

INNOVATION

Space Technology Detects, Treats Heart Disease

**Kids Learn NASA Aeronautics
Via the Internet**

"Lifeboat" Flies Through Test

**Water Purification System
Uses Future Technology**



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Editor in Chief

Janelle Turner
innovation@hq.nasa.gov

Managing Editor

Karen Kafton (NTTC)

Assistant Managing Editor

Dawn Sampson (NTTC)

Research

Dawn Sampson (NTTC)
Rebecca O'Connell (NTTC)

On-Line Editor

Jonathan Root

Art Direction/Production

Kelly Rindfusz
Chris Pysz
Jonathan Friedman

Contributing Writers

Don Amatore
Durand Begault
John Bluck
Fred Brown
Richard Callahan
Jim Cast
Donald Costello
James Hartsfield
Phil Herlth
Terri Hudkins
Bob Lessels
June Malone
Steve Roy
Dawn Sampson
Alice Wesson

Database Manager

David Gmitter

Contents

Welcome to Innovation

3 Management Message

Technology Transfer

4 Space Technology Detects, Treats Heart Disease

6 A Closer Eye Monitors Vehicles

6 NASA Brings Cinema to Television

7 The World Looks Better With JPL Map

Advanced Technologies

9 New Image for CCD Sensor Technology

10 Kids Learn NASA Aeronautics Via the Internet

10 Licensing Expands the Use of Solar System Data

Aerospace Technology Development

12 Lifeboat Flies Through Test

13 First Major X-33 Component Arrives

13 Space Payload Reduction Research Expanded

Small Business/SBIR

15 Purification System Uses Future Technology

16 Software Virtually Doing Business

16 Marshall, High-Tech Incubator Partner

Moving Forward

18 Technology Opportunity Showcase

18 NCTN Directory

20 Publications/Events/Multimedia



About the Cover: Applying research that helps heart and blood vessels weakened by time spent in space improves health and save lives in surgery as NASA continues to collaborate with professionals in the medical field to bring successful new programs to diagnose and treat heart disease.

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

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COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
8/98	STS-93 AXAF	AEROGEL Commercial Generic Bioprocessing Apparatus-04**	Marshall Space Flight Center BioServe Space Technologies
10/98	STS-95 BioTechHab (SPACEHAB short module)	<i>Includes eight commercial development payloads:</i> 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	<i>Commercial Space Centers and NASA Centers Consortium for Materials Development In Space</i> Marshall Space Flight Center (MSFC) Wisconsin Center for Space Automation & Robotics Consortium for Materials Development In Space BioServe Space Technologies Instrumentation Technology Associates, Inc. Center for Macromolecular Crystallography Johnson Space Center/MSFC

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

* As of June 1998

** In combination with National Institutes of Health payload NIH-B1 in support of Life Sciences Division requirements.

Key: STS—Space Transportation System
AFAX—Advanced X-ray Astrophysics Facility
ITA—Instrumentation Technology Associates, Inc.

WELCOME TO INNOVATION

NASA Technologies Contribute to Medical Breakthroughs

by Dr. Robert Norwood

ALTHOUGH NASA'S PRIMARY MISSIONS remain space exploration, space science and advanced aeronautical research, NASA continues to reach new heights in other fields. The medical field, in particular, has benefited from NASA research on how space flight affects the cardiovascular system. Cardiovascular disease is prioritized as a leading cause of death in the United States. Techniques derived from space research have led to more sophisticated, less costly, less painful methods of treatment. Breakthrough discoveries in research for the treatment of the cardiovascular system have proven fruitful in revolutionizing the practice of medicine.

This issue presents several examples of cutting-edge technology applied to common but important products and services that improve our health and well-being. For example, NASA research in small high-performance spacecraft has resulted in technology that has improved heart pacemakers. During the late 1970's through the 80's, NASA was a key player in the development of the first implantable heart defibrillator, which won Food and Drug Administration approval. This device, known as the Automatic Implantable Cardioverter Defibrillator (AICD), incorporates space-based miniaturized electronics to detect a broad range of spontaneous heart arrhythmias. Other NASA technologies contributing to the AICD are computer modeling and quality control techniques. We can expect more of NASA's advanced technology to be available for newer models of heart-assist devices with more capability and perhaps more intelligence. Blood flow modeling used to develop heart pumps is a direct leverage of advanced computational fluid dynamics expertise and software

used to develop high-performance turbojet engines that can propel a supersonic aircraft, as well as to obtain optimal performance for Space Shuttle main engine liquid oxygen turbopumps that can pump more than 8,000 gallons per minute into a rocket engine to generate more than 500,000 pounds of thrust. We also provide information on exercise technologies derived from medical research on

astronauts and grow special tissues in space that are applied to medical procedures on Earth.

Space technology and modern medicine often work hand-in-hand. Because of space technology, life-saving medical breakthroughs, such as laser angioplasty, a procedure in which a thin fiber optic catheter is inserted

into an artery and threaded to a blockage in a coronary artery, and digital imaging, a process that converts analog signals into digital signals to create sharp, enhanced, accurate images, are now possible.

Yesterday's accomplishments, coupled with today's innovations, pave the way for tomorrow's advances as NASA's Commercial Technology program continues to focus its efforts on the transfer of our technologies into state-of-the-art products and services. With a continued emphasis on partnering with industry, companies have transferred NASA know-how into products and services that affect and enhance our everyday life.

Technology transfer and commercialization continue to grow in importance to our economic well-being and contribute to more than one-third of all U.S. business technology needs. As NASA's research in the medical field progresses, we can expect more examples in the years to come. ✨



NASA RESEARCH IN SMALL
HIGH-PERFORMANCE SPACECRAFT
HAS RESULTED IN TECHNOLOGY THAT
HAS IMPROVED HEART PACEMAKERS.

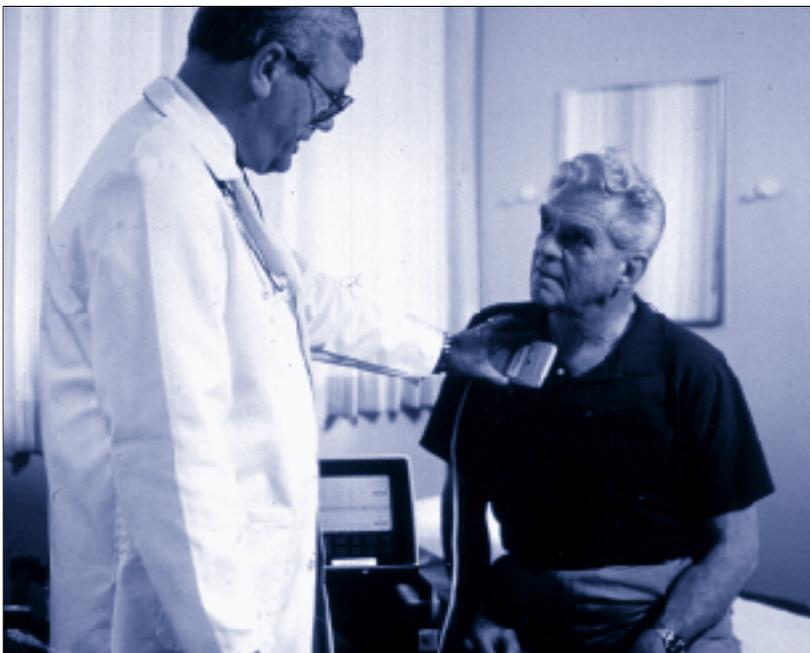
Space Technology Detects, Treats Heart Disease

NASA'S RESEARCH ON THE CARDIOVASCULAR system is leading to many breakthrough discoveries, testing procedures and treatments of heart disease—the number-one killer of American men and women. About 60 million Americans have high blood pressure, which, if left untreated, can lead to heart attacks, strokes and other medical problems.

Astronauts who spend extended periods in space often experience weakening of their hearts and blood vessels. Whether researching ways to keep astronauts healthy in space or transferring aerospace technologies to industry, America's space program has helped revolutionize the practice of medicine. NASA is working with the National Institutes of Health, the U.S. Department of Health and Human Services, dozens of hospitals, researchers and private companies. These collaborations have resulted in successful new programs to diagnose and treat heart disease.

A few of today's space-derived improvements include blood pressure monitors, self-adjusting pacemakers, electrocardiographs, exercise equipment and ultrasound images. Many are less painful, less costly and less traumatic to patients. The technology of

Physician checks a patient's advanced Trilogy pacemaker.



tomorrow will include microwave surgery, tissue replacement, heart pumps, low radiation imaging and fetal imaging.

In Your Doctor's Office Today

Advanced Pacemaker—An implanted device developed from a NASA two-way communications technology senses irregular heartbeats and automatically delivers an electrical stimulus to get the heart back on track. This allows doctors to fine-tune the pacemaker from outside the body to better regulate heart rate in keeping with the patient's lifestyle.

Blood Flow Modeling—The same technology used to study how air flows over aircraft at ultrahigh speeds has been applied to study the flow of blood in the heart. Understanding blood flow will help in the design of artificial heart valves, artificial hearts and heart pumps and may even help researchers design these devices so that damage to red blood cells is reduced. The knowledge gained may also lead to a reduction in the frequency of heart attacks by uncovering ways to prevent the formation of artery-clogging clots.

Automatic Blood Analyzer—This small device developed by NASA allows doctors to quickly perform 80 to 100 different chemical blood tests from a single drop of blood in 5 minutes.

Exercise Equipment—NASA electrode technology, developed to monitor the heart rate of astronauts in space, has led to exercise equipment, also used in gyms and rehabilitation centers, that continually monitors the user's heart rate and sets the machine's pace according to physician or trainer instructions.

Tomorrow's Technology

Gender-Based Study of the Heart—NASA and the Health Enhancement Research Organization (HERO) are studying how heart disease is different in men and women. When the study is completed, it will be reviewed by the American Heart Association and may result in new diagnosis and treatment procedures specific to women.

Controlling Blood Pressure—NASA has been studying how and why astronauts in space experience irregularities in their blood pressure and whether the body can "reset" its own blood pressure control by pressing on certain points in the body. Someday patients with unstable or dangerous blood pressure may be able to "reset" their own bodies' responses.

Monitoring Vital Signs—In the future, when doctors need to examine a patient's vital signs—heart rate, respiratory rate, temperature and oxygen level in the blood—they will use a small probe that easily fits inside the ear and quickly displays data on a laptop computer. NASA soon will be using this sensor technology to monitor crew vital signs during spacewalks and Space Shuttle launch and reentry.

Conducting Physical Exams Remotely—The Telemedicine Instrumentation Pack (TIP) allowed the crew on Space Shuttle mission STS-89 to conduct physical exams and monitor one another's heart, lung and bowel sounds and other physical conditions. On Earth, the portable unit TIP can be used by people, with limited training, to consult with medical specialists in other locations and to bring health care to people in remote areas.

Sending Medical Data Over NASA's Internet Lines—Working with the Cleveland Clinic, NASA is experimenting with transmitting digital echocardiogram video images over NASA's Research and Education Network, an Internet-based system. Echocardiography uses ultrasound to produce a motion picture of the heart in action. The clear image ultrasound helps detect unseen heart valve leaks and other heart problems. This technology was developed to image astronauts' hearts aboard the International Space Station.

Fetal Monitoring—NASA researchers working with surgeons at the University of California at San Francisco are perfecting a tiny, wireless, implantable fetal sensor that will make postoperative monitoring and care less difficult after surgery while the fetus is still in the womb. The sensor continuously transmits vital fetal health data through delivery.

Cardiac Imaging—Technology behind a device to monitor astronauts' hearts has led industry to develop a camera that images the heart six times faster than conventional devices, thus exposing patients to much lower doses of radiation. This is especially important to children and infants with heart conditions, because doctors will usually not subject them to procedures involving radiation. The camera makes imaging of these tiny hearts possible, thus possibly saving lives with a significant reduction in risk associated with radiation.

Computer Measurement of Coronary Artery Disease—NASA's Jet Propulsion Laboratory in Pasadena, California, in collaboration with the University of Southern California and with funding

from NASA and the National Institutes of Health, is a pioneer in the development of computer image processing techniques to accurately measure coronary artery blockage from x-ray angiograms. These techniques can detect very small changes over time in the coronary arteries and improves the ability of scientists to monitor clinical trials to detect the effect of drugs, diet and therapeutic procedures on heart disease.

Computer Measurement of Carotid Artery Disease—Computer methods developed and used for very high-precision measurement of carotid artery wall thickness from ultrasound images in a number of clinical trials and epidemiological studies at the University of Southern California and elsewhere have the potential to assist physicians in predicting an individual's risk of heart attack. This could become an important screening tool for coronary artery disease. This ultrasound method can detect very short-term changes in carotid wall thickness and has the advantage of using noninvasive ultrasound imaging that poses no risk to the patient.

Treating Heart Disease With Microwaves—In the future, microwaves and millimeterwaves will be used to treat certain forms of life-threatening irregular heartbeats and to remove lesions from the walls of blocked arteries. Currently used on a limited basis in special heart disease cases, tiny catheters heat diseased tissue with microwave-frequency waves and melt blood vessel lesions, reducing the risk of recurring blockage caused by artery damage from conventional treatments.

Heart Pumps From Aerospace Applications—A heart pump, developed from Space Shuttle engine pump technologies for use in surgery to temporarily assist the heart's own pumping ability, is being further developed by the Cleveland Clinic and NASA as an implantable, artificial heart pump for patients recovering from heart surgery or awaiting a heart transplant. The initial pump, the Ventricular Assist Device, was developed by NASA and Baylor College of Medicine researchers, including renowned heart surgeon Michael E. DeBakey. NASA's technology increases the pump's efficiency and thereby reduces damage to the blood cells during the pumping process.

Designing Heart Surgery Drugs—The microgravity of space allows space researchers to grow higher quality crystal proteins in the three-dimensional shapes necessary to develop drugs to counteract a disease-causing bacteria, virus or defective protein. Factor D crystals successfully grown during Space

Shuttle mission STS-50 have led scientists at NASA and the University of Alabama at Birmingham to develop a drug that may aid recovering open heart surgery patients by inhibiting the human body's inflammatory responses to open heart surgery. Factor D is an active amino acid that is part of the alternative pathway that serves as complementary activation to inhibit the body's adverse reaction to the surgery. Designed to prevent immune system overreaction, the promising drug is scheduled to begin human clinical testing this year.

Tissue Engineering in Space—In a collaboration between the University of Alabama at Huntsville and the University of South Carolina, scientists have flown experiments on the Space Shuttle to engineer and grow tissue that may someday act as living patches. This would revolutionize the way medical science treats damaged heart muscle and blood vessels. In the future, the International Space Station may prove to be a unique tissue “factory” that may prolong and improve the lives of heart patients on Earth. ✨

For more information, contact Terri Hudkins at NASA Headquarters. ☎ 202/358-1977, 📠 202/358-4331. Please mention you read about it in *Innovation*.

A Closer Eye Monitors Vehicles

NASA TECHNOLOGY THAT WILL ENABLE astronomers to look into the depths of the universe is already at work keeping a close eye on some down-to-Earth concerns. A data management system developed by NASA's Marshall Space Flight Center to handle the flow of information being received from experiments aboard the Space Shuttle-based Spacelab, and later modified to manage data during development of the Advanced X-ray Astrophysics Facility (AXAF), was adapted to create an innovative vehicle tracking system that is now available to municipalities and private businesses.

Scott Johnson of Quality Research, Huntsville, Alabama, says the tracking system has its immediate origins in a contract to facilitate accessing specific AXAF temperature and vacuum data from a telemetry stream. Quality Research worked with Walter Robinson of Marshall's Astrionics Lab Ground

Computers Team and Larry Taoramina of the Astrionics Lab Design and Implementation Branch to develop software that would enable engineers to extract specific bits of information from the stream of data received while testing AXAF in a simulated space environment.

In a commercial spinoff of the software, AVL Systems in Huntsville, Alabama, has modified it to form the heart of a system that can monitor specially equipped vehicles in operation within a specific area of operations. The system has uses in both the private and public sectors. One city is now employing it to track sludge pumping trucks used to keep public sewers clear and running. The dispatcher at the department of public works can monitor the location of all vehicles in service, determine when each vehicle operator's assigned task is completed and then reassign that vehicle to new tasks in a timely manner.

The system holds significant advantages for emergency services personnel. In a police car, for example, it can be tailored to report to the central dispatcher each time the police officer accesses the vehicle's on-board weapons or if the vehicle's air bag is deployed.

Many other types of vehicle fleet operations can be monitored with the system. Delivery vans can be monitored on their routes. Armored cars can be tracked as they haul their valuable cargoes. Also, public service vehicles such as taxis can be tracked and more efficiently dispatched. ✨

For more information, contact Charles Musitano at Marshall Space Flight Center. ☎ 256/882-1995, 📠 256/882-0464, ✉ chasmusi@airnet.net. Please mention you read about it in *Innovation*.

NASA Brings Cinema to Television

A HIGH-TEMPERATURE, HIGH-VOLTAGE SEMI-conductor called Silicon Carbide (SiC), developed by NASA's Lewis Research Center (LeRC) and delivering three times the power of conventional silicon devices, is helping accelerate the use of high definition television (HDTV). It also promises to bring cinema-quality pictures and compact disc sound to the United States and abroad during the 21st century.

Westinghouse Wireless Solutions, a division of CBS Corporation, recently introduced HDTV trans-

mitter modules made from SiC for advanced television transmission. The solid-state SiC transmitter modules—compact, more reliable, safer and easier to maintain than transmitters using tube-based technology—will ultimately cut the cost of digital television.

SiC-based transmitters hold great promise for television stations as a transmitter technology to convert from analog NTSC to digital broadcasting. Transmitter manufacturers will be able to abandon their reliance on tube-based technology for high-power transmitters and build smaller, higher power solid-state transmitters with SiC.

When compared with silicon technology, SiC modules can offer twice the power per module. When translated to the system level, this equates to a transmitter requiring less space, being more reliable, needing less maintenance and therefore being more cost effective.

As the technology is developed further, SiC devices will ultimately drop in price, becoming very cost competitive with tube transmitters. This will reduce the cost of the new digital television transmission systems being implemented by television stations in the United States and around the world.

Westinghouse has targeted a 75-watt-average power transistor as its power device, built into 500-watt-average power-amplifier modules. Using these high-power transistors will significantly reduce the space needed for high-power transmitters at the television stations and offer a solid-state solution, reducing long-term maintenance costs. A modular solid-state design provides broadcasters with an option to gradually add modules, increasing the power of their transmitters as they expand their HDTV coverage.

Over the course of six years of joint research under a Space Act Agreement, the High Temperature Integrated Electronics and Sensors Team at the Lewis Research Center played a key role in the development of the base SiC epitaxial growth technology for Westinghouse's SiC technology efforts. The team is developing SiC for advanced semiconductor electronic devices because of its superior ability to function in high-temperature, high-power and high-radiation conditions, resulting in a variety of large-performance enhancements and applications. ✨

For more information, contact Philip Neudeck at Lewis Research Center.

☎ 216/433-8902, 📠 216/433-8643, ✉ neudeck@lerc.nasa.gov

Please mention you read about it in *Innovation*.

The World Looks Better With JPL Map

USING THE TILE EXPERTISE OF THE Cartographic Applications Lab at the Jet Propulsion Laboratory (JPL), the National Geographic Society now possesses a digital satellite image map of the world that can be used in numerous ways to support stunning and exciting visualizations for television and the regional and global maps of the society's Mapping Division. JPL was a pioneer in the area of digital imaging to produce striking images from space exploration.

The JPL Technology Affiliates Program put the National Geographic Society in touch with JPL's Cartographic Applications Lab. Dr. Nevin Bryant of JPL and his group used more than 500 National Oceanic and Atmospheric Administration (NOAA) weather satellite images acquired over the past 10 years by the Advanced Very High Resolution Radiometer (AVHRR) instrument. This instrument, first developed at JPL in 1965 and continuously refined over the years, consists of an across-track scanner that covers a 1,500-kilometer swath along its orbit track. However, this broad swath is at 1-kilometer resolution (or better) only for the center half of each scene, degrading to as much as 6.5 kilometers per pixel at the scan edges.

Except for the center, most of the frame of each picture was thrown out. To obtain cloud-free imagery, twice as many passes were used, resulting in images in the early morning and mid-afternoon. JPL used 10-bit data to provide 1,024 discrete levels of gradations for a higher resolution picture. This greater information allows for the discernment of subtle features in either the rain forests of South America, the icy domes of Nepal or the deserts of the Sahara.

While others have prepared global AVHRR mosaics in recent years, JPL has introduced several innovative processing steps to the preparation of this global mosaic for *National Geographic* magazine. Using specialized software, formulas and expertise gained from producing images from space, JPL was able to produce a world map that meets the demanding criteria of *National Geographic's* photographic and visual standards. As a result of these innovations, the *National Geographic* global land area mosaic is the

highest resolution and most consistent representation to actual natural colors yet available.

The National Geographic Society is the world's largest nonprofit and educational institution in the world, supporting scientific research, exploration and geography education. The society will be offering a free world map as part of their 1998 membership

drive and will make available a free world map to any school across the nation. Now, with JPL's assistance, the world never looked so good. ✨

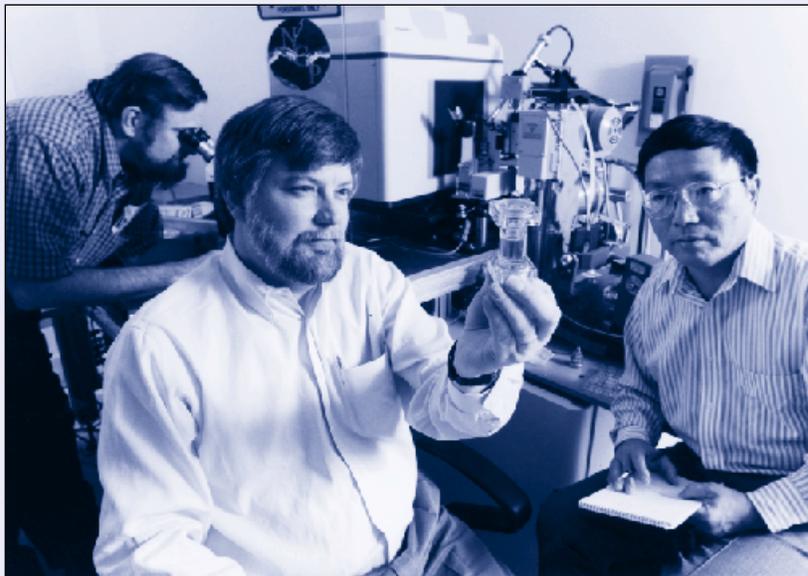
For more information, contact Alice Wessen at the Jet Propulsion Laboratory. ☎ 818/354-4930, 📠 818/393-4093, ✉ Alice.S.Wessen@jpl.nasa.gov Please mention you read about it in *Innovation*.

RESEARCHERS CLOSER TO DEADLY VIRUS TREATMENT

A joint research effort by government and industry, sponsored by the Microgravity Research Program's Biotechnology Office at NASA's Marshall Space Flight Center, has taken an important step toward developing a treatment for a life-threatening virus that causes pneumonia and severe upper respiratory infection in infants and young children. Biotechnology researchers have developed an antibody, which aids the individual's immune system by neutralizing toxins as they attempt to invade healthy cells. Knowledge of the antibody's molecular structure will permit scientists to understand key interactions between the antibody and virus, facilitating the development of treatments for the disease.

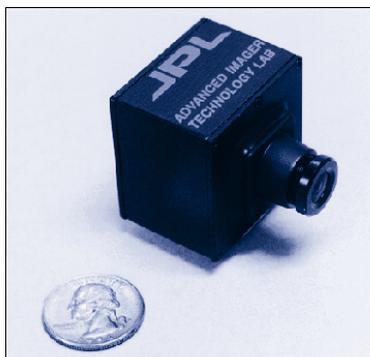
The infection, called Respiratory Syncytial Virus, attacks the respiratory airways and lungs. The research team used the disease's viral antibody to grow antibody crystals aboard the Space Shuttle *Columbia* in 1997. Using specialized x-ray equipment and computers, scientists at New Century Pharmaceuticals in Huntsville, Alabama, located the key positions of individual atoms in the crystal structure and constructed a model of the antibody. The antibodies grew larger in the weightless environment and were of better quality than those previously grown on Earth. Because of the increased size, researchers were able to get a better look at each antibody's smallest parts to more precisely determine its structure. ✨

For more information, contact Steve Roy at Marshall Space Flight Center. ☎ 256/544-6535, ✉ steve.roy@msfc.nasa.gov Please mention you read about it in *Innovation*.



Dr. Dan Carter, president of New Century Pharmaceuticals, examines a chamber of protein solutions prepared for the flight to the Mir space station, as he and his team, Dr. Joseph Ho and Dr. John Ruble, work with NASA to understand a virus that infects nearly 4 million U.S. children ages 1 to 5 every year.

ADVANCED TECHNOLOGIES



This JPL sensor is being marketed where small size, lightweight and low-power consumption are needed.

New Image for CCD Sensor Technology

JET PROPULSION LABORATORY (JPL) RESEARCH on a second-generation solid-state image sensor technology has resulted in a successful implementation of Complementary Metal-Oxide Semiconductor Active Pixel Sensors (CMOS APS), creating several expansions on Charged Coupled Device (CCD) technology. Compared to standard CCD, CMOS APS is less susceptible to radiation damage in space, thus achieving the goal of smaller and cheaper fabrications enabling the affordability of future missions and the generation of good scientific data.

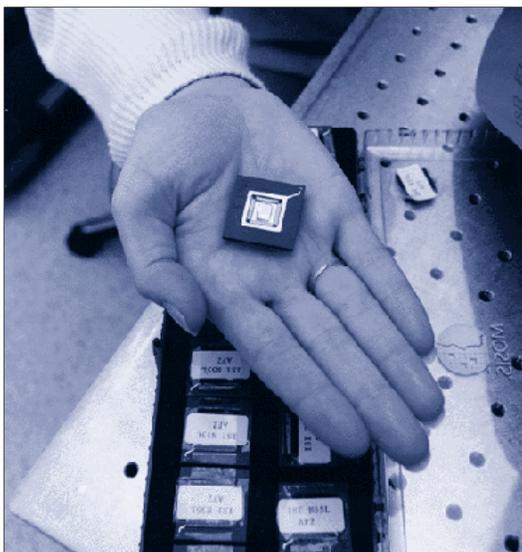
Since the 1970's, when Bell Laboratories first developed CCD, camera and video companies have been seeking to improve the technology. CCD's provide good image quality, but they are expensive, power hungry and bulky with their required accessory chips.

JPL's CMOS APS has many NASA applications, including NASA's need for lightweight imaging systems for interplanetary spacecraft. Photobit Corporation, a spinoff company from JPL formed in early 1995, obtained intellectual property rights to the CMOS APS technology to develop and commercialize this revolutionary solid-state image sensor technology. The company is aiming this technology at new markets where small size and low power consumption are needed, such as digital cameras, personal computer videoconferencing, camcorders and portable personal computer video phones. Photobit has established a strategic alliance with Eastman Kodak for digital cameras.

The automotive industry has also been tapped by Photobit. An international manufacturer of high-

quality automotive products, called Gentex Corporation, entered into an agreement with Photobit for image sensor technology for products, including automotive rear view mirrors that dim in proportion to the amount of headlight glare, trailing vehicle headlights and rear vision systems.

Dental and bone x-rays could also benefit from image sensor technology enhancements, making once costly bone density evaluation technology more affordable for primary physicians, according to David Schick, president and chief executive officer of Schick Technologies, Inc. A developer and manufacturer of digital imaging systems for the dental and medical markets, Schick Technologies is incorporating CMOS APS for medical x-ray products, including bone mineral density measurements. This allows the physician to track the onset of osteoporosis, using less than one-hundredth the dosage of a dental x-ray to the patient.



A second-generation solid state image sensor is creating several expansions on CCD technology.

With dental x-rays, the technology provides the dentist immediate digital feedback of patient dental images with smaller radiation dosage to the patient. In addition, the digital images are easier to store than x-ray film, and they can be manipulated, colorized and enhanced for additional information for the physician to aid and enhance diagnosis and treatment. ✨

For more information, contact Alice Wessen at Jet Propulsion Laboratory's Commercial Technology Office. ☎ 818/354-4930, 📠 818/393-4093, ✉ Alice.S.Wessen@jpl.nasa.gov Please mention you read about it in *Innovation*.

Kids Learn NASA Aeronautics Via the Internet

A NASA PROJECT, CALLED AERO DESIGN TEAM On-line (ADTO), is using the Internet to help students and teachers understand NASA aeronautics and airplane design to apply to their studies and introduce students to vocational opportunities and pursuing high-tech careers. Students and the general public can visit a web site, <http://quest.arc.nasa.gov/aero/>, to find out how aeronautical engineers use airplane models, wind tunnels, supercomputers, simulators and other tools during the airplane design cycle. The project continues through May, although plans are under way to extend it into the summer.

"We're teaching about airplane design through the lives of people who are doing the work," says Susan Lee of NASA's Ames Research Center, Moffett Field, California. "For example, we're following a wind tunnel test of a model of a future supersonic airliner."

In addition, the kids ask questions via e-mail, learn how an airplane flies, view pictures of aircraft and participate in Internet chats with people from teams that design and test airplanes. During Internet chats, youngsters use computers to converse with mentors by typing questions and reading responses and dialogue via the World Wide Web.

Teachers can visit the teachers' "lounge" at the web site. Various educational materials, including aeronautics lesson plans, are located in the lounge. The plans list creative ways to bring the ADTO projects into the classroom. Educators also have Internet

chats with other teachers, describing classroom problems and solutions.

"NASA is providing the web site because the agency has a mandate to help teachers and students understand NASA research in aeronautics. The web site gives knowledge to students that they can apply to their studies," says Ames Educational Group Leader, Garth Hull. "The Internet gives our engineers an effective tool to interact with audiences we normally would not reach. We hope by using this resource, these students will be better prepared to see vocational opportunities and become better informed citizens," he added.

Another segment of the online project will follow the progress of astronauts' training in the largest vertical motion simulator in the world, located at Ames, Lee said. "They are practicing their Shuttle landings with a new simulator program that includes global positioning."

The project is one in a suite of online offerings from NASA's Quest project at the following URL: <http://quest.arc.nasa.gov>. These interactive projects connect students with NASA employees to inspire them to pursue high-tech careers. ✨

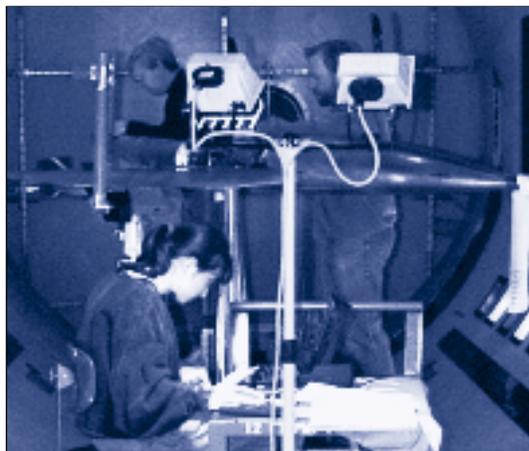
For more information, contact John Bluck at Ames Research Center. ☎ 650/604-5026. ✉ jbluck@mail.arc.com Please mention you read about it in *Innovation*.

Licensing Expands the Use of Solar System Data

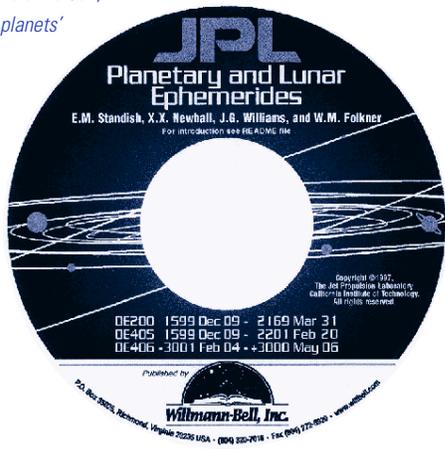
DATA OF OUR SOLAR SYSTEM ARE ONLY A KEY stroke away for space mission planners, navigators, schools, businesses, archaeologists, historians and backyard stargazers with the recently licensed and published Jet Propulsion Laboratory (JPL) Ephemeris compact disc through a contract with Willmann-Bell, Inc. The compact disc contains three different JPL planetary and lunar ephemerides (tables of data listing the positions of planets, moons and related celestial bodies). The data provide the coordinates of the Sun, the Moon and the nine planets, within 25 meters of any planet, for any time between February 23, 3000 BC, to May 6, 3000 AD.

The JPL Ephemeris is considered the standard. In the early 1960's, JPL assumed the task of navigating

The Aero Design Team On-line (ADTO) helps kids understand aeronautics and airplane design.



The JPL Ephemeris compact disc, commercially available now, accurately lists the Sun, Moon and planets' positions between February 23, 3000 BC, to May 6, 3000 AD.



U.S. spacecraft to the Moon and planets and initiated a program for developing a highly accurate ephemeris. The program still exists today and continues to be improved as newer and more accurate observational data become available. With the JPL Ephemeris, the amount of user involvement can vary considerably, from gaining simple access to the Internet's "Horizon" system, to finding the direction and phase of the Moon, to using the compact disc to compute radar range and study eclipses.

The JPL Ephemeris can be used in schools and businesses. It provides convenient access for the U.S. Department of Defense, weather forecasters, consulting firms and deep space or satellite manufacturers. Historians and archaeologists need the highest accuracy available for the dating of key events (eclipses, planetary alignments, and so on) over the previous 5,000 years, as do those in spacecraft mission planning, spacecraft navigating, telescopic predicting (where to point a telescope/antenna or how long to wait until the radar echo returns) and studies of relativity, gravitation and dynamics.

The JPL Ephemeris program has recently been used for several JPL missions, including Galileo, Pathfinder and Cassini. To meet the navigational needs of missions taking spacecraft throughout the solar system, JPL developed highly sophisticated software and voluminous data tables that can predict the position of planets with a great degree of accuracy for any time, past, present or future. One celestial data table in particular, DE200/LE200, has been adopted by most national almanac offices to form the basis of their national ephemerides—in the

NEXT GENERATION INTERNET TESTING BEGINS

Cisco Systems, Inc., of San Jose, California, has signed a memorandum of understanding with NASA to test and demonstrate Next Generation Internet (NGI) hardware and software that could bring Internet speeds of 100 to 1,000 times faster than today's speeds as early as 2002. The software and hardware research and development is a collaboration between NASA's Ames Research Center and five other federal agencies.

Ames is leading NASA's portion of a federal project to develop the NGI. The principal federal agencies involved include the National Science Foundation, the Defense Advanced Research Projects Agency, the U.S. Department of Energy and the National Institutes of Health.

"We want to guarantee levels of service that will eliminate slowdowns and network stagnation that users sometimes have to endure now while waiting for Internet images, movies and other services," Christine Falsetti, NGI Project Manager at Ames, said. According to Falsetti, NASA and other federal agencies will conduct research and development that could interconnect "core sites" with high-speed lines. "Technical advances will spin off from NGI, and industry will put improvements into the 'old' Internet to make it work better and faster," Falsetti said. ✨

For more information, contact Dr. Kenneth Ford at Ames Research Center. ☎ 650/604-3786. Please mention you read about it in *Innovation*.

United States, France, the United Kingdom, Germany, Japan and Russia.

Willmann-Bell worked with JPL's astrophysicist, Dr. Myles Standish. The compact discs are being sold for \$24.95 by Willmann-Bell (<http://willbell.com>) via a contract with JPL. For the more casual user, JPL's interactive web site and telnet service, "Horizons," provides a wide variety of astronomical information (visit the site at <http://ssd.jpl.nasa.gov/>). ✨

For more information, contact Alice Wessen at the Jet Propulsion Laboratory's Commercial Technology Office. ☎ 818/354-4930, 📠 818/393-4093, ✉ Alice.S.Wessen@jpl.nasa.gov Please mention you read about it in *Innovation*.

AEROSPACE TECHNOLOGY DEVELOPMENT

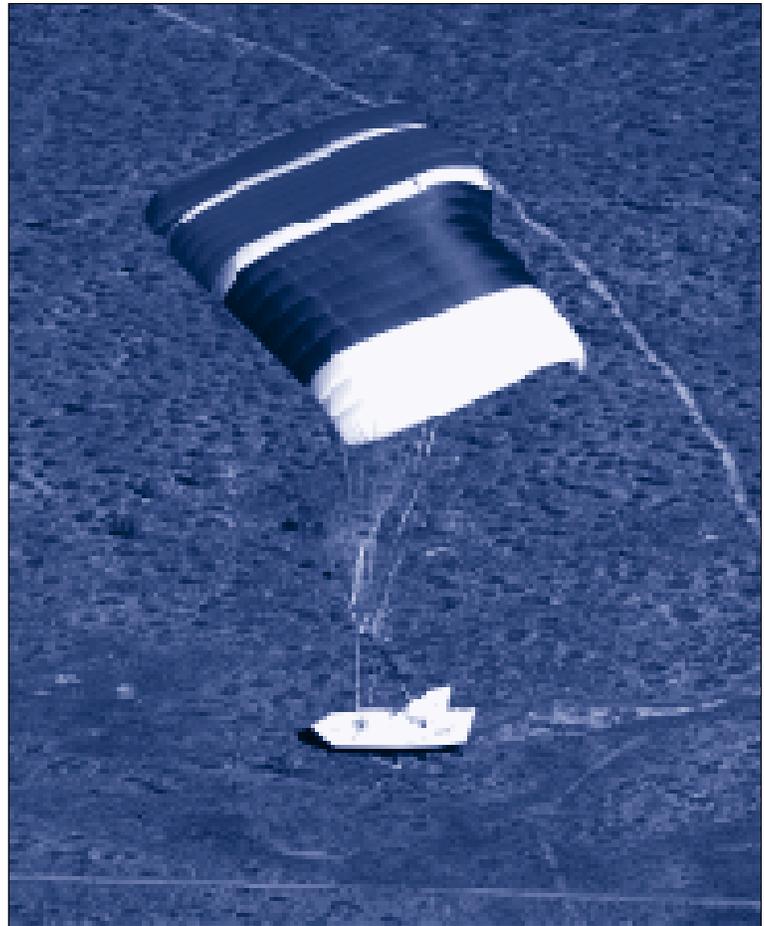
Lifeboat Flies Through Test

THE DEVELOPMENT OF the X-38, an innovative new spacecraft design planned for use as a future International Space Station emergency crew return “lifeboat,” recently passed a major milestone with a successful first unpiloted flight test. The first X-38 atmospheric test vehicle was dropped from under the wing of NASA’s B-52 aircraft at the Dryden Flight Research Center, Edwards, California, and completed a descent from a 23,000-foot altitude in 38 minutes.

“This was a real experimental flight test and the culmination of two years of hard work by a team from Johnson Space Center and Dryden Flight Research Center,” X-38 project manager John Muratore said. “We had done everything we could to minimize the unknowns. But the real proof of the concept is a successful flight. We got one of those now, and we plan to do this about 20 more times over the next two years to prove we’re ready to fly from space.”

Atmospheric drop tests of the X-38 will continue using three increasingly complex test vehicles. The drop tests will increase in altitude to 50,000 feet and include longer flight times for the test craft prior to deployment of the parafoil. In 2000, an unpiloted space test vehicle is planned to be deployed from a Space Shuttle and descend to a landing. The X-38 crew return vehicle is targeted to begin operations aboard the International Space Station in 2003.

Once operational, the X-38 will become the first new human spacecraft designed to return humans from orbit and is being developed at a fraction of the cost of past human space vehicles. The primary application of the new spacecraft would be as an



The first free flight of the X-38, the “lifeboat” for the future International Space Station.

International Space Station “lifeboat,” but the project also aims at developing a design that could be easily modified for other uses, such as a possible joint U.S. and international human spacecraft that could be launched on expendable rockets as well as the Space Shuttle. The European Space Agency is cooperating with NASA in the current development work, supplying several components for the planned space test vehicle.

The X-38 is being developed with an unprecedented eye toward efficiency. The project is taking advantage of available equipment and already-developed technology for as much as 80 percent of the spacecraft’s design. ✨

For more information, contact James Hartsfield at Johnson Space Center. ☎ 281/483-5111, 📠 281/483-2000. Please mention you read about it in *Innovation*.

First Major X-33 Component Arrives

THE FIRST MAJOR FLIGHT COMPONENT FOR the next generation of NASA's reusable launch vehicles arrived in Palmdale, California, in March, marking the start of an assembly schedule at the Lockheed Martin Skunk Works vehicle assembly facility to ready the X-33 for flight in 18 months. The wedge-shaped X-33 is a subscale prototype technology demonstrator leading to the next generation of commercially developed and operated single-stage-to-orbit vehicles flying after the turn of the century, which could dramatically reduce the cost of putting payloads into space.

The 26-foot-long, 5,500-pound aluminum liquid oxygen tank that will form much of the nose and forward third of the X-33 vehicle arrived by air from the Lockheed Martin Michoud Space Systems facility in New Orleans. "The arrival of the liquid oxygen tank marks the start of an ambitious assembly schedule that will see the X-33 vehicle roll out and begin flight tests within 18 months," Jerry Rising, Lockheed Martin Skunk Works vice president for X-33/VentureStar, said. "This is a significant achievement in making the X-33 vehicle ready for flight, as the liquid oxygen tank is the first major element to be placed into the assembly fixture," added Gene Austin, NASA X-33 program manager.

Assembly of the X-33 vehicle, expected to reduce space payload costs, begins with the delivery of the liquid oxygen tank, which will account for 65 percent of vehicle weight when filled.



The tank, designed to hold more than 181,000 pounds of liquid oxygen, will supply the oxidizer needed to burn the vehicle's fuel, liquid hydrogen. The liquid oxygen tank also plays a key structural role in the X-33. It has a complex, two-lobed structure allowing for a close fit within the vehicle's outer shell. When filled, the tank will account for about 65 percent of total vehicle weight at liftoff.

The liquid oxygen tank design is one of a number of challenging technology areas that are key to the X-33, including the vehicle's two cutting-edge composite liquid hydrogen tanks, two linear aerospike engines, the vehicle's rugged metallic thermal protection system and advanced avionics systems, all of which will be arriving at the Palmdale facility during the coming year. Vehicle assembly is scheduled to be completed in the late spring of 1999, with the first flight, to be launched from Edwards Air Force Base, California, scheduled for July 1999. ✨

For more information, contact Don Amatore at Marshall Space Flight Center.
☎ 256/544-0031, 📠 256/544-3854, ✉ don.amatore@msfc.nasa.gov

Please mention you read about it in *Innovation*.

Space Payload Reduction Research Expanded

TEST OBJECTIVES FOR THE X-34 PROGRAM, expected to lower the cost of putting a pound of payload into space, will be expanded and a second flight vehicle produced as a result of NASA modifying its X-34 contract with Orbital Sciences Corporation, Dulles, Virginia. The second vehicle will provide flexibility in demonstrating various technologies, allowing simultaneous testing of required repetitive flights and significant but time-consuming required changes to the vehicle.

Capable of flying eight times the speed of sound and reaching an altitude of 250,000 feet, the X-34 will demonstrate low-cost reusability, autonomous landing, subsonic flights through inclement weather, safe abort conditions and landing in 20-knot cross winds. The X-34 is a small, reusable technology demonstrator with a single-engine rocket, short wings and a small tail surface. The vehicle is 58.3 feet long, 27.7 feet wide at wing tip and 11.5 feet tall from the bottom of the fuselage to the top of the tail.

LICENSING AND COMMERCIAL VENTURES EXPECTED

The Center for Technology Commercialization (CTC), NASA's Regional Technology Center in the Northeast, is helping commercialize radiation-tolerant technology developed with funding from NASA's Goddard Space Flight Center at the University of New Mexico. CTC is commercializing radiation-tolerant technology as a member of a consortium of participating companies, universities and federal facilities, including the University of New Mexico, Virtual Silicon Technology, Inc., TRW, Aerospace Inc., Goddard Space Flight Center, NASA's Jet Propulsion Laboratory and a commercial foundry. As a result, some significant licensing efforts between the University of New Mexico and commercial companies have occurred, and a new commercial venture is expected to be created.

Radiation-tolerant technology allows radiation tolerance to be designed into electronic chips that can now

be manufactured in commercial, rather than government, foundries dedicated to radiation-hard electronics. NASA and other government agencies will benefit from the availability of this process through commercial semiconductor houses.

This commercialization effort has produced a commercial library of radiation-tolerant cells and a back-end process for qualifying commercially manufactured chips for space flight. This technology is currently under development at Goddard Space Flight Center. The provision of radiation-tolerant electronics to the space community will have a profound effect on the cost and reliability of space electronics. ✨

For more information, contact Dr. Richard Callahan at the Center for Technology Commercialization. ☎ 508/870-0042, ✉ rcallahan@ctc.org Please mention you read about it in *Innovation*.

Testing for the X-34 vehicle's cost-cutting payload objectives has been extended.

In August 1996, NASA entered into a \$50 million contract with Orbital Sciences to design, build and

test-fly the X-34. An additional \$10 million was committed by NASA to be spent in direct support of the X-34 by NASA's field centers and other government agencies. Now the contract has been increased by \$7.7 million to purchase long-lead-time hardware, including a new wing, fuselage, avionics set, hydraulic pump, actuator system and more.

NASA has committed \$2 million more for the government to provide wind tunnel testing, additional testing and analysis, and a second leading-edge thermal protection system. An \$8.5 million option calls for the purchase of shorter lead-time hardware, such as navigation systems, while a \$1.8 million option has been added for the assembly of piece parts into sub-systems, integration and final assembly.

The X-34 is designed to bridge the gap between the earlier Clipper Graham, or DC-XA, subsonic demonstrator vehicle and the larger, more advanced X-33 vehicle. The X-34 will demonstrate key technologies applicable to the development of a future reusable launch vehicle. The overall goal of these vehicle programs is to demonstrate the key technologies needed to dramatically lower the cost of putting a pound of payload into space. ✨

For more information, contact Don Amatore at Marshall Space Flight Center. ☎ 256/544-0031, 📠 256/544-3854, ✉ don.amatore@msfc.nasa.gov Please mention you read about it in *Innovation*.



Purification System Uses Future Technology

A WATER PURIFICATION SYSTEM DEVELOPED for use in future space missions has already found down-to-Earth applications. Micro-Bac International, Inc., of Round Rock, Texas, under a NASA Small Business Innovation Research (SBIR) contract with NASA's Marshall Space Flight Center in Huntsville, Alabama, has developed a phototrophic cell for water purification systems. Phototrophic processes use light as the principle energy source and do not require aeration.

The cell has been used for several industrial applications since the project's completion in September 1995, and it is now marketed as a liquid purification product, called Mega-BacTF™. Thus, less energy is needed than for competitive water treatment systems. The cell was initially developed for use aboard future space stations and inhabited off-Earth colonies on the Moon and beyond.

The cell is exclusively licensed and manufactured by Micro-Bac International, a full-service research and development company that specializes in manufactur-

ing environmentally friendly biological solutions for bioremediation, microbially enhanced oil recovery, wastewater treatment, food processing and animal waste collection systems. The product is an all natural, nonpathogenic, environmentally friendly bacterial solution that does not require special clothing or equipment for treatment. Other treatment processes require the use of goggles, gloves and laboratory coats.

Metabolic processes produce the enzymes necessary for degrading septic wastes and reducing odor. Such processes work on the degradation of fat, oil, fecal material and other biologically derived wastes. They do not require aeration, use sunlight as an energy source and do not generate carbon monoxide or hydrogen sulfide.

The company has successfully used its product in the treatment of municipal wastewater systems, farm ponds and industrial lagoons, as well as in food processing and animal waste collection systems. Other potential applications include septic tanks in individual homes, wastewater facilities at isolated military installations and pools at chemical manufacturing firms.

Micro-Bac International embarked on the project in 1991 to develop a wastewater treatment system for the Controlled Environment Life Support Systems



Purification plant in Brazil.

module for a four-person lunar base. Advanced life support is a critical technology for long-duration human presence in Earth orbit, on the Moon, on Mars or beyond, and wastewater treatment is a key aspect of resource recovery.

This cell represents a new concept in waste treatment, with significant differences from and advantages over existing systems that require oxygen (aerobic) and those that do not (anaerobic), according to Dr. Dennis R. Schneider, Micro-Bac International's vice president for research and development. "It offers flexibility, safety, cost effectiveness and performance," he said. ✨

For more information, contact Bob Lessels at Marshall Space Flight Center.

☎ 256/544-6539, 📠 256/544-3278, ✉ robert.lessels@msfc.nasa.gov

Please mention you read about it in *Innovation*.

Software Virtually Doing Business

A VIRTUAL REALITY software package, developed to support NASA's work on the International Space Station, is opening new worlds of opportunity for businesses on Earth. DRAW Computing of Philadelphia, Pennsylvania, developed the software under a NASA Small Business Innovative Research (SBIR) contract managed by Marshall Space Flight Center in Huntsville, Alabama.

NASA asked for software that would allow it to create virtual reality simulations to facilitate training future crews for the International Space Station. The software's scripting, hardware and graphical user interface (GUI) front-end permitted NASA researchers at Marshall to create complex virtual reality simulations while designing the station's various elements.

The software package is an open platform for Virtual Reality Modeling Language (VRML) 2.0 integration, which allows businesses the ability to have realistic, interactive, moving worlds. It provides the advanced features of VRML 2.0 without all the effort.



NASA ASKED FOR SOFTWARE THAT WOULD ALLOW IT TO CREATE VIRTUAL REALITY SIMULATIONS TO FACILITATE TRAINING FUTURE CREWS FOR THE INTERNATIONAL SPACE STATION.

The software's C++ library brings VRML 2.0 support for any applications and any graphics server. Sample source code is also included; it demonstrates implementations of VRML 2.0 browsers on various graphics layers, including OpenGL. Sample code showing the implementation of the built-in nodes is also provided, as well as a GUI-based Scene Graph Viewer.

With this software, applications can be made to support Java scripting and virtual reality hardware devices. It can also be used as a stand-alone program or as a web browser plug-in. Open Worlds is a fully open system—a set of C++ libraries that can add any level of VRML 2.0 to a client's system. Parsing, scene-graph transversal, routing, scripting, prototyping and external interfaces are provided. Customers can sample built-in nodes, user interfaces and applications or build their own.

Flexible design lets users implement the graphical core of VRML 2.0 with the graphics Application Program Interface (API)/platform of their choice. The software can support such low-level graphical API as OpenGL and high-level scene libraries, such as Optimizer, or interface with the user's

own proprietary layer. Because different applications require different levels of VRML 2.0 support, this software provides separate modules so that the user only needs to purchase the support needed. The option of extending capabilities in the future is provided. ✨

For more information, contact Bob Lessels at Marshall Space Flight Center.

☎ 256/544-6539, 📠 256/544-3278, ✉ robert.lessels@msfc.nasa.gov

Please mention you read about it in *Innovation*.

Marshall, High-Tech Incubator Partner

NASA'S MARSHALL SPACE FLIGHT CENTER has partnered with BizTech of Huntsville, Alabama, to establish an incubator for new, small

NEGOTIABLE PHASE I PROPOSALS SELECTED

NASA has selected 335 of 2,665 research proposals received for negotiation of Phase I contract awards for NASA's Small Business Innovation Research (SBIR) program. SBIR 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 combined award total for the 335 Phase I contracts is expected to be approximately \$23 million. The selected firms will be awarded fixed-price contracts valued up to \$70,000 each to perform a six-month 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 an amount up to \$600,000.

The NASA SBIR Program Management Office is located at Goddard Space Flight Center, Greenbelt, Maryland, with executive oversight by NASA's Office of Aeronautics and Space Transportation Technology at NASA Headquarters, Washington, D.C. Individual SBIR projects are managed by the NASA field centers and the Jet Propulsion Laboratory. A listing of companies can be found at <http://sbir.nasa.gov> ✨

For more information, contact Carl Ray at NASA Headquarters.

📞 202/358-4652, 📠 202/358-3878, ✉️ cray@hq.nasa.gov Please mention you read about it in *Innovation*.

businesses with a high-technology orientation. According to Joanne Randolph, BizTech's administrative director, "the incubator will recruit new clients that have the potential to grow and create jobs. As it prospers, BizTech hopes to use revenues from its clients to become self-sufficient. We require that the businesses which apply to BizTech be technology-oriented, have a viable product or service and have a well-developed business plan. We also feel an essential element in client selection is that the entrepreneur be willing to take advice."

"BizTech also provides an affiliate program for nonresident clients. This is a kind of 'outpatient' approach," Randolph said.

BizTech's mentoring program, which is offered to many successful entrepreneurs and senior business executives who have volunteered to serve on a board of advisors, should benefit clients. Through the mentors' résumés and personal profiles, BizTech matches advisors' expertise with clients' needs. "Through another network," Randolph said, "we can link clients with discounted professional services, such as legal, accounting, financial, training and employment services."

Through its co-sponsorship of the small business incubator, Marshall hopes to foster the establishment and growth of many new high-technology firms in Huntsville and Madison County. Sally Little, director

of Marshall's Technology Transfer Office and a member of BizTech's advisory committee, said, "Our interests in being a part of BizTech involves making NASA-developed technologies available to their clients for potential commercialization, establishing a presence within the incubator to provide on-the-spot assistance, and to help with local economic development. We're excited about the possibilities of this partnership."

Teaming with the Tennessee Valley Authority (TVA), the State of Alabama Department of Economic and Community Development, and the City of Huntsville, Marshall provides matching funds to operate the incubator.

Currently occupying temporary offices at 2111 Clinton Avenue in Huntsville, BizTech will move into its permanent facility in the Calhoun Community College building on Wynn Drive in Huntsville this summer. Eventually, the incubator will have 41,000 square feet of office and light manufacturing space for itself and its clients. The college donated use of the space. Approximately \$2 million will be spent in coming years to expand the facility. ✨

For more information, contact Joanne Randolph at BizTech. 📞 256/830-5930, ext. 201, 📠 256/830-0922. 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*.

Ames Spatial Auditory Display

NASA's Ames Research Center is currently seeking partnerships with industry to further develop the Ames Spatial Auditory Display (ASAD), which was designed especially for multiple communications channels. ASAD places up to five different communication channels at fixed virtual auditory positions about the listener, giving the listener a spatial sense of each channel originating from a unique position outside the head. This audio-communications breakthrough provides a substantial increase of intelligibility and safety in virtually all simultaneous, multichannel applications. The system can be effectively combined with other technologies, can be integrated into existing systems and has the potential for further miniaturization. Potential commercial uses include teleconferencing, emergency communication, inexpensive method of sound separation for video games, virtual reality and interactive multimedia. It also can be used in the broadcasting industry by directors, camera operators and editing personnel covering live events, as well as various other industrial applications. ✨

For more information, contact Phil Herlth, Commercial Technology Office, at Ames Research Center. ☎ 650/604-5761, 📠 650/604-1592. Please mention you read about it in *Innovation*.

Optimized Image Compression (DCTune)

Ames currently seeks to license the DCTune technology to U.S. companies interested in developing commercial applications. Ames has developed DCTune, a computer technology that significantly improves efficiencies in storage and transmission of documents, pictures and videos. This technology is compatible with industry compression standards known as JPEG and MPEG. DCTune can be used as add-on modules of software to existing imaging workstation software or imaging devices or as add-on functions to existing microchip designs. Potential commercial uses include medical applications, such as storage and transmission of x-rays. Other uses include Internet multimedia, still or motion picture editing, digital copiers and scanners, digital facsimile machines and personal communications services. DCTune offers the benefit of control over desired picture quality, desired compression efficiency and optimum compression at given picture quality. ✨

For more information, contact Denice Helwig, Commercial Technology Office, at Ames Research Center. ☎ 650/604-4490, 📠 650/604-1592, ✉ dhelwig@mail.arc.nasa.gov Please mention you read about it in *Innovation*.

Optical Robotic Path Planning System

Ames Research Center's Information Sciences Division is currently seeking companies to license the manufacture of an Optical Robotic Path Planning System to serve existing and expanding applications. An Ames research scientist developed the optical system, which is capable of rapidly producing a potential field map of a bounded two-dimensional region containing a goal location and an arbitrary number of obstacles. The potential field map description of the region can be used by an autonomous mobile robot to guide itself from any location to a goal location while avoiding any obstacles present. Potential commercial applications include incorporating it into mobile robots that must navigate their work environments and into specialized wheelchairs. The system could be useful in hazardous materials handling applications as a complement to remotely controlled robots and could eventually be used in specialized robotic escorts for the blind, helping guide them through unfamiliar physical environments. The planning system offers a fully parallel optical system, real-time updating potential, adaptability to various applications and several other benefits. ✨

For more information, contact Phil Herlth, Commercial Technology Office, at Ames Research Center. ☎ 650/604-5761, 📠 650/604-1592. Please mention you read about it in *Innovation*.

Rigid Insulating Support for Cryogenic Components

Ames also seeks commercial and research partners to develop, test and commercialize a Rigid Insulating Support device that provides rigid support in all directions for typical cryogenic components but transmits minimal heat. The support allows the accurate location of cryogenic components in the presence of large accelerations without needing massive structures that conduct unacceptable amounts of heat to the component. The Rigid Insulating Support is extremely strong and stiff; at the same time, it allows only a tiny amount of heat to flow to the low-temperature component. Potential commercial uses include mounting of coolers and infrared detectors for night-vision systems and support for cryogen tanks for space exploration missions. The temperature can easily be adapted to other temperature ranges, including extremely high temperatures. ✨

For more information, contact Jeanne Stevens at Ames Research Center. ☎ 650/604-0065, 📠 650/604-1592, ✉ jmstevens@mail.arc.nasa.gov Or contact Pat Roach at Ames. ☎ 650/604-3191, 📠 650/604-1094, ✉ proach@mail.arc.nasa.gov Please mention you read about it in *Innovation*.



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.

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

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

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

Marshall Space Flight Center
Selected technological strengths are Materials, Manufacturing, 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
601/688-1914
kirk.sharp@ssc.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

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

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

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

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

Small Business Programs

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

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

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

Ken Dozier
Far West Technology Transfer Center
University of Southern California
213/743-2353

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

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

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

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

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

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

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

NASA ON-LINE

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

