovation*.

NASA Technology May Ease Flight Delays

STATISTICS SHOW FLIGHT DELAYS ARE AT AN all-time high, with air passenger frustrations running even higher. New technology developed by NASA Langley Research Center (LRC) in Hampton, Virginia, may help ease some of those frustrations, allowing travelers to reach their destinations faster.

NASA researchers have designed a system to predict aircraft wake turbulence on final approach, so airliners can be spaced more safely and efficiently. The technology is called AVOSS or Aircraft Vortex Spacing System.

"All aircraft produce wake vortices, sort of like two small horizontal tornadoes trailing behind the wing tips," says AVOSS principal investigator David Hinton of LRC. "The larger and heavier the plane, the stronger the wake." That means small aircraft that follow larger ones can encounter turbulence if they're not kept far enough apart. That turbulence can be severe enough to cause a plane to crash.

AVOSS determines how winds and other atmospheric conditions affect the wake vortex patterns of different types of aircraft. The system uses a type of laser radar, or lidar technology, to confirm the accuracy of those forecasts. All of this information is processed by computers, which can then provide safe spacing criteria.

Weather plays a big part in the motion and decay rate of these trailing twisters. Until now, there has been no system to accurately predict wake vortex patterns and quantify the spacing needed for safety. This type of data is not currently available to air traffic controllers, forcing use of rigidly fixed distances to separate distinct classes of aircraft during bad weather and causing unnecessary air traffic delays that disrupt flight schedules and increase costs.

NASA's Aircraft Vortex Spacing System can provide the needed information. The system was installed at the Dallas-Fort Worth (DFW) International Airport in Texas three years ago and has undergone continued development and testing. Initial test results show that AVOSS can increase individual runway capacity as much as 15 percent, depending on weather conditions and the number of "heavy" aircraft arriving. Benefit studies estimate the dollar savings to airlines and passengers of this capacity gain to range from $20 million to more than $100 million per year by 2015. During the demonstration, AVOSS was not used to change the actual spacing of arriving aircraft. Wake detection lidars were used to validate system operation.

"WITH A SYSTEM LIKE AVOSS INSTALLED AT DFW AIRPORT, WE WOULD HAVE THE CAPABILITY TO INCREASE RUNWAY SAFETY, WHILE IMPROVING RUNWAY CAPACITY BY AS MUCH AS 15 PERCENT," SAID EXECUTIVE DIRECTOR JEFF FEGAN OF DALLAS-FORT WORTH INTERNATIONAL AIRPORT.

NASA demonstrated the prototype wake vortex spacing system in Dallas in July to news media, Federal Aviation Administration (FAA) officials and other government and industry representatives from the U.S., Canada, Germany, the Netherlands, the United Kingdom and Hungary.

"With a system like AVOSS installed at DFW Airport, we would have the capability to increase runway safety, while improving runway capacity by as much as 15 percent," said Executive Director Jeff Fegan of Dallas-Fort Worth International Airport. "DFW operations average nearly 2,300 flights per day. Increasing the amount of planes that can land every hour means fewer delays for our passengers."

NASA worked with the FAA; DFW International Airport; Massachusetts Institute of Technology's Lincoln Laboratory, Lexington; Transport Canada; Volpe National Transportation Center, Cambridge, Massachusetts; and others to develop the Aircraft Vortex Spacing System.

AVOSS is a part of the NASA Aviation Systems Capacity Program, headquartered at NASA Ames Research Center, Moffett Field, California.

For more information, contact David Hinton at NASA Langley Research Center 757/864-2040 *d.a.hinton@express.larc.nasa.gov* Please mention you read about it in *Innovation*.

Flight Research Contract Awarded

A CONTRACT FOR DEVELOPING AND BUILDING a test version of a Pulse Detonation Engine (PDE) has been awarded to McDonnell Douglas Corporation of St. Louis, Missouri, a wholly owned subsidiary of The Boeing Company. The PDE flight research project will combine the efforts of McDonnell Douglas with those of NASA Glenn Research Center in Cleveland, Ohio and NASA Dryden Flight Research Center in Edwards, California.

McDonnell Douglas Corporation will provide the engine to validate PDE inlet and integrated system performance. Ground tests of the integrated PDE system will be conducted at Glenn. Flight tests will be conducted at Dryden.

The performance-based contract provides for a base period of 27 months. Optional tasks extend the potential full contract life to approximately 36 months.

NASA engineers want to raise the technology readiness level of this air-breathing engine concept that relies on pulses of power rather than a streaming burn of fuel. These pulses collectively produce more thrust than a steady burn. The resulting application might be a high-Mach missile, or eventually on a larger scale, a tactical aircraft engine.

One study suggests a pulse detonation engine could yield a 30 to 50 percent improvement in fuel consumption over a conventional jet engine. Another promising aspect of PDE technology is its efficiency, which remains high above Mach 3, where conventional jet engines play out. Proponents of pulse detonation suggest it could even have higher efficiency than ramjets and scramjets. Dryden plans to mount a test PDE on a pylon beneath an F-15 to test its performance.

The PDE flight research project is funded through the Revolutionary Concepts in Aeronautics (RevCon) project of the NASA Flight Research Base Research & Technology program led by Dryden.

For more information, contact Barbara Kakiris at NASA Glenn Research Center 216/433-2513 *barbara.l.kakiris@grc.nasa.gov* Please mention you read about it in *Innovation*.

X-34 Begins New Test Series

A NEW PHASE OF TESTS TO PREPARE NASA'S X-34 experimental rocket plane for flight got underway last month at Dryden Flight Research Center, Edwards Air Force Base, California. The tests involve towing the X-34 technology demonstrator behind a truck and releasing it to coast on the Edwards dry lakebed. Orbital Sciences Corporation of Dulles, Virginia, is developing the X-34 technology demonstrator for NASA Marshall Space Flight Center.

"The tests, which simulate the vehicle's roll-out after landing, will verify the craft's guidance and navigation system, nose wheel steering, braking, rudder speed brake operation and rudder steering," said Jeff Sexton. Sexton is flight testing and operations project manager for the Pathfinder Program—which includes the X-34. "If we have any vehicle anomalies, we want to find them in ground tests, not in flight or landing."

For these tests, the X-34 is attached to the tow truck by a specially designed 500-foot cable. A radio link is used to provide communications between the rocket plane and the tow truck launch panel operator.

"We're pleased to begin another series of testing for the X-34 that will bring us one step closer to flight," said Antonio Elias, senior vice president and general manager of Orbital's advanced programs group. "When completed, they will provide valuable data and help ensure the success of the flight program."

After completion of ground testing, the X-34 will be attached to Orbital's L1011 carrier aircraft, Stargazer, to finish captive-carry flights required by the FAA to verify that the combined aircraft are safe to fly. Plans are to follow the certification program with approach and landing flights of the X-34 at White Sands Missile Range, New Mexico.

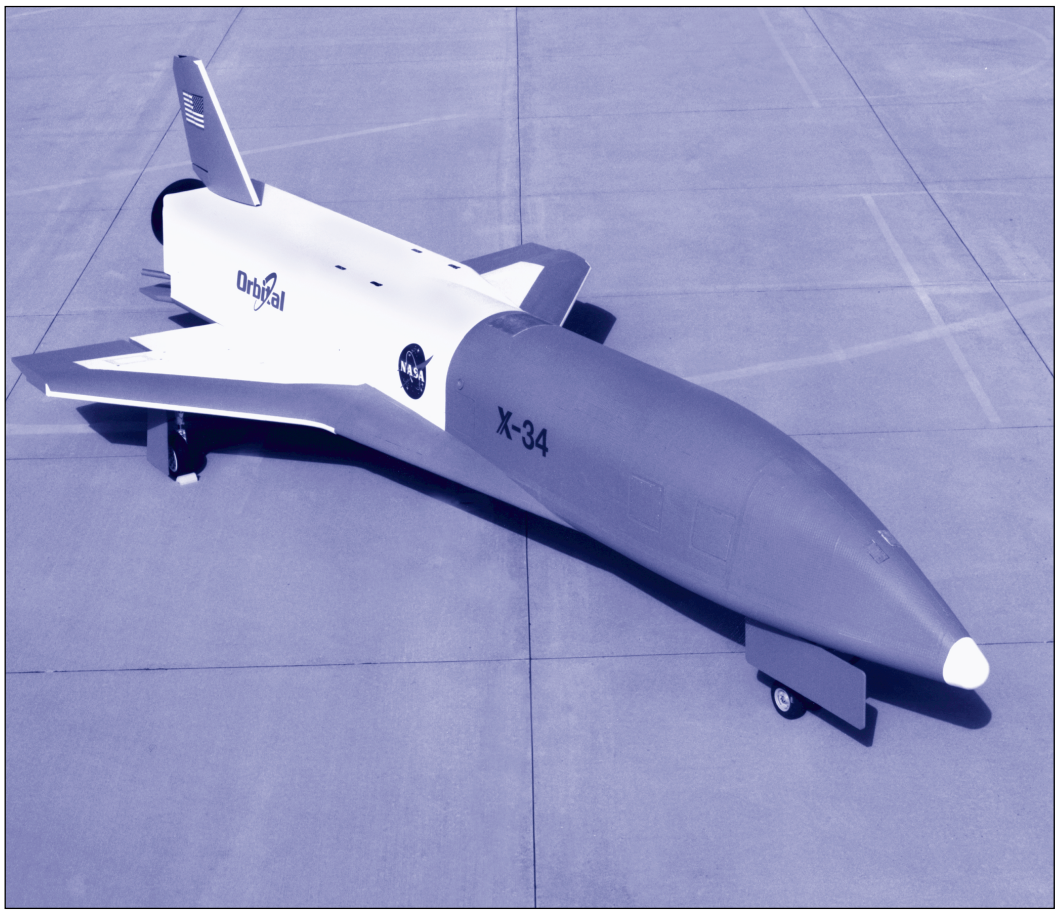
The X-34 is a flying laboratory for technologies, operations and experiments applicable to future low-cost, reusable launch vehicles. It is one of a family of technology demonstrators aimed at lowering launch costs from $10,000 to $1,000 a pound while dramatically increasing reliability. By

reducing the transportation cost, a commercial reusable launch vehicle would create new opportunities for scientific, commercial and educational endeavors while significantly improving U.S. competitiveness in the world launch market. NASA will be a customer—not an operator—for a commercial reusable launch vehicle.

"THE TESTS . . . WILL VERIFY THE CRAFT'S GUIDANCE AND NAVIGATION SYSTEM, NOSE WHEEL STEERING, BRAKING, RUDDER SPEED BRAKE OPERATION AND RUDDER STEERING," SAID JEFF SEXTON, FLIGHT TESTING AND OPERATIONS PROJECT MANAGER FOR THE PATHFINDER PROGRAM.

The suborbital X-34 is 58.3 feet (17.77 meters) long and 27.7 feet (8.44) meters wide. It is capable of flying up to eight times the speed of sound and reaching altitudes of approximately 50 miles.

For more information, contact Mark Fisher at NASA Marshall Space Flight Center 256/544-9503 *Mark.F.Fisher@msfc.nasa.gov* Please mention you read about it in *Innovation*.



The X-34 technology testbed demonstrator is undergoing tests at Dryden Flight Research Center. The X-34 is a flying laboratory for technologies, operations and experiments applicable to future low-cost, reusable launch vehicles. (Photo courtesy of Dryden Flight Research Center.)

DESIGN COMPETITION WINNERS ANNOUNCED

In an idea reminiscent of something in "George Jetson's"® fleet, a student team has designed an airplane that can double as a car, to offer true door-to-door service.

NASA and the Federal Aviation Administration (FAA) recently recognized this and other university student teams for their innovative designs by presenting the 1999-2000 National General Aviation Design Competition awards at a ceremony at AirVenture 2000, the Experimental Aircraft Association's Annual Convention and Fly-In in Oshkosh, Wisconsin.

The first place award was presented to a 28-student team from Virginia Tech in Blacksburg, and its collaborating partner, Loughborough University of Leicestershire, United Kingdom.

The team, which dubbed its design "Pegasus," undertook the challenge of designing an aircraft that would be "roadable"—capable of both ground and air travel. The ability to switch from aircraft to car-like operation allows such a vehicle to effectively utilize small airports. The team recognized that the cost to actually produce such an aircraft would exceed today's typical general aviation aircraft cost; however, the students believed the additional cost should readily be offset by the added convenience of built-in ground transportation.

Students from Virginia Tech, collaborating with Loughborough University, took first place in the 1999-2000 National General Aviation Design Competition with 'Pegasus', an aircraft capable of both air and ground travel. (Photo provided by NASA Langley Research Center.)

Second place honors went to a seven-student team from Purdue University of West Lafayette, Indiana, for the "Silairus 490," a six-passenger, high-performance piston engine aircraft with an Air Cushion Landing System (ACLS) in lieu of traditional landing gear. The design offers the capability of surface-independent takeoff and landing, permitting the vehicle to access off-airways communities, thus shortening door-to-door travel time. The Silairus 490 features a high-tech, electronically data-linked cockpit with a comfortable cabin adaptable for many client applications.

The Purdue team also won the Best Use of Air Force-Developed Technology award for its incorporation of the ACLS, developed by the United States Air Force.

Third place was awarded to a team from Pennsylvania State University at University Park. The team's design, called "Alnighter," is a modern, composite general aviation aircraft. The six-seat, single-engine, propeller-driven vehicle has a conventional layout. It features sophisticated aerodynamics and advanced systems and avionics. Penn State has the distinction of having placed in each year of the competition.

The Best Retrofit Design Award was presented to a four-student, University of Oklahoma at Norman team for development of an innovative, multi-mode tuned-exhaust system that offers noise reduction while improving the airplane's performance. The design was undertaken as a part of a larger aircraft design project to show how an older aircraft can be retrofitted with more modern technologies for increased performance and safety.

Now in its sixth year, the competition calls for individuals or teams of undergraduate and graduate students from U.S. engineering schools to participate in a major national effort to rebuild the U.S. general aviation sector. For the purpose of the contest, general aviation aircraft are defined as single or twin engine (turbine or piston), single-pilot, fixed-wing aircraft for two to six passengers. The competition seeks to raise student awareness of the importance of general aviation by having the students address design challenges for a small aircraft transportation system. NASA and the FAA hope to stimulate breakthroughs in technology and their application in the general aviation marketplace.

The competition is managed for NASA and the FAA by the Virginia Space Grant Consortium.

For more information, contact Mary Sandy at the Virginia Space Grant Consortium 757/865-0726. Please mention you read about it in *Innovation*.

Company Delivers Rockets and SBIR Success

SPACE ROCKETS MADE OF RHENIUM PROMISE to last longer, and may have greater payload capacity to orbit due to increased efficiency. Rhenium, though, is one of Earth's rarest metals. It is also hard to obtain, hard to work and hard to form.

But Rhenium Alloys, Inc., of Elyria, Ohio, has delivered two small chemical rocket thrusters made of rhenium to NASA Glenn Research Center in Cleveland, Ohio. The delivery completes the second and final phase of the company's SBIR contract with Glenn and sets the stage for further improvements in the life and capabilities of rockets for both commercial satellites and NASA space exploration missions.

Rhenium Alloys, Inc. delivered a small satellite thruster made of rhenium to NASA Glenn Research Center. The thruster was designed by Primex Space Systems. (Photo provided by NASA Glenn Research Center.)

The thrusters are the product of new manufacturing processes that reduce both manufacturing time and cost, while improving product quality. Room temperature isostatic pressing (applying pressure evenly to all sides of the item) was used to compact rhenium powder into the near final shape and dimensions of the thruster. Containerless hot isostatic pressing was used to consolidate the powder until its molecules aligned into the strongly bonded crystalline structure of conventionally cast metals.

"We would never have been able to develop these processes without the financial and technical support of the SBIR contracts," said Todd Leonhardt, chief metallurgist at Rhenium Alloys, Inc. "The advice and encouragement we received from Glenn researchers was also invaluable."

During the late 1980s, Glenn researchers began looking for ways to reduce the costs of deep space missions by making rockets last longer and use less fuel. Rhenium, with its very high melting point of 3180° Celsius and durability after repeated temperature swings, seemed to fit. A rocket made of rhenium could be cooled simply by radiating its heat into space instead of being cooled by a fuel film layer against the thruster walls, a major source of combustion inefficiency.

The problem was not just with rhenium's scarcity and high cost, but also with the high cost and difficulty of making it into useable parts. Glenn researchers found several less costly forming methods, but believed the manufacturing community was best suited to perfect those methods and put them into practice.

"Meeting NASA's future mission needs by putting together NASA researchers and small businesses inter-

ested in conducting research is our primary task," said Walter Kim, SBIR program manager. "In this case, we also contacted the two rocket manufacturers for help in evaluating both the manufacturing process and the thrusters."

The rocket manufacturers, TRW's Space and Technology Division of Redondo Beach, California, and Primex Space Systems (formerly Kaiser Marquardt) of Van Nuys, California, provided their designs for making the thrusters. After the finished thrusters are coated with an oxidation-resistant coating of iridium, TRW and Primex will test their respective thruster in their own facilities.

For more information, contact Jim Biaglow of the On-Board Propulsion Branch at NASA Glenn Research Center 216/977-7480 *James.A.Biaglow@lerc.nasa.gov* Please mention you read about it in *Innovation*.

NASA Spinoff Helps Citrus Production

A MASSACHUSETTS COMPANY IS MARKETING its patented Ethylene Monitoring and Control System, developed under a Phase II Small Business Innovation Research (SBIR) contract with NASA Kennedy Space Center (KSC).

GEO-CENTERS, Inc. principal scientist Bruce Nelson explained that the innovation, originally planned for use in the KSC biomedical office's Bioregenerative Life Support System (BLSS), provides the only fully automated, simple and rapid means for monitoring and controlling ethylene concentrations in citrus degreening, ripening and produce storage applications. Currently, GEO-CENTERS has generated more than $50,000 in cumulative sales revenues. Units have been sold to degreening facilities in the United States and Spain. Systems are presently being manufactured and sold through the company's distributor, Beshaco, Inc., of Vero Beach, Florida. Nelson said his company has invested more than $150,000 following the SBIR contract completion for product technology improvement and marketing.

The system operates as a stand-alone product and only requires a compressed air supply and a power source. Ethylene is used to degreen fruits, however, finding the proper balance in ethylene concentration

INNOVATIVE SMALL BUSINESS PROJECTS SELECTED

NASA has selected 19 research proposals for negotiation of Phase I contract awards for NASA's 2000 Small Business Technology Transfer (STTR) Program.

STTR goals are to stimulate technological innovation; increase the use of small business, including women-owned and disadvantaged firms, in meeting federal research and development needs; and increase private sector commercialization of results of federally funded research. The STTR program requires small business concerns to conduct cooperative research and development by partnering with a research institution. At least 40 percent of the work must be performed by the small business concern, and the research institute must perform at least 30 percent of the work.

The 2000 STTR solicitation closed on May 10, 2000. NASA received 96 proposals submitted by small, high technology businesses from across the United States. The combined award total for the 19 Phase I contracts is expected to be $1,896,165. Three of the winning proposals are from disadvantaged firms.

Five NASA field centers reviewed proposals for technical merit and feasibility and relevance to NASA research and technology requirements. The selected firms will be awarded fixed-price contracts valued up to $100,000 each to perform a one year Phase I feasibility study.

Companies that successfully complete the Phase I activities are eligible to compete for Phase II selection the following year. The Phase II award allows for a two-year, fixed-price contract in the amount up to $500,000.

The NASA STTR Program Management Office is located at NASA Goddard Space Flight Center in Greenbelt, Maryland, with executive oversight by NASA's Office of Aerospace, NASA Headquarters, Washington, DC. Individual STTR projects are managed by the NASA field centers.

A complete listing of companies selected for the program can be found at: *http://sbir.nasa.gov*

For more information, contact Paul Mexcur, SBIR/STTR program manager 301/286-8888 *wmexcur@pop700.gsfc.nasa.gov* Please mention you read about it in *Innovation*.

An ethylene monitor developed for Kennedy Space Center's Biogenerative Live Support System is being marketed as a device to assist in the degreening of citrus fruit.

is necessary to reduce fruit loss. Proper degreening requires exposing fruit to ethylene at five parts per million (ppm) for 72 to 96 hours. Studies have shown, Nelson said, that exposure to ethylene at 15 to 20 ppm can induce decay, causing peel breakdown, which results in fruit loss of 50 to 100 percent. GEO-CENTERS' ethylene monitor provides an unprecedented measurement range of 0 to 20 ppm and an accuracy of 0.5 ppm.

The monitoring system provides an easy-to-use, cost-effective tool that is capable of continuous monitoring at multiple points within a fruit storage area. Previous devices were either too expensive, difficult to use, too slow or did not provide continuous monitoring. GEO-CENTERS hopes to further enhance the sensitivity of the system to be used in the larger market of produce storage applications.

NASA funded the ethylene monitor research as part of the BLSS program. NASA's Dr. John Sager, Advanced Life Support (ALS) project manager, said the purpose of the SBIR project involves the monitoring of environments in "closed" plant growth chambers. As plants grow, they produce byproducts of ethylene and ammonia, both of which are harmful to plant development and create stress on the plants at certain concentration levels. A monitoring system is required to control the concentrations in order to optimize the plant growth and maintain the overall health of the plants. The results of the SBIR research concluded that while an ammonia monitor was feasible for NASA's applications, a vapor phase ethylene monitor would not meet the accuracy requirements necessary. However, the ethylene monitor developed was determined to have applications in the citrus processing market. Subsequent testing was then undertaken at the University of Florida's Citrus Research and Education Center at Lake Alfred.

The ethylene monitor and control system eliminate the requirements for manual sampling and analysis and the associated labor and material costs. The patented monitor tracks the chemiluminescent reaction of the ethylene with ozone and is the only continuous ethylene measurement technique with a proven capability in the range important to citrus degreening. The product is also currently the only commercially available system that continuously monitors and controls ethylene concentrations in citrus degreening rooms 24 hours a day. The economic impact to the packinghouse from fruit loss due to excess ethylene exposure may run from $15,000 to $100,000 per year per degreening room. This is the only system that can reliably and automatically monitor and control ethylene concentrations in the required range of 0 to 20 ppm.

For more information, contact Tom Gould at Kennedy Space Center 407/867-6238. Please mention you read about it in *Innovation*.

Contract Awarded to Build ISS Animal Habitats

THE SPACE STATION BIOLOGICAL RESEARCH Project (SSBRP) at the Ames Research Center recently awarded a contract to STAR Enterprises, Inc. of Bloomington, Indiana, to build the Advanced Animal Habitat-Centrifuge (AAH-C) for use in the International Space Station (ISS). This is the largest SBIR Phase III contract awarded by NASA.

STAR Enterprises will work in alliance with Space Hardware Optimization Technology (SHOT), Inc. of Greenville, Indiana. The five-year contract is to design and construct ten habitats for rats and mice that will be used for basic and biomedical research on the ISS. The AAH-C will allow scientists on Earth and astronauts in space to view the animals and monitor their physiology and behavior while the rodents live in space. The rodents will be exposed to microgravity

conditions or to different levels of artificial gravity created when the hardware is attached to the Space Station's centrifuge. In addition to acting as a scientific instrument, the habitat must include all the basic facilities to support the animals for up to 90 days aboard the ISS. These habitats can also be attached to an on-orbit glovebox, allowing astronauts to reach into the cages to retrieve animals and perform experiments. The habitats will be designed in consultation with veterinarians, scientists and engineers.

John Givens, the SSBRP former project manager, describes the project as "a leading edge development that must provide sophisticated systems to accommodate living specimens within very constrained resources (volume, mass, power and cooling). The SBIR approach provides an excellent, innovative environment for accomplishing these tasks with a level of cost efficiency and design flexibility that is difficult to match in large aerospace firms."

Astronauts who have been exposed to long periods of microgravity have experienced harmful physiological effects. To develop countermeasures, NASA must conduct studies to improve understanding of how bones and muscles change in space and after return to Earth, and how hormones and the immune system respond to long exposure to microgravity. Because of the similarity of animal and human physiological systems, the most effective way to obtain large amounts of data is by using animals.

NASA has previously been unable to study adaptation to life in space, because the length of Space Shuttle missions has limited the duration of exposure to less than three weeks of space flight. The ISS will provide opportunities for animal research for up to 90 days. Astronauts living on the Space Station will benefit from this research, as will future space travelers on long missions. Benefits to people on Earth are expected as well, because these studies often apply to problems of aging, osteoporosis, recovery from injury and various disease conditions.

Because of the shorter life spans of animals, many scientists also see animal research on the ISS as the site of important studies in developmental biology. The missions are long enough to provide insight into how growth and maturation might be influenced by weightlessness and other space flight factors such as radiation. It is expected that the ISS habitats will allow scientists to study the full life cycles of animals exposed to microgravity.

STAR Enterprises and Space Hardware Optimization Technology, Inc. are recent recipients of the TIBBETTS Award based on their work on this project. The TIBBETTS Award honors outstanding achievements in the SBIR program.

For more information, contact Paul Espinosa, Advanced Animal Habitat-Centrifuge project manager at NASA Ames Research Center 650/604-3150 *pespinosa@mail.arc.nasa.gov* Please mention you read about it in *Innovation*.

SOME NASA SBIR PROGRAM METRICS

Although the primary purpose of NASA's SBIR program is to produce NASA mission use technology, reports from over 600 of NASA's SBIR companies, representing about 81 percent of all Phase II's awarded by NASA since the beginning of the SBIR program, show that at least 30 percent of NASA Phase II awards have produced technology that has been incorporated in commercial products and services which have generated revenues in non-government markets. Accordingly, over $1.40 in commercial revenues have been generated in non-government markets for each dollar of NASA's investment in the SBIR program. The broad spectrum of the more than 500 associated commercial products and services, and the industrial sectors they represent, demonstrate the pervasive effect of NASA's SBIR program in the national economy. For example, NASA SBIR technology is found in aircraft and automobiles, a great variety of electronics and optical instrumentation, medical equipment, manufacturing process equipment in several key industries, environmental protection and water purification equipment, and heating and air conditioning hardware. The economic ripple effect of NASA's SBIR program is further evidenced by the firms' reporting significant strategic alliance partnering with non-SBIR firms regarding commercial applications incorporating NASA SBIR technology. For example, over 1400 strategic alliances have been entered into by NASA SBIR firms regarding commercial ventures at least partially based on NASA SBIR technology. The findings also show that about 90 percent of all firms winning NASA Phase II awards have received a total of three or less NASA Phase II awards. Over the past five years, new entrant firms into the universe of NASA Phase II firms represent about 46 percent of all firms having received NASA Phase II awards for that period. Accordingly, there exists significant opportunity for newcomer firms to enter the NASA SBIR program.

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.

Personal Cabin Pressure Altitude Monitor and Warning System

NASA Kennedy Space Center (KSC) seeks qualified companies to license and commercialize a technology designed to help prevent aircraft accidents by warning the crew of potentially dangerous or deteriorating cabin pressure altitude conditions.

Hypoxia, an insufficient supply of oxygen to the body's tissues, results from unprotected exposure above certain altitudes and insidiously affects the central nervous system and organs. The most dangerous element of hypoxia is that the victim may lose the ability for critical judgment before becoming aware of any impairment.

This technology has been developed to alert the user of dangerous cabin pressure conditions based on the limits prescribed in the Federal Aviation Regulations. The device provides an alert when a programmed cabin pressure altitude is reached and an alarm if a second programmed cabin pressure altitude is reached, or after 30 minutes between the two altitudes. The technology uses a calibrated, temperature compensated, pressure transducer that functions independently from other aircraft systems. A standard unit is the size and weight of a personal pager. It contains a battery, the pressure transducer, a timer, alarms (auditory, vibratory, and visual), and a display that indicates the cabin pressure altitude and battery life.

For more information, contact Nicole Martel at Research Triangle Institute (RTI), a technology firm assisting NASA KSC with the marketing of this technology 919/541-6310. Please mention you read about it in *Innovation*.

New Technologies for Fire-Resistant Textiles and Membranes

NASA Langley Research Center seeks industry partners to cooperatively develop commercial products based on this technology via a patent licensing agreement. These novel polyimide fibers and waterproof, breathable membranes can be used in fire-resistant textiles and membranes. Fabrics made with the novel polyimide fibers resist solvents and moisture absorption. The byproducts from burning these textiles or membranes are less harmful than from burning competing materials.

Fiber sample testing indicates a glass transition temperature near 270ºC. The quality of the fibers, based on tensile strength and elongation-to-break data, allows them to be used with normal textile equipment. Since the fibers are thermoplastic, they can be co-mingled with reinforcing media such as glass fiber, graphite fiber, and inert fillers to form composite structures that could have uses in fire-resistant applications. Melt-extruding the fibers eliminates the need for volatile liquids such as acids or organic solvents. The process also is relatively inexpensive and offers an alternative to hot compression molding, ream extrusion, direct forming, and hot coining processes using powder feed. In addition to polyimide fibers, polyimide powders are used by NASA to form waterproof, breathable, fire-resistant laminates. Suspending polyimide powder particles in silicone rubber creates pathways that allow the passage of water vapor molecules but not liquid water. Fabrics coated with this laminate simultaneously repel liquid and permit the passage of water vapor. Additionally, the laminate significantly reduces the danger of toxic compound production when exposed to high heat sources.

For more information, contact Diane Hope at NASA Langley Research Center 757/864-7294 *d.l.hope@larc.nasa.gov* Please mention you read about it in *Innovation*.

Affordable, Robust Ceramic Joining Technology (ARCJoinT)

NASA is seeking partners to finish the development and commercialization of a process to join silicon carbide-based ceramics and fiber-reinforced composites. The engineering design of the majority of these components often requires fabrication of complex shaped components, which are very expensive. The technology was developed at NASA Glenn Research Center in collaboration with Dynacs Engineering Company, Inc. This new way of joining allows the fabrication of complex shapes by joining geometrically simple shapes.

The joining technology at NASA was a winner of the R&D 100 Award in 1999 and NORTECH (EDI) Innovation Award in 2000. The as-machined surfaces are cleaned in acetone and dried before joining. The joining steps include the application of a carbonaceous mixture in the joint area and curing it at 110-120ºC for 10 to 20 minutes. A silicon or silicon-alloy in tape, paste or slurry form is applied to the joint regions and heated up to 1250-1450ºC (depending on the type of infiltrant) for 5 to 10 minutes. Molten silicon or silicon-alloy reacts with carbon to form silicon carbide with controllable amounts of silicon and other phases as determined by the alloy composition. No high temperature tooling is needed and the joint thickness and composition can be controlled.

For more information, contact Dr. M. Singh at NASA Glenn Research Center, 216/433-8883 *msingh@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, Non-destructive 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

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 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.

MOVING FORWARD

Multimedia

NASA's Office of Space Science recently announced the release of the Space Science Education Resource Directory, an Internet source for educational resources produced by NASA's space science education and public outreach programs. The directory provides easy access to high-quality, online space science educational resources for teachers and students from kindergarten through high school. This first release of the directory contains more than 100 resources, including lesson plans, educator guides, student activities, Web sites and spectacular space science imagery. To review the directory's collection, visit the Web site at: *http://teachspacescience.stsci.edu*

Events

The American Institute of Aeronautics and Astronautics (AIAA) will host the ***39th AIAA Aerospace Sciences Meeting and Exhibit*** in Reno, Nevada, January 8–11, 2001. The program encompasses technical presentations on state-of-the-art topics in aerospace sciences, lectures, workshops, an awards luncheon, technical committee meetings and exhibits. Advance registration forms must be received by December 8, 2000. Anyone not registered by that date may do so at the onsite registration desk. For more information, or to register using the online registration form, visit the Web site at: *http://www.aiaa.org/calendar/ASM01_prog.html*.

The Space Technology and Applications International Forum (STAIF-2001) will be held February 11–14, 2001 in Albuquerque, New Mexico. The forum, called "Space Exploration and Transportation: Journey into the Future," will feature a number of conferences and sessions. Included are conferences on space exploration technology, thermophysics in microgravity, a conference on innovative transportation systems for exploration of the solar system and beyond, commercial/civil next generation space transportation, as well as a space radiation and effects track, and the 18th Symposium on Space Nuclear Power and Propulsion. For more information about any of the conferences, visit the STAIF-2001 Web site at: *http://www.chne.unm.edu/isnps/staif2001/*

Publications

NASA's ***Spinoff 2000*** publication is now available. To obtain copies, contact the National Technology Transfer Center (NTTC) at 800/678-6882, or access online at *http://www.nctn.hq.nasa.gov*

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