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Aerospace Technology

INNOVATION

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John Glenn "then" orbited the Earth on February 20, 1962, in the *Friendship 7* Mercury capsule. John Glenn "now" returned to space 36 years later on October 29, 1998, in the Space Shuttle *Discovery* STS-95 mission.

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COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
1/99	STS-93 AXAF	AEROGEL Commercial Generic Bioprocessing Apparatus-04**	Marshall Space Flight Center BioServe Space Technologies
10/98	STS-95 BioTechHab (SPACEHAB short module)	*Included eight commercial development payloads:* Advanced Organic Separation Unit (ADSEP) AEROGEL ASTROCULTURE™ BioDyn-A Commercial Generic Bioprocessing Apparatus Commercial ITA Biomedical Experiments Commercial Protein Crystal Growth-15 Microencapsulation Electrostatic Processing System	Commercial Space Centers and NASA Centers Consortium for Materials Development In Space Marshall Space Flight Center (MSFC) Wisconsin Center for Space Automation & Robotics Consortium for Materials Development In Space BioServe Space Technologies Instrumentation Technology Associates, Inc. (ITA) Center for Macromolecular Crystallography Johnson Space Center/MSF

Note: Sortie flights beyond STS-95, and Space Station Operations, under review at this time.

* As of October 1998.
** In combination with National Institutes of Health payload NIH-B1 in support of Life Sciences Division requirements.
Key STS—Space Transportation System, AXAF—Advanced X-ray Astrophysics Facility

WELCOME TO INNOVATION

STS-95 Inspires and Aspires

By John Emond

THE RECENT MISSION OF STS-95 IS AN investment in America's present and future, while serving as a renewed source of inspiration for many Americans. The flight of STS-95 was a custom fit for NASA's three-part mission—to obtain knowledge through scientific research, space exploration, and technology development and transfer, as mandated by policy and legislation.

All of the activities and knowledge gained from this mission are for improving the quality of life on Earth. STS-95 is a notable commitment to partners in the science and educational communities, industry, and government agencies in the United States and around the world, to economic growth and security and to development of the environment.

STS-95 very much represents NASA's contributions to national priorities. In terms of ***Increased Understanding of Science and Technology,*** knowledge from STS-95 communicated widely the content, relevancy and excitement of NASA missions and discoveries to inspire and increase our understanding and the broad application of science and technology. For ***Sustainable Development of the Environment,*** NASA studies Earth as a planet and as a system to understand global change, enabling the world to address environmental issues. The solar studies on STS-95 collected information on the heating of the solar corona and the acceleration of the solar wind that originates in the corona. This will help explain how those phenomena affect activities both in Earth orbit and on the ground. In the area of ***Educational Excellence,*** NASA involves the educational community in its endeavors. Eight experiment modules from national and international students of all ages, elementary through university level, were on board STS-95's payload bay to collect data for postflight analysis. For ***Peaceful Exploration and Discovery,*** NASA explores the universe to enrich human life by stimulating intellectual curiosity, opening new worlds of opportunity and uniting nations of the world in a shared vision. From astronauts to partnerships to payload experiments, STS-95's international involvement includes the Canadian Space Agency, the European Space Agency and the National Space Development Agency of Japan. Finally, for ***Economic Growth and Security,*** NASA develops technology in partnership with industry, academia and other federal agencies to support the fullest commercial use of space to promote economic growth and keep America capable and competitive.

STS-95 was the 33rd Shuttle mission to participate in NASA's Getaway Special program. It offers interested individuals or groups from education—foreign and commercial—and the U.S. government access to space to test ideas that could later grow into major space experiments. The knowledge gained from STS-95's space-based experimentation will be applied to ground-based research, development and manufacturing. STS-95 was the first run at space manufacture for a product called aerogel, which, when manufactured in weightless conditions and made transparent for windows, could significantly reduce global energy needs and minimize energy production pollutants.

STS-95 HAS DRAWN THE ATTENTION OF THE AMERICAN PEOPLE HELPING THEM TO SEE THE MANY BENEFITS OF THEIR SPACE PROGRAM, AS ADMINISTERED BY NASA.

NASA has flown astronauts in their 50s and 60s. John Glenn, the first American to orbit Earth and the oldest American to fly in space, was selected as one of the highly qualified seven-member crew for very specific reasons beyond his age, including 40 years of documented medical history with NASA and previous flight experience as a NASA astronaut. John Glenn provided NASA a one-of-a-kind opportunity to study the similarities, differences and effects of microgravity and aging. Senator Glenn's participation and that of each astronaut added to the data pool on human responses to space flight. STS-95 has drawn the attention of the American people, helping them see the many benefits of their space program, as administered by NASA.

The American people have been inspired in a uniquely personal way by STS-95, its mission objectives, its payloads and its crew. This pride in the space program carries over into the international arena, reinforcing the United States' place as the leader in the commercial development of space and space technology.

Discovery Holds Commercial Promise

THE SPACE SHUTTLE *DISCOVERY* (STS-95), recently launched in October, was to take advantage of the unique environment of space to accommodate more than 80 scientific experiments. It included investigations into the inner universe of the human body and the Sun for the benefit of life on Earth.

Senator John H. Glenn, 77, the first American to orbit Earth, returned to space 36 years later as a payload specialist and test subject aboard STS-95. Glenn's specific investigations were to mimic the effect of aging, including loss of muscle mass and bone density, disrupted sleep patterns, a depressed immune system and loss of balance.

Glenn made history when he orbited Earth on February 20, 1962, in the *Friendship 7* Mercury capsule. Since then, the 121 space flights prior to STS-95 have produced a wealth of scientific data validating apparent similarities between the effects of space flight and aging.

Discovery's payload bay also supported a range of experiments, including many related to the Sun and how it affects life on Earth, drives our weather and is capable of establishing and disrupting the space environment in which our satellites, communications, power systems, weather, defense and human space flight resources operate.

OSTEO (Osteoporosis Experiment in Orbit) is being studied by STS-95 crew members during a SPACEHAB briefing.

Space Flight and Aging

Certain physiological changes that occur in space also occur with aging. It is important to note that these changes—cardiovascular deconditioning, balance disorders, weakening bones and muscles, disturbed sleep and depressed immune response—are reversible in astronauts.

Gerontologists (those studying the aging process) and space life scientists are collaborating to determine how people adapt to aging and to the virtual absence of gravity in space. Space biomedical research could improve our understanding of the basic mechanisms of aging. Aging research could contribute to a better understanding of physiological deconditioning in space.

Space Flight and Muscle and Bone Research

Exposure to microgravity results in muscle atrophy and a decrease in bone density because of microgravity's effect on the normal turnover of bone minerals. Determining how the body translates its normal bone mass process and gravity-driven stresses into the signals that control bone structure may reveal whether, and how, exercise or drugs can prevent osteoporosis in the elderly and in astronauts. This study measured changes in muscle and bone as a result of space flight.

Magnetic resonance imaging (MRI) before and after exposure to microgravity will measure the volume of back, calf and thigh muscles before and after space flight. Following space flight, spinal disc and muscle recovery may be delayed, muscle damage may be greater, back pain may be exacerbated and bone marrow response may be blunted.

The protein turnover experiment studied the effects of space flight on whole-body and skeletal muscle protein metabolism. The data gathered will help determine the relationship between protein turnover and changes in the production of two hormones—insulin and cortisol—during space flight. Previous research indicates an increased breakdown of proteins during space flight, hypothesized as a stress response. Interestingly, a decrease in protein synthesis contributes to the loss of lean body mass in the elderly. The elderly experience stressful conditions (falls, among

others), which may induce a stress-related increase in protein breakdown.

Space Flight and Cardiovascular Research

The three protocols conducted on STS-95 documented changes in heart rate and blood pressure regulation. Cardiovascular responses to standing before and after space flight were monitored to determine whether the heart rate exhibits less variability in microgravity than on Earth.

Studying the data from orthostatic function (standing upright) during entry, landing and egress will help determine whether microgravity affects the heart's ability to pump blood to the brain to maintain consciousness while standing upright. The elderly's problems with orthostatic tolerance may benefit from researchers studying the same effect on astronauts from exposure to microgravity.

In researching balance, the nervous system adapts to the loss of gravitational stimuli in the neurosensory systems after a few days in space. Information used to develop procedures to protect space crew members from such disturbances, especially when crews return to Earth after long space voyages, can be applied to developing ways to help the elderly and patients with gait and postural disorders of neurological origin.

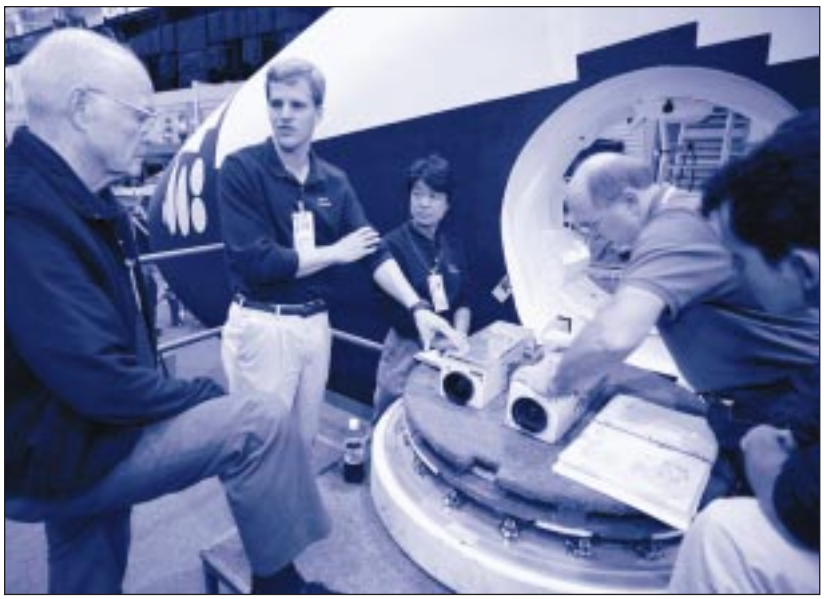
Space Flight and Immune Function

Both aging and space flight depress human immune response, but the change from aging is not reversible. However, reduced proliferation of infection-fighting cells in the immune system may underlie changes in both conditions. It is not clear whether aging or other factors typically accompanying aging (such as declining activity) cause this immune system depression.

Protein Crystal Growth

Several experiments to increase the fundamental understanding of biochemistry of proteins flew on STS-95. Proteins are involved in nearly every metabolic process in the body. The following are brief descriptions of three experiments:

- The Protein Crystallization Apparatus for Microgravity (PCAM 1) is a cost-effective, quick-turnaround crystal growth facility that produces large, high-quality protein crystals. Researchers attempted to grow large, defect-free protein crystals to determine or improve the structure of several proteins on previous flights.
- The Commercial Protein Crystal Growth (CPCG) experiment was conducted to produce in microgravity high-quality protein crystals of interest to industry, including pharmaceuticals, crop growth and harvesting, and water treatment.
- The Advanced Protein Crystallization Facility (APCF), a veteran of four previous Space Shuttle missions, provides a cooled and heated volume to crystallize solution samples in orbital microgravity and to return them for postflight analysis.



Four members of the STS-95 crew are briefed on video cameras during a crew training session in the systems integration facility at Johnson Space Center.

Cancer Experiments

Microencapsulation Electrostatic Processing System (MEPS)

This process consists of unique microcapsules containing multiple cancer treatment drugs that, when injected into main arteries, are intended to temporarily reduce the tumor's blood supply to allow for the sustained release of cytotoxic drugs to tumor cells. The objectives are to:

- Study their formation
- Microencapsulate a photo-activated drug that destroys tumors when exposed to red light
- Apply electrostatic coating to anti-tumor capsules containing powerful chemotherapy drugs with a substance that resists attack by the body's

immune system and increases its ability to destroy specific tumors

Experiments such as these could eventually lead to the development of anti-tumor drugs that allow for the delivery of several FDA-approved therapies, including high doses of chemotherapy, in the same capsule to the cancer site without affecting surrounding healthy cells while reducing unwanted side effects in cancer patients.

Studies of Key Enzymes, Human Proteins and Plant Cells

These studies may offer leads in cancer research. One experiment conducted will help researchers better understand the structure of urokinase, a protein identified as a key enzyme in the spread of brain, lung, colon, prostate and breast cancers. Such an experiment should result in more effective treatments targeting urokinase in the future. Human protein crystals stabilized by aspartame are being studied after the mission to help researchers develop a treatment for multiple myeloma bone cancer. Anticancer compounds derived from soybean cell cultures were also studied.

Other Experiments

These included manufacturing a lightweight substance with insulating properties that may be able to protect virtually anything from the heat or cold. When made on Earth, aerogel is not perfectly transparent. Manufacturing aerogel in microgravity could diminish its earthly irregularities. If aerogel could be made transparent, it could significantly lower heating and cooling costs and revolutionize the glass window industry.

Mission Information

Discovery's mission was commanded by Curtis L. Brown, Jr. (Lt. Col., U.S. Air Force), 42, making his fifth space flight and piloted by Steven W. Lindsey (Lt. Col., U.S. Air Force), 38, making his second flight. Three astronauts served as STS-95 mission specialists: Payload Commander and Mission Specialist-1 Stephen K. Robinson (Ph.D.), 43, making his second flight; Flight Engineer and Mission Specialist-2 Scott E. Parazynski, M.D., 37, making his third flight; and European Space Agency (ESA) astronaut and Mission Specialist-3 Pedro Duque, 35 and from Spain, making his first space flight. In addition to Glenn, making a second flight is 46-year-old Payload Specialist Chiaki Mukai, M.D./Ph.D., from the National Space Development Agency of Japan (NASDA).

STS-95 is an example of researchers—both nationwide and worldwide—who are working together, using experiments in space and on the ground to benefit economic, social and industrial aspects of life for all of Earth. Also, U.S. universities, designated by NASA as Commercial Space Centers, share space advancements with U.S. industry to create new commercial products, applications and processes.

For more information, contact David R. Liskowsky, Ph.D., at NASA Headquarters. 202/358-1963, 202/358-4168, david.liskowsky@hq.nasa.gov Please mention you read about it in *Innovation*.

Computer Chip Mimics Human Mind

A LICENSING AGREEMENT PROVIDING A U.S. automobile manufacturer the use of an advanced neural network technology from the Jet Propulsion Laboratory (JPL) could mean financial savings for millions of American car owners and producers in the future. JPL's neural net computer chip mimics the way the human mind works. The smart fit between JPL's hardware and Ford Motor Company's expertise in automotive engineering algorithms would, for the first time, enable the robust diagnosis of engine misfirings under the hood and possibly bring about many other diagnostic and control commercial applications.

The vehicle applications will mean that artificial neural networks will "learn" how to diagnose problems such as engine misfires and to control the engine to optimize fuel economy and emissions. Neural systems were inspired by the architecture of nervous systems of animals, which use neurons—a form of parallel processing elements—to process large volumes of information simultaneously.

The technology could virtually eliminate engine misfire false alarms, improving customer satisfaction and reliability. Current under-the-hood diagnostic technology signals vehicle misfirings and false misfirings via the dashboard.

The industrial giant's ability to meet ever-stricter Clean Air Act requirements also will be enhanced, as

they apply to continuous on-board diagnostics and control, officials said. Ford engineers do not predict a price increase for installing the chip because JPL designed a computationally powerful neuroprocessor that could be mass-produced in a highly cost-effective way.

Real-time on-board diagnostics are being enabled for the first time, according to Dr. Raoul Tawel, who led the chip development at JPL in Pasadena, California. JPL's expertise in designing and building neural network application-specific integrated circuits gives a tremendous boost in computational ability compared to traditional software approaches, Tawel said. "The introduction of our neural network chip into passenger vehicles signals the start of a revolutionary step in on-board computing since the introduction of the microprocessor in automobiles in the 70s," he added.

For misfire diagnostics, it is necessary to observe and diagnose every engine-firing event, estimated at more than 1 billion during the life of each car. In addition, the diagnostic error rate has to be extremely small, less than one in a million, to avoid sending false alarm signals. The new chip will accomplish this by "learning" diagnostic tasks during the vehicle development process.

NASA-OHIO EFFORT TARGETS TRADITIONAL MANUFACTURING

A new joint initiative will provide significant industrial innovation and change in the traditional U.S. manufactured goods industry using microsystems technology while meeting NASA mission requirements. The Glennan Microsystems Initiative, under the direction of the State of Ohio, will offer microsystems to a range of manufacturing- and technology-intensive companies. It was named for former NASA administrator and former Case Western Reserve University (CWRU) president T. Keith Glennan.

Microsystems are miniaturized electrical and mechanical devices as small as a human hair. Physical and chemical sensors and actuators will be a focus for NASA, with a particular emphasis on harsh environments, such as high temperatures, large stress/strains, rotating parts, structural curvatures, erosive flows and corrosive media. Companies as diverse as bearings makers, medical devices and imaging companies, aircraft suppliers, tire makers and consumer product companies will receive tangible results.

The initiative—including $16 million in federal and $4.5 million in state funds—is a five-year project designed to build on existing strengths and resources in Ohio. Although it emphasizes Ohio industry, participation in the initiative is open to any U.S. company. State of Ohio support is being provided through its newly established Technology Action Fund, designed to leverage federal capabilities and resources. The joint funding parties are NASA, the State of Ohio, industry and other foundations and federal agencies.

NASA's Lewis Research Center in Cleveland, the State of Ohio, CWRU and Cleveland Tomorrow's Technology Leadership Council, an organization of corporate executive officers in northeast Ohio, advanced the idea to couple cutting-edge microsystems capabilities at NASA and CWRU with industry. The Glennan Initiative builds on current partner strengths and collaborative relationships. NASA Lewis provides more than two dozen investigators, state-of-the-art analytical and testing facilities, R&D 100 Awards and a NASA Center of Excellence. CWRU, which has one of the top-four-rated microelectromechanical systems (MEMS) programs in the United States, provides a core of highly recognized investigators, state-of-the-art fabrication and clean room facilities, and multi-agency sponsorship. CWRU is in the process of expanding its program capabilities.

The Glennan Initiative will use a network of existing public-private technology intermediaries to commercialize its technology. The Great Lakes Industrial Technology Center will lead this effort, with the help of the Ohio Edison Centers (including CAMP and Edison BioTechnology Center), Ohio MEMSNet (a consortium including Ohio State University, the University of Cincinnati, the University of Dayton, the University of Toledo, Wright State University, Cleveland Clinic Foundation and the Air Force Institute of Technology), Lewis Incubator for Technology, Ohio Aerospace Institute and selected universities.

For more information, contact Walter Merrill. 440-734-0094, 440/7340686, *MerrillW-C@battelle.org* Please mention you read about it in *Innovation.*

Conventional software would not perform these tasks as well, nor would it be implemented in large production volumes with standard microprocessors. The neural network chip, designed to carry out parallel neuron computations efficiently, overcomes the computational barriers that prevent this technology from being exploited today.

JPL is retaining general rights and has applied for patents to the technology. JPL is managed by the California Institute of Technology, which serves as the party of record for this license. Under the agreement, Ford is granted use of the intellectual property rights for the automobile industry only.

For more information, contact Raoul Tawel at Jet Propulsion Laboratory. 818/354-4951, 818/393-4272, *Raoul.Tawel@jpl.nasa.gov*
Please mention you read about it in *Innovation.*

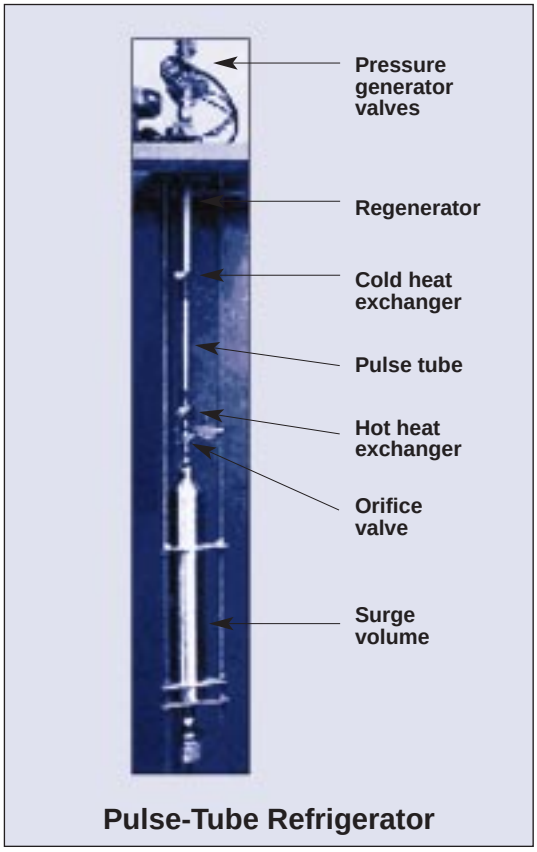
Refrigeration System Is Environmentally Friendly

A NEW, ENVIRONMENTALLY FRIENDLY PULSE-tube refrigeration system has been developed for NASA to use aboard the Space Shuttle and the International Space Station. This system offers many applications to commercial users, including increased reliability, fewer moving parts and much lower cold-end vibration than designs previously used both commercially and on spacecraft.

Working for Marshall Space Flight Center in Huntsville, Alabama, William G. Dean of Dean Applied Technology, Inc., has invented a pulse-tube refrigeration unit that offers a viable alternative to units that use ozone-destroying chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerant fluids. The pulse-tube refrigerators use helium—nontoxic to humans and harmless to the environment—as the working fluid.

Pulse-tube refrigerators can operate over a wide range of temperatures. The technology can be used in food refrigerators and freezers, laboratory freezers and freeze dryers. Pulse-tube refrigerators also can be used to cool electronic devices and detectors. It is the first unit applied to the temperature range and load level needed for typical food and laboratory freezers.

The pulse-tube refrigerator unit's design is based on the orifice pulse-tube concept. Gas is compressed in the compressor. It flows through the compressor's after-cooler, in which the heat is rejected to a water-cooling loop. Helium then flows through the regenerator, which is essentially an economizer, conserving cooling from one cycle to the other.



The nontoxic, environmentally friendly working fluid in this pulse-tube refrigeration system offers more commercial applications than previous designs used in space and on Earth.

Next, the gas enters the cold-end heat exchanger, in which heat is added to the gas from the surroundings. In the final stage, the gas enters the pulse tube, orifice and reservoir, which, together, produce the phase shift between the mass flow and pressure necessary for cooling.

The gas moves repeatedly between the hot and cold ends rather than circulating continuously around a loop, as is found in some other types of refrigeration systems. Heat is lifted and rejected at the hot-end heat exchanger, which is also cooled by water.

The new unit's compressor uses dual-opposed pistons displaced 180 degrees out of phase to minimize

vibration. This is of great importance to NASA because vibrations can affect sensitive experiments being performed aboard the Space Shuttle and the International Space Station.

For more information, contact Bob Lessels at Marshall Space Flight Center. 256/544-6539, 256/544-3151, *Bob.Lessels@msfc.nasa.gov* Please mention you read about it in *Innovation.*

Protective Shuttle Tiles Insulate on Earth

A NEW CONCEPT FOR SPACECRAFT TILES ALSO can be used on Earth to make efficient, vacuum-like insulation for refrigerators, furnaces and automobile catalytic converters. The new material is a composite based on the ceramic fiber tiles on the Space Shuttle to protect the vehicle from the heat generated during reentry into Earth's atmosphere. However, the new tiles have a layer of aerogel, sometimes called "solid smoke," inside the tile's air spaces.

"Solid smoke, or aerogel, works similarly to a chunk of solid vacuum because it prevents air or other gases from transporting heat through the material," said aerogel tile co-inventor Dr. Susan White of Ames Research Center at Moffett Field, California. "It's a great insulator. The aerogel filling the air spaces inside the tiles has such small pore spaces that it traps air inside the tile's air spaces. Microscopically, it would look like clouds of smoke or strings of nano-sized pearls, tangled up. The new aerogel tiles can insulate spacecraft significantly better than today's tiles," she said. A nanometer is a billionth of a meter.

The fibers that form the tiles are mostly a mixture of silica and alumina oxides, according to co-inventor Dr. Daniel Rasky, also of Ames. The spaces inside the untreated spacecraft tiles are less than a millimeter wide.

Aerogel is a porous solid made of silica, alumina, carbon or other materials. Pure aerogel was invented decades ago and has evolved tremendously, becoming lighter, cheaper, safer and easier to manufacture, and it is useful for specialized applications. A pure aerogel can be almost invisible, or so light it nearly vanishes, whereas the aerogel tile composite is heavier because of the strengthening tile matrix.

The lightweight, brittle material from these cylinders fills air pockets in Space Shuttle tiles, serving as insulation. Aerogel that fills tiles can be manipulated for use in many commercial products.

Pure lightweight aerogel is very fragile and brittle and cannot be easily handled, but spacecraft insulation tiles filled with a layer of aerogel can be cut, machined, drilled, dropped and attached to a surface. The aerogel tile composite was developed to exploit the insulating properties of aerogel's under-demanding operating conditions, which would shatter a pure aerogel.

"The reason the aerogel tile composite will act as a great insulator for keeping freezers cold, or furnaces hot, is that the air flowing through the tile is almost completely blocked by aerogel," White said. "It is like having a chunk of solid vacuum where you need it."

Aerogel tiles can be machined into different shapes for many uses here on Earth. The aerogel space tile material could be used in commercial products that require mechanically tough superinsulation. In addition, the new material potentially could be used for furnaces, automobile catalytic converters, liquefied gas transport trucks, and liquid carbon dioxide, special nitrogen, and oxygen containers.

The new aerogel tiles also could be used to insulate future spacecraft fuel tanks. Not only will the aerogel tiles protect future spacecraft from very high reentry temperatures, the materials also will better protect spacecraft from ice formed on the extremely cold fuel tanks when the vehicle is waiting on the pad for launch.

High-temperature and environmental testing of aerogel space tiles was conducted at Ames for seven years. A patent is pending for the new material.

For more information, contact Technology Access Services at the National Technology Transfer Center. 800/678-6882. Or contact Dr. Susan White at Ames Research Center. 650/604-6617, *swhite@mail.arc.nasa.gov* Please mention you read about it in *Innovation.*

Space Shuttle Experiment a Sweet Success

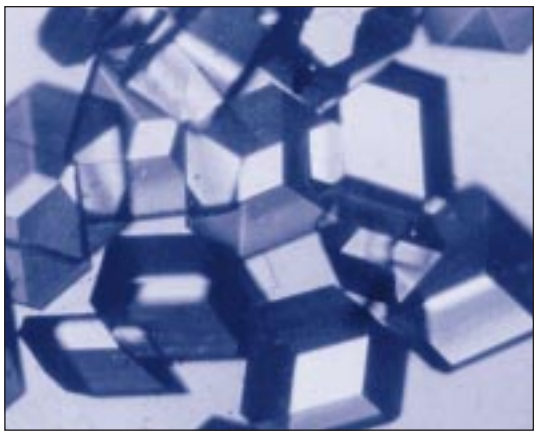
EXPERIMENTS ABOARD THE SPACE SHUTTLE may help safely satisfy the sweet tooths of diabetics and those watching their waistlines. A team of French and American scientists reports they have crystallized one of the most interesting families of intensely sweet proteins, a natural molecule called thaumatin, isolated from the African Serendipity Berry (*Thaumatococcus daniellii*).

In a control study, the team compared space-grown thaumatin crystals with some previously obtained from Earth in a conventional laboratory. Using otherwise similar crystallizing conditions, the space crystal showed a nearly 25-percent larger volume and yielded twice the crystalline order, compared to its Earth-grown counterparts.

The complex and costly management of human diabetes, obesity and oral health has spawned a widespread search for natural sugar substitutes that are both noncaloric and safe. The calorie-free thaumatin protein, sometimes called nature's "artificial sweetener," was analyzed by scientists from the University of California at Irvine and the Institute for Molecular Biology in Strasbourg, France.

The natural proteins as a group are the sweetest compounds ever discovered. On a scale in which 0 refers to no sweetness and 1 refers to table sugar or sucrose, thaumatin is nearly off the scale at 3,000, more than ten times sweeter than other sugar substitutes such as saccharin or aspartame. Scientists hope to use the space-grown crystals to improve the biological understanding of how these molecules work, based on detailed knowledge of their shape and exact atomic positions. According to the study, the visual quality of the space crystals "appeared virtually flawless, with no observable imperfections, striations or anomalies." The scientists found that the space crystals provided 30-percent more real information about the molecule's shape. This moves the investigation closer to revealing the biological function of these complex molecules.

According to the team's report, the space crystals reinforce the conclusion of other reports based on different macromolecules that a microgravity environment provides distinct advantages. In the best of only a few thaumatin crystals grown in microgravity, compared with many more trials conducted on Earth, the microgravity-grown crystals were consistently and significantly larger, as well as substantially more defect free. This is the first experiment to produce space crystals by multiple methods, with both methods suggesting the same conclusion: crystals grown in microgravity can be significantly improved in their x-ray diffraction properties when compared with those grown on Earth.



Molecular information from crystals grown on the Space Shuttle may help develop a noncaloric sweetener to help control diabetes, obesity and other health-related uses.

Thaumatin already is being marketed as a nutritional supplement in blood sugar stabilizers for childhood behavioral problems and the more than 3.5 million sufferers from attention deficit disorder. Among soft drink consumers alone, nearly 20.6 million tons of chemicals are used around the world—nearly four kilograms per capita—with a growth of about 20 percent toward the end of the decade.

For more information, contact Dr. David Noever at Marshall Space Flight Center. 205/544-7783, 205/544-2102, *david.noever@msfc.nasa.gov* Please mention you read about it in *Innovation.*

NASA Joins the Race for the Cup

HIGH-FIDELITY COMPUTATIONAL ANALYSIS tools used for propulsion applications at Lewis Research Center are joining in the race for the America's Cup, the oldest trophy in sailing

history. An official Space Act Agreement between Lewis and America True, the San Francisco Yacht Club's challenge for the America's Cup 2000, calls for research consultation on sail and mast design.

Designers will use the tools to analytically test the performance qualities of different sail and mast designs to select the optimal shapes and material configurations for the racing boat. Computational analysis measures the effect of elements such as wind and water as they pass over objects and surfaces.

According to America's Cup innovator Phil Kaiko, engineers at NASA have the most advanced computers to perform the type of simulation tests needed for advanced boat design, and their experience using those computers establishes a competitive advantage for America True. "The process is not an exact science," Kaiko says. "You can adjust knobs on the computer to produce any answer you want. The key is knowing how and when to turn the knobs so you get the right answer."

Kaiko, who leads the America True design team, also said, "The contribution is extremely significant because NASA deals with this research on a daily basis, and their background is unrivaled. What they'll give us is a reality check on our designs."

"The commonality between the work done at NASA with simulating jet engine performance and the capabilities required for advanced boat designs enables America True to benefit from NASA's experiences," said America True crew member John Cutler, who is assisting the sail design team. "The effects of wind and turbulence are not as important for jet engines because the speed is so fast. But, on a sailboat traveling at 25 knots, those effects are crucial to performance."

The America's Cup team that possesses the most advanced design technology has consistently won the America's Cup since it began in 1851. The alliance between NASA and America True gives the America's Cup syndicate a distinct technological advantage over the other challengers in the field.

This alliance is encouraged through Mission HOME (Harvesting Opportunity for Mother Earth), the official public awareness campaign of the U.S. space community. Mission HOME has brought together leading nonprofit space organizations and aerospace corporations representing all aspects of U.S. space—civil, commercial and national defense—to urge Americans to "Take Up Space."

For more information, contact Laurie Stauber at Lewis Research Center. 216/433-2820, 216/433-2555, *Laurel.J.Stauber@lerc.nasa.gov* Or contact Chuck Lawrence at Lewis. 216/433-6048, 216/433-8000, *Charles.Lawrence@lerc.nasa.gov* Please mention you read about it in *Innovation.*

Shuttle Coating More Than Applies

DOW CORNING AND KENNEDY SPACE CENTER are continuing to test and refine a material that has brought significant savings to NASA launch pad coating efforts and is already used commercially in the aerospace and automotive industries. The Dow Corning® 3-6376 Fast Cure Elastomer, a two-part, primerless, 100-percent silicone material, is used in the automotive industry

Ablative-type coatings that protect the Space Shuttle and reduce recoating costs have found commercial applications in the automotive and aerospace industries.

as a sealant and to coat engine compartment firewalls, according to Dow Corning spokesman John Torgerson.

The Dow Corning® 3-6376 Fast Cure Elastomer benefits NASA and private industry in several ways. It saves NASA money on materials, equipment and labor. It also reduces turnaround time for the launch structure because of fewer refurbishment operations. The new coating technology allows for easy spray application of large areas, and fewer solvents are used to help protect the delicate environment surrounding the launch pad. The product provides stronger protective coating to protect the Space Shuttle's Mobile Launcher Platform, the gantry structure and other valuable equipment from the rocket's heat, abrasives and chemical exposure.

Kennedy has been working on better protective coatings and easier, environmentally friendly applications since the 1980s, according to Kennedy's Materials Science Laboratory spokesman Lou MacDowell. NASA decided to investigate using more resistant ablative-type coatings to reduce the costly recoating of highly exposed sections of the launch pad, damaged from heat, abrasion and chemical exposure after each launch.

Ablative-type coatings form tough, abrasion-resistant surface films and also resist intense heat. MacDowell said that Kennedy's Materials Science Laboratory tested and evaluated many formulas of silicone ablative materials. A primerless, spray-on formula was of particular interest to replace the trowel-applied silicone that required separate primer steps.

Finally, in 1994, with NASA's recommendations and testing, Dow Corning's Fast Cure Elastomer was formulated. The new product, applied with special spraying equipment and techniques, has withstood more than a dozen launches to date without the need for recoating.

For more information, contact Tom Gould at Kennedy Space Center. 407/867-6238, 407/867-2050, *Thomas.Gould-1@kmail.ksc.nasa.gov* Please mention you read about it in *Innovation.*

TELEMEDICINE COLLABORATIONS AND EFFORTS CONTINUE

NASA is working closely with Yale University to explore potential collaborations with French organizations in the field of telemedicine, for commercial and space applications of next-generation technologies. NASA and Yale most recently tested new health care devices based on space science technology by analyzing data from sensors monitoring the vital signs and location of four climbers making their ascent on Mt. Everest. Health data traveled from the base camp at an altitude of 17,500 feet to the NASA-Yale Telemedicine Project site at Yale, where Yale medical personnel monitored the health status of the climbers.

Tests on Mt. Everest may lead to design improvements in future automated medical monitoring and care systems for astronauts who may be in space for months. The problems of high-altitude adaptation, physiological stress and the climbers' location represent great medical challenges similar to those experienced by an astronaut in space.

NASA and Yale have been working in partnership since July 1997 to contribute to the nation's competitive lead in the commercial applications of telemedicine. In Toulouse, France, both the Institute of Telemedicine and the Institut de Médecine et de Physiologie Spatiale (MEDES) have agreed to explore potential collaborations in the telemedicine field with NASA's Commercial Space Center, Medical Informatics and Technology Applications (MITA), at the Yale University School of Medicine. Cooperation between NASA's National Space Biomedical Research Institute and MEDES also is being explored.

In 1997, NASA's Office of Life and Microgravity Sciences and Applications established a Commercial Space Center—MITA—at the Yale University School of Medicine. This center is focused on activities in telemedicine and technology applied to the delivery of health care.

For more information, contact Debra J. Rahn at NASA Headquarters. 202/358-1638, *debra.rahn@hq.nasa.gov* Please mention you read about it in *Innovation.*

Smart Software "Learns" Precise Docking

DOCKING ONE SPACECRAFT WITH ANOTHER will be much easier, thanks to smart computer software being developed at NASA's Ames Research Center. The neural net software will "learn" the motion behavior of a spacecraft as it flies, so it will not undershoot or overshoot docking targets.

The Ames "neurocontroller" will be able to automatically dock a spacecraft of unknown mass with another by flying the spacecraft short distances in different directions and learning the handling characteristics of the craft, according to Dr. Robert W. Mah, an Ames research scientist. "The neurocontroller automatically enables precise, safe docking. This software learns similar to the way human beings learn—by experience, handling the spacecraft," Mah said. The neural net software used in the controller is similar to that used to automatically focus home camcorders.

"Current methods used to dock spacecraft will be improved to make docking easier for astronauts," Mah said. "Docking a spacecraft by manual joystick control depends on the skill of the operator."

Manual docking can be slower than desired, and in some cases precious fuel can be wasted. Conventional software has been used to automatically dock spacecraft, when the spacecraft mass properties are known, according to Mah. "But conventional automated docking doesn't work well when the exact mass is unknown or changing robot arm positions alter spacecraft flight characteristics," Mah said.

A future "worker bee" spacecraft, which would be used during construction in space, might grab a construction part and rotate, Mah said. "The arm and the part held by the spacecraft have a tendency to keep rotating," he added. In contrast, the same spacecraft equipped with the neurocontroller would immediately learn the new "feel" of the way the spacecraft rotates in space while firing its impulse jets. The smart software would then precisely slow the spacecraft's rotation by "burning" the jets for just the right amount of time.

The Ames neurocontroller has not yet been tested in space. "We hope to do space tests eventually, but first we need to fine-tune the software in the lab, making more realistic simulations with test vehicles floating on a cushion of air over a special granite table," Mah concluded.

The neural net software is a form of artificial intelligence. It can be used in the medical field for neurosurgery and for breast and prostate cancer surgery to identify tissues and tumors with less damage. The software has the ability to "learn" the characteristics of a system or different kinds of tissues, such as brain or tumor tissue. In the aircraft industry, neural net software could be used to safely land damaged planes and could be an effective tool for the next generation of flight controllers.

Neural net software programs that are smart enough to "learn" the way humans learn may automatically dock spacecraft more precisely and safely.

For more information, contact Dr. Robert Mah at Ames Research Center. 650/604-6044, 650/604-3594, *rmah@mail.arc.nasa.gov*

Please mention you read about it in *Innovation.*

Wind Tunnel Lined for Sound

NASA HAS COMPLETED A SOUND INSULATION project in the world's largest wind tunnel to help the U.S. aircraft industry design quieter engines and test advanced helicopters and other new aircraft. During the refurbishing that began in September 1994, workers installed a dense acoustic lining in the National Full-Scale Aerodynamics Complex (NFAC) at NASA's Ames Research Center at Moffett Field, California. The purpose was to reduce the test section's background noise and echoes during jet engine tests in the wind tunnel's 40-foot by 80-foot test section.

Background noise and echoes adversely affect the accuracy of sound measurement during jet engine tests, according to Project Manager Joe Hurlbut of Ames. Hurlbut said the refurbished wind tunnel will enable engineers to conduct very accurate acoustic tests.

Insulation material and 1,600 acoustic panels in the floor, walls and ceiling of the wind tunnel's 40-foot by 80-foot test section were installed. The new custom-made metal gray panels are made of perforated sheet metal bonded to stainless steel mesh,

Workers make aeroacoustic testing improvements by installing insulation material and acoustic panels of a 40-foot by 80-foot test section at Ames.

similar to that used in automobile oil filters. The insulation material behind the panels is similar to the spun fiberglass commonly used to insulate houses.

NASA engineers also upgraded the wind tunnel's control system to improve efficiency, and National Electric Company of Columbus, Ohio, modified the wind tunnel's main fan drive system to reduce noise. The Scott Company of San Leandro, California, served as the project's primary contractor.

Each of the wind tunnel's six fan-drive motors has 22,500 horsepower, for a total of 135,000 horsepower. These motors are capable of generating air speeds of up to 345 miles per hour in the 40-foot by 80-foot test section and up to 115 miles per hour in the 80-foot by 120-foot test section. Each of the six fans measures 40 feet in diameter and contains 15 variable pitch blades. The wooden blades weigh 800 pounds each and measure 15 feet in length.

Hurlbut said a series of technical problems, including the discovery of cracks in the fan blades in May 1995, delayed the completion of the project. The cracks have since been sealed with an epoxy resin, and the blades have been wrapped with a carbon and fiberglass composite to strengthen them.

This overhead view of the refurbished test section at the Ames Research Center wind tunnel shows installed flow liner panels on the east door that allows for measuring low sound frequencies, resulting in more accurate acoustic tests for aerospace use.

Tests are scheduled to resume in the wind tunnel following the completion of the integrated systems testing in October. In November, Ames engineers are scheduled to begin a two-month test of the Subsonic High Alpha Research Concept (SHARC) aircraft. Sponsored by the Department of Defense and the U.S. Air Force, SHARC is a design concept being studied to improve the maneuverability of jet fighter aircraft.

For more information, contact Joe Hurlbut at Ames Research Center. 650/604-4953, 650/604-7197, *jhurlbut@mail.arc.nasa.gov* Please mention you read about it in *Innovation*.

SCIENTIFIC PAYLOADS TAKE COMMERCIAL FLIGHT

NASA has awarded a contract to a Maryland firm to procure excess space aboard commercial satellites for various scientific and engineering missions. NASA's Goddard Space Flight Center in Greenbelt, Maryland, has awarded a contract known as "Quick Ride" to Final Analysis, Inc., of Lanham, Maryland.

Under NASA's current contract consolidation initiative, any NASA Center and other government agencies will be able to purchase excess space aboard commercial satellites for various Earth science, space science and technology instrumentation payloads, resulting in faster, better, cheaper science missions.

During contract performance, NASA will develop a catalog for potential customers. It will include information regarding satellite launch dates, intended orbits and the configuration of available space for each contractor participating in Quick Ride."On-Ramps" is a precedent-setting contractual mechanism under the Quick Ride contract. It will allow NASA to solicit additional proposals and accept unsolicited proposals from commercial satellite firms during the contract's five-year performance period, to allow NASA to provide additional Quick Ride services to potential customers.

NASA's intent is for Quick Ride to conform with commercial industry practices. Government-provided instrumentation and/or payloads will be expected to conform to the accommodations aboard the commercial satellites to prevent any impact to commercial integration and launch schedules or primary payloads.

For more information, contact W. James Adams at Goddard Space Flight Center. 301/286-1289, 301/286-0530, *jadams@pop400.gsfc.nasa.gov* Please mention you read about it in *Innovation*.

NASA Flies With Java™ Software

This modified L-1011 aircraft was used for the first testing of a real-time software assessment tool that interfaces different computer platforms via common computer language. Increased air safety and more productive flight research could result by integrating all possible data sources to identify and address risk-increasing events.

INCREASED AVIATION SAFETY AND MORE productive flight research could result from innovative software developed through a Small Business Innovation Research (SBIR) contract awarded to a Hanover, New Hampshire, company by NASA's Dryden Flight Research Center in Edwards, California. The new Ring Buffered Network Bus™ (RBNB™) software, developed by Creare, Inc., allows different computer platforms to interface with each other in real time.

The software flew its maiden voyage in August, aboard an L-1011 aircraft owned and operated by Orbital Sciences Corporation of Dulles, Virginia. NASA engineers are using the L-1011 aircraft for the Adaptive Performance Optimization (APO) test program to develop drag reduction technology for increased efficiency of existing or future aircraft fleets.

The RBNB™ allows for the integration of all possible data sources in a massively decentralized decision-making computing environment to identify and address risk-increasing events before they turn into accidents. The software was incorporated into the onboard research engineering test station to automate data analyses that previously could only be performed after a flight. Dryden engineers used the new collaborative computing software to provide an immediate assessment of each flight maneuver as it progressed.

Originally commissioned as a tool for developing distributed signal-processing applications specifically for aircraft vibration testing, the resulting software design was capable of much more. The RBNB™ is actually a general-purpose, real-time queuing and messaging system with features similar to data acquisition systems. It is written in the Java™ computer language developed by Sun Microsystems, Inc, of Palo Alto, California, and it communicates via standard Internet protocols.

Glenn Gilyard, principal investigator on the APO project at Dryden, is pleased with the new online analysis capability. "This flight demonstration of adaptive configuration optimization for performance enhancement is a first for this technology," Gilyard said. "This software is an integral part of the real-time optimization process, and it performed flawlessly. The RBNB™'s role was key to providing instantaneous results, which greatly enhanced productivity of the flight."

Larry Freudinger, Dryden's project manager responsible for developing the RBNB™ software, said the tests have helped future application developers. "The lessons learned here have had a positive influence on the product, and the risks have been reduced for application developers who will soon have the option of using the RBNB™ as a new commercial product. By using distributed computing tools over standard Internet protocols, I believe the world of flight test has taken a significant step toward a more productive future."

The RBNB™ has many commercial applications to the aircraft, the health care and other industries.

For more information, contact Larry Freudinger at Dryden Flight Research Center. 805/258-3542, *l.freudinger@dfrc.nasa.gov* Or contact Matt Miller at Creare, Inc. 603/ 643-3800. Please mention you read about it in *Innovation.*

Company Develops Clog-Free Cryostat

A NEW TYPE OF JOULE-THOMSON CRYOSTAT developed under an Small Business Innovative Research (SBIR) contract awarded by Kennedy Space Center features exclusive, anti-clogging flow-regulation capabilities for custom-design applications.

General Pneumatics Corporation (GPC) of Phoenix, Arizona, is meeting a need to provide very low-temperature cooling for infrared sensors, superconductors, supercooled electronics, spacecraft, nuclear contamination detectors and cryosurgery.

GPC company spokesman Woody Ellison said the Joule-Thomson cryostat can operate continuously with gas contamination levels that would quickly clog conventional cryostats. GPC cryostats employ a more rugged and stable means of flow regulation than conventional cryostats, and they can be equipped with a manual- or actuator-driven flow adjustment, especially useful in developmental and laboratory applications.

GPC CRYOSTATS EMPLOY A MORE RUGGED AND STABLE MEANS OF FLOW REGULATION THAN CONVENTIONAL CRYOSTATS. . . .

NASA originally needed the innovation for vapor boil-off liquifiers capable of extended operation for long periods without maintenance. Ellison pointed out that GPC has also designed and produced custom Joule-Thomson cryostats for several prospective applications, including spacecraft, computer electronics, nuclear contamination detection and counterproliferation, and cryosurgery.

The patented features have been incorporated in cryostats ranging in cooling capacity from 0.25 watt to 50 watts. In simultaneous testing with commercial grade nitrogen, GPC's cryostat demonstrated continuous operation with contamination levels, which repeatedly clogged conventional cryostats within six minutes. Under SBIR Phase II, the cryostat design was extended to 50 watts with a cooling capacity at 77 degrees Kelvin. NASA's Kennedy Space Center received a design that was incorporated into a prototype closed-loop cryocooler featuring a new oil-free, sealed high-pressure compressor and novel closed-loop control scheme.

One development was a highly sophisticated adjustable two-stage xenon/krypton cryostat assembly for Aerojet ESD. Also for Aerojet ESD, GPC's research unit designed an anti-clogging cryostat to continuously produce solid hydrogen at 10 degrees Kelvin. Another cryostat was successfully tested at NASA's Jet Propulsion Laboratory in an experimental 80-degree Kelvin sensor cooler, which achieved a temperature stability three orders of magnitude better than conventional cryostats. For CryoGen, GPC's research unit provided a prototype anti-clogging cryostat for a closed-cycle cryosurgery system.

A recent development for the U.S. Department of Energy's Remote Sensing Laboratory, operated by Bechtel Nevada, is a common-module-size (0.204-inch bore, 2.62-inch-deep coldwell), self-regulating cryostat, which produces up to 16 watts of refrigeration for several hours using 3,000 pounds per square inch of argon to cool an HPGe gamma-ray detector to below 100 degrees Kelvin.

Global security is an important commercial application. GPC's cryostat innovation is a key part in the development of more portable high-purity germanium gamma-ray spectrometers. These spectrometers are necessary to discern among radionuclides in medical, fuel, weapon and waste materials. The ability to monitor nuclear materials, verify possible hazards and develop counterproliferation tactics has become increasingly crucial to global security.

The Joule-Thomson effect is the change in temperature that occurs when a gas expands into a region of lower pressure. A decrease in temperature takes place when gas expands through a throttling device. A gas must be below its inversion temperature. If above, it gains heat on expansion.

For more information, contact Tom Gould at Kennedy Space Center. 407/867-6238, 407/867-2050, *Thomas.Gould-1@kmail.ksc.nasa.gov* Please mention you read about it in *Innovation.*

First Industry Partner at Ames

NASA'S AMES RESEARCH CENTER AT MOFFETT Field, California, has signed an agreement with Arkenstone, Inc., establishing the Sunnyvale, California, nonprofit corporation as its first industry resident partner at the sprawling Ames Moffett Complex. Arkenstone is a leading provider of technology for people with visual or reading disabilities. It is a nonprofit organization dedicated to developing and distributing adaptive technology to people with visual and reading impairments.

"Arkenstone and Ames have common interests," according to Arkenstone President and CEO James Fruchterman. "NASA Ames is the leading center for information technology, while our primary mission is information access for the disabled," he said. "As an industry partner in the Ames Moffett Complex, we can develop many joint projects to help transfer and commercialize NASA technology, while Arkenstone will benefit by tapping into a source for technology solutions and NASA expertise to serve our clients."

Arkenstone is working with Ames in adapting Ames software to provide the disabled with voice interfaces and Internet access, as well as creating a staff position responsible for technology transfer for the disabled. Arkenstone is also hoping to use NASA's Global Positioning System (GPS) to refine the mobile version of an existing orientation tool for the disabled, a talking map for personal computers that plots the best path from one place to another and can be transferred to a Braille printer or into personal tape recorders. The company wants to increase the accuracy and affordability of the mobile version, a notebook computer that plots out the route ahead of time and guides the disabled along the route, using a GPS receiver to keep on course or determine location while walking.

A Reimbursable Space Act Agreement was signed, providing the framework for the partnership between the two organizations. It supports NASA's mission to use the agency's unique competence in science and engineering systems to assist bioengineering research, development and demonstration programs designed to alleviate and minimize the effects of disability. In addition, the agreement promotes NASA's *Agenda for Change* by disseminating NASA Ames technology and expertise to the community through external partnerships for humanitarian and possible economic purposes.

"Under the terms of the agreement, Arkenstone located its offices in Building 23 at the Ames Moffett Complex and is the first industry partner to locate at the complex," Ames Research Center Director Dr. Henry McDonald said. Ames is pursuing many new tenants for the complex and industry partners for research and development activities.

Arkenstone products are distributed in the United States and abroad by a network of more than 100 dealers. The company also provides information and technical support directly to people with disabilities through its toll-free number, 800/444-4443, supporting all of the United States and Canada.

For more information, contact Roberta Brosnahan at Arkenstone, Inc. 408/245-5900, *roberta@arkenstone.org* Please mention you read about it in *Innovation*.

NEW BUSINESS INCUBATORS JOIN NETWORK

NASA has awarded cooperative agreements to three entities to establish a new business incubator, in addition to its existing six incubators, for the primary purpose of commercially applying NASA technology. This puts in place a nationwide resource for NASA to expand the growing high-technology interests of small businesses and educational institutions. Each entity, made up of a mix of public- and private-sector groups, must match the NASA funding it receives with cash or in-kind funding from nonfederal sources.

A high-technology business incubator will be established at each of three NASA centers. One will be at Goddard Space Flight Center in Greenbelt, Maryland, and a second will be at Langley Research Center in Hampton, Virginia. The third will be at the Jet Propulsion Laboratory (JPL) in Pasadena, California, combined with Dryden Flight Research Center in Edwards, California. In addition to the establishment of these three new business incubators at NASA centers, funds also were provided to enhance services to firms at the six existing NASA incubators at Ames Research Center, Johnson Space Center, Kennedy Space Center, Lewis Research Center, Marshall Space Flight Center, and Stennis Space Center.

These business incubators provide U.S. start-up or small existing high-technology firms and U.S. educational institutions with a wide array of critical business development support services for the primary purpose of commercially applying NASA technology.

For more information, contact Mike Braukus at NASA Headquarters. 202/358-1979, 202/358-3750, *mbraukus@hq.nasa.gov* Please mention you read about it in *Innovation*.

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

Hot NASA Technologies

Acoustic Phased Arrays for Noncontact Fluid Agitation and Manipulation

A new ultrasound technique using low-cost solid-state piezoelectric transducers has been developed to nonintrusively agitate fluids. Acoustic radiation pressure is the mechanism used to drive a phased array of these transducers—analogous to larger scale radar installations—to deliver controlled, focused patterns of acoustic-wave energy to a liquid volume without direct contact or the use of conventional hardware. Applications for acoustic radiation pressure agitation include mixing and delivery systems for inks, paints, and adhesives, as well as advanced particle-liquid separation systems, pharmaceutical fluids handling and food processing.

National Combustion Code

NASA's Lewis Research Center is currently soliciting nonaerospace companies for specific application areas in which the accuracy and reliability of the National Combustion Code (NCC) could be demonstrated under cooperative research agreements. This joint federal industrial partnership to develop the NCC will provide engineers with insight—for the first time—into the entire combustion process using a versatile and comprehensive set of software design tools. Advanced design, simulation and postprocess evaluation of liquid and gaseous combustion systems can be performed using the NCC. This period of industrial demonstration and problem solving will precede the licensing of nonproprietary executable NCC source code to U.S. companies, which is currently planned for the summer of 1999.

Intercalated Graphite for Lightweight Electromagnetic Interference (EMI) Shielding

Bromine-intercalated-graphite-fiber-polymer composites have been developed at NASA Lewis to shield EMI-sensitive electronics using lightweight, durable housings. These housings weigh less that 15 percent of aluminum structures. While this materials technology is attractive for aerospace fuel savings, it is also attractive for weight savings in automotive as well as portable, lightweight equipment applications, such as notebook computers, cellular phones and consumer electronics. Recent breakthroughs have now made this technology more attractive for commercial development, and process patents are currently available for licensing. Bromine-intercalated-graphic fiber is available commercially in modest quantities for prototype applications.

Spacebridge Advanced Internet Database Communication Tool

To access multimedia database information via the Internet, NASA Lewis has developed the Spacebridge Internet software tool. Spacebridge provides users with non–real-time communications linkage to information records stored using commercially available multimedia database tools. The Spacebridge software provides users with an advanced software backbone tool that links databases to either Intranet or Internet communications systems and allows for the proper transmission and display of detailed multimedia databases. For example, a medical expert could electronically review the detailed status of a hospitalized patient and provide comments on treatment and prognosis. Other applications for Spacebridge include human resource departments, long-distance learning, crisis management and industrial health management. Interested companies can obtain Spacebridge through a private-use arrangement.

For more information on any of the above, please contact Priscilla Diem at the Great Lakes Industrial Technology Center (GLITeC). 440/734-1186, 440/734-0686, *diem@battelle.org* Please mention you read about it in *Innovation.*

Optical Robotic Path Planning System

Ames Research Center is seeking companies to license and manufacture the Optical Robotic Path Planning System to serve existing and expanding applications. Ames developed the optical system to rapidly produce a potential field map of a bounded two-dimensional region that can be used by an autonomous mobile robot to guide itself from any location to a goal location while avoiding obstacles. Benefits of the system include a fully parallel optical system, real-time updating potential, no local minima in the final potential field, adaptability to various applications and further miniaturization possible. Commercial uses for the path planning system could include mobile robots that must navigate their work environments, specialized wheelchairs that allow the occupant to navigate the chair around, remotely controlled robots that handle hazardous materials, specialized robotic escorts to guide the blind through unfamiliar environments and smarter robots for use on prespecified lines in warehouses and industry floors.

For information, contact Phil Herlth at Ames Research Center. 650/604-0625, 650/604-1592, *pherlth@mail.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 (Acting)
Ames Research Center
Moffett Field, California 94035-1000
650/604-0893
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.

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

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

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

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

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

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

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

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

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

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

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

Larry Viterna
Lewis Research Center
Cleveland, Ohio 44135
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Larry.A.Viterna@lerc.nasa.gov

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

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

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

Kirk Sharp
Stennis Space Center
Stennis Space Center, Mississippi
39529-6000
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

Lyn Stabler (Acting)
Mississippi Enterprise for Technology
Stennis Space Center, MS
228/688-3144

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

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

Kirk Wiles
Business Technology Development Center
Huntsville, AL
256/704-6000

Kathleen Weiss
Maryland Economic Development Corp.
Greenbelt, MD
301/528-1546

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

Catherine Renault
Hampton Roads Technology Incubator
Hampton, VA
757/689-3024

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

Events

Predicting future market activity and how to do it will be the topic of ***"Application of Signal Processing to Financial Markets,"*** an Engineering Colloquium open to general audiences, Monday, December 14, 1998, at 3:30 p.m., in the Building 3 Auditorium at Goddard Space Flight Center in Greenbelt, Maryland. Speaker Richard A. Mueller, Ph.D., demonstrates a complete mathematical computer methodology of nonlinear equations to perform the process with precision. Call Jim Gatlin at Goddard at 301/286-6680. Or call Ronald Zaleski at Goddard at 301/286-8449.

Preschool, kindergarten and first-grade classes are invited to participate in ***Early Education Monday (EEM),*** a lively, one-time, three-hour program to enhance awareness of space science in children ages 3 to 6. Held every Monday, September through May, at Stennis Space Center, the program is specifically designed to motivate children through the excitement of space adventure by introducing them to age-appropriate scientific and mathematical concepts. It includes hands-on activities during mock space travel, slide shows, stories, skits, a look at a NASA spacesuit and rocket and Space Shuttle models, all featuring NASA's Astronaut Bear Extraordinaire. For more information, call Stennis Space Center at 601/688-2370 or 800/237-1821, or visit *http://www.ssc.nasa.gov/*

The ***Tenth Biennial Coherent Laser Radio Technology and Applications Conference,*** to be held June 28–July 2, 1999, Mount Hood, Oregon, will emphasize the latest advancements in the field of coherent lasers, including theory, modeling, components, systems, instrumentation, measurements, calibration, data processing techniques, operational uses and comparisons with other remote-sensing technologies. The conference chair is Dr. Michael J. Kavaya of the Global Hydrology and Climate Center at Marshall Space Flight Center in Huntsville, Alabama. Call Debra G. Hallmark at Marshal at 205/895-0582, ext. 3003, e-mail *debra@space.hsv.usra.edu* Or visit *http://hsv.usra.edu/tenth_biennial_coherent_laser.html*

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