



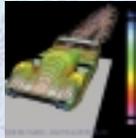
**Industrial Productivity/Manufacturing Technology**



**Environment and Resources Management**



**Consumer/Home/Recreation**



**Computer Technology**



**Health and Medicine**



**Transportation**



**Public Safety**

# 2000 SPINOFF

National Aeronautics and  
Space Administration

# Spinoff 2000

National Aeronautics and Space Administration  
Office of Aerospace Technology  
Commercial Technology Division

Developed by  
Publications and Graphics Department  
NASA Center for AeroSpace Information (CASI)



# Foreword

As we move into the 21<sup>st</sup> century, NASA's ambitious missions will require revolutionary new technologies, and many of these technologies will dramatically improve people's lives here on Earth.

We do not know which future technologies will hold the most promise. We do know that the innovative people at NASA and our partners in the entrepreneurial community will continue to surprise and amaze us, and the products they deliver will continue to make our lives better and safer.

From healthcare and advances in computing to improvements in everyday products, technologies derived from the space program provide incredible benefits to humankind.

There are three core technologies that will be essential to NASA's future success: biotechnology, nanotechnology, and information technology.

When you look through this year's *Spinoff*, you will see a large number of computer technology articles, and I am very pleased to see that. NASA has always been at the leading edge of technological development, and this trend in our technology spinoff program shows that we are still leading the world in innovation.

In addition, I am pleased that more and more of the technologies highlighted in *Spinoff* are resulting from NASA's **Small Business Innovation Research (SBIR)** program. As we widen the net we cast for industrial partners, NASA is able to draw on the full strength of America's diversity to enrich our missions and the innovative genius of America's entrepreneurial community.

The pioneers of the Apollo era led America to the moon, and as we move to the stars and beyond, a new generation of pioneers will lead the way. Many of the tools we develop to take them there will have profound implications for the quality of our lives here on Earth.

*Spinoff 2000* catalogs many of this year's most exciting tools. Every one of us should take pride.



A handwritten signature in black ink that reads "Daniel S. Goldin". The signature is written in a cursive, flowing style.

Daniel S. Goldin  
Administrator  
National Aeronautics and Space Administration

# Introduction

For the past 42 years, NASA has made special efforts to ensure the widest possible dissemination of its research and technology developments. We share the wealth of technology developed for our missions with the nation's industries to contribute to U.S. economic strength and quality of life. For the past 27 years, this publication has provided you with over 1,200 examples of products and services developed as a direct result of commercial partnerships between NASA and the business community. Examples have covered products from fire retardant materials and air pollution monitors to non-invasive cardiac monitors and sensors for environmental control.

Research and development across a broad range of technology disciplines, such as micro-devices, fiber optics, lasers, enhanced imaging, and data communication, have generated technologies applicable to many commercial products we have used for our benefit. The NASA Commercial Technology Network is an excellent vehicle for easy access to use of these technologies. The application of NASA technologies by the private sector increases productivity by contributing to the development of new products and services that meet consumer demands, benefit the national economy, and enhance human health and quality of life.

At the same time, application of NASA technology helps the U.S. meet international competitive challenges and stay at the leading edge of technical innovation. The return benefits—spinoffs—represent a significant dividend to the taxpayer and the nation's investment in aerospace research. *Spinoff 2000* is an instrument of the NASA Commercial Technology program and documents the outcome of our spinoff successes. It is a true measurement of NASA's commitment to transfer as many technologies to the private sector as possible.

In the **Technology Transfer and Outreach** section of *Spinoff 2000*, we highlight the activities of our Ames Research Center's Commercial Technology Office (CTO). Their efforts to facilitate and support technology commercialization are representative of the CTO at each field center. Increased activities to accelerate the dissemination of technologies, speed up the process of patent licensing, quicken the release of software for beta testing, support and manage incubators, and hasten the collaboration with commercial and academic organizations will continue to maximize the earliest potential commercial utilization of NASA's new inventions and technologies.

*Spinoff 2000* is organized into three sections: 1) **Aerospace and Development** highlights major research and development efforts currently carried out at the 10 NASA field centers; 2) **Commercial Benefits—Spinoffs** describes commercially available products and services resulting from the transfer of NASA technology; and 3) **Technology Transfer and Outreach** features this year's center spotlight, NASA's Ames Research Center, and its commercialization efforts, as well as the mechanisms in place nationwide to assist U.S. industry in obtaining, transferring, and applying NASA technology, expertise, and assistance.

We hope that each year *Spinoff* continues to show, through a collage of NASA commercial successes, the breadth of technologies resulting in transferable technology adopted by industry and the mechanisms in place to affect commercialization.

It is with pleasure that we present *Spinoff 2000* to make you aware of our Commercial Technology program. Our efforts will continue to enhance all of our lives and contribute to the economic success of the U.S. industry in a very competitive global environment.



Dr. Robert L. Norwood  
Director, Commercial Technology Division  
National Aeronautics and Space Administration

Spinoff developments highlighted in this publication are based on information provided by secondary users of aerospace technology, individuals, and manufacturing concerns who acknowledge that aerospace technology contributed wholly or in part to development of the product or process described. Publication herein does not constitute NASA endorsement of the product or process, nor confirmation of manufacturers' performance claims related to the particular spinoff development.



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# Aerospace Research and Development

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The research and development efforts encompassed in NASA's Strategic Plan are designed to ensure the continued success and leadership of NASA in scientific and technical advances that are beneficial to the scientific and engineering community of the United States.

Through a network of 10 field centers, managed by NASA Headquarters, NASA pioneers break through technologies and scientific advances that allow the agency to take the next steps in expanding human knowledge of Earth and the universe. Studies into new propulsion mechanisms, next-generation aircraft and spacecraft, robotics, and many other fields not only serve the research community, but private industry as well.

The technologies of the future are being developed today by NASA. They hold the promise to impact private industry and result in commercially developed products and services for the benefit of all. The efforts and activities at each of the NASA field centers serve to maintain our economy's global leadership and better the lives of people everywhere.



# NASA Headquarters

**N**ASA Headquarters is the manager for the agency's multi-pronged mission of scientific research, investigating the far reaches of outer space, and developing new technologies. NASA has evolved into an amalgam of four strategic enterprises to coordinate activities in pursuit of its mission. The enterprises consist of Human Exploration and Development of Space, Space Science, Earth Science, and Aerospace Technology. Each serves as a piece of NASA's puzzle to solve the mysteries of not only outer space, but the world we live in as well.

## **Human Exploration and Development of Space**

NASA's Human Exploration and Development of Space (HEDS) Enterprise includes the International Space Station, Space Shuttle, and Expendable Launch Vehicles programs, as well as Life and Microgravity Science Applications. The mission of the enterprise is to open the space frontier by exploring, using, and enabling space development and to expand the human experience into the far reaches of space.

The Space Station, which will expand our knowledge and help bring the benefits of space to Earth, is a key element of the HEDS Enterprise. Scheduled for completion in the 2005-2006 timeframe, the Station will greatly expand research opportunities, leading to exploration breakthroughs, scientific discoveries, technology development, and new space products. Beginning in Fall 2000, a series of three-person international crews will live aboard the Space Station, assisting with the assembly process and eventually conducting scientific research. When complete, the Space Station will be able to accommodate crews of up to seven people and will have a pressurized volume equivalent to that of a 747 jumbo jet.

The delivery of the U.S. Destiny Lab module, scheduled for launch in early 2001, will enable a full complement of scientific research. Research onboard could provide a better understanding of diseases like cancer, diabetes, and AIDS. By unmasking the effects of gravity, the basic properties of materials can be studied, perhaps yielding products of direct benefit to Earth. The Space Station will also serve as a valuable platform for studying the long-term effects of microgravity on the human body. This international project, the largest peacetime scientific and technological project in history, includes the U.S., Russia, and 14 other nations, who are cooperating on this complex venture. The Space Station will require more than 38 Space Shuttle launches to bring it to completion.

To double Space Shuttle safety by 2005, a series of high-priority safety enhancements are now being studied or are under development. The new "glass cockpit," which first flew in May 2000, features 11



*A NASA astronaut takes a space walk during the Space Shuttle's STS-101 mission to deliver supplies to the International Space Station in preparation for the first inhabitants.*

new full-color, flat-panel display screens, is 75 pounds lighter, and uses less power than before. Additional planned improvements for the Space Shuttle include a next-generation “smart cockpit,” which will build upon the “glass cockpit” upgrade, as well as main engine improvements and new electric generators for the vehicle’s hydraulics. Other proposed enhancements will make steering systems for the solid rockets more reliable, make the manufacturing of solid propellant safer, and increase the strength of external fuel welds.

The HEDS Enterprise has also made great strides towards the commercialization of space. In June 2000, NASA announced an unprecedented partnership with Dreamtime Holdings, Inc., the first commercial partnership of the Space Station era. As part of the agreement, Dreamtime will provide, for the first time, high-definition television coverage of astronaut activities aboard the International Space Station and on Space Shuttle missions. It will also create an easily accessible, web-searchable, digital archive of the best of NASA’s space imagery.

## Space Science

Human beings are players in the greatest drama of all, the story of cosmic origins, evolution, and destiny. Now, for the first time, we truly have the opportunity to seek scientific answers to questions as old as humanity itself: How did the universe begin? How did life on Earth arise? What fate awaits our planet and our species?

We have begun to assemble answers to these grand questions using remarkable new tools on Earth and in space. This is a Golden Age of discovery as exciting and significant as the time when humans turned their first telescopes to the heavens.

The past few years have provided an opportunity to witness faint folds in the fabric of the universe, the most ancient ancestors of all the galaxies, stars, and planets that surround us. Living creatures have been found in extreme environments previously not thought capable of sustaining life—the dark depths of Earth’s oceans and the dry valleys of the Antarctic. Recent studies of meteorites from Mars show evidence of the presence of ancient water and the chemical building blocks of life, and—possibly—tiny, fossilized microbes. Spacecraft have returned images of what may be ice floes above a liquid water ocean on Jupiter’s moon, Europa, leading to speculation that life may begin on moons as well as planets. Discoveries have concluded that the Earth’s climate, biosphere, and the workings of our entire technological civilization are profoundly influenced by the behavior of our varying Sun, a star we can study close-up. Giant black holes have been detected that may be as massive as a billion suns at the center of our galaxy and in other galaxies, turning centuries of theory into fact. Bursts of gamma rays from distant



*Previously unseen details of a mysterious, complex structure within the Carina Nebula.*



## NASA Headquarters *(Continued)*

reaches of space and time have been detected, momentarily more powerful than a million galaxies.

These discoveries have altered our understanding of the universe forever. While much has already been learned, many questions remain. How could an ordered universe emerge from a formless beginning? Is life in our solar system unique to Earth, or might there be evidence of past or present life on other moons and planets? Can we forecast space weather by better understanding the forces that drive our Sun? Will a “Big Crunch” follow the Big Bang, billions of years from now, or will our Universe expand endlessly?

In the decade ahead we have the opportunity to address many of these exciting and engaging issues, developing missions to gain new answers and enrich the story. NASA’s Space Science Enterprise will provide more precise answers to fundamental questions about the formation and evolution of the universe, how the Sun influences the Earth, the history of planets and satellites in our solar system, and the occurrence of life either in our tiny region of space or in the larger neighborhood of our galaxy.

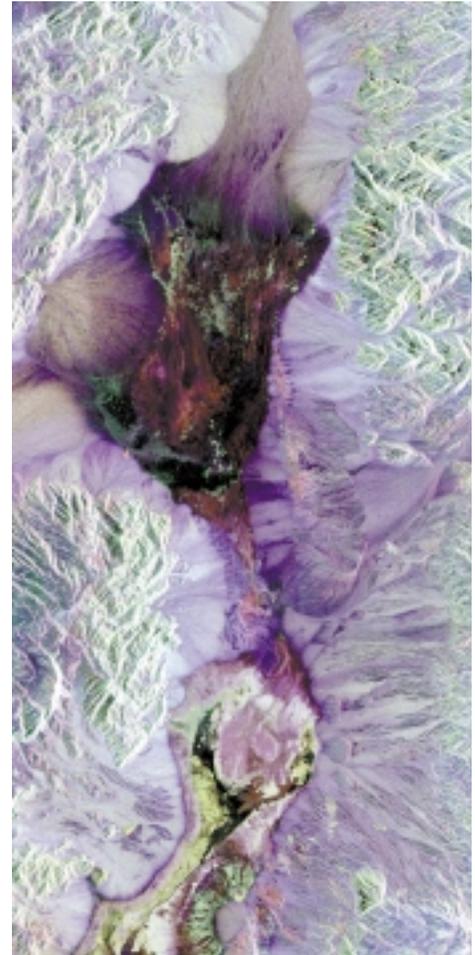
### **Earth Science**

NASA’s Earth Science Enterprise has been organized to better understand the entire Earth system and the effects of natural and human-induced changes on the global environment. To this end, the field of Earth System Science is being pioneered. An emerging interdisciplinary field, this research considers Earth’s land surface, oceans, atmosphere, ice sheets, and life as both dynamic and highly interactive.

The Earth Science Enterprise is structured to study five major Earth System Science areas: land-cover and land-use changes, seasonal-to-interannual climate variability and prediction, natural hazards research and applications, long-term natural climate variability and change research, and atmospheric ozone research.

To comprehend our changing planet, new knowledge and tools for better weather forecasting, urban and land-use planning, agriculture, and other areas that yield both economic and environmental benefit are being sought. Space-, air-, and ground-based platforms are providing the scientific foundation for policies that strive for sustainable development of Earth.

The space agency’s Earth Observing System (EOS) era was initiated with the launch of the Landsat 7, to be followed by the EOS-AM-1. This scientific duo, along with others being readied for orbit, will collect needed data to help answer key questions about Earth. With EOS, changes in land and coastal regions over time can be evaluated. Also, it may be feasible to forecast precipitation a year in advance. Furthermore, by determining the probabilities of floods and droughts, predicting changes in Earth’s climate a decade to a century in advance will be a reasonable expectation. Lastly, plans exist to monitor ozone depletion to determine the effectiveness of efforts to control harmful chemicals. EOS launches will continue into the second decade of the 21<sup>st</sup> century.



*This radar image shows the area of Death Valley, California, and the different surface types in the area.*

A series of lightweight, low-cost science missions dubbed Earth System Science Pathfinders (ESSP) are also being prepared. The first two ESSP missions are scripted, with one designed to make the first global inventory of the world's forests, and the other focused on measuring the variability of Earth's gravity field. As part of NASA's New Millennium program to validate cutting-edge technology, an Earth Orbiter-1 mission will demonstrate an advanced land imaging system with multispectral capabilities. Another technology validation mission is the Space-Readiness Coherent Lidar Experiment to be flown aboard the Space Shuttle in 2001. This experiment will test the ability of a space-based sensor to precisely measure atmospheric winds from the Earth's surface up to a height of 10 miles.

NASA's goals are to predict the weather, climate, and natural disaster with a much higher accuracy and make forecasts on a seasonal and interannual basis.

## **Aerospace Technology**

The Aerospace Technology Enterprise strives to deliver the long-term, high-payoff aerospace technologies that will add value to improve people's quality of life by strengthening the nation's economy, improving the environment, increasing our mobility and safety, and ensuring the continued national security. NASA relies on partners such as the Federal Aviation Administration (FAA), U.S. industry, the Department of Defense, and the university community to help establish requirements, participate in our technology development, and implement those technologies in civil and military air and space transportation products.

The projected increase in the number of air travelers makes the need for improved aviation safety more pressing. The Advanced Subsonic Technology (AST) program aims to reduce the aircraft accident rate. Strategies to achieve this objective include technologies to identify, understand, and correct aircraft system problems before they lead to accidents; technological interventions to address specific accident causes such as human error and weather; and aircraft modifications to minimize injury in the event of an accident.

NASA is committed to helping the aviation community achieve significant reductions in nitrogen oxides and carbon dioxide. Without effective action, carbon dioxide emissions from aviation are projected to increase, with the potential to accelerate climate change. Similarly, aviation-generated nitrogen oxides are a suspected cause of ground-level ozone at airports, a key contributor to air pollution problems in those localities. NASA's goal is to reduce the impact of aviation-related emissions despite the projected increase in aircraft operations.

Moving from runways to the launching pad, NASA is also working to make space travel as safe as today's air travel, moving space travel out of the realm of the extraordinary into the mainstream. Specifically, NASA is working to reduce the risk of crew loss by integrating intelligence into vehicle systems for improved health management and self repair, improving reliability, and using advanced engineering environments to design, test, and verify the entire vehicle system and mission, before the first piece of hardware is cut. Safe space travel will not only help make space accessible to all, but enhance the development of the commercial space sector.

NASA aims in ten years to reduce the cost of taking payloads to orbit through improved reusable launch vehicle concepts and advanced launch systems and operations. New propulsion systems along with improved materials and structures for lightweight and durable in-space transportation vehicles will open opportunities for near-Earth operations and commercialization. By developing launch capabilities for both medium/heavy and small payloads, NASA will create a true "Highway to Space."

NASA intends to develop and apply cutting-edge technologies that will change the definition of what is possible in aeronautics and aerospace. NASA will increasingly look to fields such as biotechnology, information technology, and nanotechnology, for the ability to create new structures by building them at the molecular level, atom by atom—enabling advanced performance attributes such as self-corrective maintenance, system compensation in emergencies, or even capabilities such as changing shape. Space vehicles can also be enabled by the same technologies. Self-configuring systems, self-repairing skins on a vehicle to "heal" damage from micrometeorites, and intelligent agents that control flight paths or acquisition of scientific data at the spacecraft's destination may become a reality if this objective is realized.

NASA is committed to providing the best possible space and aeronautics program in the world. Through the diversity of its missions and research activities, the agency continues to look forward, building on existing knowledge and anticipating the next challenge the universe has to offer.



# Ames Research Center

**A**mes Research Center conducts critical NASA missions in both aeronautics and space research. However, Ames also plays an even more fundamental role central to the conduct of all NASA missions. Specifically, all agency missions, in both aeronautics and space exploration, require order-of-magnitude forward leaps in many areas of scientific research and technology development. The most critical among the enabling technologies required is that group known collectively as Information Technologies (IT). To ensure that NASA fully exploits this vital and enabling set of tools, Ames, located in the heart of California's Silicon Valley, serves as NASA's Center of Excellence for Information Technology.

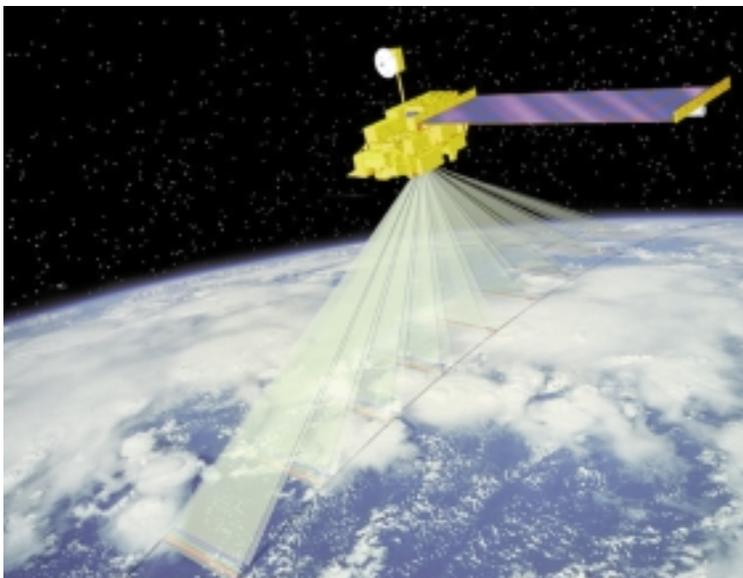
NASA has a long history of leadership in high-performance computing for both scientific and engineering applications. Today, the field of high-performance computing is changing rapidly. On the high end, new architectures are under development that combine the performance gains of massively parallel machines with the flexibility of shared-memory multiprocessor approaches. On the low end, powerful microprocessor-based systems are now performing computations that would have required a specialized supercomputer until very recently. Ames researchers are also playing an important role in developing tomorrow's networking capabilities, up to 1,000 times faster than today's.

The emerging concept of "human-centered computing" represents a significant shift in thinking about information technology in general and about intelligent machines in particular. It embodies a "systems view," in which the interplay between human thought and action and technological systems is understood to be inextricably linked and an equally important aspect of analysis, design, and evaluation. Within this framework, Ames researchers are inventing and deploying sophisticated computational aids designed to amplify human cognitive and perceptual abilities.

The next generation of robotic explorers must exhibit an unprecedented level of autonomy. They will need to be smart, adaptable, curious, and self-reliant in harsh and unpredictable environments. Ames research on automated reasoning for autonomous systems will enable a new generation of spacecraft to do more exploration at a much lower cost than traditional approaches. An impressive example developed

by Ames, the Remote Agent Autonomy Architecture, has already demonstrated its utility during the Deep Space 1 mission.

The projected growth in air traffic over the coming decade will strain already congested management systems. In collaboration with the Federal Aviation Administration (FAA), Ames is developing advanced information technology systems that will play a major role in expanding the capacity of the national (and world's) aviation system. These tools will enable NASA to realize the twin national goals of safer aircraft operation and higher throughput of the airport and ground control infrastructure.



*The satellites in the Earth Observing Systems (EOS) will be laden with sensors to monitor global climate change.*

NASA is responsible for launching and gathering data from progressively more sophisticated orbital and deep space instruments. For example, the Earth Observing System (EOS) is being deployed to monitor global climate change. When fully operational, the sensor-rich satellites will generate about one terabyte of data per day. Equally important is the development of tools aimed at facilitating human understanding of these immense data sets. Emerging results from Ames' IT research is the key to enabling scientists to better understand our world, as well as distant ones.

Future NASA space exploration missions, such as probe and human missions to Mars, pose extremely difficult design and engineering challenges. Early in the design cycle, complex trade-offs between spacecraft characteristics and mission concepts must be performed. Ames IT researchers are making it possible for geographically distributed teams of experts to perform these trade-offs working together — in a virtual environment or so-called “collaboratory.”

In the area of space research, Ames is NASA's lead center for astrobiology, the study of the origin, evolution, distribution, and destiny of life in the universe. In this capacity, Ames develops science and technology requirements for current and future flight missions relevant to astrobiology research. Ames also leads NASA in information technology applications and astrobiology education and outreach programs that inform and inspire the American public.

Ames scientists conduct basic research, participate in flight missions, and facilitate the participation of the national science community in astrobiology. Ames led in the development of a NASA astrobiology “roadmap” and continues to bring together the science and technology communities to identify research priorities and translate them into appropriate NASA programs, technology challenges, and flight missions. Through its Center for Mars Exploration, Ames is continuing to support planning for future Mars missions.

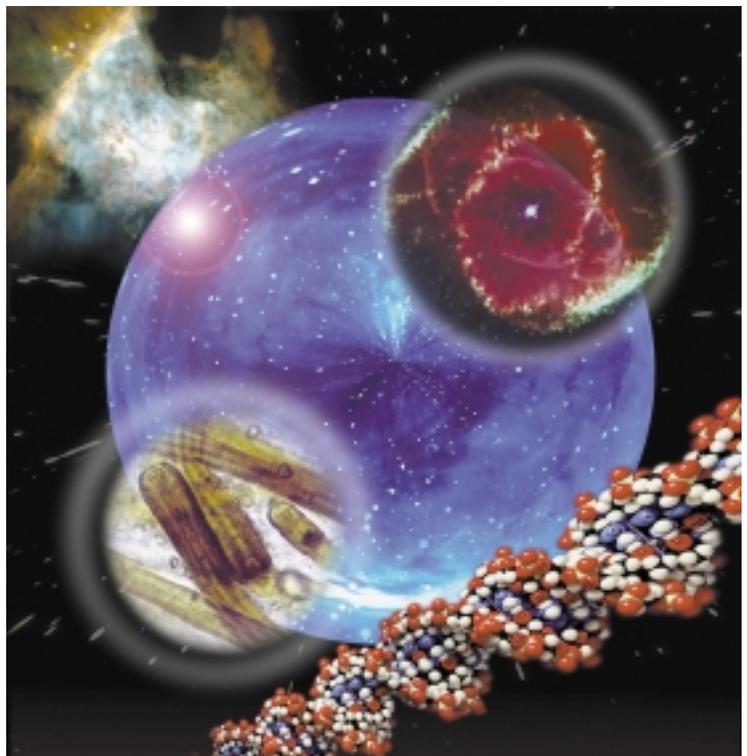
In the area of aeronautics, Ames is NASA's lead center for Aviation Operations Systems (AOS). In this capacity, Ames champions NASA research efforts in air traffic control and human factors; leads agency research in rotorcraft technology; creates design and development process tools; and operates wind tunnel and simulation facilities. AOS encompasses those ground, satellite and aircraft systems, and human operators that control the operational safety, efficiency, and capacity of aircraft operation in the airspace and airports.

In December 1999, Ames opened FutureFlight Central, the world's first virtual airport control tower. Constructed at a cost of \$10 million, the two-story facility was jointly funded by NASA and the FAA. FutureFlight Central will permit integration of tomorrow's technologies in a risk-free simulation of any airport, airfield, and tower-cab environment. The facility provides an opportunity for airlines and airports to mitigate passenger delays by fine-tuning airport hub operations, gate management, ramp-movement procedures, and various other airport improvements.

The facility's tower cab provides a three-dimensional visual model of an airport which can be viewed out of the tower cab's 360-degree windows in stunningly realistic detail. It is anticipated that airport and airline management and researchers will want to look primarily at the feasibility, safety and reliability, and cost benefits of technologies prior to incorporating them into airports.

Through its leadership roles in AOS and astrobiology, and through its Center of Excellence responsibility for Information Technology, Ames is playing a fundamental and crucial role within NASA, central to agency programs and success throughout the foreseeable future.

*Astrobiology, the study of life in the universe, will hinge on future advancements in information technology.*





# Dryden Flight Research Center

In the western Mojave Desert of California, NASA evaluates cutting-edge aircraft and aeronautical developments, along with the atmospheric flight characteristics of future space vehicles, in relentless pursuit of aerospace technology breakthroughs at the NASA Dryden Flight Research Center. NASA's earth science aircraft call Dryden their home, that is, when they are not ranging the globe in pursuit of environmental data to expand the body of knowledge about the evolving Earth. Located at Edwards, California, Dryden's charter is to research, develop, verify, and transfer advanced aeronautics, space, and related technologies. Dryden also supports the Space Shuttle program as a back-up landing site and as the facility for testing and validating design concepts and systems used in the orbiters.

Co-located with Edwards Air Force Base at the edge of vast Rogers Dry Lake, Dryden's legacy reaches back to its role in developing the first aircraft to break the sound barrier, the X-1. Dryden has a long, storied history in aeronautics research and testing. Today, Dryden works to expand the envelope in aeronautics with projects including the ongoing X-Planes, Revolutionary Concepts (RevCon), Environmental Research and Sensor Technology (ERAST), and Airborne Science. Vast test ranges over the desert and the presence of the huge omnidirectional landing field provided by Rogers Dry Lake, coupled with a flying schedule that can count on 345 days of good weather a year, make Dryden the ideal site for this exciting work.

The Hyper-X program is a joint project between Dryden and Langley Research Center to develop an unpowered research aircraft, the X-43A, which can fly up to 10 times the speed of sound. The first of three X-43As is expected to reach Mach 7 this year. The current series of X-Planes includes the X-33, X-34, X-37, X-38, X-43, and X-45. The X-38 project is providing technology for an emergency crew return vehicle, or "lifeboat," for crews aboard the International Space Station. The X-38 is poised to become the first new human spacecraft design in two decades. It is an economical concept, building upon atmospheric lifting body technology proven in the X-24A program in the 1960s.

The X-38 prototype vehicle No. 132 completed its longest, highest, and fastest test flight in March 2000 when it was released from a B-52 carrier aircraft at 39,000 feet over Dryden. Simulating re-entry from space, the X-38 was slowed from 500 miles an hour to 70 miles an hour by a 60-foot parachute. A 5,500-square foot parafoil, using a new design, then performed a phased unreefing, or opening, that culminated in a smooth touchdown squarely on the targeted landing spot on Rogers Dry Lake. This milestone mission also gave engineers their first test of the X-38's automatic flight control software, which performed flawlessly.



*The X-38 with its parachute deployed after a successful flight test in the California desert.*

Most of the new X-Planes are part of NASA's goal to develop reusable launch vehicles (RLVs) for low-earth orbits at a reduced cost per payload pound. Dryden is testing these vehicles to collect data and evaluate their characteristics and capabilities, especially during the atmospheric portions of their flights.

The RevCon program seeks to accelerate the development of revolutionary aeronautical concepts. RevCon, a program of the NASA Office of Aerospace Technology, with input from the Langley, Ames, and Glenn research centers, will prove its various revolutionary concepts in the skies over Dryden. To give the RevCon adventure a running start, three projects were identified for first emphasis. These Quick Start projects include:

- *Autonomous Formation Flight (AFF)*: A quest to fly aircraft in close formation, using autonomous flight control to maintain precise positions that may result in significant fuel savings for the aircraft following the leader by taking advantage of wake conditions conducive to fuel economy.
- *Blended Wing Body-Low-Speed Vehicle (BWB-LSV)*: This scaled version of a possible future transport aircraft will explore technologies intended to permit new efficiencies and carrying capacities by using a design that blends the wing and fuselage of the aircraft.
- *Pulse Detonation Engine (PDE)*: Increased efficiency and fewer moving parts are benefits expected from this radical engine technology. The program at Dryden is intended to demonstrate PDE performance in actual flight conditions, and to establish opportunities for its application.

Nine additional RevCon projects have entered the systems analysis and feasibility study phase. Preliminary evaluation of the nine projects will be completed in May 2001. From these nine, some may be selected for further development.

Another aeronautics goal of NASA is to develop the technology for a family of remotely or autonomously operated uninhabited aerial vehicles (UAVs). UAVs can be effective for long-duration earth science and environmental missions at high altitudes. Aircraft developed under the project have achieved an unofficial altitude record of 60,200 feet for single-engine, propeller-driven craft, as well as a world record for both propeller-driven and solar-powered aircraft of 80,201 feet.

Two goals have been set for the solar-powered Helios Prototype aircraft, one of several ERAST designs. The Helios Prototype is scheduled to reach 100,000 feet in 2001 and remain aloft for four days by 2003. The key to meeting the endurance goal is development of an energy storage system using a regenerative fuel cell that would allow an aircraft like Helios to fly for up to six months at a time. This developing fuel cell technology could have wide applications.

Dryden is also the operations base for the Airborne Science program for NASA researchers, as well as other government agencies, the academic community, and private industry. Three planes are used for this research: two ER-2 variants of the U-2 and a DC-8 jet transport. The ER-2s carry high altitude experiments, while the DC-8 flying laboratory is used for sensor development, satellite sensor verification, and basic research about the Earth's surface and atmosphere.

Dryden Flight Research Center has grown substantially since its beginnings in 1946 as a group of five engineers. As it has grown so has its mission, while never straying from the core focus on aeronautics and flight. As NASA moves forward with a new generation of flight vehicles, Dryden will play a crucial role in developing new ideas for air travel and testing those ideas to see if they will fly.



*The cockpit of the ER-2, one of the planes used in NASA's Airborne Science Program.*



# Glenn Research Center

As NASA's Center of Excellence in turbomachinery, Glenn Research Center, located in Cleveland, Ohio, is responsible for developing technologies applicable to fans, pumps, compressors, turbines, and air-breathing propulsion needed to propel NASA into the next century. Additional research activities in power generation, propulsion, and communications make Glenn a very busy place these days. With support roles in aviation safety, the International Space Station, microgravity research, and advanced space transportation, Glenn has a hand in practically all of NASA's research and development activities.



*Flywheel technology offers an alternative energy source with the potential to replace chemical batteries.*

A recent breakthrough at Glenn in power generation systems may find its way to the Space Station. In March 2000, researchers at Glenn in collaboration with industry partners, announced that they had achieved full-speed operation at 60,000 revolutions per minute of a flywheel energy storage system. This achievement, the highest speed ever demonstrated for a flywheel spun on magnetic bearings, makes flywheel technology a viable candidate for replacing chemical batteries on the Space Station. Flywheel energy sources have a longer life expectancy than chemical batteries, are more efficient, provide more power, and operate over a wider temperature range.

Glenn's propulsion research, in cooperation with NASA's Jet Propulsion Laboratory, was recognized with *Discover's* Award for Technology Innovation in 1999 for the ion propulsion system used on Deep Space 1. The award went to NASA's Solar Electric Propulsion Technology Application Readiness (NSTAR) program team, a partnership formed in the early 1990s between JPL and Glenn. Test results from research on Glenn-built xenon ion engines for use on deep space missions were used to refine the design for the flight hardware for Deep Space 1. Ion drives provide 10 times more thrust per pound of fuel than liquid or solid fuel engines. Researchers believe ion engines will open the door to future deep space and Earth-orbiting missions that are otherwise impractical or too costly using conventional propulsion methods.

While looking to advance space flight, researchers at Glenn are never far removed from working on ways to make aviation safer. Glenn's newest addition is its ballistic impact test facility. The

facility features a 40-foot-long gas gun that ejects projectiles at speeds in excess of 1000 miles per hour and a high-speed camera that can capture 2.5 million images per second. The facility's main task will be to test the ability of new, lighter airplane engine housings to withstand high-speed impacts with hail or birds that can occur during flight and damage the engine or, worse, cause the engine to separate from the wing of the airplane. Similar research over the last 20 years at Glenn contributed to proving the worth of ballistic materials used today in jet engines as well as in bulletproof vests.

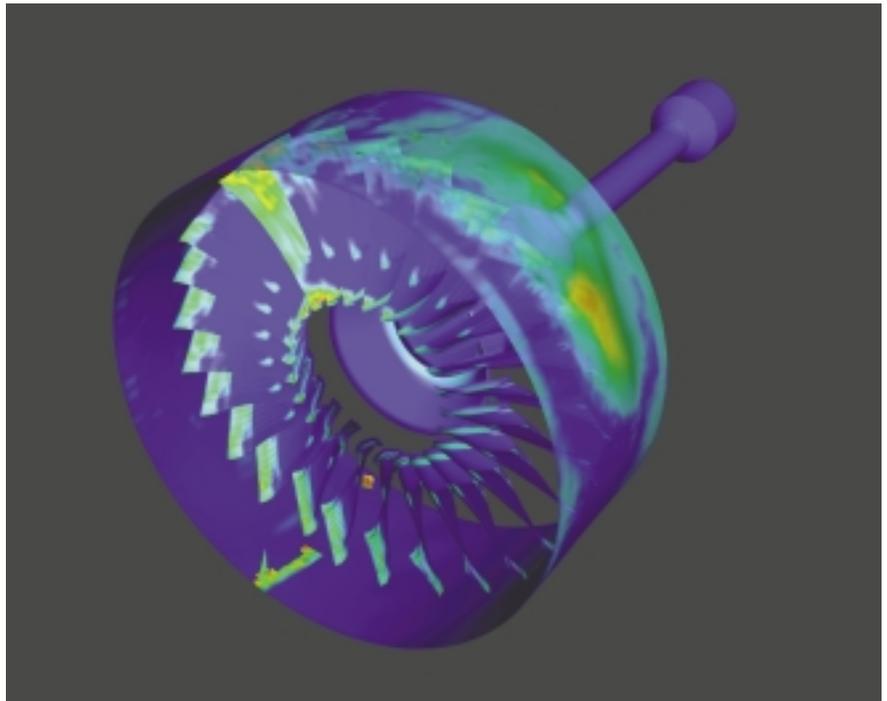
In addition to making aircraft safer, Glenn researchers are exploring new technologies to design advanced turbine engines. To achieve these state-of-the-art engines, Glenn has performed research in a variety of disciplines, including new high-temperature materials, coating and lubrication systems, flow physics and heat transfer, and combustion physics.

Other research activity at Glenn has taken on a unique perspective. As part of its efforts under the turbomachinery and combustion technology program, Glenn has been working on a “smart green engine,” with the principal aim of developing technologies to minimize all environmentally harmful engine emissions, such as nitrous oxide, carbon dioxide, aerosols, and particulates. A key to accomplishing the program’s goals is the creation of low-fuel-burn, low-emissions flight. Currently Glenn is pursuing a number of technologies to attain this goal, including magnetic bearing suspension, active combustion controls, computational fluid dynamics tools and models, and coolant flow management.

The year 2000 marks the completion of Glenn’s seven years of technology verification experiments for the Advanced Communications Technology Satellite (ACTS). ACTS explored the possibility of using the previously untapped high frequency Ka-band technology for satellite communications. The goal was to relieve orbital crowding and demonstrate a wide-band frequency capable of carrying simultaneous services at optical fiber rates. After 81 months of operation, far in excess of the intended 24-month mission, the knowledge gained from ACTS achieved remarkable milestones with 103 experiments, paving the way for the next generation of communications satellites. Launched in 1993, ACTS has been yet another step in Glenn’s long history of developing advanced communications technology.

Glenn is also active in researching new materials for use in a wide array of applications from heavy industry to space missions. Last December, some of Glenn’s knowledge in material design was taken up to the Hubble Space Telescope during the last servicing mission. Following a previous servicing mission, NASA scientists became aware of cracks in Hubble’s multilayer insulation blankets, which protect equipment from temperature extremes when the telescope moves in and out of Earth’s shadow. A review board of Glenn and Goddard Space Flight engineers evaluated 100 potential replacement materials by subjecting them to space environmental simulations equivalent to 10 years in low Earth orbit. The team selected the same material as before, but with modifications to retard crack growth and help keep the outer layer in place even as it becomes brittle. The new blanket material was added to Hubble and is expected to last for the remaining life of the mission, until 2010.

The research at Glenn exemplifies the diversity of NASA’s knowledge and interests. In the not too distant future, the results of the work at Glenn will open new worlds and possibilities for space missions and travel, enhance communication systems, and improve the quality and safety of terrestrial aviation.



*Data captured from a turbine shows the deformation that occurs when a blade is out.*



# Goddard Space Flight Center

Located in Greenbelt, Maryland, NASA's Goddard Space Flight Center was established in 1959. The center was named after rocket research pioneer Dr. Robert H. Goddard. Since its inception, Goddard has played a major role in space and Earth science. The center is involved in implementing suborbital programs as well, using aircraft, balloons, and sounding rockets. This function is located at the Wallops Flight Facility on Wallops Island, Virginia.

In the realm of astronomy, a spectacular morning launch of the Space Shuttle Discovery ten years ago, on April 24, 1990, ushered in a new golden age in star gazing. The payload in Discovery's cargo bay, NASA's Hubble Space Telescope, was released by the crew into Earth orbit the next day and the universe has not looked the same since.

On Earth, the Goddard team is made up of some of the world's premier scientists and engineers devoted to research in Earth science, space science, technology, and space communications. Goddard's fundamental mission is to expand our knowledge of the Earth and its environment, the solar system, and the universe through observations from space.

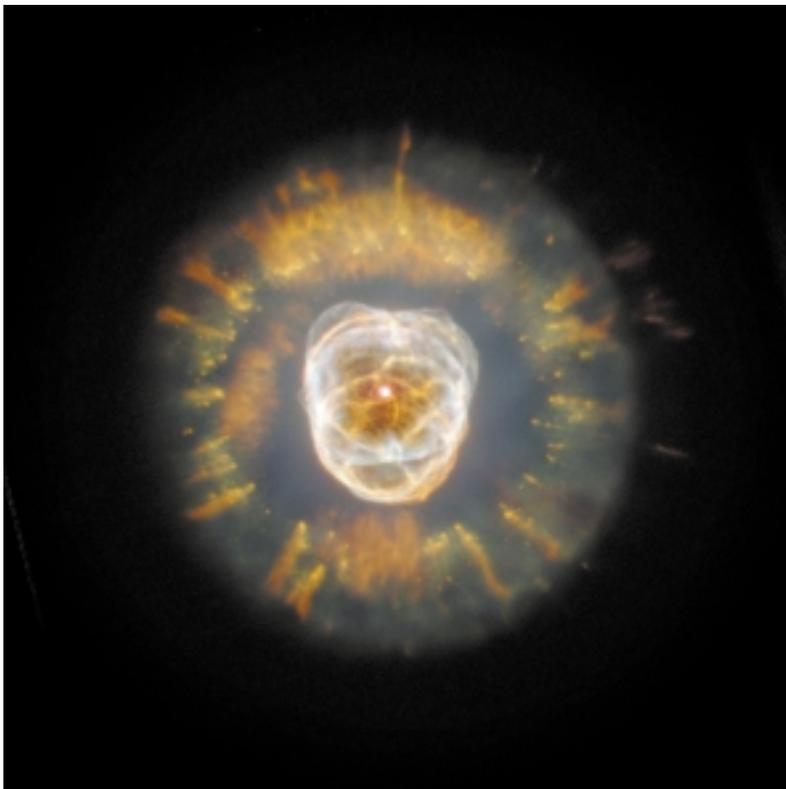
Recent missions, like the Solar and Heliospheric Observatory (SOHO), with its scientific and operational nerve center at Goddard, continue to reveal surprising new details about the Sun's complex behavior. SOHO, a joint mission by NASA and the European Space Agency, has already found hot, electrically-charged gas, called

plasma, flowing like a river beneath the Sun's surface. It has also helped scientists solve a mystery about why the Sun's high-speed solar wind travels twice as fast as theory predicts, showing that the solar wind "surfs" magnetic waves in the Sun's outer atmosphere.

The Advanced Composition Explorer (ACE) spacecraft has become the world's primary sampler of extraterrestrial matter. Goddard's Transition Region and Coronal Explorer (TRACE) spacecraft has revealed frictional forces in the Sun's outer layer, or corona, that are hundreds of times stronger than expected. This friction, or viscosity, may help explain why the corona is more than 100 times hotter than the Sun's surface.

Since the first days of observing Earth from space in the early 1960s, NASA and Goddard have been pioneers in helping scientists, policymakers, and the general public gain a better understanding of how Earth's land, atmosphere, oceans, and life interact with each other.

The most extensive archive of images of Earth—nearly four million of them—originates from a series of orbiting, Goddard-managed



*The Hubble Space Telescope has spied a giant celestial "eye," known as planetary nebula NGC 6751.*

satellites called Landsats. This archive is an invaluable record of changes in the land surfaces of Earth, from natural causes like volcanic eruptions to accelerating human development of urban areas, where more than 60 percent of the world's population will live by the year 2025. Landsat data has been used for everything from agricultural planning, real estate forecasts, forestry management, and mapmaking to oil exploration and airline pilot training.

The successful launch of the Landsat-7 mission in April 1999 was another major step forward in our investigation of Earth's land surfaces. Operated under the joint leadership of Goddard and the U.S. Geological Survey, a key feature of this program is the decrease in costs for images. This is making the information more easily accessible to a wider range of users.

Recent successes in measuring and modeling rainfall patterns and biological properties of the land surface, as well as important ocean studies, are the building blocks for more precise 14-day weather predictions and projections of biosphere changes.

The Tropical Rainfall Measuring Mission (TRMM), launched in 1997, is providing new insights into how and where rainfall occurs during El Niño and La Niña events. These extreme weather patterns, which occur every three to five years, have far-reaching effects on people and property. In addition, incorporation of weather pattern data into global predictive models improves their predictive capabilities. Rainfall estimates by Goddard scientists are growing much more precise. Information from TRMM has significantly improved hurricane track predictions, and the NASA Seasonal Interannual Prediction Project is developing techniques to use satellite observations of the ocean and land surface to improve predictions of El Niño and its impact on North America.

Future Goddard-sponsored missions will include the Swift Gamma Ray Burst Explorer, to be launched in 2003. Swift will be a three-telescope space observatory for studying gamma ray bursts. Although gamma ray bursts are the largest known explosions in the universe, outshining the rest of the universe when they explode in distant galaxies, the underlying cause of the explosions is an astrophysical mystery. Swift will have the unique ability to rotate in orbit and point its gamma ray telescope, X-ray telescope, and ultraviolet/optical telescope at gamma ray bursts within minutes of a burst's first appearance. Because gamma ray bursts are believed to originate billions of light years away, Swift will use these sources as a beacon to probe distant regions of the universe.

Also among Goddard's upcoming telescopes is the Next-Generation Space Telescope (NGST), set to be launched in 2009. NGST represents challenges on numerous engineering fronts, from light-weight structures to multi-segmented, deployable mirrors. The powerful NGST will be built to see objects 400 times fainter than those currently studied with larger ground-based infrared telescopes or their spaceborne counterparts. Moreover, NGST will study objects with the image sharpness achieved by the Hubble Space Telescope.

Whether making fascinating discoveries about the Sun's corona and how it affects our planet and the solar system, designing new ways of understanding the Earth's complex atmosphere and biosphere, or revolutionizing how we see the universe, Goddard is expanding the scientific knowledge that is enhancing our lives.



*The Atlas IIAS expendable launch vehicle with the Solar Heliospheric Observatory (SOHO) before launch.*



# Jet Propulsion Laboratory

In the mountains above Pasadena, California, is the Jet Propulsion Laboratory (JPL), NASA's lead center for the robotic exploration of the solar system. Knowledge gained in such fabled missions as Voyager, Galileo, and the Mars Pathfinder has led to an exciting future in space. JPL director Dr. Edward Stone has projected this future as a time to send probes into deep space for detailed exploration and, in some cases, to return samples to Earth. At the dawn of the 21<sup>st</sup> century, innovative scientists and engineers at JPL are creating the missions that will bring our space neighborhood closer.

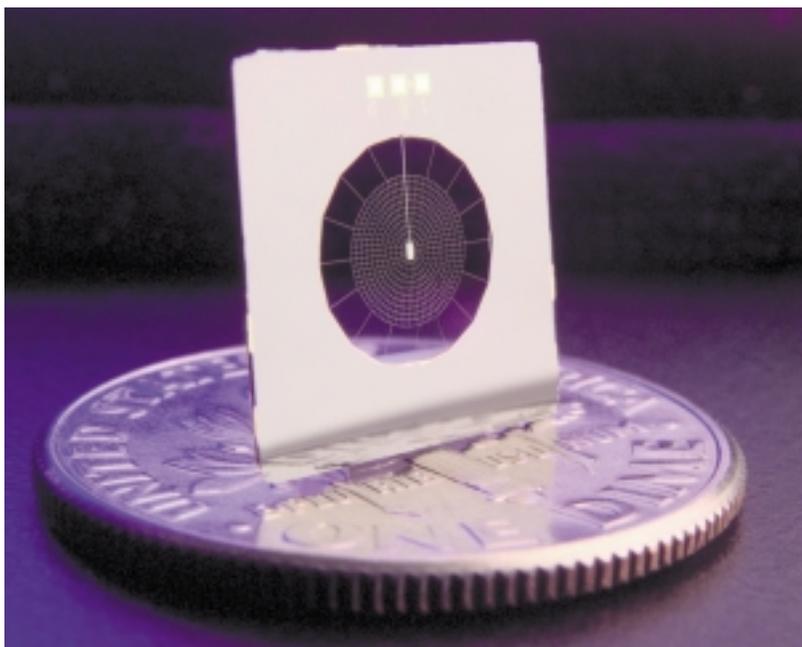
In addition, JPL manages the worldwide Deep Space Network, which communicates with spacecraft and conducts scientific investigations from its complexes in California's Mojave Desert near Goldstone; near Madrid, Spain; and near Canberra, Australia. JPL is NASA's Center of Excellence in deep space systems. Managed by the California Institute of Technology for NASA, JPL is also a leader in the space agency's Space Science Enterprise.

Almost 30 years ago, the Mariner 9 spacecraft found evidence that water flowed across the surface in Mar's ancient past. For decades, researchers have debated whether liquid water might have existed on the planet's surface. In what could turn out to be a landmark discovery in the history of Mars, imaging scientists using data from NASA's Mars Global Surveyor spacecraft have recently observed features that suggest there may be current sources of liquid water at or near the surface of the red planet.

This exciting discovery moves the debate to present-day Mars. The new pictures suggest that some of the water that flowed across Mar's surface millions of years ago went underground, and is quite possibly still there. NASA will continue to investigate using the Mars Global Surveyor and in 2001 will launch a scientific orbiter with a high spatial resolution middle-infrared imaging system that will examine the seepage sites in search of evidence of water-related minerals.

At the beginning of the year, the Shuttle Radar Topography Mission, with its science instruments, was launched into space aboard the Space Shuttle Endeavour. With its radar sweeping most of the land surfaces of the Earth, SRTM acquired enough data during 10 days of operation to obtain the most complete near-global high-resolution database of our planet's topography.

In other developments, a tiny sensor has been created that borrows its design from nature's spider webs. The sensors, known as bolometers, can plot a map of cosmic background radiation. JPL bolometers, one hundred times finer than a human hair, allow technologists to capture temperature variations of only 100-millionths of a degree (0.0001) Celsius in just a few seconds of observation. The bolometers are sensitive enough to detect the heat given off by a coffee maker all the way from the Moon. The measurement of temperature



*Tiny bolometers, with a design inspired by spider webs, can be used to detect cosmic radiation which can lead to a better understanding of the history of the universe.*

variations provides a snapshot of the universe when radiation formed about 300,000 years after the Big Bang. Scientists theorize that in the first moments after the Big Bang, the universe went through a period of extreme exponential inflation that could mean the universe was flat. Further study in this exciting field is planned.

JPL scientists have gone back to the garden, “planting” wireless webs of small sensors in gardens here on Earth in preparation for missions to help monitor biological activity on planets. Like satellites and telescopes remotely “measuring” planets across the vast reaches of space, the webs allow large areas to be monitored. Unlike remote operations, sensor webs are placed inside the environment, thus making them capable of on-site detection not possible from afar. For example, satellite measurements cannot penetrate deep below the ocean surface or detect extremely small quantities of gases coming off a planetary surface. The sensor webs could combine the spatial coverage of a satellite with the precision of an on-site instrument. Sensor webs like those being tested will help make possible a key NASA goal to establish a virtual presence for exploration throughout the solar system.

Breakthroughs in ultralight, inflatable materials are helping to lead development of technologies that will show the way to researchers at JPL in their quest to explore the farthest reaches of the universe. Very light, very powerful telescopes will someday peer far into deep space, looking for Earth-like planets

around stars much like our own Sun. Solar-, laser-, and microwave-powered sails weighing less than a paperback book will propel spacecraft through the stars. Robotic rovers with inflatable wheels will explore planets and asteroids and tell us their secrets.

Here on Earth, these same low-cost materials offer potential uses such as portable clean rooms that can be used by one person, perhaps to develop pure drugs; small ultralight devices that can make today’s cellular phones seem like rocks; flexible devices for dispensing drugs such as insulin; and lightweight, easily launched weather and communication satellites—all for a future that requires initiative, innovation, and creativity.



*Small sensors such as the one shown here are being used to prepare for missions to monitor biological activity on other planets.*



# Johnson Space Center

There are probably no words more emblematic of NASA and the space program than “Mission Control.” Johnson Space Center, home to the Mission Control Center for every piloted U.S. space mission, is also NASA’s Center of Excellence for human operations in space. Located in Houston, Texas, Johnson has played a critical role in the Gemini, Apollo, and Skylab projects, as well as today’s Space Shuttle and International Space Station flights.

As the principle center for NASA’s Human Exploration and Development of Space (HEDS) Enterprise, Johnson is focused on researching and developing technologies for the Space Shuttle program, the International Space Station, space operations management, biomedical research, extravehicular activity, robotics, space medicine, and long-range exploration mission planning and design.

As the lead center for the Space Station, Johnson looks forward to continuing to oversee its

assembly. The next big step in the Space Station’s assembly took place in July 2000, with the launch of the Russian-built Zvezda service module on a Russian Proton Rocket. Zvezda will provide early power, propulsion, communications, life support, and living quarters for the station. With Zvezda in place, Johnson will prepare for Shuttle mission STS-106, scheduled for Fall 2000. The crew of STS-106 will transfer supplies to outfit the station in preparation for the first resident crew, scheduled for arrival in the latter part of the year.

Assembly of the station’s more than 100 components will require a combination of human space walks and robot technologies. As a result, refinements are underway at Johnson on a robotic system aimed at assisting spacewalking astronauts. A mechanical hand has been developed that operates comparably to a human hand and can operate tools used by people in spacesuits. With a delicate touch capable of lifting items as small as tweezers, combined with the strength to lift a 21-pound weight, the hand has considerable capabilities in a zero gravity environment. The robotic hand will be part of the Robonaut system, which includes two arms and a swiveling head with cameras inside. NASA has an eye on making use of this robotic system in the future on the Space Station.

Work on the Space Station extends beyond building the actual structure. Johnson is working on assembling the X-38 Crew Return Vehicle, which is intended to serve as an emergency “lifeboat” for the crew of the Space Station. Successful flight tests of the X-38 have been conducted at Dryden Flight Research Center, with more planned for the future. Johnson is to complete assembly of the X-38 in time for a space flight test scheduled for 2002.

*The X-38 is being prepared for a space flight test in 2002. The ship will serve as a “lifeboat” should an emergency occur on the International Space Station.*



Occasionally, the history of the cosmos can be studied without ever leaving Earth. Johnson scientists have been studying the Yukon meteorite that exploded over northwest Canada in January 2000. The 4.5-billion-year-old meteorite may provide insight into the original composition of the solar system before the formation of the planets. As a carbonaceous chondrite, the meteorite is a rare type with many forms of carbon and organics, the basic building blocks of life. Johnson has worked in cooperation with Canada to glean information from the meteorite such as measuring induced radioactivity to determine how much exposure it had to space radiation. From these measurements, the size of the meteoroid from which the meteorite originated can be determined.

As the heart of NASA's space medicine research, it was a natural fit when the Heart Center at Texas Children's Hospital in Houston turned to Johnson for assistance in designing a new echocardiography lab. Because of Johnson's experience in responding to information quickly without technical errors as Mission Control, the Heart Center wanted to capitalize on the technologies and knowledge that enabled NASA to manage complex missions such as a Shuttle flight. The result is a cutting-edge facility that allows for



*A Johnson scientist manipulates the Robonaut system, which includes a mechanical hand capable of moving with dexterity similar to a human.*

integrated training and operation, expandability, operating cost reduction, and better patient diagnosis and care. The main innovation of the lab is a mission control desk modeled after its counterpart in NASA's emergency preparedness center.

The complexity of space travel and human space missions has allowed Johnson to perform research in a wide array of fields. Johnson is developing technologies in disciplines such as automation, biotechnology, computer hardware, energy, environment, advanced materials, medicine, photonics, software, computer hardware, telecommunications, and transportation. With such a diverse background, Johnson will surely continue to serve as the center for NASA's future in space.



*NASA astronauts work to attach a Russian crane to the International Space Station in preparation of future assembly.*



# Kennedy Space Center

Located on Florida's central Atlantic coast, NASA's premier space launch facility, the John F. Kennedy Space Center, is as busy as ever with launches while adding a few new looks at the same time. As NASA's designated Center of Excellence in launch and payload processing systems, Kennedy's primary responsibilities are in acquisition and management of Expendable Launch Vehicle launch services, payload carriers, payload processing, and support. In addition, Kennedy has several other lead and support assignments, many of which are directly related to its areas of excellence.

Space transportation integrates many systems, such as launch and landing of spacecraft, payload processing, vehicle ground processing, range systems, flight vehicle systems, and ground and flight crew training systems. To facilitate this systems approach and provide a strong foundation for achieving the maximum value from the investment in Kennedy's Launch and Payload Processing Systems, Kennedy has established the Spaceport Technology Center. The Spaceport Technology Center will be recognized as the world's preeminent source of information and technologies for systems used to process, launch, land, and recover launch vehicles and payloads from spaceports on the Earth, Moon, Mars, and beyond. Kennedy will benefit from the new Spaceport Technology Center's ability to provide the knowledge, expertise, and facilities to develop, test, and certify the continuous infusion of advanced spaceport technologies required for modern, state-of-the-art spaceport systems.

Part of Kennedy's agenda is to increase safety and reliability and dramatically reduce the cost of access to space. Meeting these goals will require advanced technologies applied in a highly integrated manner to all of the systems operated at Kennedy. Kennedy provides highly complementary, advanced technologies in support of spaceport systems for current and future vehicle launches and landings at spaceports on Earth and other planetary launch and landing sites. Spaceport Technology Development Initiatives cover key technology areas in Fluids and Fluid Systems; Materials Evaluation; Process Engineering; Command, Control, and Monitor Systems; and Range Systems.

In the Fluids and Fluid Systems area, the OmniBot Mobile Base is a project to develop a hazardous duty mobile base as an advanced development test bed to research alternate technical approaches for remotely controlled operations in hazardous areas. In addition, this base will be used to test various automated umbilical technologies for autonomous mobile vehicles. In hazardous environments where it is

too dangerous to send in unprotected personnel, a mobile base could be used to perform remote inspections, site surveys, and operations. The OmniBot has been selected to be the motion platform for the Mars Umbilical Technology Demonstrator project.

In the Command, Control, and Monitor Systems area, Kennedy's Navigation and Landing Aids Laboratory was created initially to support the Space Shuttle program's requirement to certify the



*The OmniBot Mobile Base can be used in hazardous environments to perform remote inspections, site surveys, and operations.*

*Wheat plants growing “gray water” in a growth chamber as part of waste water processing tests for the Advanced Life Support program.*



accuracy of the navigation systems the orbiter uses to find and land at designated sites. This effort led the laboratory to develop Global Positioning System (GPS) applications, like the X-34 Reusable Launch Vehicle’s ground-based Differential GPS and other research and development projects for the Kennedy Weather Office. The Navigation and Landing

Aids Laboratory is responsible for the design of the system hardware and software, fabrication of the workstations, and the test and implementation of the Flight Inspection System for the flight checks at Continental United States (CONUS) and Transatlantic Abort Landing (TAL) landing sites.

Environmental leadership is a guiding principle at Kennedy. The center is located on the Merritt Island National Wildlife Refuge, where the sensitive ecosystem supports many threatened and endangered species of flora and fauna, as well as many wildlife species. Operational requirements must be planned and conducted to minimize the impact to the surrounding environment. To this end, process improvements are continually sought that demonstrate environmental stewardship. For example, less toxic materials are substituted to reduce human exposure health risks and the amount and type of hazardous waste produced. Technologies are also developed to improve the environment, such as cleaning up contaminated groundwater more efficiently or reducing air pollution from point sources.

The Life Sciences Research and Technology Development is focused on establishing excellence in understanding and managing biological and ecological systems for applications in space and on Earth. Developing the biological systems for life support during long-duration space flights is a research effort in bioregenerative life support systems that is divided into two areas. One involves the development of crop systems and the study of plants for the removal of carbon dioxide and the production of oxygen, water, and food for the crew. This effort also develops and evaluates newly constructed plant flight hardware to optimize the experimental systems and determine the biocompatibility of the flight hardware. The other area investigates resource recovery systems, primarily microbial bioreactors, to determine the capacity to recycle water and solid waste. The ecological systems effort utilizes the unique characteristics of the center’s ecology. The ecological effort maintains a comprehensive database that includes air and water quality measurements; vegetation maps; wildlife distribution and population dynamics; structural and functional data on selected habitats and communities; predictive habitat suitability modes; and the effects that certain environmental factors such as fire, water level, and salinity have on habitat sustainability.

The combination of pressures to achieve successful space launches while maintaining the integrity of the fragile environment around it, has pushed Kennedy into new fields of study and research. As Kennedy pushes forward into the 21<sup>st</sup> century, it is poised to bring us new knowledge not only about outer space, but our own world as well.



# Langley Research Center

With an eye to the sky, Langley Research Center is working to reduce frustrating air travel delays, and increase the safety and performance of civilian and military aircraft. Langley also has satellite “eyes” in the sky with its atmospheric science instruments and programs to help us better understand our environment. It is the NASA Center for Excellence in structures and materials and has a lead role in airframe systems.

In addition, Langley plays an increasingly large role in supporting the nation’s space programs by developing revolutionary technologies for affordable, advanced, space transportation systems, as well as small spacecraft and instruments. This research includes spaceframe technologies that are synergistic with the center’s airframe systems capabilities. Langley’s unique research facilities, located in Hampton, Virginia, include more than 20 operational wind tunnels, an indication of the center’s dedication to advancing and improving aerospace research.

Tapping into a wealth of knowledge and resources in structures and materials, Langley has provided research support to the Reusable Launch Vehicle Program. Langley has performed research on cryogenic propellant tanks, composite structures, metallic and composite thermal protection systems, vehicle systems analysis, aerodynamic testing and analysis, and flight controls. Additionally, Langley has been the site of extensive wind tunnel tests of the X-37, the first orbital experimental vehicle to be lifted to orbit on the Space Shuttle and returned to Earth under its own power.

Langley researchers are developing the technologies to enable aircraft to fly faster, farther, safer, and quieter, while making them less expensive to manufacture, more energy efficient, and more maneuverable. Langley participates in many projects aimed at achieving these goals, such as: The NASA Aviation Safety Program (AvSP), Earth Observing System (EOS), Geostationary Imaging Fourier Transform Spectrometer (GIFTS), and SAGE III Ozone Loss and Validation Experiment (SOLVE).

Through the AvSP, one need not look far to find a way NASA research can provide benefits to the public. A partnership between NASA, the Federal Aviation Administration (FAA), the Department of Defense (DoD), and the aviation industry, AvSP is working to develop advanced, affordable technologies to make travel safer on commercial airliners and smaller aircraft. To meet the national goal of reducing the fatality rate of aircraft accidents by 90 percent in 25 years, Langley researchers have gone looking for danger.



In June 1999, three aircraft, supported by a team of government and industry researchers, took to the skies over Colorado in search of turbulence associated with thunderstorms. Radar onboard the planes and on the ground collected atmospheric data to gain a better understanding of turbulence and determine if airborne Doppler radar can reliably detect it.

When not looking to fly into stormy weather, Langley researchers can be found purposely crashing aircraft. There is a method to the destruction, as researchers are looking for possible

*The X-43 is part of NASA’s research into the next generation of advanced aircraft.*

design changes that could help pilots and passengers better survive accidents. In October 1999, engineers dropped a Lear Fan composite aircraft from a height of 150 feet. The plane, which hit the ground at 60 miles an hour, was equipped with instruments to record the conditions on impact and 6 instrumented crash test dummies.

While one set of researchers study how to make planes, another team of Langley personnel is studying ways to prevent accidents from ever occurring through research into “self-healing” and “refuse-to-crash planes.” The vision is for an integrated computerized health management system

that oversees vital aircraft functions to prevent and reduce malfunctions, enhance flight crew responses to problems, and reduce a pilot’s workload in an emergency situation. In addition to health management, NASA is also researching control upset management systems. Such technologies include advanced detection/prevention algorithms, display formats, pilot cueing, and guidance and control methods to prevent accidents when failures occur.

Advancing aircraft technologies does not end there. Building on the gains of the highly successful Advanced General Aviation Transport Experiment (AGATE) consortium, NASA is planning a small aircraft technologies (SATS) program. SATS, in partnership with the FAA, hopes to gain access to more communities in less time via air travel. The specific goal is to reduce public travel times by two-thirds in 25 years at equivalent highway system costs. Bruce Homes, manager of the NASA General Aviation Program at Langley, says, “imagine a third dimension for the interstate highway system...a ‘virtual’ interstate skyway system.”

Along with aeronautic ventures, NASA Langley is dedicated to Earth Science, which will benefit society through the understanding of weather and climate forecasting, agriculture, natural resource management, and urban and regional planning. One attempt to improve the knowledge of Earth’s atmosphere is through the EOS’s Terra spacecraft, launched in late 1999. One of the instruments aboard Terra is the Clouds and the Earth’s Radiant Energy System (CERES). CERES will collect data to study the energy exchanged between the Sun; the Earth’s atmosphere, surface, and clouds; and outer space. CERES EOS-Terra is the second CERES instrument to fly above Earth. The first, launched in 1997, is aboard the Tropical Rainfall Measuring Mission (TRMM) observatory.

Langley scientists are also participating in an international effort known as the SAGE III Ozone Loss and Validation Experiment (SOLVE) to expand present understanding of polar ozone dynamics and improve ozone loss prediction forecasts over the North Pole. Additional data will be collected using Langley’s future Stratospheric Aerosol and Gas Experiment (SAGE) III satellite, to be launched in the summer of 2001. The second stage of SOLVE involved more than 350 researchers from the U.S., Canada, Europe, Russia, and Japan.

Meanwhile, Langley researchers are currently developing the Geostationary Imaging Fourier Transform Spectrometer (GIFTS) for launch in 2003. Set to be the third Earth-observing mission under NASA’s New Millennium project, GIFTS will test advanced technologies for measuring temperature, water vapor, wind, and chemical composition of the atmosphere. The weather information to be obtained by GIFTS will be equivalent to that obtained by launching 100,000 weather balloons every minute at intervals of 2 miles.

Whether it is developing new aircraft, making present air travel safer for everyone, or observing the heavens to improve weather forecasting, Langley has the skies covered today and in the future.



*Langley researchers perform various crash tests on airplanes, such as the one shown here, in an effort to improve aircraft safety performance.*



# Marshall Space Flight Center

The Marshall Space Flight Center in Huntsville, Alabama, is NASA's lead center for space transportation systems and development, and its Center of Excellence for space propulsion. The center also is NASA's leader in microgravity research and space product development programs. This unique field of science is conducted in the near-weightlessness of space, but holds the key to a broad range of benefits on the ground.

As world leaders in access to space, Marshall's scientists and engineers are defining the cutting edge of technology to unlock the doors for space development and exploration. A key to doing so is the Space Launch Initiative, a comprehensive, long-range plan to increase commercial development and civil exploration of space. It is intended to enable at least two competitive second generation reusable launch vehicle concepts by 2005. It will do so by clearly identifying all the requirements for such a vehicle and making technology investments needed to reduce risks associated with them.

A series of experimental, reusable launch vehicle demonstrator projects is focused on technologies for dramatically increasing safety and reliability while slashing launch costs. These programs are tackling the difficult task of lowering the current \$10,000 per pound cost of putting payloads into space—first to \$1,000 per pound, then to as low as \$100 per pound.

The lightweight X-33, with its unmistakable wedge shape and revolutionary "linear aerospike" rocket engines, will take off vertically, fly to altitudes of 60 miles, travel at up to 13 times the speed of sound, and land horizontally.

The X-34 will be launched from beneath a modified jetliner and powered by a new reusable engine, designed and developed by Marshall engineers and built by industry partners. Capable of 8 times the speed of sound, the X-34 can fly to roughly 50 miles high and land on conventional runways.

Unlike the X-33 and X-34, the X-37 will make history as the first reusable demonstrator to fly in both orbital and reentry environments, at up to 25 times the speed of sound.

Marshall also oversees a series of "Future-X" experiments, plus other space transportation technology efforts, all pursuing the key goals of cost-reduction, greater safety, and reliability. Approaches being pursued range from the relatively simple to some that are radically exotic.

While such future-focused programs aggressively seek to create a "highway to space," Marshall has a

critical role in today's flight operations by helping to keep the nation's flagship space vehicle safely flying. The center provides and manages propulsion elements for the Space Shuttle: the vehicle's reusable main engines, the incredibly powerful solid-rocket boosters, and the enormous external fuel tank required for every Shuttle flight.



*NASA engineer Zena Hester of the Microgravity Research program monitors a test run of an experiment designed to predict the formation of tiny tree-like crystals important to the study of physical properties of materials used in the casting of metals in turbine blades, industrial tools and engine parts.*

*One proposed alternative to the use of combustion propellants for future space travel is solar sails that would enable solar winds to propel a spacecraft away from Earth and toward its destination.*

Virtually no modern industry has been untouched by four decades of space research and development—and virtually every human life has benefited from the scientific endeavors conducted at Marshall. As world leaders in the use of space for research and development to benefit humanity, center scientists and engineers are helping industry create new medicines and medical procedures, manufacturing processes, and electronics and communications breakthroughs.

As a prime example, Marshall is the lead NASA center for use of microgravity—the near-weightless environment of space—to conduct experiments that would be all but impossible on Earth. This research is advancing our understanding of key biological, chemical, and physical processes. In the process, it is opening doors to commercial development of space, improved health care, advanced alloys and composite materials, and new theories in physics.

The International Space Station is soon to become operational as the premier laboratory in which microgravity researchers conduct experiments. The scope and complexity of these experiments will increase dramatically when the primary U.S. research element—the Destiny Laboratory module—is launched. As one of its array of facilities, Marshall is designing, developing, and testing the Microgravity Science Glovebox—an enclosed miniature laboratory for permanent installation aboard the station.

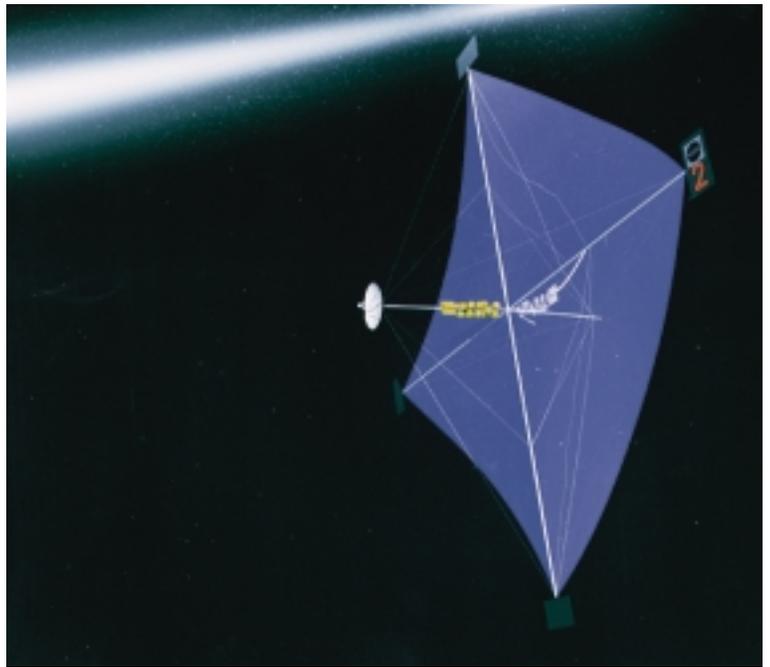
Marshall is also providing several other components that are vital to making the station a fully productive orbiting research facility:

- An Interim Control Module, as a backup or supplemental propulsion source for reboost and positioning capabilities during the initial years of Station construction.
- The Station Propulsion Module, to provide long-term Station altitude and position propulsion—a key part of the system to prevent the Station from crossing paths with potentially dangerous space debris.
- The Environmental Control and Life Support System, a water recycling and oxygen generation system intended to eliminate the need to continuously resupply the Station crew with thousands of pounds of life-sustaining air and water.
- The Deorbit Propulsion Stage—the primary source of propulsion for the Space Station Crew Return Vehicle, a “lifeboat” to safely return the crew to Earth in emergencies.

In 1999, Marshall celebrated the spectacular results of many years of hard work on the Chandra X-ray Observatory. The most powerful X-ray telescope ever built was launched and began several years of studying violent, high-temperature objects in space—comets, exploded stars, even black holes at the heart of far-off galaxies.

Unwilling to rest on its laurels, NASA is already looking ahead to the development and launch of even more advanced telescopes. Marshall’s new Space Optics Manufacturing Technology Center is taking the lead for NASA’s development of advanced, ultra-lightweight optics materials, fabrication technology, precise measurement standards, and state-of-the-art testing facilities.

NASA’s Global Hydrology and Climate Center, located in Huntsville and managed by Marshall, is the scientific powerhouse for climatology research in the southeastern United States. Benefits of its work and expertise include improved hurricane and severe storm prediction, more reliable day-to-day weather forecasting, and more effective urban planning.





## Stennis Space Center

**J**ohn C. Stennis Space Center prepares for the 21<sup>st</sup> century on the heels of an ambitious and unprecedented year for the men and women in rocket propulsion testing, commercial remote sensing, and Earth system sciences.

All major test stands are now occupied with rocket engines for the Space Shuttle, the X-33 and X-34, larger, more powerful hybrid rocket motors, hydrogen peroxide engines, and other new rocket engines being tested for private industry. Expansion, improvements, and modifications to the test stands have been completed to accommodate increased testing activities.

For the first time in Stennis' history, the center is the site of an engine assembly facility. The Boeing Company, in an unprecedented government/industry partnership, opened the RS-68 Engine Assembly Facility in March 2000 that will produce the latest large, liquid-fueled engine developed at Rocketdyne Propulsion & Power, a division of Boeing. The new assembly facility is located at the former Mississippi Army Ammunition Plant at Stennis. The RS-68 is a 650,000-pound thrust engine that will power the Delta IV family of expendable launch vehicles.

The single-engine test phase for the XRS-2200 Linear Aerospike Engine, the engine that will power the X-33 Advanced Technology Demonstrator, was completed in May 2000. The linear aerospike engine set a new duration record of 290 seconds in an abbreviated test at Stennis.

Modifications to the test stand will be made to accommodate the next phase of testing on two aerospike engines in a flight configuration, as they will be mounted on the X-33 vehicle. The dual engine testing will begin in late summer 2000.

Stennis' E-3 test facility is running at full pace, with both of its testing cells occupied. The facility has tested new hybrid and hydrogen peroxide rocket technology propulsion systems, including a small-scale hybrid rocket motor positioned horizontally in cell one. Testing was also performed in cell two on a low-cost, upper-stage propulsion system that uses hydrogen peroxide as the oxidizer propellant.

The first test firing of the 250,000-pound thrust hybrid rocket motor, the largest hybrid rocket motor yet tested at Stennis, occurred in July 1999. Longer duration tests were also conducted on the motor, designed and constructed by a consortium of aerospace corporations.

The Hybrid Sounding Rocket (HYSR) passed its first ground test at Stennis in February 2000. The HYSR project was performed under a Space Act Agreement managed by Marshall Space Flight Center in Huntsville, Alabama. The

*An ignition system test of the XRS-2200 Linear Aerospike Engine for the Lockheed Martin X-33 prototype vehicle was successfully conducted. The ignition system serves as a kind of "pilot light" to ignite the combustible propellant and oxidizer and literally "light" the engine.*



HYSR, produced by Lockheed Martin Michoud Operations in New Orleans, is designed for suborbital space and atmospheric science missions and will also be used as a flyable testbed for small-scale experiments.

NASA's Commercial Remote Sensing Program (CRSP) at Stennis is continuing to explore new ways of doing business to develop faster, better, and cheaper methods of acquiring data for scientific research and to make the results available to the public. The CRSP and its partners, have recently developed a new website devoted to sharing the practical uses of Global Positioning System (GPS) technology, called the GPS Application Exchange. The GPS Application Exchange was developed at Stennis by NASA, members of the U.S. GPS Industry Council, and the RAND Corporation. The website can be found at <http://gpshome.ssc.nasa.gov>.

From aiding the visually impaired in France to improving the efficiency and safety of taxicab service in Australia, GPS has the ability to touch our everyday lives. Using survey systems that incorporate GPS measurements, researchers developed models of the riverbeds and the water discharged into the waterways. These models will be used to develop plans to alleviate damage caused by flooding in Bangladesh.

An agreement reached between Stennis and the Wolf River Conservation Society, Inc. has provided a new champion for conservation management in southern Mississippi. This partnership will investigate how emerging commercial space technologies can help preserve the Wolf River, Mississippi's first officially designated scenic river. It is the Society's responsibility to manage the easement, promote the river's scenic and recreational value, and collect baseline information on plants and animals within the easement.

Stennis will use the easement and the surrounding watershed as a testing site for new remote sensing technologies and products. The first such products to be tested over the Wolf River will be produced from images taken with IKONOS—the first commercial, high-resolution Earth observation satellite. Products will be created from IKONOS images that can address the conservation management needs of the Society. As NASA tests other products in a similar fashion against the Society's needs, the Wolf River could become one of the most often-imaged locations in the South.

The Earth System Science Office (ESSO) continued its study of the world's oceans in partnership with the Naval Oceanographic Office, also located at Stennis.

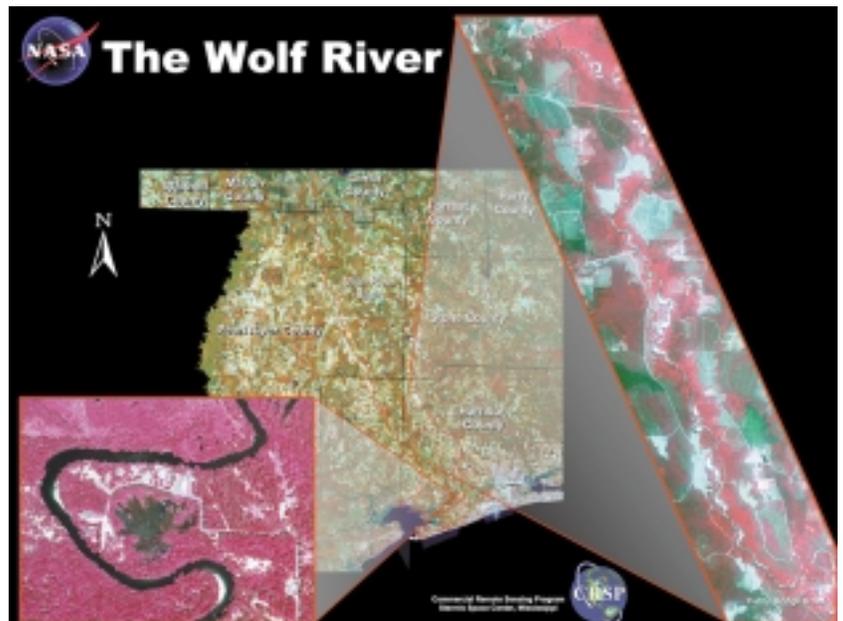
Scientists from the ESSO sailed from Pusan, South Korea, to Singapore to gather data from the South China Sea on phytoplankton—microscopic ocean plant life. The data will be used to calibrate and validate ocean color algorithms taken by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) satellite. Subtle changes in ocean color indicate various types and quantities of marine phytoplankton, which has both scientific and practical applications. The SeaWiFS project will develop and operate a research data system that will process, calibrate, validate, archive, and distribute data received from an Earth-orbiting ocean color sensor.

ESSO research scientists also helped the U.S. Navy and the University of West Florida's (UWF) Archaeology Institute uncover prehistoric American Indian shell middens—dump sites—and historic sites.

Using Ground Penetrating Radar (GPR), a team composed of members of UWF's Archaeology Department and the U.S. Navy's Coastal System Station, was able to locate artifacts and map nine midden sites used as refuse heaps by Native American tribes in the Florida area between 900 and 1200 A.D.

With a full slate of engine testing, the development of new applications for remote sensing, and a flood of Earth science data pouring in, it is clear that all engines are go at Stennis.

*Airborne Terrestrial Applications Sensor (ATLAS) imagery of the Wolf River was acquired at 4-meter resolution from the NASA Stennis Learjet on April 18, 1999.*



# Commercial Benefits—Spinoffs

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**T**he NASA Commercial Technology Network (NCTN) continues to flourish as it expands its services and organization nationwide to promote commercialization of NASA technologies.

NASA's **Small Business Innovation Research (SBIR)** program has played a key role in the development and transfer of new technologies through the partnerships it fosters between NASA and private companies.

As we enter an era many refer to as the “New Economy,” one constant is the value and applicability of the research and development activities taking place at NASA. Whether it is NASA working in tandem with private industry or the commercial sector turning to NASA for technological assistance, many of these activities have found their way into new products and services—known as “spinoffs.”



## Robotic Surgery

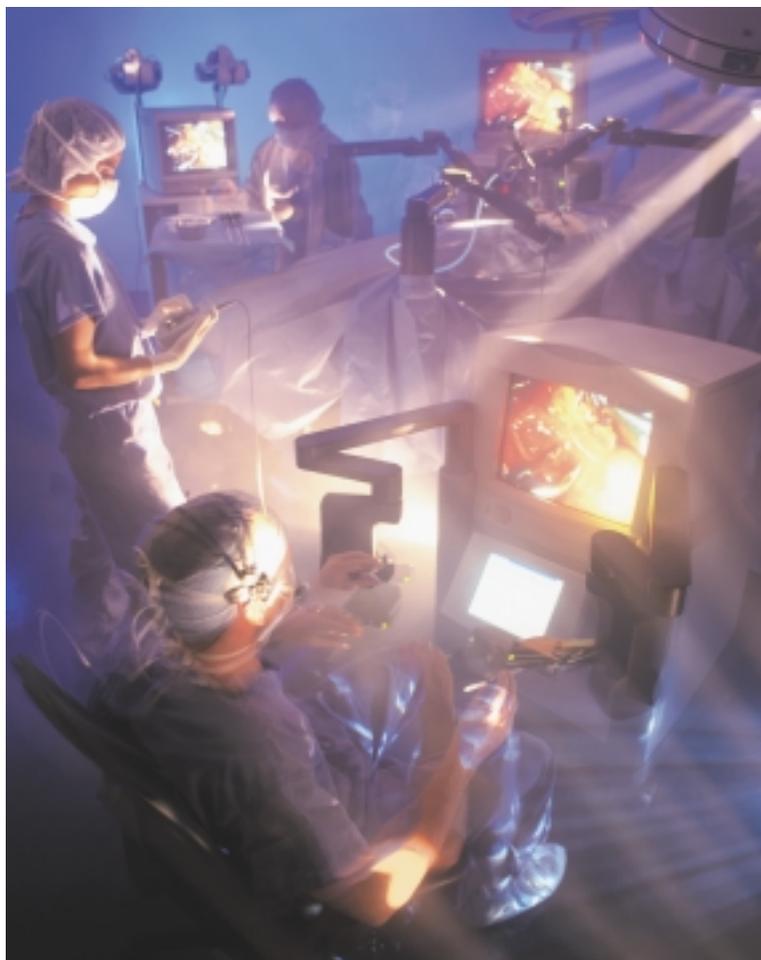
Operating rooms are stepping into the 21<sup>st</sup> century thanks to a robotic arm that can assist surgeons in non-invasive, endoscopic procedures. Computer Motion, Inc., in Santa Barbara, California, originally performed research under a NASA **Small Business Innovation Research (SBIR)** contract from the Jet Propulsion Laboratory to develop AESOP,<sup>®</sup> (Automated Endoscopic System for Optimal Positioning).

NASA hopes to make use of the technology powering the robotic arm of AESOP to service satellites and inspect payloads on the Space Shuttle in the future. The hope is to use robotics on space repair missions requiring exact and precise movements that exceed human dexterity.

Nearly a million endoscopic surgeries are performed annually by inserting a slender camera into a small incision in the patient to access the part of the body targeted for the operation. The surgeon uses the camera to monitor the operation, which requires long, narrow instruments. This endoscopic approach reduces the healing and recovery time needed by the patient and lowers healthcare costs.

Now, with Computer Motion's AESOP, surgeons can control the motion of the camera, which is attached to a robotic arm. AESOP eliminates the need for surgical staff to hold the camera in place. The robotic arm also allows for a steadier view of the surgery and more precise and consistent movements of the camera.

The AESOP arm uses Computer Motion's voice recognition software, which is pre-recorded onto a



*Doctors seated in the ZEUS™ Robotic Surgical System can perform minimally invasive surgeries without suffering from fatigue or stress during lengthy operations.*

voice card and inserted into the controller. Computer Motion's NASA-funded research determined that voice controlled commands are preferred in the operating room as opposed to alternatives such as eye-tracking and head-tracking, which control motion in response to movements of the surgeon's head.

A second generation of this technology, called the ZEUS™ Robotic Surgical System, has the potential to make endoscopic procedures even more accessible. Traditional endoscopic methods require a long learning curve and a greater dexterity than some possess. Also, suturing for microsurgical procedures such as endoscopic coronary artery bypass graft often exceeds typical human dexterity limits.

However, through the use of a master-slave robotic system, surgeon motions are scaled down, allowing the doctor to make more natural movements. By manipulating additional robotic arms, the surgeon can move the instruments with the precision the procedure requires. Incisions can be made smaller than the diameter of a pencil as compared to the 12- to 15-inch incision and cracked ribs traditional open-heart surgery requires.

One final benefit of the ZEUS system is that it allows the surgeon to perform the operation seated in an ergonomic position, eliminating the problems of fatigue and frustration resulting from leaning over the patient in an awkward posture for hours.

Last summer, the first completely endoscopic coronary artery bypass graft was performed using the ZEUS system and has now been put in use at 19 sites. Computer Motion hopes to use AESOP and ZEUS as the cornerstone technologies for tomorrow's Intelligent Operating Room.™

AESOP® is a registered trademark of Computer Motion, Inc.  
ZEUS™ and Intelligent Operating Room™ are trademarks of Computer Motion, Inc.



*AESOP,® a voice-controlled robotic endoscopic positioning system, provides an absolutely steady picture during minimally invasive surgeries.*



## Monitoring on the Move

Given the recent investigation into the physiological effects of space on famed astronaut John Glenn, it is evident that NASA scientists are interested in researching how microgravity affects the human body. Among the areas of interest is the muscular performance of astronauts. Muscular activity, however, is not easily monitored in space with traditional and cumbersome electromyographic (EMG) machines. This has changed with the assistance of **Small Business Innovation Research (SBIR)** funding from NASA's Johnson Space Center. NASA, along with other government agencies, has helped Delsys, Inc., of Boston, Massachusetts, develop the MyoMonitor<sup>®</sup> EMG system—a wearable 4-channel device that offers a new dimension in electromyography. Delsys, a spinoff company from the NeuroMuscular Research Center at Boston University, is also developing an 8-channel version of the MyoMonitor.

Currently, the battery-powered device is capable of storing over 3 hours of continuous 4-channel

data and has a convenient carrying case that offers the freedom to monitor muscle performance with a portable cable-free unit. The MyoMonitor is being marketed for monitoring rehabilitative therapy, work place injury prevention, sports medicine, ergonomics, exercise training, and motion studies.

Now muscle performance can be monitored away from the laboratory in unconstrained environments. The complete instrument can be worn around the waist and weighs approximately one kilogram. It is now possible to monitor muscle activity during a tennis serve, a baseball pitch, or a golf swing.

All of the company's systems use an active parallel bar electrode. This type of electrode requires no skin preparation or conductive gel. Two of these electrodes are offered for the Delsys Bagnoli-series EMG systems: a two-bar differential electrode and a three-bar double differential electrode. The three-bar electrode is particularly useful for reducing the cross-talk from overlapping signals of adjacent muscles. The Bagnoli-series in the Delsys product line consists of 2-, 4-, and 8-channel systems. The MyoMonitor uses a two-bar single differential electrode.

During vigorous activity, the movement of the skin causes electrode detection surfaces to become compromised. Because of the accumulation of sweat, for instance, EMG signals become contaminated. This makes the electrode-skin interface the



*The MyoMonitor<sup>®</sup> can monitor carpal tunnel syndrome in a workplace setting without negatively affecting workers' ability to perform routine tasks.*





*The MyoMonitor® is being evaluated to study the muscles of astronauts in the weightless environment of space.*

limiting factor in traditional EMG equipment. The MyoMonitor's capacity for detection is significant because it can monitor muscle activity, despite rigorous conditions. The system has an easy-to-apply, effective electrode-skin interface that facilitates the uncontaminated detection of EMG signals. The ability to make such recordings, for example, enables novel experiments aboard the International Space Station for investigating the effect of microgravity on muscle performance.

Once collected, data can be transferred to a regular personal computer and analyzed with the EMGworks® software package, which provides real-time data collection and a comprehensive suite of analysis programs. These products are proof of the company's goal of providing the highest quality EMG equipment and promoting the proper use of surface electromyography. Additionally, the company actively seeks partners for developing EMG-based consumer products.

MyoMonitor® is a registered trademark of Delsys, Inc.

EMGworks® is a registered trademark of Delsys, Inc.



*The Delsys system can be used by physical therapists and sports medicine clinicians to evaluate the condition of a patient recovering from an injury.*



## Breast Cancer Detection

Recent statistics published by the American Cancer Society show that approximately one in nine women in the United States will develop breast cancer. Now, early detection has a new weapon. An advanced method for screening breast cancer using technology developed at NASA's Jet Propulsion Laboratory (JPL) is expected to be widely available in U.S. medical facilities and in selected foreign markets by the end of the year. In December of last year, OmniCorder Technologies, Inc., of Stony Brook, New York, received 510K clearance from the Food and Drug Administration (FDA) to market the company's innovative BioScan System.<sup>TM</sup>

The BioScan System has been used to locate and confirm the presence of a cancerous breast lesion by detecting the cancer's ability to recruit a new blood supply—one of the hallmarks of a malignant lesion. Studies have determined that cancer cells exude nitric oxide. This causes changes in blood flow and temperature in tissue surrounding cancer, which can then be detected by the extremely heat-sensitive BioScan System sensor.

OmniCorder owns the exclusive, worldwide licenses to use the quantum well infrared photodetector (QWIP) sensor for biological applications,

including disease detection. The digital sensor detects the infrared energy emitted from the body and, therefore, "sees" the minute differences associated with the local increase in blood flow changes. In addition to the BioScan System, the QWIP sensor, originally designed for planetary exploration and terrestrial surveillance, has also been useful in locating hot spots during fires and while observing volcanoes. The camera can see radiation at wavelengths invisible to the human eye.

As a cancer-detection device, the detector is sensitive to temperature differences of less than .01 degrees Celsius and detects the slightest rise in temperature in tissue surrounding cancer cells. Just like having your picture taken with a video camera, it causes no discomfort to the patient and uses no ionizing radiation.

"Since we announced the BioScan System's clearance by the FDA, we have been inundated with requests to install and test the unit in clinics and hospitals across the country and overseas for a variety of cancer, as well as other disease applications," says OmniCorder's president and CEO, Mark Fauci.

At the moment, not only is the BioScan System being used to detect cancerous legions, but it is also being tested as a monitoring device during cancer treatment. The Dana-Farber Cancer Institute in Boston, Massachusetts, is testing several new classes of anti-cancer products that are designed specifically to inhibit the growth of cancer by greatly reducing the blood supply to it. Dana-Farber doctors are using the BioScan System to detect important treatment-induced changes in an array of cancerous lesions of the breast and skin, among others.

Unlike mammography, which detects calcification associated with cancer cells after they are well into development, the BioScan System detects blood flow differences associated with cancerous cells. Blood flow differences are known to occur in the earliest stages of cancer development. The goal of this technology is to reduce the amount of time it takes to detect a lesion, allowing for much earlier treatment intervention and, therefore, better the survival rates.



*OmniCorder Technologies, Inc.'s BioScan System<sup>TM</sup> detects blood flow differences associated with cancerous cells.*

BioScan System<sup>TM</sup> is a trademark of OmniCorder Technologies, Inc.



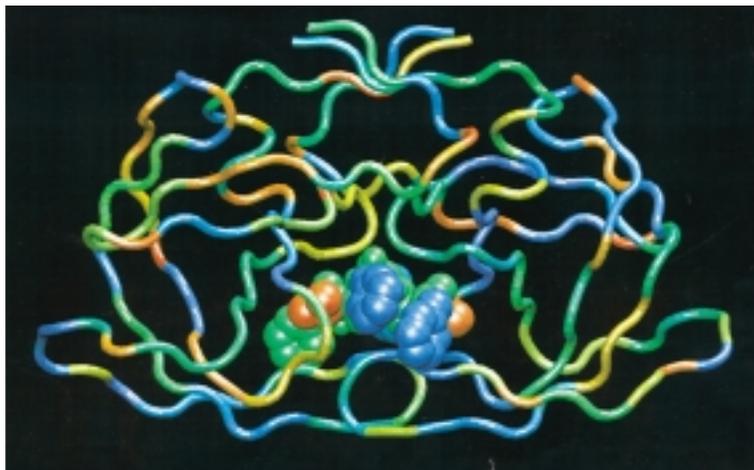
# Modeling Molecules

Thanks to the space program, scientists are modeling molecules with the goal of effectively discovering new treatments for diseases. NASA's Goddard Space Flight Center, along with other government organizations, provided **Small Business Innovation Research (SBIR)** funding for technology that could simulate spacecraft, vehicle, and machine dynamics, as well as biomechanical motions. This SBIR project spunoff into the development of software that can model the dynamics of molecules. Moldyn, Inc., of Cambridge, Massachusetts, patented a technology that can simulate low-frequency molecular motions and properties, such as movements among a molecule's constituent parts.

This commercially available modeling method is known as Multibody Order (N) Dynamics (MBO(N)D). In MBO(N)D, a molecule is substructured into a set of interconnected rigid and flexible bodies. Substructuring organizes groups of similarly behaving atoms into interacting flexible bodies. These flexible bodies replace the computational burden of mapping each individual atom. MBO(N)D reduces the number of calculations from tens of thousands of atoms to a few hundred, or less, bodies. Conventional atom-by-atom molecular dynamics can require weeks, sometimes months, to simulate the behavior of a few molecules. Moldyn's multibody approach cuts the computational time by up to a hundredfold, while also yielding comparable accuracy with all-atom methods.

Moldyn's MBO(N)D technology is available as Insight II 97.0 from Molecular Simulations, Inc. The software is an accelerator for molecular dynamics that uses the same mathematical algorithms originally developed for large flexible satellites to reach time and size scales that were not attainable through conventional methods. In the aerospace industry, the method is used to account for forces on hundreds of thousands of parts in spacecraft and satellites.

Pharmaceutical companies are using the method for a variety of molecular analyses, including realistic modeling of drug/protein interactions and



*Pharmaceutical companies are using the method for a variety of molecular analyses, including realistic modeling of drug/protein interactions.*

comparison of these interactions with others found in vast databases. Drug companies use databases containing hundreds of thousands to millions of different molecules and molecule fragments to look for potential medicines. The MBO(N)D software allows efficient screening of these large databases to find molecules that can “dock” successfully with the active sites of proteins. The result of this innovation is faster, less expensive drug development than what is allowed by conventional atom-by-atom computational methods.

Drug discovery has changed over the past two decades to include the study of significant structural components in and around the cell. Molecular structures of proteins and receptor-ligand complexes play an important role in the discovery of pharmaceutical agents. A ligand is a biological compound that fits a receptor within or on the cell surface. This fitting is analogous to a lock-and-key arrangement. Drugs that mimic the shape of a natural ligand can be used to regulate a signal in order to manipulate a therapeutic interaction between the synthetic ligand and the cell.

A major breakthrough with this development is to permit the solution of realistic-sized molecular dynamics problems on a moderate workstation, rather than on supercomputers.



## Shipping Monitor

When it comes to shipping payloads for NASA, it takes a lot more than Styrofoam peanuts and bubble-wrap to insure the safety of the delicate instruments aboard. NASA's need to track the vibration and movement of payloads for the Space Shuttle led to funding for a **Small Business Innovation Research (SBIR)** contract between Kennedy Space Center and Silicon Designs, Inc., of Issaquah, Washington. The result was a tri-axial data acquisition system that acquires, stores, and analyzes shock, vibration, and temperature data during payload transport.

A data acquisition system such as this improves NASA's ability to determine if any damage has occurred to Space Shuttle payloads during transport to the launch pad. Operations at Kennedy require numerous payloads to be transported from assembly and test facilities to other assembly facilities or the launch pad. Kennedy's Payload Operations need for this invention led to the Smart Tri-Axial Acceleration Data Acquisition and Storage System.

Silicon Designs' tri-axial system, known commercially as the G-Logger™ Acceleration Acquisition System, is a portable, self-contained device powered by two D-cell batteries. The system is sealed for protection from the weather and can be left unattended for up to three weeks as it collects data.

The G-Logger can store up to four million samples of acceleration and temperature data in its flash memory. The unit is able to make maximum use of its eight megabytes of memory by preprocessing data to screen out unwanted information. G-Logger can measure and record three directional acceleration components by attaching the acquisition unit to the payload for monitoring.

The data acquisition unit links up easily to any desktop or laptop computer, running Windows 95/98, through a serial connection. Through this

linkup, data can be downloaded from the data collection unit, analyzed, and displayed almost immediately.

There are several industry applications for the G-Logger line of tools. John Cole, president of Silicon Designs, projects uses for the line of tools in automotive, shipping, aerospace, and rotating machining operations. As an automotive application, the G-Logger could be used for racecar instrumentation, suspension testing, or as a crash detector. In the shipping industry, the G-Logger may monitor acceleration, shock and vibration of payloads during shipping and handling. Finally, it can serve as a flight vibration monitor for aircraft.

The potential of the G-Logger being used in such a wide array of applications because of its versatility has Silicon Designs excited and hopeful about its future prospects.

G-Logger™ is a trademark of Silicon Designs, Inc.



*Silicon Designs' G-Logger™ products provide instant data analysis on the status of payloads during shipping and handling.*



## Giving Bigger Satellites a Boost

With the increased complexity of communications here on Earth, satellite makers are becoming compelled to send heavier equipment into orbit. Just as sport utility vehicle owners begrudge the amount it costs to fill up the tank on their gas guzzlers, satellite makers are eager to find ways of making more efficient thrusters for their weightier satellites. With this in mind, NASA, private industry, and other government agencies have been pooling their resources to help Ultramet, Inc., of Pacoima, California, make blasting satellites into orbit a more efficient and inexpensive process. **Small Business Innovation Research (SBIR)** funding from NASA's Glenn Research Center has spurred a new process for producing rocket engine thrust chambers.

Liquid rocket engine performance has historically been constrained by the limitations of materials and processes used for component fabrication. Typically, the thrust chamber, in which the propellants are combusted, must be cooled to avoid the breakdown of materials, causing possible failure during operation. Cooling can effectively be achieved by various means that, unfortunately, result in a loss of efficiency.

Rocket engine efficiency is generally defined by a measurement that indicates pounds of thrust per second of consumed fuel. This measurement is called specific impulse, or  $I_{sp}$ , which is more or less analogous to miles per gallon. Higher values of  $I_{sp}$  indicate higher operating efficiency. Considering the high costs of sending a single pound payload to orbit, the value of a modest gain in  $I_{sp}$  is important. Such a gain in efficiency requires high temperatures—over 2,000 degrees Celsius! These temperatures, however, also bring the possibility of materials breakdown. Therefore, engineers do not want increases in operating temperatures at the expense of engine reliability.

The key to achieving high-temperature capability without compromising reliability was developed, in part, because of NASA SBIR funding. High-temperature oxidation-resistant thruster materials are being fabricated by Ultramet with a



*Ultramet, Inc., is manufacturing high-temperature oxidation-resistant thruster materials.*

novel process, which has been proven effective during successful flights of the latest generation satellites.

The approach used for the development of such high-performance materials is simple in concept, but innovative in its execution. Using a process called chemical vapor deposition (CVD), Ultramet is producing high-temperature capability thrust chambers. CVD involves heating precursors for metals, such as iridium and rhenium, to temperatures at which they become gaseous and depositing them onto a mandrel, or spindle, layer-by-layer to produce high-density, highly resistant materials from the inside out.

In addition to NASA, several large companies have invested nearly \$25 million in the development of this technology. The payoff for the satellite industry will prove to be quite large. Ultramet estimates that a three-percent improvement in propulsion system performance of a satellite could be gained. That can be equated to a 50- to 100-kilogram increase in the weight of communications mass on a satellite, a significant increase in satellite thrust capability. This gives the ever-advancing communications industry some room to broaden its capabilities.



# Emergency Response Breathing Apparatus

**S**CAMP® (Supercritical Air Mobility Pack) is a self-contained breathing apparatus (SCBA) that was originally developed under a NASA Kennedy Space Center **Small Business Innovation Research (SBIR)** contract. The use of supercritical cryogenic air in SCAMP came from the technology developed for the life support fuel cell support systems for both the Apollo and Space Shuttle programs, which required its use in microgravity environments.

In addition to functioning in microgravity, the SCAMP fluid recovery system produces a flow, regardless of the position of the supply tank in Earth's gravity. The SCAMP SCBA system applications are also ground-based, such as those in emergency services and industry.

The developer of SCAMP, Aerospace Design & Development (ADD), Inc., of Niwot, Colorado, was charged with producing a compact breathing apparatus that would meet the needs of Kennedy Space Center rescue personnel. In a launch pad emergency, rescue personnel must be able to crawl through a 20-inch square opening. Therefore, the compact air system required a usage time in excess of 30 minutes, as well as a backpack thickness of less than 5.5 inches.

Many of the propellants used aboard U.S. launch vehicles are toxic to humans. Protective measures, traditionally provided by an SCBA with air as a compressed gas, must be provided to personnel handling these agents and those who must respond to spills or other emergency situations. However, this old technology relies upon heavy, high-pressure cylinders that the emergency worker must carry. ADD extended its development of SCAMP by creating a suit that offers a smaller and considerably lighter system than the older technology. What's more, the longer reserve time provides firefighters and hazardous materials workers greater flexibility and a greater margin of safety.

*Aerospace Design & Development, Inc.'s SCAMP® is a self-contained breathing apparatus (SCBA) that uses supercritical cryogenic air.*

At the heart of the SCAMP SCBA system is its cryogenic vacuum container, or Dewar, which contains the supercritical air (-320°F) and replaces the standard SCBA high-pressure bottles. The SCAMP SCBA 1-hour Dewar is approximately the size of a standard 30-minute SCBA compressed air bottle, but stores twice the quantity of air, because of its high-density capacity.

ADD's SCAMP achieves both body cooling and breathing from supercritical cold (cryogenic) air, therefore, no additional systems are required. SCAMP absorbs a large fraction of body heat. The heat is transferred from the body to the breathing air through fluid transfer loops between the suit and heat exchangers designed into the SCAMP backpack. This allows for a lighter cooling system with a longer reserve capacity.

This improvement over the traditional SCBA aids both in the reduction of injury, such as heat stress, and increases the possibility of saving lives.

SCAMP® is a registered trademark of Aerospace Design & Development, Inc.





## Saving Lives With Rocket Power

NASA's scientific research, which benefits people everywhere, would not get very far without the rocket fuel that powers the Space Shuttle flights. A Utah company is now taking that rocket fuel and using it to benefit millions around the world in a whole new way. Thiokol Propulsion is using NASA's surplus rocket fuel to produce a new flare that destroys land mines safely and easily.

Through a Memorandum of Agreement between Thiokol and NASA's Marshall Space Flight Center, Thiokol is allowed to make use of scrap Reusable Solid Rocket Motor (RSRM) propellant. Such an arrangement benefits both parties, as NASA is able to reduce propellant waste without negatively impacting the environment, and Thiokol is able to access the materials needed to develop the flare at a low cost. The result is a Demining Device, developed by Thiokol in collaboration with DE Technologies, Inc., which neutralizes land mines in the field without setting off their explosive materials.

NASA always makes sure they have a small excess of propellant than they will actually use for each Shuttle mission to provide a margin of error in case extra fuel is required. Rocket fuel must be used quickly once it is mixed or it begins to solidify. Once it solidifies, it cannot be used for another launch. However, in its solid form, the rocket fuel is the perfect ingredient for the Demining Device.

It is estimated that between 60 and 120 million active land mines are scattered around the world in approximately 70 countries. Every year, 26,000 people, usually women and children, are killed or maimed by a land mine. Two techniques commonly used to disarm mines are a direct, attended operation or a remote operation using high explosives. The direct approach poses considerable risk to the military or humanitarian agency personnel who serve on the detonation teams, as well as to civilians. Remote detonation, which creates a high order detonation of the mine by detonating an explosive charge, can produce shrapnel, which



*Thiokol Propulsion's demining flare burns through the outer casing to neutralize the explosive agents inside.*

may damage buildings or increase minefield contamination.

Thiokol's approach provides a more affordable and safer method of defusing land mines. The technique involves placing a Thiokol-produced flare next to the uncovered land mine. The flare is then ignited using a battery-triggered electric match. Using the solidified rocket fuel as an incendiary, the flare burns a hole in the land mine's case and ignites the explosive contents. With the explosive material burned away, the mine is disarmed and no longer poses a threat.

Occasionally, the mine will detonate before the explosive material has been burned away. According to Thiokol's project manager, Charles Zisette, even when this occurs, the resulting explosion is more controlled and minimized than other disarmament techniques.

So far, Thiokol has sold over 700 units for use in the field in Kosovo and Jordan. Thanks to NASA's rocket science, hundreds of thousands of innocent lives will be saved or protected from permanent disabilities.



CONSUMER/HOME/RECREATION

COMMERCIAL BENEFITS—SPINOFF

## A New Lift for Those Who Need It

**A**n engineer, who worked to design a launch pad safety exit for NASA, put his knowledge to use when he developed the eZ-uP™ lift device. Paul Neal worked with NASA's Kennedy Space Center in the late 1960s to help develop a safety exit to allow workers to get off launch platforms in an emergency—a design that was patented by NASA. Now retired, Neal watched as his wife struggled to get out of a chair or lift herself from a sofa because of her arthritis. So, he decided to devise an aid for people to lift themselves from seated positions.

Amazingly, the 79-year-old retiree with a degenerative eye disease that has left him legally blind was able to design the device by himself. His

original design was elegantly simple—the apparatus was placed under a seat cushion so that two hand supports were then in front of the seat just below shoulder level. This way, a seated person could take hold and easily lift herself from the seat. It wouldn't work, however, on any chair or sofa that didn't have removable cushions. So, Neal took his model and drawings to RJDesigns & Associates of Panama City, Florida.

Immediately, RJDesigns recognized the benefit the elderly and disabled would receive from such a device. With refinements, Neal and the firm went through seven prototypes as they tested the device at retirement homes, the Council on Aging, and on all designs of beds, sofas, and chairs at a furniture



*The eZ-uP™ device will not slip on tile or wood flooring and can be secured to just about any furniture design.*

store. According to RJDesigns, the eZ-uP device can support people in excess of 500 pounds. It can be quickly and easily assembled without tools.

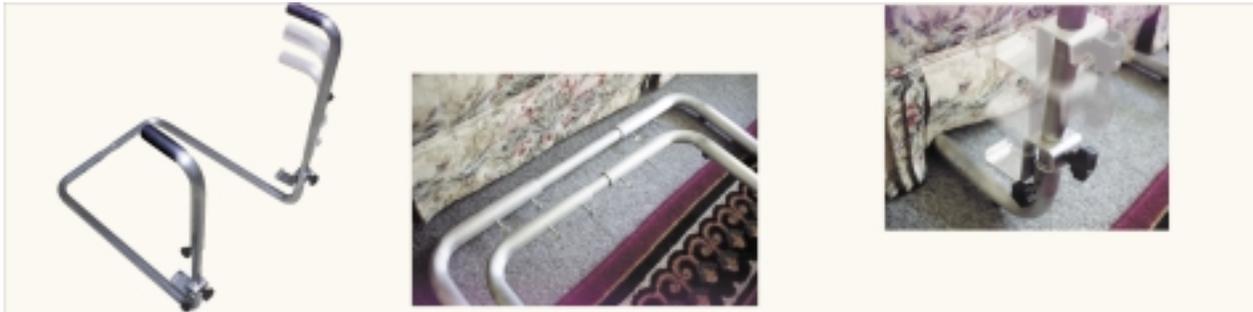
The eZ-uP is constructed of lightweight aluminum and features telescopic arms for maximum support. Broken into its individual pieces, the eZ-uP fits inside a seat cushion-sized box. The telescopic arms have easy-to-turn clamps that make it completely adjustable in height and width, and the device slides under most sofas, chairs, and beds. It will not slip on tile or wood flooring and can be secured to just about any furniture design.

RJDesigns is also marketing an attachable table tray that adjusts to all positions while

supporting level objects. According to RJDesigns, the lift aid is an inexpensive alternative to other products in the same general market. Chairs that lift a seated person using a pneumatic device can cost almost ten times the amount of the eZ-uP.

Neal's royalties from sales are just a secondary benefit of his invention. "[The money] doesn't worry me a bit," Neal says, "If I can help somebody that's great. The important thing is it worked so good for [my wife]." The eZ-uP is a true accomplishment for a husband who wanted to give a helping hand. The fact that others could benefit is such a great plus for his efforts.

eZ-uP™ is a trademark of RJDesigns & Associates.



*The eZ-uP™ is constructed of lightweight aluminum and features telescopic arms for maximum support. Broken into its individual pieces, the eZ-uP fits inside a seat cushion-sized box.*



## Picturing Video

Video cameras have become so commonplace today, they often are used in place of still cameras. However, trying to generate a high quality still image from a frame of video footage has been no easy task until now. After completing a Phase I and Phase II NASA **Small Business Innovation Research (SBIR)** contract with Marshall Space Flight Center, Irvine Sensors Corporation created a subsidiary, Redhawk Vision, Inc., to commercialize the resulting technology.

Redhawk is now prepared to introduce Video Pics,<sup>TM</sup> a software program that generates high-quality photographs from video. Using Irvine Sensors' patented neural network technology originally developed for NASA and the U.S. Air Force, Video Pics takes information content from multiple frames of video and enhances the resolution of a selected frame of interest. The resulting images have the sharpness and clarity of 35mm camera photos and are generated as digital files compatible with image editing software.

The software uses a complex patent-pending algorithm to extract clear images from noisy, grainy video similar to the way the human brain "sees" video content. Video Pics removes jitter, noise, and compression artifacts, while increasing resolution so a shot can be re-framed and magni-

fied. Brightness can be adjusted without reducing image quality.

The NASA SBIR work was performed on technology known as Real-Time Self-Contained Image Compensation for Spaceborne Imaging Instruments (SIMC). The SIMC algorithm determines which direction the scene has moved and repositions it back to the original position. Redhawk believes its method is considerably faster and more flexible than traditional signal processing techniques. Video Pics will also salvage otherwise unusable video with its ability to zoom and motion stabilize video without any loss of detail.

Video Pics represents Irvine Sensors' first commercial application to stem from its Silicon Brain research, the company's initiative to develop a computer that thinks like a human brain. Redhawk's first product line will be targeted at video editing professionals and can be used in conjunction with Adobe and Apple<sup>®</sup> video editing software. Redhawk envisions bringing the technology to the average consumer to facilitate e-commerce photo finishing. James D. Evert, chairman and CEO of Redhawk Vision, believes, "[C]onsumers of all ages could use such a tool to extract photographs of interest from the estimated five trillion frames of video that are captured by camcorders each year."

Irvine Sensors, located in Costa Mesa, California, is engaged in the development of high density electronics, miniaturized sensors and sensor readout circuits, miniature cameras, optical interconnections, image processing software and devices, and low-power analog and mixed-signal integrated circuits for diverse systems applications. The company worked with NASA on previous SBIR contracts to develop a three-dimensional memory system.

Video Pics<sup>TM</sup> is a trademark of Redhawk Vision, Inc.

Apple<sup>®</sup> is a registered trademark of Apple Computer, Inc.



*Video Pics<sup>TM</sup> allows users to turn video recordings into high-quality still photographs, with all the clarity of a 35mm camera.*



## Personal Beacon

Hikers, mountain climbers, and other adventure-seekers can now set out on their travels with an innovative personal locator beacon (PLB). NASA's Glenn Research Center and Goddard Space Flight Center, along with other government agencies, provided **Small Business Innovation Research (SBIR)** funding for the development of a miniature PLB called the MicroPLB. This commercial product is the brainchild of Microwave Monolithic, Inc. (MMInc.), of Simi Valley, California.

The MicroPLB is a state-of-the-art search and rescue satellite-aided tracking (SARSAT) transmitter that, when activated, emits a 406 MHz distress signal to a constellation of internationally operated satellites. A stranded person's identity and location anywhere on Earth is automatically deciphered and forwarded to central monitoring stations around the world. In the U.S., the National Oceanic and Atmospheric Administration (NOAA) operates the mission central center. The monitoring stations notify appropriate rescue organizations, guiding rescue personnel directly to the emergency location. The MicroPLB can be a life-saver for individuals engaged in activities such as hiking, hunting, mountain climbing, boating, and cross country skiing, where even a simple accident can escalate into a dangerous, or even life-threatening, situation. In such circumstances, timely assistance is critical.

Using the external Global Positioning System (GPS) receiver location data, the MicroPLB has been proven accurate to within just a few meters. It is a fully operational, all-weather SARSAT system that works worldwide, 24 hours a day. The system has already assisted in the rescue of over 11,000 people around the globe, including over 4,000 in the U.S. It is operated, funded, and maintained by an international consortium that assesses no fees from users.

Until recently, the primary application of the SARSAT emergency notification system has been restricted to specialized SARSAT beacons on seafaring vessels. Unlike other SARSAT beacons, the MicroPLB is a pocket-sized unit about the size of a king-sized cigarette pack. Because of its



*Microwave Monolithic, Inc.'s MicroPLB is a state-of-the-art search and rescue satellite-aided tracking (SARSAT) transmitter.*

advanced, NASA-derived transmitter technology, it is also the only PLB to use a safe battery approved by the U.S. Department of Transportation for carriage via all commercial transportation, including commercial passenger aircraft. It is dangerous, and illegal in most countries, to carry most other PLBs on commercial aircraft. The batteries of many other PLB devices have demonstrated enough volatility to explode with power almost equivalent to a stick of dynamite. For this reason, many people consider it unwise to personally carry such PLBs, even though they could possibly save lives.

According to the company, the MicroPLB is safe, easy to carry, and can go wherever the user goes. In the unfortunate event that rescue is needed, it is easily activated, offering a revolutionary way of helping people stranded in times of need. The user simply uses the device's serial interface to download navigation data from a global positioning satellite receiver. Once the download process is complete, the MicroPLB will function as a self-locating beacon.

MMInc. was founded in 1982 to supply custom microwave components and subsystems to its mostly government and industry customers. With the addition of its MicroPLB product, MMInc. is now bringing its expertise to individual consumers by offering safer travel to remote places.

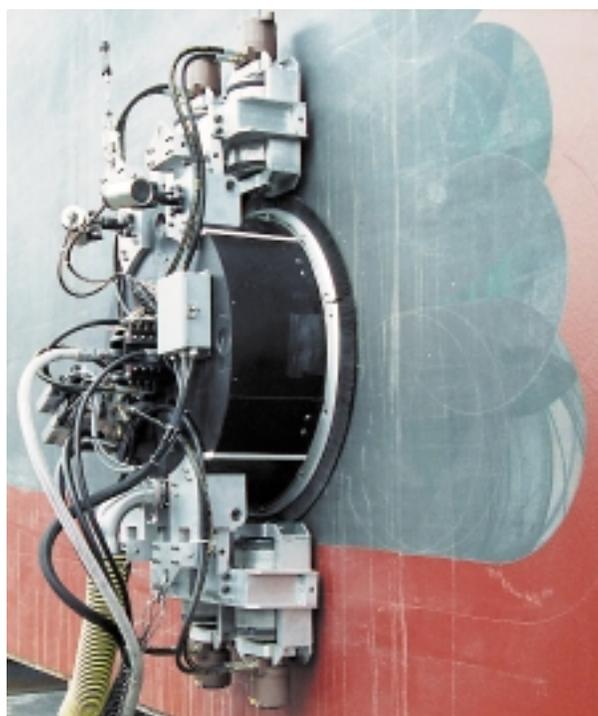


## Robotic Stripping

Mother Nature's new best friend is a robot. NASA's efforts in robotics are paying off in the commercial sector, as UltraStrip Systems, Inc., of Stuart, Florida, took advantage of NASA's funding, technology, and lessons learned in developing robotics for space missions, such as the unmanned exploration of Mars, to develop the patented M-2000 Robotic Paint Stripping System. Built out of a partnership between NASA's Jet Propulsion Laboratory (JPL), the National Robotics Engineering Consortium (NREC) at Carnegie Mellon University, and UltraStrip, the M-2000 is a robotic paint removal system that strips paint from ships without polluting the environment with toxic airborne dust.



*Traditional grit blasting produces toxic dust which poses a health risk to workers as well as the environment.*



*UltraStrip Systems, Inc.'s M-2000 removes paint from the hulls of ships faster and without producing toxic airborne particles common to traditional grit blasting.*

Before a ship can be painted, marine growth, corrosion, and layers of old paint must be removed. The semi-autonomous paint removal system attaches itself magnetically to the hull of a ship, with a vacuum hose running from it. A controller helps navigate the robot along the surface of the ship with 360 degrees of movement. The M-2000's high-pressure water jet generates 40,000 pounds per square inch of pressure to blast away the paint right down to the ship's steel substrate.

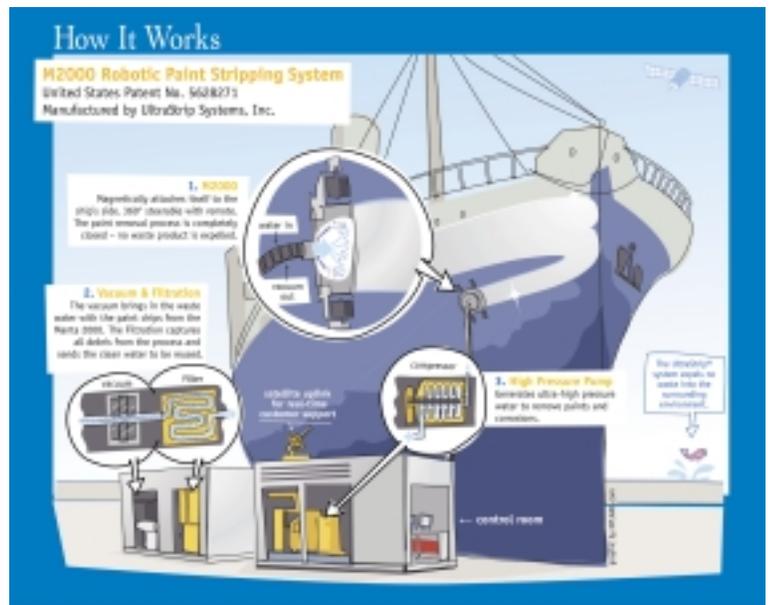
The resulting by-product is nothing more than water and dried paint chips, both of which are captured by the powerful vacuum system so no toxic residues escape to pollute the environment. The waste products are passed through a filtering system in a closed loop, extracting the paint from the water into a container, and recycling the water.

Using robotics to remove paint is a major advancement from the traditional method of paint stripping. Traditional grit blasting techniques

release environmental contaminants via the toxic dust produced, placing workers at risk for injury. It is also more expensive, which is an important consideration given the frequency ships need to be repainted. By using recycled water, water usage is reduced and there is no costly grit removal to landfills.

Other benefits of UltraStrip's M-2000 extend beyond preserving the environment. The robotic system is able to strip paint faster and remove more contaminants from the paint surface, all at a cost savings over grit blasting. The M-2000 removes salt and surface contaminants at a rate 200 percent greater than grit blasting. The result is improved paint coat adhesion, extending the coating life and reducing the need for constant repainting. The shorter time spent in dry dock increases profits for companies in the shipping industry. The M-2000 requires as few as four operators to remove the six to twelve acres of paint surface found on a typical supertanker, which also reduces the cost of labor and contributes to the reduced risk of injury.

While this technology is going to market, improvements are underway at JPL that will enhance the performance and reduce the time to remove the paint by at least 50 percent, using ultrasound to blast the paint off while the water



*The diagram demonstrates the high-pressure water jet and vacuum pump that make UltraStrip Systems' robotic paint stripping system environmentally safe.*

removes it. A brush sensor is also being developed to sense any paint residue, which will optimize the speed of the operation while improving the quality of the paint removal.

UltraStrip is currently working with shipyards from around the world to transition them to the M-2000 system. The company is also already looking into a second-generation of the technology to include computer vision, allowing the robot to adjust its course. Sensors are also being developed to detect surface quality, paint thickness, and amounts of paint remaining on the hull.



*Jean-Michel Cousteau, president of a non-profit organization dedicated to preserving the global water system, seen here with the M-2000 has partnered with UltraStrip Systems to keep the world's water ecosystems clean.*



## Preserving Fresh Fruit

**F**resher fruit may soon be arriving on produce stands thanks to research on extending future space missions. NASA's interest in developing a renewable food source for future long-term space travel has led to a new product that will improve the freshness of fruit on Earth.

Geo-Centers, Inc., has developed a patent-pending Ethylene Monitoring and Control System under a combination of a Phase II **Small Business Innovation Research (SBIR)** contract with NASA's Kennedy Space Center and an internally sponsored Phase III Program. NASA funded the research as part of the Controlled Ecological Life Support Systems (CELSS) breadboard project, with the purpose of monitoring environments in "closed" plant growth chambers.

As plants grow, they produce byproducts of ethylene and ammonia, both of which are harmful to plant development and create stress on the

plants at certain concentration levels. A monitoring system is required to control the concentrations in order to optimize the plant growth and maintain the overall health of the plants.

The results of the SBIR research concluded that while an ammonia monitor was feasible for NASA's applications, a vapor phase ethylene monitor would not meet the sensitivity requirements. However, it was determined that the ethylene monitor developed would have applications in the citrus processing market.

Specifically, the ethylene monitor could be used during the de-greening process of citrus fruits; however, finding the proper balance in ethylene concentration is necessary to reduce fruit loss. Proper de-greening requires exposing fruit to ethylene at five parts per million (ppm) for 72 hours. Studies have shown that exposure to ethylene at 15-20 ppm can cause a fruit loss of 50 to 100 percent.

Geo-Centers' ethylene monitor provides an unprecedented measurement range of 0-20 ppm and an accuracy of 0.5 ppm. The monitoring system provides an easy to use, cost effective tool that is capable of continuous monitoring in fruit packing houses. Previous devices were either too expensive, difficult to use, too slow, or did not provide continuous monitoring.

The Ethylene Monitoring and Control System can be installed in a central location and tubes are run to each de-greening room to collect air samples from up to 12 rooms per system. A pumping system draws an air sample from each room and injects it into the sample chamber. Ozone is used in the sample chamber to create a chemiluminescent reaction that produces light. A light detector monitors the level produced, and measures the ethylene concentration against predetermined light levels associated with certain ethylene concentrations. Control signals are then sent to either introduce or stop the flow of more ethylene gas into the room. The entire process takes less than 30 seconds per room.

Currently, Geo-Centers has provided the system to a customer in Europe, as well as two de-greening facilities in the United States, through its distributor, Beshaco, Inc. Geo-Centers hopes to further enhance the sensitivity of the system to make it useful to the larger potential market associated with produce storage applications.



*The Ethylene Monitoring and Control System provides optimal exposure of citrus fruit to ethylene, the gas that turns fruit from green to a ripened color.*



## Cleaner Landfills

With assembly of the International Space Station underway, scientists have been working to install a water treatment system that will efficiently purify waste products consisting of laundry, shower, hygiene water, and humidity condensation. The treated water will then replenish the clean water supply. However, support systems for the Space Station are subjected to extremely severe restrictions. Because the cost to put each kilogram of mass aboard the Space Station is very expensive, the total mass of the water supply and water purification systems must be kept to an absolute minimum. The Space Station, therefore, needs a system that purifies efficiently, is relatively light, and consumes a low amount of electricity to avoid the necessity of a large solar energy system.

With **Small Business Innovation Research (SBIR)** funding from NASA's Ames Research Center, Osmotek, Inc., of Corvallis, Oregon, delivered a system that met the stringent criteria for flight aboard the Space Station. The company also brought this technology into the development of their Direct Osmosis (DO) commercial treatment system. This unit differs from most water purification systems by using a direct osmosis process followed by a reverse osmosis treatment. Osmosis is a natural process of diffusing fluid through a semipermeable membrane until the fluid concentration on both sides of the membrane is equal. Reverse osmosis is a natural process used to separate small molecules from large molecules by selective diffusion through the same membrane. The diffusion is provided by pressure across the membrane.

During the course of the SBIR work, Osmotek researchers came up with the idea of using their osmosis technique, not to produce water for consumption, but to extract water from a waste product. The company is marketing the unit for use in landfills, where toxic chemicals, or leachate, can be "leached" into a water source that can eventually reach a river or lake. The company's system can treat leachate onsite at municipal or industrial

landfills by filtering the water and leaving behind the leachate, which can then be solidified into a substance that will not seep into water.

Another advantage to the DO system is its ability to reduce membrane fouling. Because of the unique design of Osmotek's DO system, substances on a membrane are prevented from obstructing the filtration process. The unit employs osmotic pressure, which keeps the membrane functioning properly.

After competing with other leachate treatment techniques in extensive testing, a landfill company selected Osmotek's technology for use in western Oregon, where the system has been in operation since July 1998. Osmotek also sold a unit to a food processing company. The company continues to market the product with the intention of promoting safer landfills. The threats posed by waste from landfills are a serious concern among legislators and citizens alike. Advancement in the treatment of such hazards is critical to the preservation of our environment.



*Osmotek, Inc.'s Direct Osmosis treatment system is being used to keep a landfill's surroundings clean.*



## Earth Science Goes E-Commerce

Curiosity and concern about the well-being of our planet has spurred the establishment of NASA's Earth Science Information Partners (ESIP) Federation, an organization that is dedicated to finding new ways of distributing earth science information to both the public and private sectors. The ESIP Federation stems from NASA's Earth Science Enterprise (ESE), which is charged with advancing the understanding of the total Earth system, including the effects of natural or human-induced changes in the global environment.

Among the many partners within the ESIP Federation is the Department of Forest Resources at the University of Minnesota-St. Paul. Researchers there, in collaboration with a number of natural resource management organizations, including the Minnesota Department of Natural Resources, are developing software that increases public access to Earth science information via the Internet. These software packages, in turn, are being commercially marketed by Agri ImaGIS of North Dakota.

Satellite imagery can be a valuable tool in precision farming, also known as "site-specific" or "prescription" farming. Satellite images, for example, can be used to map highly variable patterns of productivity within a given farm field. These patterns are based on spatial variations in soil characteristics, elevation, average yield, and other factors. Once mapped, these different patterns can be used to establish "management units" for carrying out precision farming techniques, such as variable-rate applications of fertilizer. Precision farming is economically attractive because it allows farmers to add fertilizer, pesticides, or other chemicals only to areas needing treatment, and only in necessary amounts, providing significant savings and increased yields. In addition, precision farming has important environmental benefits: it prevents excess applications of farm chemicals that run off and pollute neighboring streams and other sources of water.

Agri ImaGIS, a company that provides satellite images of farmland and agricultural views to clients throughout the United States, approached



*Images like this section of Arkansas are provided to Agri ImaGIS' customers for analyzing farm fields.*

NASA-MSU TechLink in Bozeman, Montana, for access to technology that would improve the company's capabilities to deliver satellite images over the Internet. In addition, the company wanted to develop the ability to provide digital cartographic, or geographic information systems (GIS), data over the Internet, including maps of road networks, topography, soil classification, and agricultural yields.

TechLink learned that software with the desired functions had been developed through NASA's Remote Sensing Database Program.

Agri ImaGIS has formed a partnership with the University of Minnesota group, allowing the company to adapt and further develop the software to meet its Internet commerce needs. The company is helping to bring a new dimension to land and farm management, providing cultivators the opportunity to use their land more practically, economically, and with more emphasis on the environmental impact of farming.



## Space Age Spuds

Around the world, many countries lack an adequate supply of healthy potatoes, a staple crop capable of feeding many people. A new technique for growing seed potatoes using NASA technology has the ability to change all that. By combining a growing technique from China with NASA-developed growth chambers, American Ag-Tec International, Ltd., of Delavan, Wisconsin, has developed a system they call Quantum Tubers.<sup>TM</sup>

American Ag-Tec International worked with the Wisconsin Center for Space Automation and Robotics (WCSAR), a NASA-sponsored Commercial Space Center located at the University of Wisconsin-Madison. NASA's Commercial Space Centers assist companies to develop products derived from space based research as part of the Space Product Development Office at Marshall Space Flight Center.

Using computerization and technologies originally intended for growing plants in outer space, American Ag-Tec and WCSAR developed a growth chamber that accelerates plant growth, and is free of plant pathogens. This unique growth chamber provided the perfect vehicle for taking advantage of a Chinese technique for growing minitubers, which serve as nuclear seed stock for potatoes.

Typically, minitubers are grown from tissue-cultured plantlets inside traditional greenhouses. There is little control over the environmental conditions such as light and temperature, so that only one small crop of minitubers can be produced annually. In China, researchers moved the small plants to different locations in the greenhouse to create the maximal environmental conditions.

NASA's growth chambers provided the solution to these problems. Using unique lighting technology, high-efficiency temperature and humidity controls, and automation technology, the minitubers can be generated in one closed facility without the labor-intensive handling. Also, the self-sustaining chambers bring production indoors, removing the grower's dependence on weather or



*Quantum Tubers<sup>TM</sup> potato minitubers weigh 0.3 to 0.5 grams and produced the potatoes in the background.*

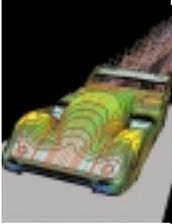
the sun. This allows minitubers to be grown year-round in extreme environmental settings, such as deserts or excessively cold regions.

The ability to accelerate the growth cycle of minitubers allows for the introduction of new varieties of potatoes to the commercial market within two years of developing the nuclear generation of seeds. Previously, seed multiplication could take up to seven years of planting, cultivating, and harvesting to multiply a sufficient stock of seed potatoes for commercial planting.

American Ag-Tec's new system eliminates the need for multiple generations of seed. The minitubers are pathogen-free and not exposed to diseases and pests that can reduce seed stocks. The Quantum Tubers system can produce 10 to 20 million tubers throughout the year, about equal to the world's supply of this generation seed stock. The system also lends itself to creating genetically altered potatoes and even potentially growing plants that produce edible vaccines.

American Ag-Tec has sold its first franchise of the Quantum Tubers system and expects it to produce minitubers in Poland this year. Robert Britt, president of American Ag-Tec, foresees use of the system in other developing countries. Because many of these countries import seed potatoes, they can save millions using the Quantum Tubers technology.

Quantum Tubers<sup>TM</sup> is a trademark of American Ag-Tec International, Ltd.



## Web Time-Management Tool

A NASA Software of the Year finalist has found a place on the World Wide Web. Thanks to a licensing agreement between the California Institute of Technology (Caltech) and Oak Grove Systems, of Pasadena, California, an entirely new generation of software that allows users to integrate workflow processes like never before is available as Oak Grove Reactor.<sup>TM</sup>

Oak Grove Systems is the first company to operate under a new Jet Propulsion Laboratory (JPL)/NASA technology transfer policy designed to speed up the transfer of space age technologies to the commercial sector. Oak Grove believes process integration software, such as Reactor, will join e-mail and the World Wide Web in transforming the way we learn and correspond.



The software, developed by JPL/Caltech, was originally put to use at Johnson Space Center as part of Johnson's High Volume Data Management project. It was applied to the management of mission critical operations in the Space Shuttle and International Space Station programs. The software connected multiple project teams at independent sites, despite differing levels of software sophistication, user interaction, and user interfaces. Specifically, the software allowed a 1,000-person team to interact with each other and the data as it was adjusted, reorganized, and updated day to day.

With Reactor technology in place, NASA has experienced a 40-percent reduction in process cycle time as decisions and changes are made more immediately. Since hitting the commercial market, customers who have implemented Reactor products are enjoying a dramatic increase in improved team efficiency and individual productivity.

Oak Grove Systems president Chuck Ames says that this cutting-edge technology can join e-mail, calendar/scheduling, and legacy applications into one interactive system via the web. Reactor process delegation server lets organizations with large numbers of employees who are disconnected due to geographic, technological, and systems barriers improve their efficiency and workflow.

Most similar products focus on either product data management (PDM) or vertical workflow management systems. PDMs focus on controlling access and eliminating mistakes as projects are passed around to several people, while workflow

*When used with portable communication tools, Reactor<sup>TM</sup> allows business and customer questions to be handled anywhere, even from a parked car.*

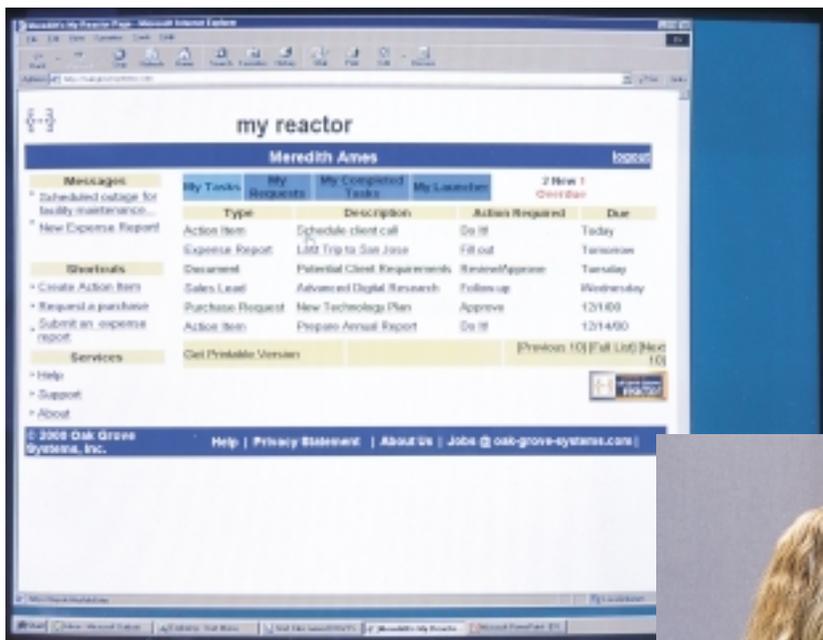
management tools aim to notify persons when pieces of a project are completed or have deadlines approaching.

The typical program combines a little of both systems into one application, but requires organizations to tailor their own system to the workflow system, and train employees on how to use the new program. Oak Grove Reactor provides improved workflow management with tools typically available to most users. Reactor is employee-friendly because it works with existing software and few new skills are needed to use it proficiently.

Reactor uses a web browser, such as Microsoft Internet Explorer® or Netscape Navigator,® as its interface. A user can edit, reassign tasks, modify text, change preconditions, and add or remove steps to a procedure. Other users may work on the same procedure or view its status while it is being worked on at a different site.

Oak Grove Systems is partnering with other companies to power their software with Reactor-enabled processes. Ames believes Reactor can revolutionize the way businesses communicate internally, and how projects are completed. The prospect of working with colleagues located in New York and France, as though they were just down the hall from each other, has Oak Grove believing they can change the way the world works together.

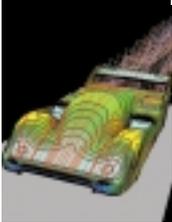
Oak Grove Reactor™ is a trademark of Oak Grove Systems. Internet Explorer® is a registered trademark of Microsoft Corporation. Netscape Navigator® is a registered trademark of Netscape.



*Priority tasks and due dates are organized and highlighted to keep the user abreast of developments.*



*Oak Grove's software also works in the office as a tool for sales people providing a new level of customer service, especially online.*



## Rocket Science for the Internet

As more people move onto the information highway, computer networks must balance the open, free-access of the Internet with security and manageability concerns. A new software product, derived from research conducted at the California Institute of Technology (Caltech) under contract with NASA's Jet Propulsion Laboratory (JPL) and the Defense Advanced Research Projects Agency (DARPA), is the first fully distributed gateway clustering solution for the Internet.

The original research was sparked by DARPA. Wanting to know if reliable systems can be built with off-the-shelf-products, DARPA approached JPL to make use of their world class expertise in designing fault-tolerant systems. Existing testbeds and future applications at JPL made the NASA center the ideal place for DARPA to turn. JPL then contracted Caltech scientists to build a system of interconnecting computers with a redundant system.

After four years of development, Caltech delivered a software program making use of Reliable Array of Independent Nodes (RAIN). It has been in use at JPL's Center for Integrated Space Microsystems (CISM). Center director Leon Alkalai foresees using RAIN on International Space Station missions or the Space Shuttle, where

astronauts could string together laptop computers to behave as a single system.

Upon completion of the research, RAIN developers, Caltech professor Shuki Bruck, and four of his colleagues, secured a patent and exclusive licensing agreement from Caltech to make RAIN commercially available. The result is Rainfinity, a software company that released its first product, Rainwall, in April 1999.

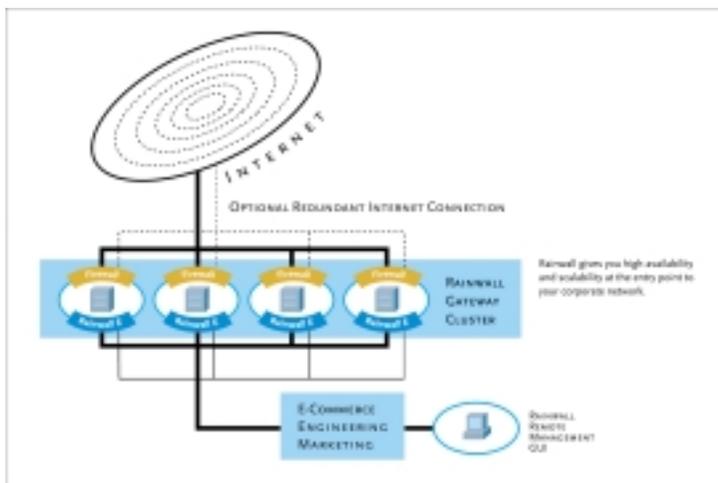
RAIN has three components: data storage across nodes and retrieval even if some nodes fail, communications in a redundant network between multiple nodes, and computing that transparently recovers if a node fails. Rainwall utilizes these capabilities to run a cluster of computer workstations, creating a distributed Internet gateway.

When Rainwall detects a failure in software or hardware, traffic is automatically shifted to a healthy gateway without any interruptions in service. This makes Rainwall-powered computers ideal for hosting applications such as firewalls.

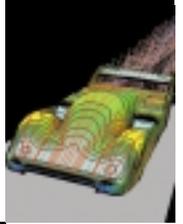
Traditional systems using firewalls have typically worked like a gate and heavy traffic or system failure could cause bottlenecks. Rainwall provides load balancing for systems by directing network traffic evenly across several machines, or in cases where one machine fails, redirecting traffic to the remaining operating connections.

One of the many innovative features of Rainwall is its ability to detect when a firewall node has crashed and to inform the other remaining firewall nodes of the status of the health of each node. A second innovation is Rainwall's ability to get downed servers back online and functioning within the cluster on the fly. This allows information technology personnel to perform scheduled maintenance during normal business hours.

During 2000, Rainfinity will release products addressing availability, scalability, and performance of web servers and web caching servers. To date, Rainwall is being used at several large corporations in the telecommunications and Internet industries, as well as banking and other financial institutions.



*Rainwall provides a more evenly distributed workload across servers and less downtime.*



# Agent Building Software

One sure sign of the development and advancement of technology is the ease with which average people are now able to do tasks that were once reserved for only the most highly educated or technically skilled. A perfect example of this trend is found in AgentBuilder® a software component developed under **Small Business Innovation Research (SBIR)** contracts between Reticular Systems, Inc., and Goddard Space Flight Center.

Reticular Systems, of San Diego, California, created AgentBuilder to allow software developers with no experience in intelligent agent technologies to easily build software applications using intelligent agents. Agents are components of software that will perform tasks automatically, without any intervention or command by a user. Software agents act as a personal assistant by making use of pre-programmed knowledge to evaluate incoming information and handle it accordingly, or it will realize it needs more information from the user and will request further input in order to continue.

NASA's interests stemmed from a desire to incorporate intelligent agents into ongoing research of agent applications in both ground- and space-based systems. The success of the SBIR research led NASA to expand the agent research into intelligent information management. NASA hopes to use agents soon to support web-based information access and management, according to

Walt Truszkowski, NASA Technical Officer on the SBIR contracts with Reticular Systems.

Reticular Systems' AgentBuilder makes intelligent software agents more readily available to the average programmer. Programmers with no background in intelligent systems can quickly and easily build intelligent agent applications using AgentBuilder. Using the Java™ programming language, AgentBuilder can work on any machine or operating system that supports Java. The software package comes with a toolkit and run-time system. The toolkit allows a user to build an agent system tailored to the needs of the individual. It also has a test feature that allows the user to check for any bugs in the agent program before initiating it. The run-time system serves as a high performance agent engine to execute the agent programs.

AgentBuilder reduces the time and costs of developing agent systems and provides a simple mechanism for implementing high-performance, robust agent systems. The use of Java programming language, a development resulting from the Phase II SBIR work, will make AgentBuilder useful to a wide array of software application developers.

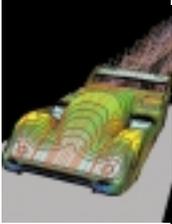
Initially introduced in 1998 as AgentBuilder Lite, Reticular Systems continued to develop the product and in 1999 released AgentBuilder Pro, which features an advanced suite of tools for building and testing multi-agent systems.

AgentBuilder has achieved worldwide sales, from Sweden to Japan to South Africa. As interest in intelligent agents grows globally, Reticular Systems expects demand for products such as AgentBuilder to be on the rise.

AgentBuilder® is a registered trademark of Reticular Systems, Inc.  
Java™ is a trademark of Sun Microsystems, Inc.



*Intelligent software agents are poised to be used more extensively thanks to Reticular Systems' easy-to-use software.*



## Age and Stress Prediction

As anyone who has been to a carnival knows, guessing the age of someone or something is not an exact science—until now. Enter Genoa, a software product in the making since the 1970s, and the only software that can predict progressive aging and failure in a variety of materials. Genoa is the result of a NASA **Small Business Innovation Research (SBIR)** contract between the Glenn Research Center and Alpha Star Corporation.

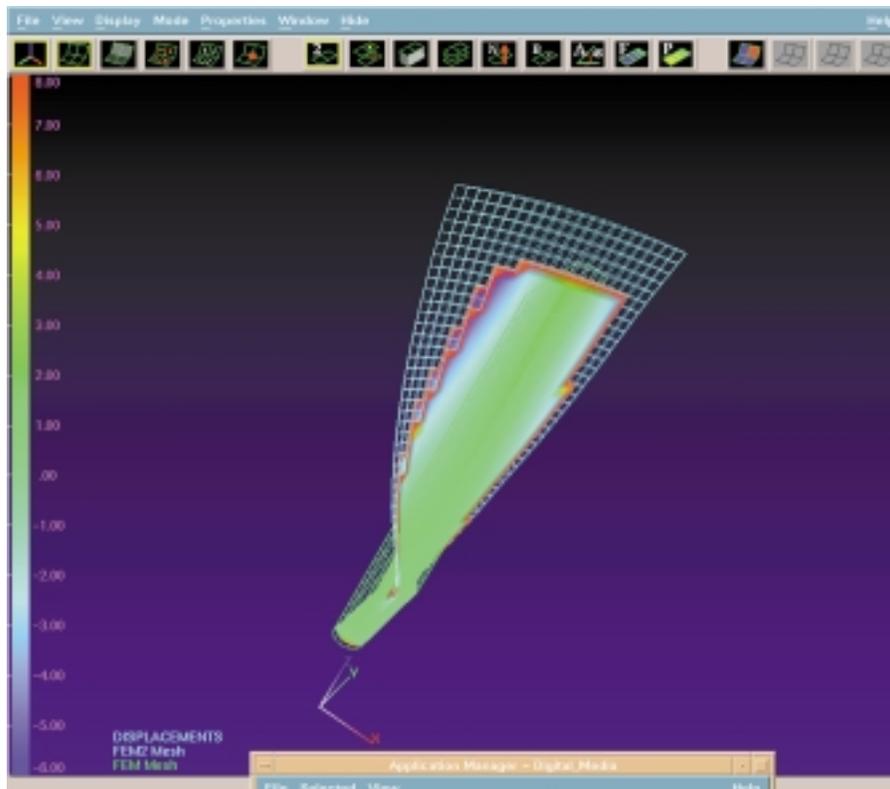
Alpha Star, located in Long Beach, California, is a small, woman-owned business established in 1989 through a series of contracts funded by the SBIR Program. Glenn awarded the contract to Alpha Star to develop a cost-effective method for predicting strength, durability, and reliability of structural components used in aerospace applications during the design stage.

Everybody knows that materials such as metal, ceramic, concrete, and other composites wear out over time. However, when using these materials in

space travel, airplanes, automobiles, or even bridges, it is important to detect or project when age is catching up to them. Using Genoa allows designers to determine stress limitations at an early stage, that is, if the materials they plan on applying to the structure are up to the task or if alternates should be considered.

Genoa can perform three-dimensional analysis that predicts crack initiation, as well as growth and failure of materials, eliminating the need for much experimental testing. This is an improvement on the finite element analysis (FEA) tools currently on the market, which struggle to perform accurate three-dimensional modeling simulations of complex materials. Genoa's predictive software has been able to successfully match experimental data within one to six percent of the actual results.

Other benefits of using Genoa include reduction in inspection frequency, rapid design solutions, and manufacture of low cost materials. While currently aerospace, airlines, and automotive industries are

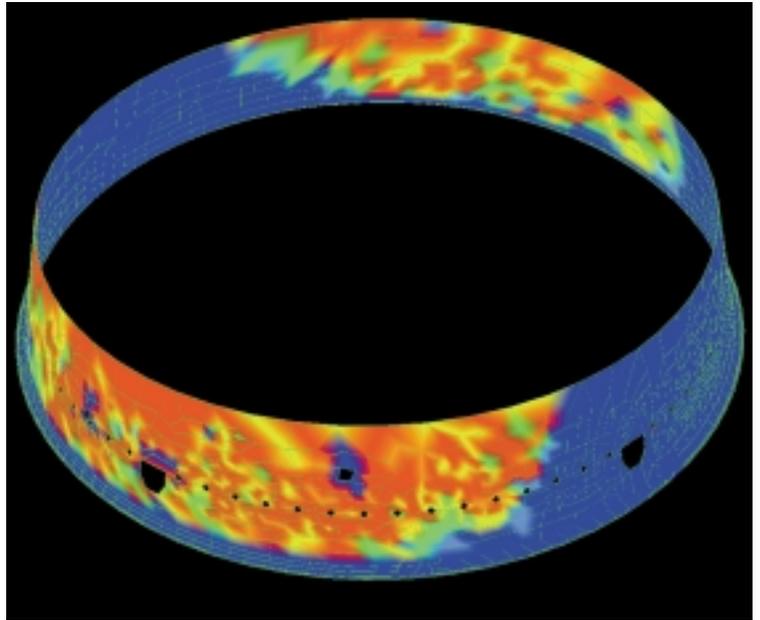


*Genoa has been used for composite wind mill and turbine blade manufacturing.*

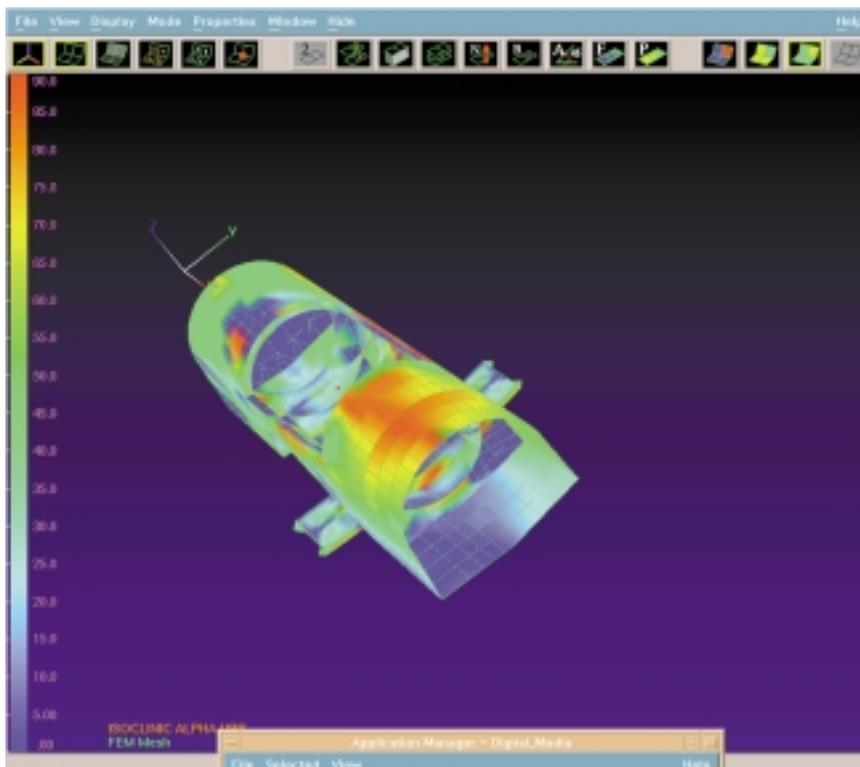
viewed as the key beneficiaries of Genoa's capabilities, Alpha Star sees future applications in sporting equipment, computer chips, museum artifacts, and biomedical tools. All of these would benefit from a degradation analysis to correct problems before they happen.

The end results are improvements in design and safety, while at the same time reducing time and money spent in testing. The ability to provide so many benefits is why Genoa received the 1999 NASA Software of the Year award. Genoa was chosen from among 50 entries representing more than 150 corporations, universities, and government laboratories.

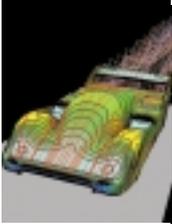
Successful completion of the development of Genoa has led to its use in many NASA projects. Several NASA contractors have made use of Genoa to design or redesign engines, wings, and turbines. With the road and bridge infrastructure in the United States, as well as many commercial aircraft fleets beginning to age, an advanced FEA tool such as Genoa is especially important.



*Genoa software is used for simulating medium sized ceramic matrix composite engines. The simulation shown here is at 2500 degrees Fahrenheit with a lifetime of 1000 hours.*



*Progressive failure simulations and test verifications are two applications of Genoa demonstrated here on a mini-space plane.*



## The Imagery of Sound

Engineers and designers can enjoy the benefit of software that measures the acoustical performance of products. Automated Analysis Corporation (AAC) of Ann Arbor, Michigan, and NASA have made this innovation possible.

With the help of **Small Business Innovation Research (SBIR)** funds from NASA's Langley Research Center, AAC developed computer technology that creates images of the acoustical characteristics of systems and components in many industries, such as the aircraft, automotive, and audio systems industries. This type of software is useful in Langley's efforts to optimize the acoustical performance of aircraft by predicting design effects, such as those within aircraft sidewalls and seating. AAC has made this technology available to its customers by offering COMET<sup>®</sup>—a suite of acoustic analysis software for advanced noise prediction. COMET is used during the design and analysis cycle of product development and offers engineers and designers the benefit of cost reduction and sound quality improvement by predicting the product's sound performance even before the first prototype is built.

COMET analyzes the origin, radiation, and scattering of noise, and supplies information on how to achieve noise reduction and improve sound characteristics. This software is a valuable tool in reducing design time and expense, while simultaneously optimizing a final product's acoustical performance.

COMET's Structural Acoustic Foam Engineering (SAFE) module extends the sound field analysis capability of foam and other absorptive materials. SAFE shows how noise travels while airborne, how it travels within a

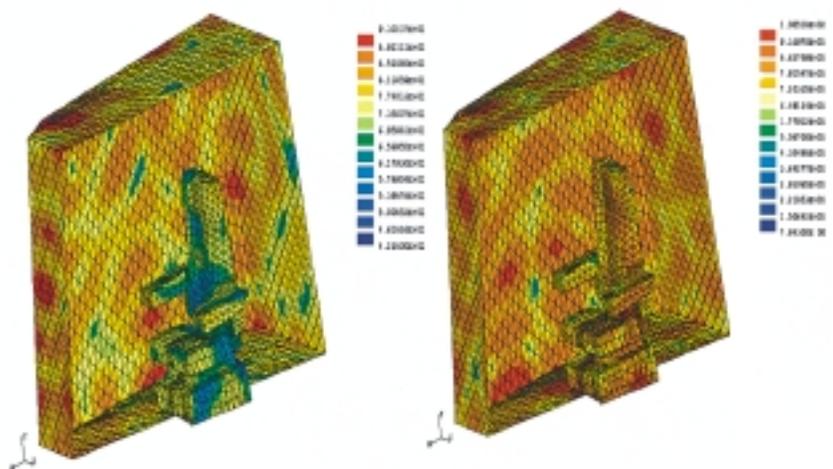
structure, and how these media interact to affect other aspects of the transmission of noise. Although foams themselves are not useful as sound barriers, they are useful for sound absorption, and for this reason, SAFE can help users optimize those absorptive qualities.

The interactions among various domains are generalized so that all types of interface conditions can be accurately modeled. This is especially important in foam-like materials, because the type of interaction among domains can significantly affect the acoustical performance of the product.

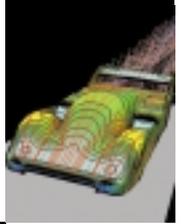
"[SAFE] enables product engineers and designers to predict the noise performance of a wide variety of materials, such as glass fiber, mineral wool, and open or partially open cell foams," according to Kim Novak, AAC company representative. These materials are found in a variety of products such as headliners, seats, carpets, trim lining, panel damping, aircraft skin insulation, building wall insulation, machinery, and enclosure liners, and its uses continue to grow. SAFE provides a powerful tool that can be used for the design of optimal modern noise control treatments, thereby solving many acoustic problems in foam materials.

AAC is a computer-aided engineering company, founded in 1983, and provides consulting services to the aerospace and automotive industries. Other NASA-inspired products are being commercialized by AAC as well, promising great strides in effective sound design.

Comet<sup>®</sup> is a registered trademark of Automated Analysis Corporation.



*Both seats were modeled by Automated Analysis Corporation's SAFE. The left incorporates absorptive material and the right was modeled as rigid.*



# Geographic Freedom

**W**ith the demands of a high-tech society, it seems like people are being asked to be in several places at the same time.

While this may seem impossible, NASA managed to find a way to do just that through the Internet. NetLander, Inc., a Titusville, Florida, company has licensed the technology from Kennedy Space Center for use in a variety of commercial applications.

Kennedy originally developed a web-based, near real-time monitoring system called JView, used in Space Shuttle operations. Written in the Java™ programming language, JView allows users to access Space Shuttle and ground support equipment data from any desktop computer with a web browser. Engineers can view information found in Mission Control rooms with a delay as short as two seconds.

NetLander has taken this technology and developed its commercial cousin, JTouch, to monitor and distribute data using the Internet. JTouch can be used to monitor sensors around the globe from one location using a standard web browser and any existing web connection. The capability to monitor systems from multiple sources without leaving your desk, also known as geographic independence, has significant benefits for companies using the JTouch system.

Most of the benefits reaped are increases in efficiency, through reductions in time and costs. Company travel expenses can be reduced as facilities fanned out around the globe can be monitored at one desktop computer rather than by visiting each site. Productivity is increased through better communications and improved decision making by company executives, who have access to real-time data rather than outdated material. In the past, outdated information did not allow for timely solutions, so that by the time a decision was made, the problem had passed or a new, more pressing problem had arisen.

JTouch is presently finding a home in the manufacturing and telemedicine fields. It can support up to 200 users in its original form and up to 800 with a scalable design. JTouch also has

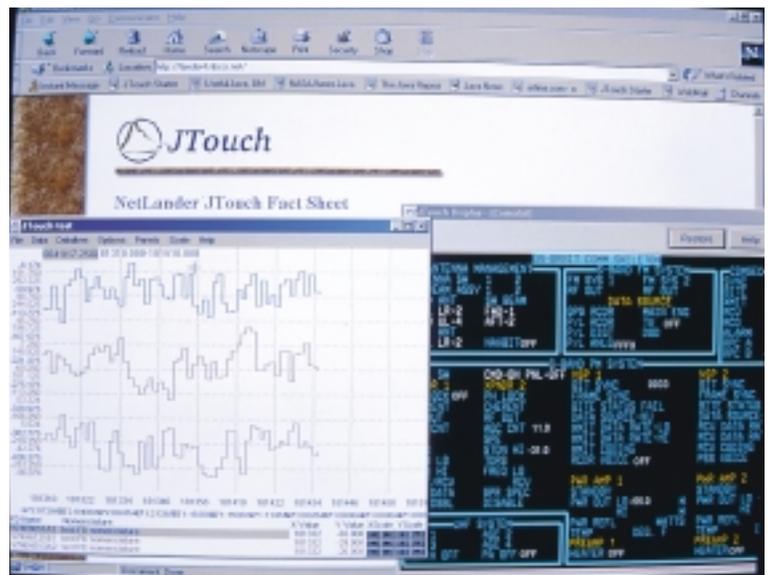
graphic capabilities that allow for the generation of color charts and graphs to capture incoming data in a usable, visual format. The system can process multiple data streams with up to 50,000 measurements per stream. Due to its Java programming language, it can run on Unix or Windows® operating systems.

NetLander is a tenant of the Florida/NASA Business Incubation Center (FNBIC). The FNBIC aims to foster the successful development of new high tech companies in the region by providing office space and other resources to young, developing companies. Prior to creating NetLander, company president Thomas Beever was a NASA employee for 13 years and the original leader of the “Java Think Tank.”

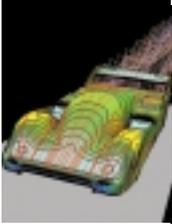
Besides current sales, NetLander has received interest in the JTouch system from semi-conductor manufacturers, clothing manufacturers, utility companies, and university labs. With JTouch, anybody can turn a local desktop computer into Mission Control.

Java™ is a trademark of Sun Microsystems, Inc.

Windows® is a registered trademark of Microsoft Corporation.



*JTouch provides continuous perfect information by graphing any number of measurements to aid visual interpretation of numerical data.*



## Increasing the Flow

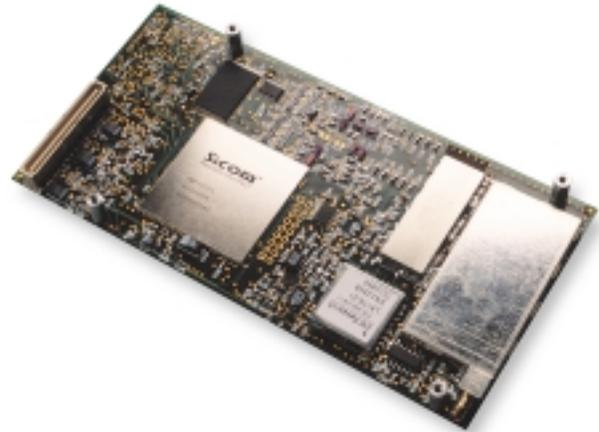
Everywhere you go people are looking for increased bandwidth. Whether it is a faster dial-up modem, digital subscriber line (DSL), cable, or a wireless connection, people want to transmit data as fast as they can. The desire for faster data transmission is greater nowhere else than at NASA.

Seeking to increase the speed of wireless communications for space missions, such as the International Space Station and Earth Science missions, NASA's Glenn Research Center funded a series of **Small Business Innovation Research (SBIR)** contracts with SiCOM, Inc., located in Scottsdale, Arizona. NASA has since contracted with SiCOM to provide a radiation-hardened version of their original innovative modulator. NASA plans to make use of the technology for more efficient satellite-to-earth communications links in terms of more data per watt of power, or more data through an assigned frequency channel, or both.

The high-speed wireless digital modem, resulting from the SBIR work, provided SiCOM with the technology to develop a commercial line of circuit cards and Application-Specific Integrated Circuit (ASIC) products. The programmability and choice of modulation makes SiCOM's modem products ideal for high-speed wireless data.

SiCOM's products are on the leading edge of high-speed, high-performance, and low-cost, digital wireless communications, enabling significant power and bandwidth efficiency in a single integrated circuit. These advanced modems can be used to transmit wireless data at over one Gbps (one billion bits per second) and allow users to optimize performance by providing control of waveform shaping, symbol rates, code rates, modulation order, pre-equalization, and post equalization.

SiCOM's technology has the potential to increase link throughput by as much as 50 percent even through existing ground terminals and satellite transponders. SiCOM's products are well-suited for satellite applications such as broadband

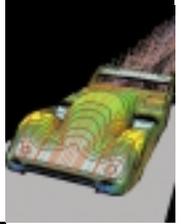


*SiCOM's modulator and demodulator circuit cards offer high-speed, wireless transmissions of data for satellite applications.*

distribution, including high definition television (HDTV), multimedia broadcasting, and digital satellite news gathering (DSNG), as well as terrestrial applications such as local multipoint distribution service (LMDS), Sonet/Synchronous Digital Hierarchy (SDH), fast Ethernet and gigabit Ethernet links. These applications require a continuous link, for which current SiCOM products are designed.

The company claims to offer the broadest feature set for ASIC-based solutions. The flexibility provided by their chips can generate efficiency in many areas, including cost, transmission power, spectrum use, antenna size or distance, or some combination of any of these variables. This allows communications link designers to make use of SiCOM products to meet the specific and unique needs of varying applications.

SiCOM continues to advance its technology to provide improved value in communications link designs. Specific concentration is on advanced coding, modulation and demodulation coding techniques, and semiconductor processes. Also, products for burst (packet) applications are under development. SiCOM recently won a Defense Advanced Research Projects Agency (DARPA) contract under the Next Generation Internet (NGI) program to develop and demonstrate an OC-12 (622 Mbps) modem for wireless connectivity to DARPA's SuperNet.



## Software Sleuth

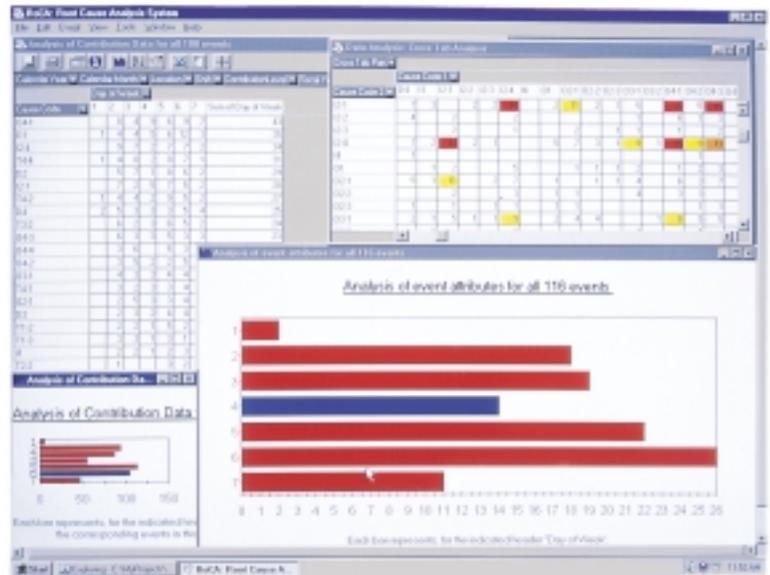
Most people make mistakes and can usually just write them off as an accepted part of being human. NASA, however, must minimize the frequency and impact of errors by aggressively analyzing and fixing their root causes. Often this requires extensive investigation and detective work to track down what went wrong. Driven by the need to be error-free, NASA's Kennedy Space Center funded a **Small Business Innovation Research (SBIR)** contract with Prevision, Inc., to develop a Root Cause Analysis (RoCA) system.

Fair, Isaac & Co., Inc., uses predictive technology to provide customers with forward-thinking solutions to prevent mishaps before they happen. When complex systems fail, companies, especially manufacturers, want to be able to trace the problem to its source. More often than not, the mistakes are caused by human error. RoCA provides tools for entering investigation information and maintaining a database of mistakes, trends, and recommendations.

The system was developed for Kennedy to help track incidents and other events involving human errors during Space Shuttle ground processing. Although NASA has used similar systems in the past, RoCA helps organize the areas that may need additional training or other forms of preventive and corrective action. With all the inspections, maintenance and repairs that take place on each of the Space Shuttles between missions, tracking all the activity is quite a task. Sorting through the reports after a mistake has been made to determine the cause is even more daunting.

Using the RoCA system, investigation data can be stored, organized, and converted into detailed reports. When an event occurs, investigators are assigned to find the problems. The conclusions and analysis provided by the investigators are entered into a database. The updated database is placed on a shared network so other investigators can access the data to generate various reports. With each event accurately tracked in the database, RoCA can be used to detect trends, which can be entered in the database as a Trend Analysis. The database can also be used to track Recommendation Analyses conducted for individual events and trends.

Events are entered into the database with a variety of attributes associated with the incident. Information such as the event name, date, time, location, and a



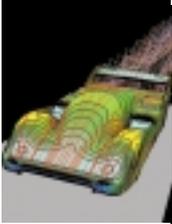
*The RoCA data can be customized into reports that allow the user to readily identify underlying problem areas. Cross-tab and graphing abilities aid in the recognition of numerical data.*

text description are all required to be entered into the database. Events are also comprised of two components, a Contribution Analysis and a Qualitative Analysis.

The Contribution Analysis lists the contributing factors, an associated cause code, and a contribution weight ranging between None-Low-Medium-High. The Qualitative Analysis breaks down complicated events into smaller pieces and specifies cause and time relationships. The resulting report provides a timeline of the events and a causal network diagramming how the components of the event worked together to lead to the mistake.

The RoCA system is divided into two separate applications: RoCA and RoCAReport. RoCA is used to manage the event database, describe events, store the analyses, and create reports. RoCAReport provides a more streamlined, easy-to-use, single-click method for accessing the major reporting features of RoCA.

Using the RoCA system, Fair, Isaac is able to help its customers find advanced decision-making solutions. Fair, Isaac expects that application of RoCA in the manufacturing industry would reduce costs and improve efficiency, by allowing for an examination of how to fix the anomalies captured in the production process.



## Finding Diamonds in the Rough

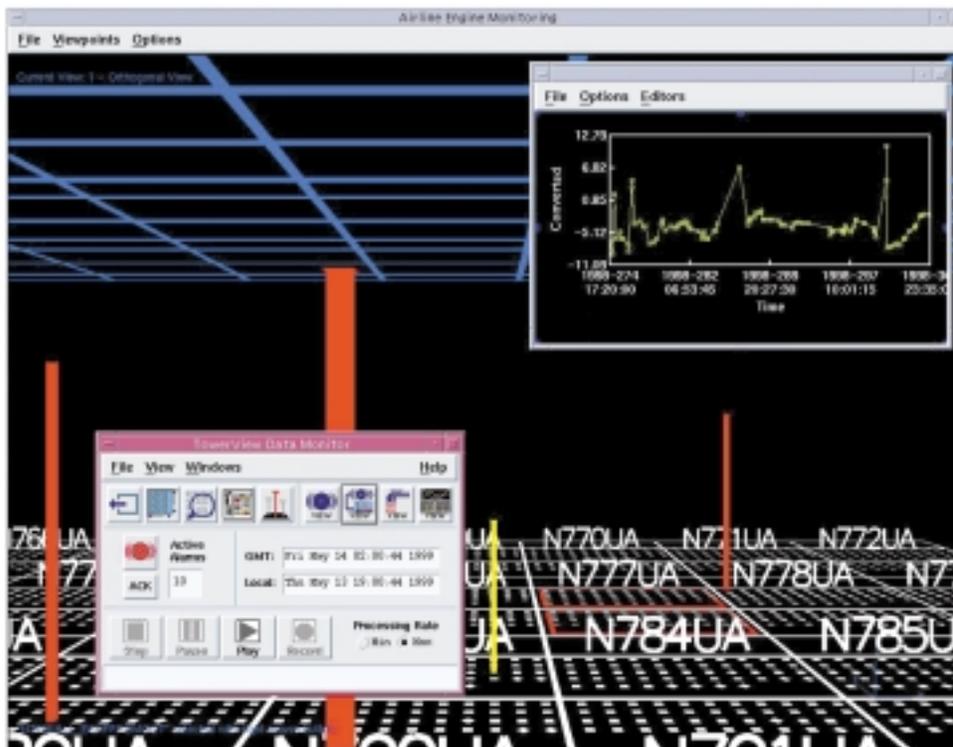
Sorting through massive quantities of data to find meaningful information from space is no easy task. NASA needed just the right tool for that kind of undertaking. HighTower Software, Inc., of Irvine, California, now markets TowerView,<sup>®</sup> a product based on technology that was originally developed for monitoring transmissions from NASA's unmanned spacecraft.

The company's founders developed this technology at NASA's Jet Propulsion Laboratory (JPL), and early versions of the product still support NASA's Voyager, Galileo, and Cassini missions. NASA's first successful deployment of real-time monitoring and analysis technology was TowerView's predecessor, MARVEL, which has been in continuous real-time use since Voyager's encounter with Neptune in 1989.

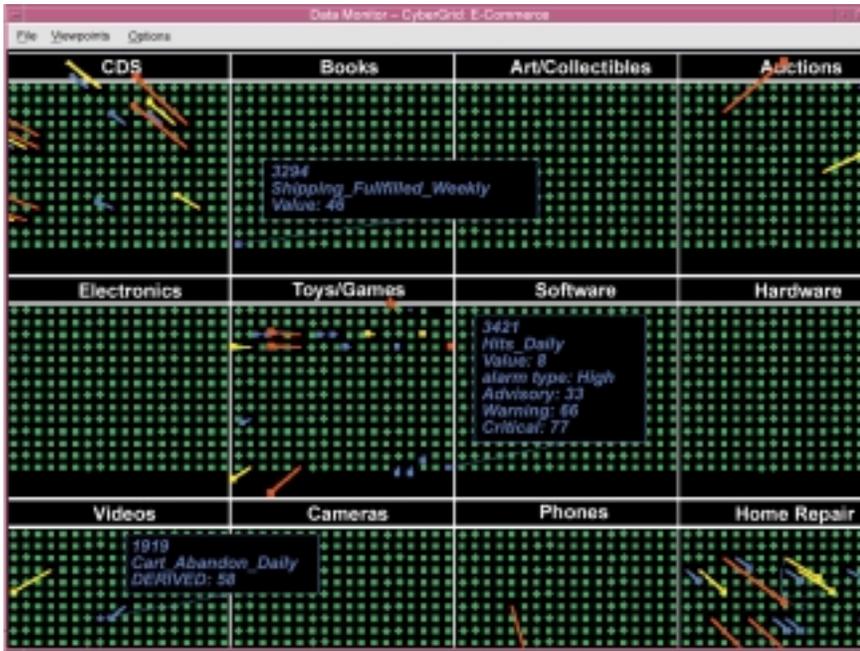
The inventors of this visual data discovery technology are offering an integrated suite of software tools with underlying analysis capabilities and represented visually within the CyberGrid,<sup>®</sup> a three-dimensional display. The CyberGrid is

designed to help users see, at a glance, critical information buried in massive quantities of data by highlighting data that is unusual. Unusual data are represented by towers on the CyberGrid and the height of the towers is proportional to how unusual a particular piece of data is. It also allows users to set trend alarms, which are triggered by fluctuations in data over time. These alarms are displayed as flashing objects in the CyberGrid, giving users the opportunity to focus on essential information and respond instantly. The CyberGrid integrates thousands of potentially diverse measurements into one display.

The CyberGrid was developed in response to cognitive research, which has demonstrated that humans are not able to hold more than seven (plus or minus two) information "chunks." Graphs can pull numbers together into a "picture" that can be held in a single chunk of short-term memory, while tables tend to overwhelm the observer's ability to absorb pertinent information. CyberGrid takes the



*TowerView<sup>®</sup> lets the user set trend alarms, which are triggered by fluctuations in data over time. These unique and powerful alarms are displayed as flashing objects in the CyberGrid.<sup>®</sup>*



*TowerView® offers solutions spanning a range of e-business infrastructure applications*

traditional graph a step further by adding a third dimension, permitting an even larger amount of information to enter the single picture.

This data snapshot can be a very useful tool during clinical trials, such as aiding in expediting Food and Drug Administration (FDA) drug approval. TowerView’s visual analysis capabilities can significantly reduce the time it takes to close a trial for FDA approval. A large clinical research organization used TowerView to evaluate safety of a new AIDS treatment. Clinicians managing the trials needed immediate access to data that indicate unusual trends, anomalous information, and a means of analyzing different values, such as a continuous decrease in platelet and white cell counts over the course of a patient’s visits for monitoring in the trial. Furthermore, the sooner drugs critical to the treatment of very ill patients come to market, the earlier these drugs can begin saving lives.

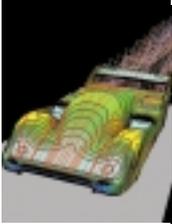
Other industries, such as e-commerce, can benefit from TowerView’s rapid information analysis capabilities. TowerView enables the user to monitor and analyze important data, such as web

page traffic statistics, inventory records from data warehouses, and critical marketing information—integrating all of it into a single real-time view.

According to the company: “The evolution of this technology first at JPL and more recently at HighTower, has led to a highly sophisticated and widely applicable product that can be easily and inexpensively installed, maintained, and modified.”

This technology can clearly offer the user an entirely new way of sifting through mounds of data to find crucial information.

TowerView® is a registered trademark of HighTower Software, Inc.  
 CyberGrid® is a registered trademark of HighTower Software, Inc.



## The Center of Attention

With the dizzying amount of software available on the market today, communication across different computer platforms and applications has become a must. A data-collection and processing “middleware” package that was developed with NASA’s **Small Business Innovation Research (SBIR)** funding is making strides in computer systems integration.

Creare, Inc., of Hanover, New Hampshire, has made it possible to synchronize interaction among different computer applications. Originally created in conjunction with NASA’s Dryden Flight Research Center for collecting and processing aircraft vibration test data, DataTurbine™ is now used as a software tool for industrial monitoring, collaborative simulation and modeling, and multimedia data streaming.

DataTurbine serves as “glueware,” allowing communication among dissimilar computer platforms and permitting analysis, storage, and acquisition of shared data. The middleware technology solves many problems posed by real-time or online data management in collaborative environments. These environments must be capable of exchanging large volumes of data from dissimilar systems at local and remote sites. DataTurbine’s underlying technology, Creare’s

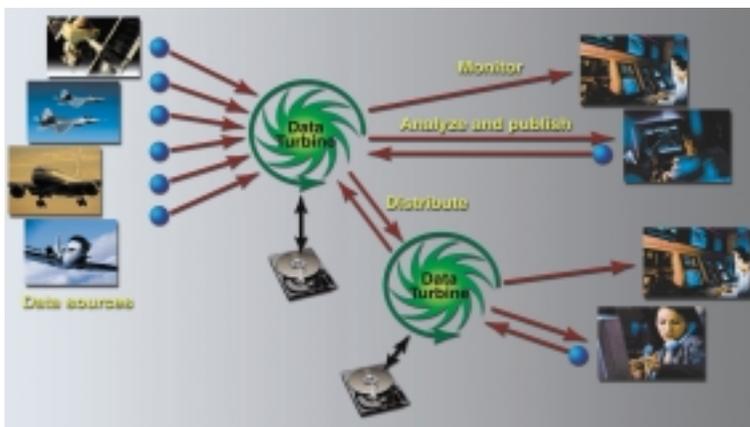
patent-pending Ring Buffered Network Bus (RBNB), is a software server that provides a buffered network data path between suppliers and consumers of information. Diverse distributed applications pool and share data using DataTurbine as a common intermediate point of contact. Therefore, the RBNB manages all aspects of inter-application data traffic, including storing, retrieving, and routing information within the network.

The RBNB acts as a nerve center within a network of applications, enabling synchronized data distribution, application integration, and collaborative processing. Like a neuron, RBNB uses a mechanism to receive, store, process, and forward signals from many sources to many destinations. A network of DataTurbine servers creates a type of nervous system that bonds applications and data sources together.

The software allows connected users to extract or input audio and video information nearly instantaneously, no matter what type of computers they are using. DataTurbine can separate information, as well as integrate it. If a user wishes to receive only news from a data stream that also includes sports and concert information, he or she can use DataTurbine to filter out only the news information. Using this method of data extraction, the RBNB can also be used for securing information through authorization restriction on a client-by-client basis.

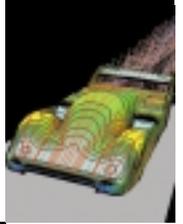
Many applications for DataTurbine continue to emerge. Advantages of this technology include a possible network-oriented infrastructure for managing information on an aircraft. Continuous updates of weather information to and from an aircraft can be integrated with engine health monitoring and other tools.

The RBNB fills multiple needs that would otherwise require ad hoc and expensive software development. Given the benefits of DataTurbine off-the-shelf products, faster development of more useful software is possible.



*Creare, Inc.’s DataTurbine™ serves as “glueware,” allowing communication among multiple users and dissimilar computer platforms.*

DataTurbine™ is a trademark of Creare, Inc.



## Giving E-Commerce a Boost

Imagine walking into a store and having all your favorite items, or things you buy regularly, neatly organized right in front of you rather than having to search up and down the aisles wondering why dish soaps and laundry detergent are not kept together. Now imagine walking into that store via the Internet on your computer. Such stores are becoming available online and are being powered by technology developed by a former NASA employee who transferred the knowledge and skills he acquired at NASA into a successful entrepreneurial endeavor, Blue Martini Software.

Blue Martini president Monte Zweben used his nine years at Ames Research Center to develop ideas on how to use artificial intelligence for automated scheduling and planning. As the Deputy Branch Chief of the NASA Ames Artificial Intelligence Branch, Zweben oversaw research in machine learning and data mining. NASA implemented the technology to automate the maintenance and refurbishment on the space shuttles at savings of \$4 million per year.

Blue Martini provides software to companies seeking to personalize their products to each individual customer. Many of the methods developed and studied during the research at Ames are useful for mining clickstream and purchasing behavior, and similar techniques are now used in Blue Martini's applications.

Blue Martini's primary product is its Customer Interaction System, which can be used to automatically tailor an online catalog to a shopper's interest or past purchase history. The software allows merchants to spot trends in buying patterns and correspondingly change its website to leverage those trends.

The merchant can attach characteristics to a target market and then apply those same descriptors to a range of products so that visitors to the website are shown products in which they are most likely to have an interest. Blue Martini Software then provides analysis and reports to merchants, which allow them to determine optimal cross-sells, pricing, and promotions. This ability combines dynamic merchandising and targeted selling.

Blue Martini Software also offers flexible functions to provide a variety of service programs such as



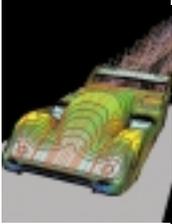
*Portable devices modified with bar code readers allow salespeople to access detailed information about previous purchasing history or related products that compliment the item being purchased using Blue Martini databases accessed through the Internet.*

frequent shopper rewards, gift registries, order status, and a direct link to customer service.

The software driving all this is built on a three-tier architecture that is easily expandable across servers, secure from unauthorized access to customer data, and uses load balancing to optimize response time and eliminate crashed servers from the pool to ensure no-delay shopping. The Customer Interaction System can manage millions of distinct customers and process millions of page or catalog views per day.

The advantage of Blue Martini comes not just from the personalization capabilities of the software, but also teaches its customers how to personalize. The user-friendly interface is designed using intuitive graphics so that business can actually make Blue Martini Software a powerful tool that delivers on its promise.

So far, Blue Martini has sold its system to a major clothing maker and a leading motorcycle manufacturer, and has several other large merchandisers lined up. It is this kind of leading edge approach that has Blue Martini positioned to become a market leader in providing e-commerce services to companies.



# Visualizing Progress

**I**ndustries, large and small, needing shared, visual and spatial information, can benefit from technologies developed by NASA and other government agencies. Reality Capture Technologies (RCT), Inc., of San Jose, California, is a spinoff company of the NASA Ames Research Center. RCT offers e-business solutions for optimizing management, design, and production processes through visual collaboration environments (VCEs).

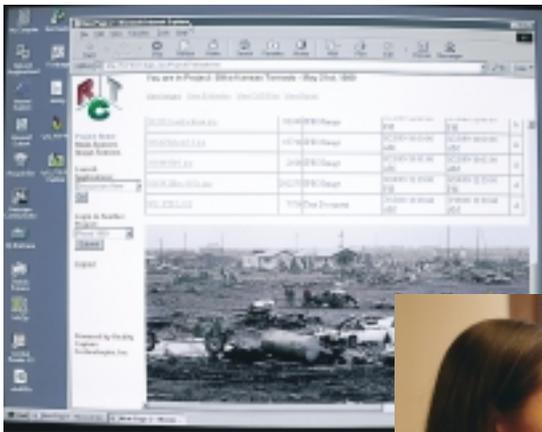
NASA used a predecessor of RCT's VCEs to prepare for the Mars Pathfinder mission and to observe data transmissions from the Mars Sojourner Rover. In 1989, RCT founders worked with the Pioneer Project, which was formed to contain radiation from the failed Chernobyl reactor. VCEs were used to develop a robot that carried instruments for visually imaging the reactor's interior.

The Department of Energy (DOE) and NASA helped fund a \$2.7 million project to visually assess

the damaged interior of the reactor. The Ukrainian operators could remotely control the robot to create a virtual, three-dimensional, photo-realistic model of the site. The accurate three-dimensional model could then be used to determine the volume of radioactive spillage, map radiation levels throughout the various rooms, and prepare for the planned deconstruction of the facility by measuring entranceways for equipment passage. This successful visualization solution was spunoff into RCT's commercial products.

RCT's products and services use telepresence technology that includes visual data capture, visualization, and real-time collaboration that allows multiple users to effectively manage and share data. The VCE intelligently updates, integrates, and compares a project's current data with previous project designs, allowing project participants to work from a shared 4-D Reality Framework,™ a database for time-space (4-D) constructability simulation and process optimization. The VCE product tightly integrates all of the project information with ongoing project management, plant modeling, facilities management, and resource-planning systems.

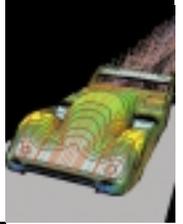
A major potential application for the VCE is in the insurance industry. In the case of natural disasters, insurance companies could make better decisions with virtually instant data available for review, allowing them to make decisions quickly on liability and responsibilities, speeding up reconstruction processes significantly. The technology's capability of sharing and working on the same data from multiple field sites and offices is key to its appeal. Customers can also customize their VCEs, making the products industry-specific.



*Insurance companies could make better decisions with virtually instant data available for review from disaster sites.*



4-D Reality Framework™ is a trademark of Reality Capture Technologies, Inc.



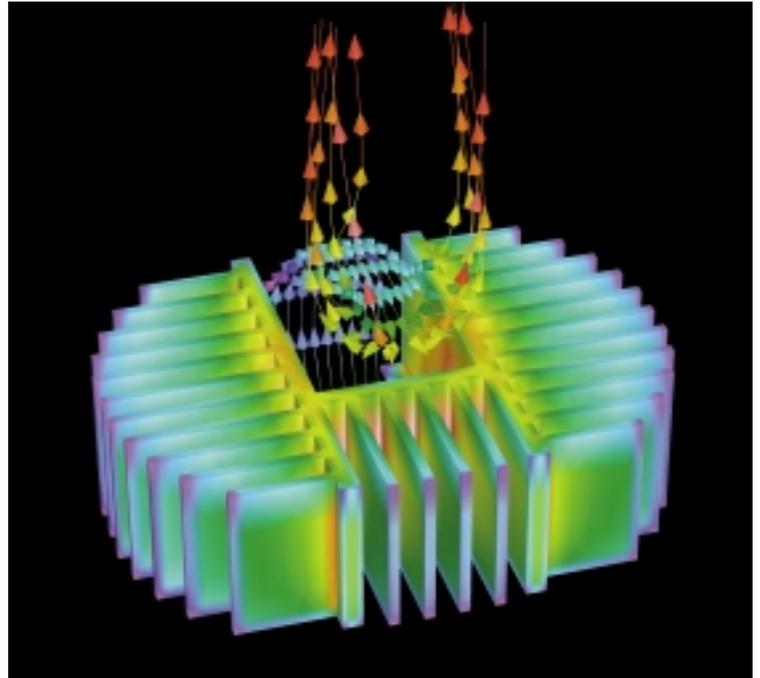
## Designing Cool Components

A group of computer designers needs to design a high-speed personal computer enclosure. In the computer designing business, high speed means high heat, delivering a challenge to any thermal engineer. The computer components need to be placed in a small envelope, leaving few placement options for heat-dissipating mechanisms and fans. Add a requirement for super-quiet operation to the order, as well as an accelerated production schedule, and designers will be facing a headache in thermal design. How do engineers overcome these hurdles?

Daat Research Corporation's Coolit® could be just the solution. Partially derived from software developed for designing combustion systems and material processing, Coolit began with funding from NASA's Glenn Research Center under a **Small Business Innovation Research (SBIR)** contract. The software can provide a variety of solutions to thermal engineering challenges. The software is a unique computational fluid dynamics (CFD) application for addressing thermal and cooling design problems.

In a small enclosure, slight changes in component placement, fan size, and vent location can have a major impact on thermal performance. To analyze the influence of these modifications, engineers traditionally use a cumbersome process that involves prototype building, testing, modifying, and retesting. If a company is under pressure to quickly design and produce a computer component enclosure that can deliver fast and efficient performance, the engineers would need to eliminate some of the standard prototype-building steps. Coolit has the capability of solving this type of dilemma by giving the engineering firm the ability to trade physical models for virtual ones and turn invisible thermal and flow conditions into visible patterns.

Coolit provides accurate three-dimensional representations of the thermofluid environment. The product to be evaluated can be "sketched" on a computer screen, using components from the extensive Coolit built-in library of electronic devices, fans, vents, and heat sinks, just to name a

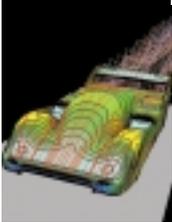


*Daat Research Corporation's Coolit® provides accurate three-dimensional representations of an electronic component's thermofluid environment.*

few. Once the geometry is specified, the user can access an online library to identify material properties, such as thermal conductivity for heat-transmitting components. Color-coded surfaces and components show temperature variations, making hot spots easily identifiable. Arrows indicate airflow and heat-flow paths and their intensities. The color-coded surfaces and arrows can be overlaid, giving the user an overall view of the interaction between airflow and temperature, creating a clear picture of the internal conditions of the product.

Dr. Arik Dvinsky, president of Daat Research, notes that, "As electronic products continue to shrink in size and increase in power, adequate thermal management has become an important element in product reliability. Software modeling of alternative designs reduces the time and effort invested in prototype building and testing, contributes to improved design, and helps optimize component characteristics and layout."

Coolit® is a registered trademark of Daat Research Corporation.



## Go With the Flow

Through work beginning in the 1970s with NASA's Ames Research Center, Analytical Methods, Inc. (AMI), began developing a technology that has evolved into the innovative computational fluid dynamics (CFD) analysis method called VSAERO.™ The focus of the NASA research was to provide advanced tools to predict the low-speed, or subsonic, aerodynamics of aircraft for the purpose of reducing the risks involved in flight and minimizing the cost and time to develop advanced aircraft.

Researchers create mathematical models of flight vehicles and “fly” them by computer simulation. This permits study of the performance and behavior of many different designs before settling on a final configuration. This technique of computational simulation has expanded in recent years to develop visual imagery of many types of forces acting upon a flight vehicle, including phenomena that cannot be cost effectively simulated in wind tunnels. AMI has advanced this type of research into a commercial product that helps aircraft, marine craft, and rotorcraft makers, among others, predict and understand the physics behind a vehicle's motion. VSAERO stems from an effort to realize a major goal in aeronautical science: the

ability to routinely simulate complex three-dimension fluid flow around a complete airplane and understand its propulsion systems. Such a capability has allowed the solution of many problems and made possible many of the computations required to develop advanced vehicles with greater reliability and performance.

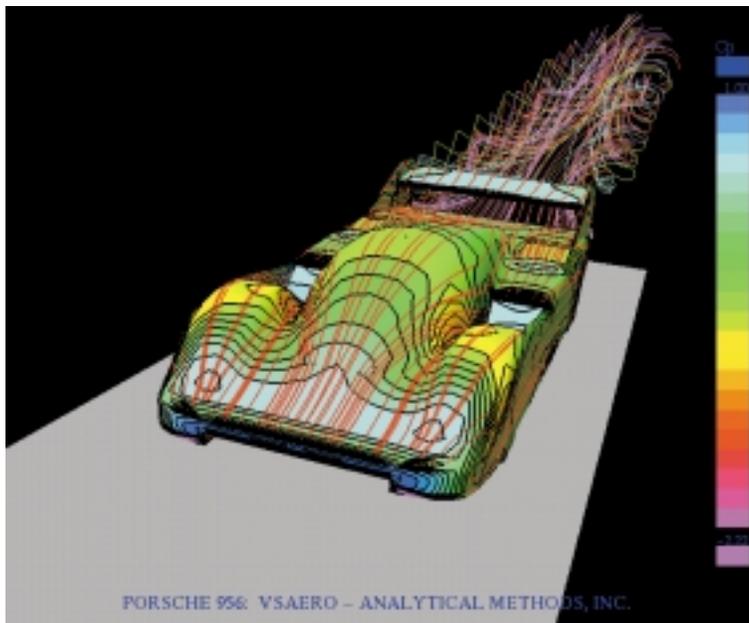
VSAERO has been used in a number of unique designs. Skipper Dennis Connors used VSAERO to design the hull of his ship, Stars and Stripes, which went on to win the America's Cup in 1986. VSAERO has also been used in the design of innovative solar automobiles, such as the award-winning Sunraycer solar automobile, as well as solar airplanes. With more conventional uses, VSAERO can image aerodynamic flows around a complete Boeing 727 in just five minutes! The ability to calculate internal and external flows and body rotation makes VSAERO applicable to fluid flow problems in aerospace, aeronautical, automotive, and marine engineering.

VSAERO also has special-purpose modules that expand the software's simulation capabilities to include effects of flow on interactions between a helicopter's rotor and fuselage. Other modules help the user design simulations involving complex geometric models of structures and wake analysis.

AMI was incorporated in 1971 to conduct research and development in aerodynamics and hydrodynamics for government and industry. Since then, AMI has developed a series of CFD packages and has provided consultation services using company and third-party applications software. AMI offers design and analysis services in addition to software development. Company engineers have experience in all aspects of internal and external aerodynamics and hydrodynamics. AMI provides design, wind tunnel, and flight-testing services. AMI customers include the international aerospace, automotive, and marine industries.

VSAERO™ is a trademark of Analytical Methods, Inc.

*AMI's VSAERO™ can calculate internal and external body flows, making the software ideal for automobile design.*





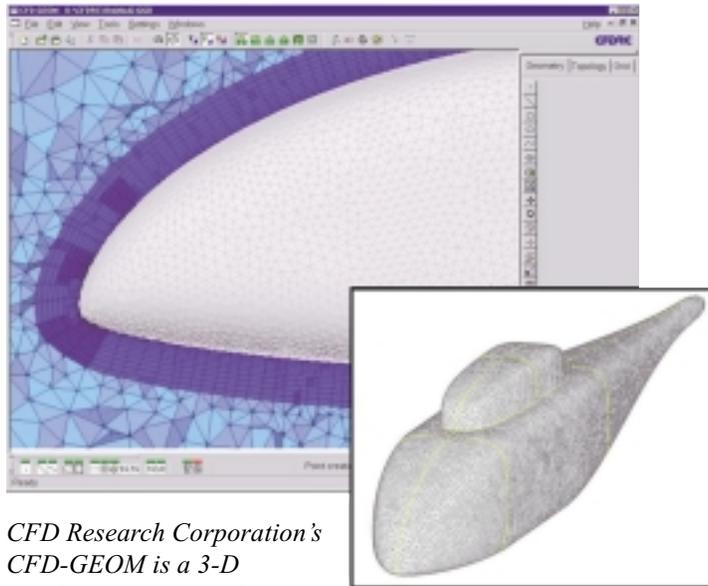
## Complicated Geometry

With the ever-increasing advancement of computer technology comes the rapidly changing realm of computer modeling software. Whether it's an automobile maker designing a prototype car, a semiconductor manufacturer designing a new wafer, or an aircraft designer developing a new escape system, engineers are on the look-out for advanced computer-aided drawing (CAD) software.

With the help of **Small Business Innovation Research (SBIR)** funding from NASA's Glenn Research Center, CFD Research Corporation (CFDRC) developed a software package that generates grids for CAD designs. As an extension of CAD, computational fluid dynamics (CFD) is a rapidly growing field that uses cutting-edge methods for designing and understanding the various elements of a wide array of objects, from airplanes and cars to microelectronics. CFD is an invaluable tool for rapid virtual design prototyping and design optimization of semiconductor fabrication equipment and processes.

Within CFD is the relatively new discipline of automated mesh generation. CFD-GEOM, which evolved from the NASA SBIR work, is an advanced, interactive, 3-D modeling and mesh-generation tool used in creating, visualizing, and gridding complex geometries. A mesh represents a surface and/or volume comprised of a network of nodes that connect to form the surfaces, faces, and edges of the modeled object. CFD-GEOM can interface with almost any major commercial CAD program to read geometry information. Depending upon the desired geometry of the grid, the user can create what are known as structured, unstructured, or hybrid meshes. These extremely complex meshes can be used to best simulate the surfaces of a variety of objects.

CFD-GEOM's modeling enables quick and easy updating and editing of the grid in response to changes in the CAD model. CFD-GEOM is designed for fast and intuitive performance, whether the user is designing from scratch or importing data from another CAD package. Easy manipulations include rotation, scaling, and



*CFD Research Corporation's CFD-GEOM is a 3-D mesh-generation tool.*

copying. CFD-GEOM is available as a stand-alone package, as well as an integrated part of CFDRC's CFD-ACE+ flow solver package. CFD-ACE+ is used to perform multi-disciplinary analysis on the geometries and grids created by CFD-GEOM.

Along with some of its other software packages, CFDRC is using CFD-GEOM to develop aircraft escape system analysis. When first designing an escape system, the user must make a model from the original CAD surfaces supplied by the seat manufacturer. CAD models are directly imported from another software platform into CFD-GEOM, which then filters the models to produce a baseline aerodynamic structure. The next step involves developing a grid to represent the structure.

CFDRC conducts research and development projects and provides engineering services and software for multidisciplinary designs. The company's core modeling expertise encompasses fluid flow, heat transfer, chemical kinetics, fluid-structure interaction, electrostatics, geometry modeling and grid generation, and scientific visualization. CFDRC technology is used in conventional engineering disciplines, such as aerospace, mechanical, automotive, and chemical engineering, as well as in the new areas of semiconductor materials processing, microelectronics, optoelectronics packaging, nanoelectronics, microelectromechanical systems (MEMS), and biomedical engineering.



## Cool Software for Hot Materials

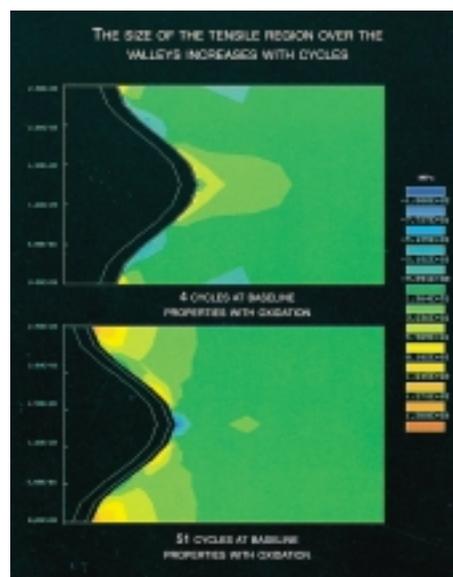
As part of NASA's efforts to build upon the philosophy of "cheaper, better, faster," one way to achieve that standard is through the increased efficiency of turbine engines. To help this goal along, NASA's Glenn Research Center awarded a **Small Business Innovation Research (SBIR)** contract to Deformation Control Technology, Inc. (DCT) of Cleveland, Ohio.

Under the contract, DCT has developed a computer model as an aid to designing ceramic coatings to extend the life of the coating and the coated component. NASA's interest in the research stemmed from a desire to develop quantifiable descriptors for the complex interactions experienced in thermal barrier coating systems (TBCs). Typical TBCs are composed of three "layers": the metallic component, an oxidation resistant "bond coat," and finally, the ceramic top coat.

This software allows for coating designers to measure the stresses being placed on coatings using computer simulation. Thermal barrier coatings have traditionally been evaluated using expensive "Burner Rig" tests. These tests involve a series of sequential heating and cooling cycles run on cylinders coated with the substance undergoing testing. The coated cylinders are run through varying configurations within a temperature range of 30-1200 degrees Celsius. DCT's new software will contribute toward reducing the need for extensive "Burner Rig" tests, since results can be predicted prior to actually producing the coating.

DCT's pioneering work involved the modeling of the thermal barrier coating system through finite element analysis and adding a statistical software package that measures the influence of material stress drivers on the internal stresses developed during thermal cycling.

The benefits of this research have meant a reduction in the cost of experimentation and the development of new design concepts. The results derived from the prediction models will support the development of coatings that can be applied to turbine engines. The turbine engines, with im-



*DCT's software can generate predictive computer models for coatings, saving time and money on coating design.*

proved coatings, can operate at higher temperatures with improved efficiency.

The modeling aspect of the research provided one of the first descriptions of the role of bond coat oxidation in thermal barrier coating breakdown. In addition, other bond coat and top coat properties which may influence TBC fatigue have been identified.

Another innovation in the DCT model was accounting for the growing oxide layer between the bond coat and the ceramic layer. This oxide is formed at high temperatures when the porous properties of the ceramic enable oxygen to penetrate to the bond coat surface. By accounting for the oxide layer in its models, DCT was able to provide a sound description of the role of oxidization in TBC failure.

DCT's new method has been successfully used in the TBC design for electrical power generation turbine applications. Future applications for improved TBC systems include aerospace, land-based turbine, and diesel engines.



## A Faster Fastener

A new nut has arrived from outer space to benefit the people on Earth—possibly even saving lives. M&A Screw and Machine Works of Philadelphia, Pennsylvania, has a non-exclusive license with NASA Marshall Space Flight Center to market a quick connect nut.

Evolving from technology developed from Pathfinder, a project for developing in-space assembly techniques, the space-aged nut is installed by simply pushing it onto a standard bolt and giving it a quick quarter-turn to lock it in place. It can be removed by unscrewing it like a conventional nut. The patented design uses a coiled spring and C-clips to provide the necessary tension to secure the nut in place around a bolt.

The new design is portable, easy to store, has an unlimited shelf life, and can be used under the same conditions as a conventional nut. The nuts can be made from several metals, including aluminum, stainless steel and cast iron, depending on the weight and strength requirements of the application.

The quick connect nut is usually three times the size of nuts typically found in hardware stores, and is custom made for specific applications. The cost of each varies with the materials and size required. The devices have the strength of conventional nuts and are virtually fail proof.

Bruce Weddendorf, former engineer at Marshall and the inventor of the quick connect nut, foresees possibilities of using his invention undersea. Weddendorf believes similar problems are faced undersea and in space that the nut could address, such as the need for speed during assembly in such dangerous environments. One place the quick connect nut could be used undersea is on oil drilling platforms.

M&A has already supplied the nuts to an aerospace company for use on a portable wind tunnel and has received interest from several other companies, including a poultry producer looking to speed up repairs on conveyor belts.

Norman Morse, vice president of M&A, projects other applications for the quick connect nut as well, such as in fire and rescue missions,



*The quick connect nut licensed by M&A Screw and Machine Works is pushed onto the bolt and locked into place with a single twist.*

disaster relief, and in the mining industry. The device could be used to erect support barriers during mining operations, where speed is a necessity to reduce the risk placed on the miners.

Morse also sees the possibility of replacing the multiple lug nuts on automobiles with just one quick connect nut. Even racecars could use the single nut, which would substantially reduce the amount of time pit crews expend changing tires during a pit stop.

The quick connect nut is suitable for any situation where assembly is required and time is of the essence. Currently, the quick connect nut is being used in a new magnetic resonance imaging (MRI) table under development. M&A hopes to expand its customer base by finding more applications for this speedy fastener.



## A Shocking New Pump

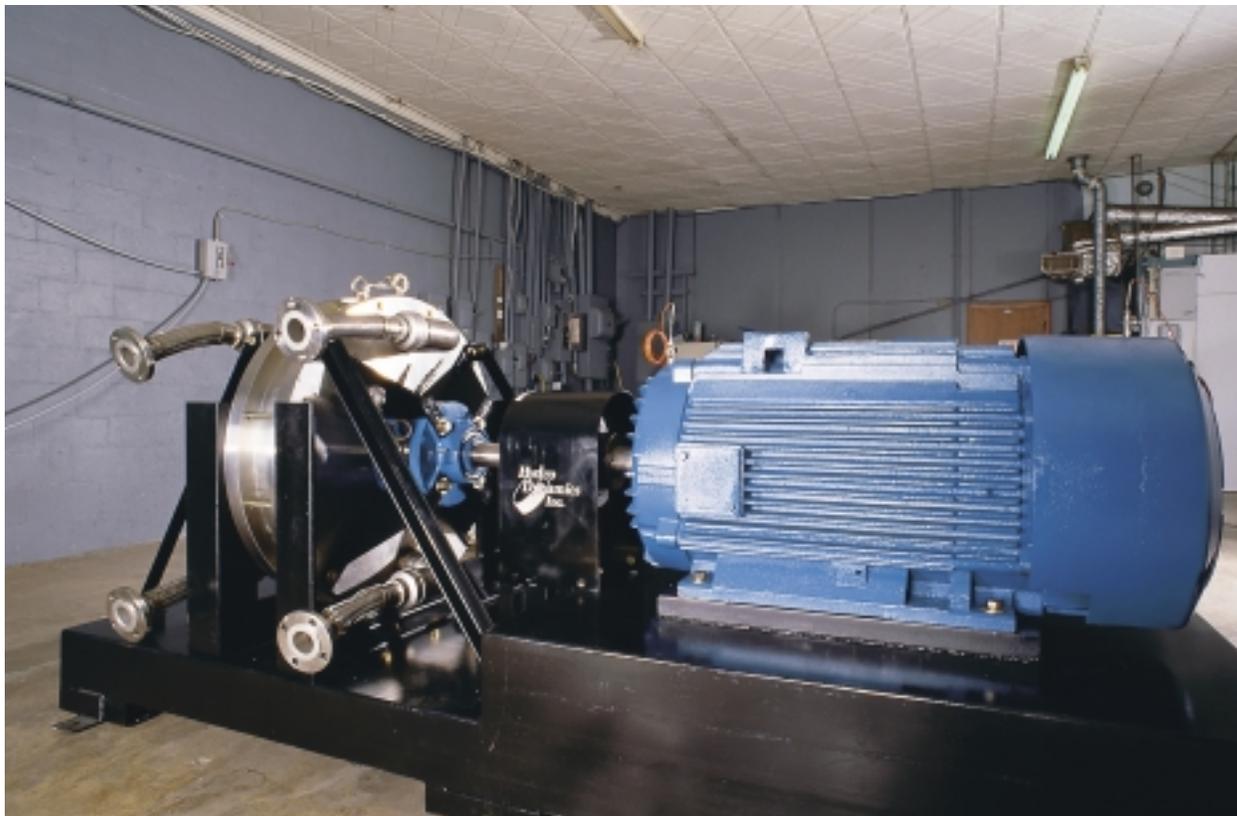
**N**ASA engineers are well known for their skills overcoming obstacles encountered when designing space missions; but they are also able to provide solutions for more down-to-earth problems. Just ask Hydro Dynamics, Inc., of Rome, Georgia, which benefited from the helping hand Marshall Space Flight Center was able to provide.

Hydro Dynamics' patented device, the Hydrosonic Pump,<sup>TM</sup> (HPump) kept running into problems with the bearings needed to operate a rotor inside the device. In search of an answer for how to fix the problem and make the device marketable, Hydro Dynamics turned to Marshall. Through a Technology Transfer Agreement, Marshall scientists and engineers were able to

examine and analyze the problem and provide some solutions for the company.

Tests conducted at Hydro Dynamics indicated that the rotor generated high temperatures when the pump was operating. The bearings being used were not capable of handling the high temperatures. NASA recommended changing to bearings, housings, and mounting hardware that could withstand the stress placed on them by the high level of heat generated.

Thanks to Marshall's engineering solutions, Hydro Dynamics was able to introduce the HPump to the market. The HPump is designed to heat liquids in a more energy efficient manner. The patented technology converts mechanical energy to heat energy with a high efficiency rate.



*The rotor inside the Hydrosonic Pump<sup>TM</sup> generates shock waves to provide the energy needed to heat various liquids, such as organic salt used by the petroleum industry.*

The secret to the HPump's success, according to the inventor, is the use of shock waves to produce the heat, rather than electric heating elements or fossil fuels. The shock wave effect is commonly referred to as a "water hammer" and is usually considered a problem that needs to be removed. Hydro Dynamics founder Jim Griggs began his research into harnessing the benefits of the "water hammer" in 1985 and founded Hydro Dynamics five years later.

The rotor inside the HPump produces shock waves, which in turn generate millions of microscopic bubbles inside the liquid. As the bubbles collapse, heat is released creating a heating "inside the liquid" effect rather than from an outside surface. Conventional technologies transfer heat into liquids using high temperature metal surfaces or flames. This causes large temperature differences between the heat source and the liquid, forcing impurities to build up on the hotter surface of the heat source. This impurity build up is called "scale" which can degrade the heating efficiency. Now, after years of development and some NASA assistance with the bearing problem, Hydro Dynamics is providing savings to industries in need of a non-scaling heating device.

The advantages of the technology used in the HPump can be applied to many industries. There are current uses for it in pulp and paper, petroleum, chemical heating, and environmental cleanup industries. Hydro Dynamics also sees future applications in developing combustionless heating through the use of wind power.



*NASA engineers solved a design problem with Hydro Dynamics' rotor for use in the Hydrosonic Pump.™ The holes in the rotor produce microscopic bubbles, preventing the buildup of impurities (scale).*

Hydrosonic Pump™ is a trademark of Hydro Dynamics, Inc.



## A Blast of Cool Air

**H**ave you ever had something not work so you borrowed a tool or asked advice from your neighbor? What if your neighbor was several dozen skilled NASA scientists and engineers? DynEco Corporation was experiencing problems with a rotor in its refrigerant compressor, known commercially as the Orbital Vane.<sup>TM</sup> Having exhausted its capabilities to find a solution, the Rockledge, Florida, company asked their neighbors at NASA for help.

Desperate for a solution, DynEco turned to Florida's Technological Research and Development Authority (TRDA), a state agency, whose goal is to enhance education, space research, and economic development. TRDA, through its Space Alliance Technology Outreach Program (SATOP), put DynEco in contact with NASA metallurgists and material experts to see if they could solve the engineering riddle.

Despite making a Request for Technical Assistance (RTA) during the Christmas holiday, a notoriously difficult time to get work done, NASA engineers at Kennedy Space Center seized the challenge and were able to provide a quick answer just a few days later. The primary contributors to the solution were the Analysis Group at Kennedy and the NASA Material Science Laboratory, although other NASA personnel were involved. The Analysis Group performed the primary

physical analysis of the failed rotor while the Material Science Lab performed the optical and scanning electron microscopic examination of the failure region.

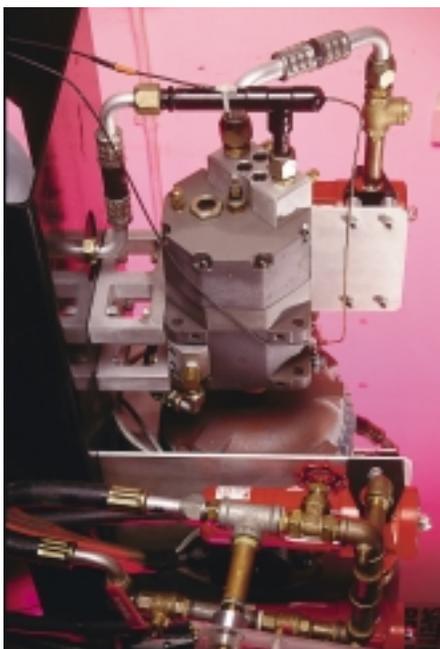
The conclusion was that one of the oil supply holes of the Orbital Vane compressor rotor was causing a large concentration of stress. After short periods of operation, the stress initiated fatigue cracking, which was then followed by almost instant failure of the rotor. The solution was a redesign of the compressor's lubrication system, which eliminated the necessity of using the problematic rotor oil passage. Such a problem, if unresolved, could have been a "show-stopper" for DynEco's efforts to commercialize the Orbital Vane line of machines.

With the problem resolved, DynEco has been able to move forward in developing the Orbital Vane compressors. The Orbital Vane is distinguished from other compressors and pumps in that they have no rubbing parts, are vibration-free, and consist of a few simple round and flat components. As a result, these machines are efficient, reliable, quiet, and easy to manufacture. They are also scalable and provide the same benefits to a wide range of compressor and pump sizes, ranging from hand-held units to large industrial machines.

Currently, the first line of commercial products to come from the Orbital Vane technology is a refrigerant compressor suitable for mobile air conditioning and refrigeration related to buses, custom vehicles, large trucks, rail units, marine vessels, and agricultural equipment. These refrigerant compressors have been installed, on a limited basis, on a line of bus air conditioning units.

DynEco has also been tapped as a NASA subcontractor, with Oak Ridge National Laboratory in Tennessee, to produce a special air conditioning compressor that can operate in zero gravity for the International Space Station. According to DynEco CEO Thomas Edwards, "A positive outcome without this [NASA] support is difficult to imagine."

Orbital Vane<sup>TM</sup> is a trademark of DynEco Corporation.



*A rotor fatigue problem solved by Kennedy engineers allowed DynEco to move forward with their Orbital Vane<sup>TM</sup> compressor, shown here operating in a metering system for a micro-turbine alternator.*

## Papering Over Corrosion

NASA has yet to find the fountain of youth, but its research has created a new product that will extend the operating lives for an unlimited number of items. A licensing agreement between Kennedy Space Center and GeoTech Chemical Company of Tallmadge, Ohio, has allowed GeoTech to commercialize a patented technique for producing superior corrosion control coatings.

GeoTech's corrosion control system, marketed under the Catize<sup>®</sup> name, uses ligno sulfonic acid doped polyaniline (Ligno-Pani) as the key component. Ligno-Pani is an inherently conductive polymer (ICP) also known as a synthetic metal. GeoTech is offering products to the coatings industry in the form of an additive to provide more coatings with enhanced protection capabilities.

Kennedy has been researching corrosion inhibitors for many years. Florida, especially the coastal region where Kennedy is located, is one of the most corrosive areas in the world due to the ocean's salt spray and its damp, humid climate. In addition, each time the Space Shuttle is launched, 13 tons of hydrochloric acid is generated, corroding the launch pad. Existing zinc-based paints are ineffective because the hydrochloric acid dissolves the zinc protective coating.

The technique licensed to GeoTech has several advantages over other existing methods for producing electrically conducting polymers. Developed at the University of Arkansas at Little Rock through funding from Kennedy, the method increases the solubility of the polymers. The processing method uses lignosulfates (papermaking byproducts), making it inexpensive and environmentally safe. The lignosulfonic acid also helps improve the solubility of polyaniline, the electrically conducting polymer used in the process.

The properties exhibited by Ligno-Pani create the potential for use of the coating in a wide array of applications. One example of the benefits of Catize is in corrosion protection for steel bridges. A typical steel bridge requires a three-coat system to adequately protect the structure. However, when



*Using synthetic metal, GeoTech has developed Catize,<sup>®</sup> a new corrosion control additive for use in protective coatings.*

a break occurs in the coating, corrosion begins to break down the exposed area as well as the entire steel substrate. Catize focuses the corrosion at the break and prolongs the migration process of corrosion to allow the steel substrate to remain intact. The result is years of extended service of the bridge before repairs or maintenance are required.

Ligno-Pani can also be used as a coating for cotton and polyester clothing to eliminate the potential for sparking in hazardous atmospheres, such as clean rooms. It can also be used on electronics to provide electromagnetic interference (EMI) shielding for computers to ensure safety and security. In addition, the cost of producing circuit boards is reduced when using the polymers in photolithography processes.

There are a number of other potential applications for Ligno-Pani polymers that have yet to be fully explored. The polymers may be used in conductive inks, pH and moisture sensors, stealth technology (radar invisible coatings), high temperature adhesives, and electrostatic dissipation in packaging. GeoTech hopes to eventually see Ligno-Pani being used to improve many household items such as computers, televisions, and cellular phones by making them lighter, smaller, and more powerful.

Catize<sup>®</sup> is a trademark of GeoTech Chemical Company.



## A Little Sensor That Packs a Wallop

**S**pectraSensors, Inc., a spinoff company of NASA's Jet Propulsion Laboratory (JPL) has commercialized a gas sensor that was originally developed to measure the composition of the atmospheres of Earth and Mars. The company acquired exclusive patent rights from the California Institute of Technology, where JPL is managed and located. NASA and the Department of Defense's Ballistic Missile Defense Organization (BMDO) funded the development of the technology at JPL. The BMDO required the lasers for high-speed optical communications. NASA required the technology for atmospheric gas-sensing applications, using the tunable diode laser (TDL) gas sensor on aircraft and on balloons to study weather and climate, global warming, and emissions from aircraft.

SpectraSensors, Inc., is an Altadena, California-based TDL gas sensor systems developer and manufacturer. The company's commercial TDL gas sensors have applications for oil and gas pipeline monitoring, industrial process control, smokestack monitoring, environmental monitoring, atmospheric science, aircraft safety, and medicine. The company's technology is capable of detecting

several gasses that are critical to industrial process control and environmental monitoring. Such detection includes water vapor, ammonia, acetylene, carbon dioxide, hydrogen fluoride, and hydrogen chloride.

The heart of TDL systems is a small laser diode that produces a very narrow and specific

wavelength of light tuned to a harmonic frequency of the target gas molecule in the near infrared band. The light causes the molecule to vibrate and, therefore, absorb energy. Once adjusted to the specific frequency of the molecule, the laser is minutely tuned to different wavelengths on either side of the target wavelength. The light energy being absorbed at the target gas frequency is compared to the light energy at the surrounding frequencies, resulting in an extremely precise measurement. New data are integrated every second, making the system quick to respond to variations in the target gas.

Natural gas distributors are currently using the company's extraction monitors to quantify levels of water vapor and carbon dioxide in their natural gas pipelines. The application calls for a rugged device, which can withstand the harsh environments in these pipes and measure moisture levels in methane pipes with low parts-per-million sensitivity. Today, many suppliers transport their product to many customers through a shared pipeline infrastructure. Market rates for gas products are determined, in part, by the moisture level and purity of natural gas. Relative moisture levels indicate whether a gas is "wet" or "dry," while carbon dioxide levels tell the distributor whether the product is "clean" or "dirty." The requirement to measure humidity is also driven by the corrosive effect that water can have in combinations with other chemicals in the pipes. Corrosion can lead to leaks, which can lead to a potentially dangerous situation.

TDL gas-sensing technology is particularly good at detecting low levels of gases at the parts-per-million or even parts-per-billion level. With many industrial processes involving gas measurement of some kind, commercial applications for this technique are very wide ranging. From detecting moisture and carbon dioxide levels in natural gas pipelines to wafer-fabrication process control for the semiconductor industry, TDLs will be making news in the industrial and environmental monitoring sectors for years to come.



*SpectraSensors, Inc.'s Tunable Diode Laser is capable of detecting several gasses that are critical to industrial process control and environmental monitoring.*



## Putting the Pressure On

**H**igh-density compacting is a new way of putting a lot of pressure on metal powder. Simulating the pressure and heat conditions that aerospace vehicles undergo during atmospheric flight spawned the development of a technology that is now used in fabricating industrial components.

NASA's Langley Research Center provided **Small Business Innovation Research (SBIR)** funding to support IAP Research, Inc., of Dayton, Ohio, in creating an electromagnetic launcher. NASA wanted to help develop a technology that would predict the temperature and pressure conditions of hypersonic flight. The interest in obtaining such information led to IAP's ultimate development of the Magnepress™ process.

This novel technology, which implements IAP Research, Inc.'s patented Dynamic Magnetic Compaction (DMC) process, has found its way into the commercial sector as a process that can manufacture high-density parts at rapid rates. The innovative powder compaction technology uses magnetic energy to squeeze the air out of powdered materials to form high-density solid material.

The powder is loaded into an electrically conductive tube, such as copper, aluminum, or steel. The tube is placed at the center of the electromagnetic (EM) coil. A current pulse is put through the coil, creating high magnetic pressure within less than a millisecond! For parts like rings or gears, the powder is loaded around a die centered in the tube to form part features such as gear teeth. A round die can be used to form rings or tubes.

In the automotive industry, there is a constant demand for high-density, net-shaped parts at an affordable cost. At the moment, automotive parts, such as powertrain gears for high-performance applications, are typically machined from forged and wrought blanks, which is a costly process. Due to high machining costs, these components are much more expensive than conventional press and melted powder metallurgy. However, these presses lack the density that automakers need from their



*IAP Research, Inc.'s Magnepress™ is an innovative powder compaction technology that uses magnetic energy to form high-density, solid material.*

parts. IAP contends that the Magnepress system can produce parts with higher density at higher repeatable and reliable rates than those created by conventional presses.

Magnepress is also used to form or join metals, such as aluminum, steel, and copper through the application of electromagnetic forming (EMF). According to the company, this process is more rapid and cost-effective than processes such as hydroforming and superplastic forming. The company also maintains that EMF can eliminate sheet surface problems present in conventional metal forming methods.

IAP recently sold the system to a manufacturer that is using Magnepress to assemble an evaporator component for soft-serve ice cream dispensers. IAP is continuing to further develop its Magnepress process to create an even broader market. The company might very well find itself pressing its method into an industry standard.

Magnepress™ is a trademark of IAP Research, Inc.



## Cleaning up Silicon

Ultra-high purity silicon is ideal for the production of computer chips. For this reason, a space-based manufacturing technique, developed in the 1970s, has found a coveted place in the semiconductor industry. Thanks to the help of NASA's Jet Propulsion Laboratory (JPL), Advanced Silicon Materials, LLC—formerly Advanced Silicon Materials, Inc. (ASiMI)—is producing silane gas and ultra-high purity polycrystalline silicon (polysilicon) at very high volume.

In 1975, Union Carbide Corporation, entered a development program with JPL for a low-cost, high-volume silane process as part of the Low Cost Silicon Solar Array Project. From that original contract, Union Carbide was able to harness a manufacturing process that went from producing small amounts of silane to one that could yield silane in commercially viable quantities. Later on, Union Carbide's research was expanded to develop a process that would convert metallurgical-grade silicon to silane gas and ultra-high purity polysilicon.

Union Carbide built a small pilot plant that manufactured silane to supply the production of ultra-high purity polysilicon for electronic devices. By 1985, a full-scale commercial plant for producing silane and polycrystalline silicon was built in Moses Lake, Washington. In 1990, ASiMI ac-

quired the rights to the Union Carbide technology and built a second production facility in 1998 in Butte, Montana.

ASiMI's high-volume manufacturing operation produces silane and ultra-high purity silicon through a four-step distillation process, which begins with the gasification of metallurgical-grade silicon—a compound that contains impurities, such as iron, aluminum, and manganese. Gasifying the impure silicon involves grinding it down to a fine, sand-like consistency and super-heating it with hydrogen and silicon tetrachloride. Through a series of reactions and separation steps, silane and ultra-high purity polysilicon are produced.

Silane was previously manufactured in small batch facilities and distributed in individual gas cylinders. Only applications that could make use of minor quantities of silane were practiced. With the operation of Union Carbide's original pilot plant, the technology for bulk shipment of silane was also developed. The advantages of having a substantial amount of a consistently high-quality source material appealed to semiconductor manufacturers.

The availability of bulk quantities of silane fostered the commercial development of new applications outside of the traditional electronics industry. Today, silane is finding new uses in the manufacturing processes of energy efficient glass coatings, thin film transistors, photosensitive copier drums, and photovoltaics. In the semiconductor industry, silane is used for several process steps, such as epitaxial, polysilicon, nitride, oxide, and silicide films. The ultra-high purity of silane is a key factor in its use in these demanding applications.

The purity of silane is 99.9999 percent. Electronically active impurities, such as boron, phosphorus, and arsenic are controlled to less than 10 parts per trillion, making silane one of the purest materials on Earth.



*ASiMI's high-volume manufacturing operation produces bulk quantities of silane.*



## A New Way to Spray

An idea that started around the dining room table of Plasma Processes, Inc.'s president Tim McKechnie has blasted off with the assistance of the NASA Marshall Space Flight Center. Working with Marshall on a **Small Business Innovation Research (SBIR)** contract, Plasma Processes developed Vacuum Plasma Spray (VPS) nozzles to be used in applying coating materials.

Plasma spraying has long been used to provide coatings of heat or wear resistant material onto a substrate. Typically these coatings extend the life of the coated object and improve strength and resistance to corrosion and heat. Rocket engines are a classic example of an item traditionally receiving a plasma spray coating to withstand rapid temperature changes. Plasma spray techniques have recently been used to build up a thick coating of material over a preformed mold, allowing the plasma spray to form a part net shape.

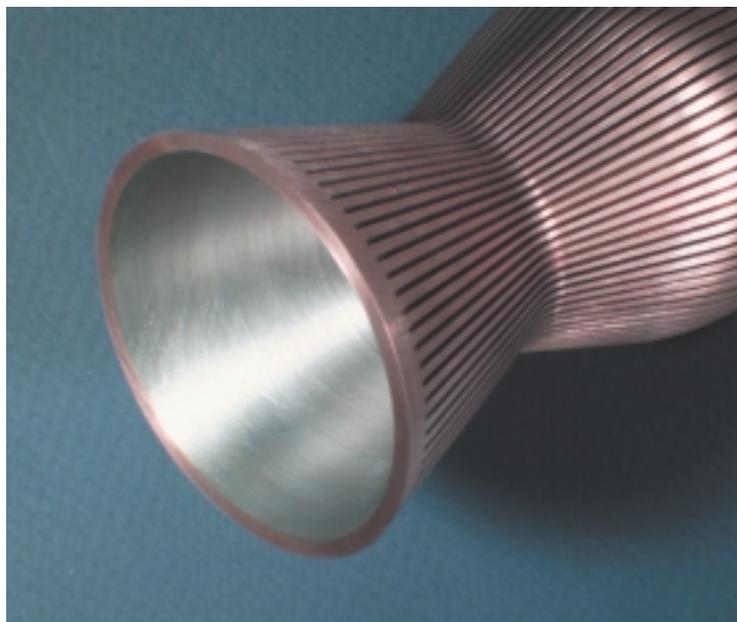
Designed for thermal spray applications, Plasma Processes' patented nozzles use a bell-contoured design that is superior to traditional conical nozzles. The result is a purer stream without the shock waves and expansion fans that occur with traditional nozzles. Shock waves and expansion fans create a problem that plagues plasma spray nozzles—overspray. Overspray occurs when powder escapes the plasma flow prior to deposition on the targeted substrate. In order to correct overspray, ideal flow expansion is required at the nozzle exit. Ideal flow expansion occurs when the pressure of the exiting plasma is the same as the ambient pressure around the nozzle.

Plasma Processes' bell-shaped nozzle creates an ideal flow expansion and virtually eliminates shock waves and expansion fans, reducing overspray significantly. Conical shaped nozzles can see as much as 10 percent of the intended coating lost to overspray. By using the bell-shaped design, overspray is reduced by at least 50 percent. This results in a significant decrease in the cost of the plasma spray process. In addition, the quality of the finished coating is greatly improved. Further cost savings are realized with the newly designed

nozzles improved coating efficiency. By increasing the coating efficiency, the plasma spray process takes less time to complete a job. Reducing overspray also improves the quality, purity, and integrity of the coating. The result is a longer lasting coating.

Each nozzle is custom designed specifically for the material used and the required flow rate. Plasma Processes offers the nozzles for sale, as well as plasma spray coating services at their facilities. NASA makes use of the nozzle for projects such as spray forming crystal growth furnaces cartridge tubes in microgravity research, and advanced propulsion thrust chambers. According to McKechnie, without NASA's backing, the nozzle would still be an idea.

From its humble beginnings around the dining room table, Plasma Processes has expanded to occupy 24,000 square feet of space in their plasma spray facility. Plasma Processes has a client list from around the world and can offer the same services to anyone, from a private inventor to NASA.



*The bell-shape of Plasma Processes' plasma spray nozzle reduces overspray, increasing the speed of plasma spraying while reducing costs.*



## Data Goes the Distance

NASA's lead center for rocket propulsion testing, Stennis Space Center, has always faced the dilemma of collecting accurate data from the inherent hostile environment of rocket engine tests. It is essential, however, to be able to test and predict the behavior of the Space Shuttle Main Engine during its eight and one-half minute flight toward orbit. Unfortunately, remote recording of high-speed digital data has been impossible because of various technological and bandwidth constraints. For this reason, NASA sought a way to collect propulsion test data accurately.

When NASA began looking for such a method, the system developed not only provided a safe solution, it also served as a shot in the arm for a small Louisiana business. Omni Technologies, Inc., of New Orleans, Louisiana, worked with Stennis on the development of the FOTR-125—a redundant fiber-optic transceiver for the remote transmission of high-speed digital data.

Initially, data collection involved methods that either posed the risk of corrupting the test data or were very time-consuming. In one method, signals were transmitted from the test stand to a safe processing and data recording location over long

copper lines. These signals could become corrupt though pickup of electromagnetic noise from the environment. In another method, analog signals were tape recorded on the test stand, and the tapes were then moved to a safe place, which required extra time to digitize and process the data after the tests. Data could also be lost if the test stand was damaged or destroyed during the test. The ideal solution would be to digitize the analog signal on the test stand and then immediately transmit this digital data for recording in a safe location.

To solve the problem of remote recording of digital data, NASA Test Operations at Stennis and Omni developed a 125-megabit-per-second fiber-optic transceiver. The fiber-optic transceiver was designed as a cost-effective solution for long-distance, duplex data communications between the Racal Tape Transport Unit (TTU), or recorder, and the Signal Processing Unit (SPU), or digitizer. The fiber link allows a user to separate the TTU and SPU over greater distances. Each FOTR-125 accepts a customized interface developed by NASA engineers for both input and output. The fiber-optic link can be as long as 25 km (15.54 miles) with the connection of two transceiver units, much longer than the standard coaxial link, which can be no longer than 50 meters (164 feet).

According to NASA officials, Stennis chose Omni Technologies for the co-development of the transceiver because of the company's experience and expertise with similar fiber optic applications. Once the work was completed, the NASA Technology Applications Team at the Research Triangle Institute assessed the technology's potential in the commercial marketplace. Omni Technologies has an exclusive license to the technology and has sold the unit. The FOTR-125 is being marketed to anyone who is gathering large amounts of data. The company has had success with such applications as undersea data acquisition and plant floor data acquisition. The unit can be used in extremely hazardous testing as well, such as explosives, ordnance, nuclear, and some combustion turbine engines.



*Omni Technologies, Inc.'s FOTR-125 is a redundant fiber-optic transceiver for the remote transmission of high-speed digital data.*



## Pumped up Lasers

Lasers are a part of our everyday lives and the more uses found for them, the greater the need for them to be more efficient, accurate, and powerful. A Phase II **Small Business Innovation Research (SBIR)** contract between NASA's Goddard Space Flight Center and Cutting Edge Optronics (CEO) sought to develop such a laser.

The results so far have produced a key component to the ultraviolet (UV) laser Goddard is looking for to conduct atmospheric remote sensing using lidar (Light Detection and Ranging). NASA hopes to use the laser to profile atmospheric wind vectors and potentially to support a spaceborne lidar wind profiling system. Although the laser is still under development, CEO has commercialized a component of the laser system, the diode pump module, which serves as an amplifier.

The commercial version of the diode pump, the Whisper MiniSlab™ is the “engine” for high performance laser systems. The device magnifies the laser output using a “zig-zag slab,” so named for the path the beam takes through the slab-shaped laser crystal. This technique can be advantageous because it eliminates thermal lensing to first order.

One of the innovations of the MiniSlab is the use of conduction cooling as opposed to the more traditional direct water cooling method for cooling the slab. In conduction cooling, two of the slab surfaces are attached to heat sinks while the diode pump arrays pump the other two sides. This technique reduces thermal turbulence typically associated with the direct cooling method.

The absence of thermal turbulence makes the beam pointing very stable. Conduction cooling is also flexible in terms of which cooling scheme is used, with little effect on the laser's performance. Water-cooled heat sinks could be replaced with alternative heat transfer mechanisms such as heat pipes or CEO's phase-change heat sinks. One last benefit is that the coolant does not have to be optically clear and cleanliness is less important since the beam does not pass through the coolant.



*Cutting Edge Optronics' slab pumphead, the Whisper MiniSlab™ uses innovative cooling methods to produce smaller lasers with better beam quality.*

Given the numerous applications of lasers, CEO projects a large potential market for their diode-pumped lasers. Diode-pumped lasers are superior to excimer lasers currently popular for medical and industrial applications. Diode-pumped lasers are more reliable, efficient, versatile, stable, rugged, and smaller with a better beam quality than excimer lasers. They are also safer to use, because they do not rely on poisonous gases like gas-discharge laser systems.

The newly designed diode pump has made its first splash in the commercial market. A CEO customer has received two laser units with the new diode pump installed, and applied them to the company's manufacturing process. CEO also has potential clients looking to incorporate the diode pump into lasers used for corneal surgery and commercial lidar activities.

CEO hopes to soon commercialize other parts of the laser system being developed under the SBIR contract, as well as eventually, the entire laser system. With their improved technology, CEO is locked onto its target.

Whisper MiniSlab™ is a trademark of Cutting Edge Optronics.

# Technology Transfer and Outreach

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In order to ensure the benefits of NASA's research and development activities reach the widest possible audience and have the broadest impact, NASA established the Commercial Technology Network. The network of organizations is dedicated to transferring technology, and serving as a resource of scientific and technical information with real-world applications.

The Commercial Technology Office at each NASA field center serves as the touchstone for the ever-growing network of transfer mechanisms. As the volume of knowledge has grown, so too have the methods of transferring the technology.

The following section serves as a roadmap to the path of accessible cutting-edge technology and research. In addition, *Spinoff* provides a close-up view of the technology transfer activities at this year's spotlight center, Ames Research Center.



## Spotlight on Ames Research Center

**N**ASA Ames Research Center is located at Moffett Field, California, in the heart of Silicon Valley—a technology hotbed for the country. In December 1999, Ames celebrated its 60<sup>th</sup> anniversary and reflected on the center's

Ames is also the lead center for Aviation Operations Systems. In support of these efforts, Ames recently unveiled its newest facility, "Future Flight Central," the world's first full-scale virtual airport control tower for simulation of air and ground

traffic control scenarios. The Ames community celebrated the grand opening in December 1999 and looks forward to performing critical research to improve ground and air traffic control and safety, as well as reduce flight delays and improve cost efficiencies.

As a result of the NASA Administrator's Agenda for Change, the Ames Commercial Technology Office (CTO) has evolved to focus on protecting Ames' intellectual property and working in partnership with industry to leverage precious research and development resources. This shift in focus demanded careful analysis of "commercial potential" for all invention disclosures. With a staff of ap-

proximately 25 professionals, including support from contractors and student interns, the CTO works to identify new technologies and assess them for commercial potential. The CTO supports technology commercialization objectives through the efforts of the marketing team, paralegal staff, intellectual property analysts, licensing representatives, and senior scientist expertise.

### Ames Technology Transfer Successes

With an increased effort to disseminate technology, patent prosecution is based heavily on technologies that demonstrate commercial potential. For example, a promising patent pending technology, "Smart Surgical Probe" is a surgical tool that uses artificial intelligence technology to increase the safety, accuracy, and efficiency of delicate



*Future Flight Central is the world's first full-scale virtual airport control tower for simulating air and ground traffic control scenarios.*

growth from a premier aeronautics research facility with the world's largest wind tunnel to its current role as NASA's Center of Excellence for Information Technology (IT). In this role, Ames provides research leadership and world-class capabilities in the fields of supercomputing and networking, high-assurance software development, verification and validation, automated reasoning, planning and scheduling, and human factors. To support NASA goals, Ames has signed 124 cooperative agreements since 1996 with universities, companies, and federal agencies to leverage IT resources and promote use of NASA technologies.

surgical operations. The probe technology was recently licensed to BioLuminate Inc., with plans to develop, produce, and market a device for early breast cancer diagnosis based on the NASA technology. After developing a product for breast cancer diagnosis, BioLuminate plans to develop additional products for other medical applications.

Another patent pending technology, developed by the Sensors 2000 program, incorporates advanced miniaturized sensors and wireless communication for complex medical applications. This project evolved through a partnership with the University of California at San Francisco Medical Center in an effort to find a solution for monitoring prenatal vital signs. The collaboration led to implanting sensors in the mother to efficiently collect critical data on the health of the fetus. The patents coming from this work may have many uses for effective non-invasive health care in terms of monitoring vital signs and providing accurate data in hospital room and home care environments.

In addition, Ames' CTO accelerated efforts to grant licenses for Ames' patents. The licensing activities range from tangible materials to information technology software. The following are examples of recent licenses awarded by Ames:

- Environmentally friendly de-icing fluid has produced four non-exclusive licenses for various de-icing fields of use.
- The electro-expulsive de-icing method for airplane wings has yielded two recent licenses.
- Wessex, Inc., was awarded a license for producing the protective coating for ceramic materials (PCCM).
- In software, the Oracis Medical Group licensed the reconstruction of three-dimensional visualization software for use in planning surgical procedures and training medical staff.
- Skywatch Information System licensed a NASA-developed interferometer for calibration of satellite imagery.
- Ames granted Modern School Supplies a license for the educational Mars CD-ROM. Modern School Supplies lists the CD-ROM in the 2000 edition of their nationwide educational products catalog.



*The CTAS software for managing air traffic control systems at major airports is in use daily at Dallas/Ft. Worth International, one of the world's busiest airports.*

In further support of the center's IT mission, the CTO has focused on improving the process of releasing software for beta test while concurrently protecting the intellectual property rights.

### **Honors, Awards, and Recognition**

The CTO has proactively sought recognition for Ames' technological accomplishments through the NASA Space Act Award program. Ames information technology projects have placed in the winner and honorable mention categories for the 1998 and 1999 NASA Software of the Year competition. In 1998, the Center-TRACON (Terminal Radar Approach Control) Automation System (CTAS) software was a winning nomination. CTAS software systems at major airports: Traffic Management Advisor, Final Approach Spacing Tool, and Conflict Predictor Trial Planner. CTAS is designed to optimize flight operations. It is in daily use at Dallas/Ft. Worth International, one of the world's busiest airports, and was seamlessly integrated into the existing radar system, with displays in the control room supplementing the manual air traffic control system. CTAS saves an average of two minutes per flight, in turn saving money for the airlines and their passengers.

OVERSET tools for computational fluid dynamics (CFD) analysis, a suite of CFD tools achieved honorable mention in the 1998 competition. The OVERSET software system is a comprehensive



## Spotlight ... *(Continued)*

package of programs that streamline the process of performing CFD analysis for complex geometry. This program has had significant impact in the development of Boeing's Next Generation 737 aircraft and in solving aerodynamic-related problems for future U.S. Naval and U.S. Marine Corps fleet aircraft.

In 1999, two other outstanding IT-based projects from Ames were honored. Top honors went to Remote Agent, which was a joint Ames and Jet Propulsion Laboratory (JPL) project. Remote Agent is a reusable artificial software system designed to allow spacecraft, life support systems, chemical plants, or other complex systems to operate robustly with minimal human supervision. The Ames Virtual Interactive Imaging and Cybersurgery for Distant Healthcare received honorable mention. This software enables medical staff to analyze human tissue and organs in a 3-D environment in preparation for major surgical procedures.

In addition, seven Ames technologies have been inducted into the U.S. Space Foundation-Space Technology Hall of Fame. To date, 34 technologies have been recognized for their contributions to American society. In 1999, the DeBakey Heart Pump, a joint Ames and Johnson Space Center project, was enshrined. Temper Foam was recognized in 1998 for the numerous spinoffs generated, such as orthopedic cushions in wheelchairs, sports equipment, and mattresses. Anti-Shock Trousers and Fire-Resistant Aircraft Seats were inducted in 1996. Prior to that, in 1993, two more Ames technologies, Liquid-Cooled Garments and Physiological Monitoring Instrumentation, joined the select few technologies honored in the Hall. Finally, Ames' first inductee was a Scratch-Resistant Lens Coating, which was honored in 1989.

### **Additional Ames CTO Programs**

The CTO is participating in the Agency initiative to target industry sectors for commercializing technology. Commercialization plans are being developed to accelerate IT advancement. The goal is to generate partnerships that focus on big picture technology leaps—aiding NASA in IT mission requirements while providing mutual benefit for the industry partner.

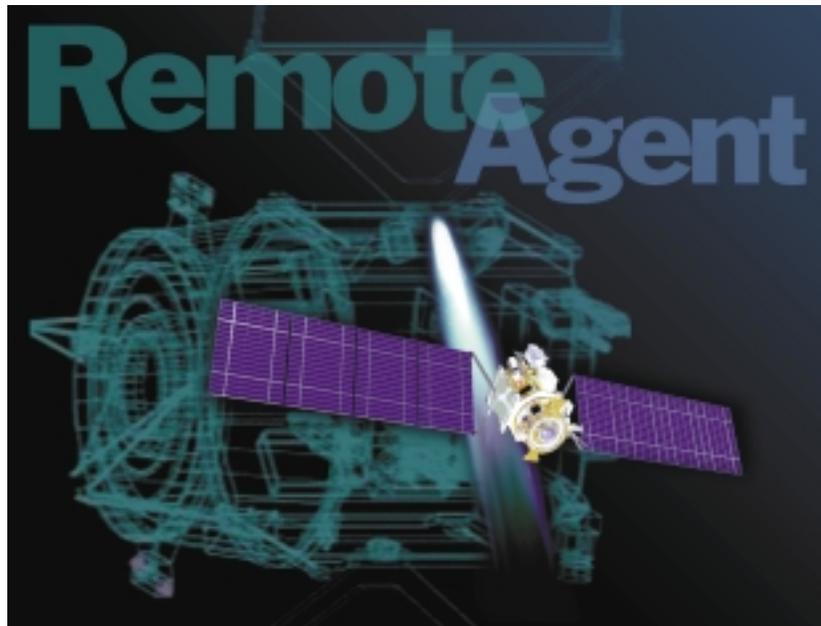
Another important CTO program benefiting U.S. businesses and NASA is the Ames Technology Commercialization Center (ATCC) small business incubator. The ATCC, founded in 1993, was established as NASA/Ames' response to a February 22, 1993 White House technology policy directive. As a nonprofit new business incubator and mentoring service, the ATCC's focus is to develop and commercialize NASA supported technologies. The ATCC is a physical and virtual small business incubator, located in San Jose, California, and provides opportunities for start-up companies to utilize NASA technologies. The center uses a lab-to-market approach that takes the technological output of Ames' lab and pairs that technology with appropriate markets to create and foster new businesses. The incubator provides access to a network of business experts in marketing, sales, high-tech management and operations, financing, and patent and corporate law. The ATCC also offers low-cost office space and other start-up services. A current tenant within the ATCC is Reality Capture Technologies, Inc., which is based on a license from Ames for the "Mars Virtual Exploration and Mars Map" technologies. An Ames researcher started this company and is using three-dimensional mapping technologies for diverse applications. The company recently customized mapping products for use in dentistry

by mapping the inside of a mouth instead of taking the traditional dental impressions. In addition, mapping the surface of Mars is serving as an educational product for use in museums.

Ames' CTO has been a major contributor to the **Small Business Innovation Research (SBIR)** program. The SBIR program was established by Congress in 1982 to provide seed capital to assist American-owned small businesses to participate in U.S. federal agency research and development efforts. Legislation enacted in 1992 extended and strengthened the SBIR program and increased its emphasis on pursuing commercial applications for innovations developed with SBIR funding. Ames SBIR contractors have generated three of the top four largest Phase III successes in NASA and have been the leader in Phase III funding to SBIR contractors.

In coordination with Ames management, the CTO has collaborated with the California Space and Technology Alliance (CSTA) and other regional groups this past year. Ames hosted a conference with CSTA bringing many esteemed guests from California public office and local industry together. These representatives discussed maximizing statewide space resources and expertise to create jobs and business opportunities for California's space stakeholders.

From award-winning technology to improving the quality and safety of air travel, Ames has demonstrated that it is up to the task of advancing the frontiers of knowledge and new technologies.



*Remote Agent software allows complex systems such as spacecraft, life support systems, and chemical plants to operate with minimal supervision. The software, a joint effort between Ames and Jet Propulsion Laboratory, was recognized as the 1999 NASA Software of the Year.*



## Outreach Achievements

The benefits of NASA's technology and research can be felt beyond contributions to the economic health of the United States. Through a variety of partnerships, NASA provides space age technology to improve all aspects of society.

A Pennsylvania boy has had the world outside his house opened to him thanks to NASA. The 10-year-old suffers from erythropoietic protoporphyria (EPP), a rare, inherited condition that results in severe burns when skin is exposed to ultraviolet rays, such as in sunlight. For his entire life, any trip outside his Rossiter, Pennsylvania, home threatened his well-being, until NASA came through with a suit that blocks 99.9 percent of ultraviolet light. Based on NASA's research into space suit technology, the outfit resembles a sweat suit, but includes a facemask and goggles. The cost of the suit was covered by private donations, with NASA supplying the technology.

Recently, NASA-sponsored clinical trials were completed on a portable heart-rate monitor. The



monitor takes advantage of NASA technology originally designed to measure airflow over airplane wings. Besides portability, the new monitor allows for remote monitoring over the Internet. A pregnant at-home patient can strap a soft, wide belt equipped with sensors across her abdomen and send the signal directly to her doctor's office via the Internet, with all the ease of tuning a radio. NASA developed the technology in partnership with Veatronics Corporation, who hopes to commercialize the monitor in the near future.

Sixteen years ago, a NASA engineer began a dialogue, with heart surgeon Dr. Michael DeBakey, about a heart pump device that would help patients bridge the gap while awaiting a heart transplant, as well as assist in the recovery process. In 1992, NASA began funding the project through the Johnson Space Center. In more recent years, Ames Research Center has contributed its experience with simulating fluid flow through rocket engines to simulate blood flow through the pump. The simulations led to improvements in the miniature heart-assist pump. This year, the device was implanted in a patient in the United States for the first time. The 31-year-old woman has suffered from heart failure most of her adult life and is awaiting a heart transplant. In the meantime, the heart pump will supplement the weakened heart's ability to pump blood through the body. In Europe, trials have been ongoing with the device and 32 patients have received implants to date.



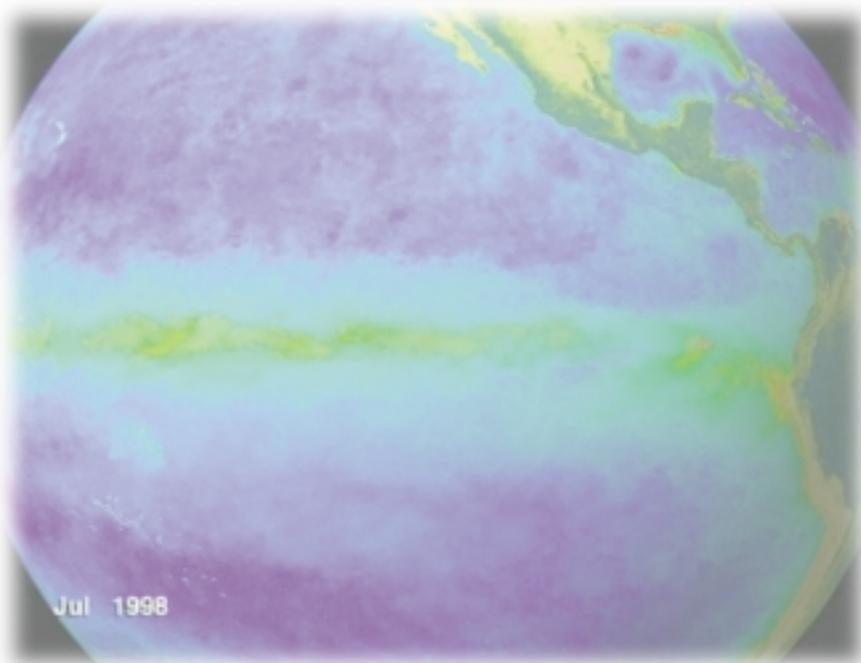
For major metropolises along the coasts of the United States, climate change is an important issue. Goddard Space Flight Center researchers recently completed a 2-year study in collaboration with researchers from other institutions that took the temperature of New York City. With over 19 million people living in the New York metropolitan region, changes in climate could have a significant impact on the area. The study showed that the temperature has risen 2 degrees Fahrenheit over the past 100 years. An overall rise in temperature increases incidents of summer heat-stress, particularly in the poor and elderly, while increasing the strain on electric utility systems. The results of the study will be used in future decisions about infrastructure, public health, water supplies, energy usage, and environmental conservation.

NASA experiments above the Earth have also provided new insights into predicting threats to public health. Scientists are taking advantage of risk analysis approaches using satellite data developed by NASA to track plankton “blooms” space and ocean temperatures, which are indicators of environmental health. Sea surface

temperatures have demonstrated a cycle mirroring cholera outbreaks. The NASA technique has also been used to study malaria, Lyme disease, and Rift Valley fever.

Land mines pose a serious health risk to millions of people around the world. NASA technologies in the field of robotics are being applied to help rid war-ravaged nations of abandoned and forgotten land mines. Using a NASA parafoil design developed at Marshall Space Flight Center, Scout Technologies has designed a land mine scouting and removal system. The parafoil allows the device to be dropped from an aircraft, and flown by remote control to its intended operating area. On the ground, the robot uses global positioning system (GPS) technology to determine its exact location. The unit can be programmed to operate autonomously or through remote control either on site by video link.

Whether helping expectant mothers and heart patients or making gains in knowledge about our planet’s health, NASA is using its vast resources in knowledge and cutting-edge technology to improve the quality of life on Earth.





## The Educational Frontier

Some of the most oft-overlooked contributions NASA makes are in the classroom. For decades, NASA has been a partner in educating America's youth at the elementary, secondary, and higher education levels. The following activities are just a sampling of NASA's attempts to inspire teachers and educators in the fields of science and mathematics.

One of NASA's approaches to expose students to the agency's exciting activities is to get them to be active participants. One of those projects is the EarthKAM (Earth Knowledge Acquired by Middle school students) program, which enables middle school students to take photographs of the Earth from a camera mounted on the Space Shuttle. EarthKAM, led by former astronaut Sally Ride, allows students to use the Internet to submit photo requests, which are uplinked to the camera aboard the shuttle. The digital images taken by the camera are made available to participating schools at EarthKAM's website. Students use the images to conduct investigations into topics such as human settlement patterns, mountain ranges, or agricultural patterns. The final reports are reviewed by scientists and educators to provide feedback to the students. The EarthKAM project is a collaborative effort between NASA, the University of California at San Diego, the Jet Propulsion Laboratory, TERC,

and industry sponsors. So far, EarthKAM has flown on five shuttle missions.

This summer marks the 20<sup>th</sup> anniversary of a collaborative effort between NASA and Modern Technology Systems, Inc., called the Summer High School Apprenticeship Research Program (SHARP). SHARP is an 8-week program, sponsored by NASA's Education Division, that assigns mentors from 11 participating NASA field installations to participating students. The mentors work with the students in a specific area of science or technology gaining hands-on experience while getting paid. Since its inception, approximately 2,914 students and more than 3,300 NASA employees have participated in the program.

Another NASA summer program, aimed at college students, is the Spaceflight and Life Sciences Training Program (SLSTP) at Kennedy Space Center. A challenging, 6-week course designed to teach undergraduates how to successfully design and conduct biological research and operations in space, as well as how to assess the environmental impacts of a launch site. The curriculum consists of lectures from leading researchers, engineers, managers, and astronauts from NASA centers, universities, and industry.

Goddard Space Flight Center also looks to use the summer to expose students to career fields in engineering, science, and mathematics. Through the Summer Institute for Science, Technology, Engineering, and Research (SISTER) Program, Goddard aims to increase the awareness of female middle school students to the possibilities of careers in science fields. Sponsored by NASA's Equal Opportunity Programs Office and the Education Programs Office, female students entering the eighth grade participate in mentoring sessions and group activities, attend lectures and demonstrations, and take a local field trip, encouraging the participation of women in science and mathematics careers.

Alternately, NASA also brings state-of-the-art facilities to the students. Johnson Space Center has hit the road with a 53-foot long trailer to educate the public about how technology derived from the



space program benefits the daily lives of people. The trailer will visit special events across the country as well as make stops at malls, universities and schools when the schedule permits. The exhibit includes dozens of space program spinoffs and a 10-minute video presentation in a Surround-Sound Theater onboard the trailer. The trailer will be on the road approximately 8 months out of the year as it criss-crosses the nation giving Americans a closer look at the benefits they have received from the space program over the last 40 years.



Another such project is the new Aeronautics Education Laboratory (AEL), located on the campus of Los Angeles Southwest College. The laboratory puts cutting-edge technology in the hands of students in grades 7 through 12. Various workstations allow students to examine elements of satellite global positioning, remote sensing, amateur radio, and aircraft design in an effort to strengthen math and science skills. NASA's Office of Equal Opportunity Programs provided the funding, while Glenn Research Center oversaw the design and implementation of the laboratory. The new AEL is modeled after the Mobile Aeronautics Education Laboratory (MAEL), established in 1996 by Glenn and Cuyahoga Community College. Originally the vision of former Ohio Congressman Louis Stokes, the program has grown from a single location to a multi-site organization. MAEL proved to be so popular and demand exceeded availability that permanent AELs have been established at multiple sites.

NASA is also tapping students to help them gear up for the next century. The multi-agency Mars Millennium Project (MMP) and the White House Millennium Council Youth Initiative effort has students designing communities for 100 people to inhabit on Mars in 2030. Each Mars Millennium team must come up with a livable and life-sustaining community on Mars that is cultur-

ally and artistically rich. NASA, the Department of Education, the National Endowment for the Arts, and numerous private and public organizations and businesses have collaborated on the project which hopes to encourage students to investigate the best of the past and present and apply it to the future.

Every April at Marshall Space Flight Center, over 400 high school and undergraduate students and teachers from around the nation participate in the Great Moonbuggy Race. The event challenges students to apply engineering skills and develop team spirit to design a human-piloted vehicle capable of traversing a lunar racecourse. The race is timed and the team with the fastest assembly and course time combined wins. Prizes are also awarded for originality of design.

NASA continues to play a vital role not only in discovering new information for the scientists and researchers of today, but also in helping to develop the next generation of engineering genius and scientific imagination that will assure the continued vitality and prominence of the American space program.



# Commercial Technology Network and Affiliations

The NASA Commercial Technology Program sponsors a number of organizations around the country that are designed to assist U.S. businesses in accessing, utilizing, and commercializing NASA-funded research and technology. These organizations work closely with the Commercial Technology Offices, located at each of the 10 NASA field centers, providing a full range of technology transfer and commercialization services and assistance.

## Technology Transfer Network

The Robert C. Byrd **National Technology Transfer Center** <<http://www.nttc.edu>>, located on the campus of Wheeling Jesuit University in Wheeling, West Virginia, was established by Congress in 1989 to strengthen American industry by providing access to more than \$70 billion worth of federally funded research. By helping American companies use federal technologies, NTTC helps them manufacture products, create jobs, and foster partnerships between federal laboratories and the private sector, universities, innovators, and economic development organizations. From that mission, NTTC has grown into a full-service technology commercialization center. In addition to

providing access to federal technology information, NTTC provides technology commercialization training; technology assessment services that help guide industries in making key decisions regarding intellectual property and licensing; assistance in finding strategic business partners and electronic business development services.

NTTC developed a *leads management system* for NASA that is the formal reporting and tracking system for partnerships being developed between NASA and U.S. industry. The leads system allows all members of the NASA Technology Commercialization Team to have an easy-to-use and effective tool to create and track leads in order to bring them to partnerships. NTTC also utilizes the expertise of nationally recognized technology management experts to create and offer technology commercialization training. Course topics range from the basics of technology transfer to hands-on valuation, negotiation and licensing. Courses are developed at NTTC and around the country. In addition, on-line courses, supporting publications, comprehensive software applications and videotapes are also available.

**NASA TechTracS** <<http://technology.nasa.gov>> provides access to NASA's technology inventory and numerous examples of the successful transfer of NASA-sponsored technology for commercialization. TechFinder, the main feature of the Internet site, allows users to search the technologies and success stories, as well as submit requests for additional information. All NASA field centers submit information to the TechTracS database as a means of tracking technologies that have potential for commercial development.

Since their inception in January 1992, the six NASA-sponsored Regional Technology Transfer Centers (RTTCs) have helped U.S. businesses investigate and utilize NASA and other federally-funded technologies for companies seeking new products, improvements to existing products, or solutions to technical problems. The RTTCs provide technical and business assistance to several thousand customers every year.



*The National Technology Transfer Center is located on the campus of Wheeling Jesuit University in Wheeling, West Virginia.*

The network of RTTCs is divided up as follows:  
**Far West** (AK, AZ, CA, HI, ID, NV, OR, WA):

The **Far West Regional Technology Transfer Center** (FWRTTC) <<http://www.usc.edu/dept/engineering/TTC/NASA>> is an engineering research center within the School of Engineering at the University of Southern California in Los Angeles. Using the Remote Information Service to generate information from hundreds of federal databases, FWRTTC's staff works closely with businesses and entrepreneurs to identify opportunities, expertise, and other necessary resources. The FWRTTC enhances the relationships between NASA and the private sector by offering many unique services, such as the NASA On-line Resource Workshop, NASA Tech Opps, and links to funding and conference updates.

**Mid-Atlantic** (DC, DE, MD, PA, VA, WV):

The **Mid-Atlantic Technology Applications Center** (MTAC) <<http://oracle.mtac.pitt.edu/WWW/MTAC.html>> is located at the University of Pittsburgh in Pennsylvania. MTAC has designed TechScout, a highly specialized set of matchmaking services, created to help companies locate technologies, as well as technical expertise, within NASA and the federal laboratory system. Close relationships with the Goddard Space Flight Center and the Langley Research Center allow MTAC to help the U.S. improve its competitiveness.

**Mid-Continent** (AR, CO, IA, KS, MO, MT, ND, NE, NM, OK, SD, TX, UT, WY):

The **Mid-Continent Technology Transfer Center** (MCTTC) <<http://www.mcttc.com/>>, under the direction of the Technology and Economic Development Division of the Texas Engineering Service, is located in College Station, Texas. The MCTTC, which provides a link between private companies and federal laboratories, reports directly to the Johnson Space Center. The assistance focuses on high-tech and manufacturing companies that need to acquire and commercialize new technology.

**Mid-West** (IL, IN, MI, MN, OH, WI):

The **Great Lakes Industrial Technology Center** (GLITeC) <<http://www.battelle.org/glitec>>, managed by Battelle Memorial Institute, is located in Cleveland, Ohio. GLITeC works with industries primarily within its six-state region to acquire and use NASA technology and expertise, especially at the Glenn Research Center. Each year, over 500 companies work with GLITeC and its affiliates to identify new market and product

opportunities. Technology-based problem solving, product planning and development, and technology commercialization assistance are among the services provided.

**Northeast** (CT, MA, ME, NH, NJ, NY, RI, VT):

The **Center for Technology Commercialization** (CTC) <<http://www.ctc.org>> is a non-profit organization, based in Westborough, Massachusetts. Covering New England, New York, and New Jersey, the CTC currently has seven satellite offices that form strong relationships with the Northeast industry. Operated by the CTC, the NASA Business Outreach Office stimulates business among regional contractors, NASA field centers, and NASA prime contractors.

**Southeast** (AL, FL, GA, KY, LA, MS, NC, SC, TN):

The **Southern Technology Applications Center** (STAC) <<http://www.state.fl.us/stac>> is headquartered at the University of Florida in Gainesville. Working closely with the Marshall Space Flight Center, the Kennedy Space Center, and the Stennis Space Center, STAC helps to spur economic development in each of the nine states in the southeast. To facilitate the transfer of NASA technologies and expertise, the three NASA centers and STAC formed the NASA Southeast Technology Alliance.

#### NASA Incubator Programs

Ten NASA incubators are included within this network of programs. They are designed to nurture new and emerging businesses with the potential to incorporate technology developed by NASA. They offer a wide variety of business and technical support services to increase the success of participating companies.

The **Ames Technology Commercialization Center** (ATCC) <<http://ctoserver.arc.nasa.gov/incubator.html>>, located in San Jose, California, provides opportunities for start-up companies to utilize NASA technologies. The center uses a lab-to-market approach that takes the technological output of Ames' labs and pairs that technology with appropriate markets to create and foster new industry and jobs. The incubator helps businesses and entrepreneurs find NASA technology with commercial potential, then provides access to a network of business experts in marketing, sales, high-tech management and operations, financing, and patent and corporate law. The ATCC also offers low-cost office space and other start-up services.



## Commercial Technology Network and Affiliations *(Continued)*

**BizTech** <<http://europa.uah.edu/biztech/index.html>>, of Huntsville, Alabama, is a small business incubator, offering participating companies access to services at Marshall Space Flight Center laboratories for feasibility testing, prototype fabrication, and advice on technology usage and transfer. BizTech is sponsored by the Huntsville-Madison County Chamber of Commerce.

The **Emerging Technology Center (ETC)** <<http://www.etcbaltimore.com/index2.html>>, located in Baltimore, Maryland, is among the newest of the NASA-affiliated incubators. Partnering institutions include the Goddard Space Flight Center and area universities and colleges.

The **Florida/NASA Business Incubator Center (FNBIC)** <<http://www.trda.org/fnbic/>> is a joint partnership of NASA's Kennedy Space Center, Brevard Community College, and the Technological Research and Development Authority. The mission of FNBIC is to increase the number of successful technology-based small businesses originating in, developing in, or that relocated to Brevard County. FNBIC offers support facilities and programs to train and nurture new entrepreneurs in the establishment and operation of developing ventures based on NASA technology.

The **Hampton Roads Technology Incubator (HRTI)** <<http://www.hr-incubator.org>> identifies and licenses NASA Langley Research Center technologies for commer-

cial use. HRTI's mission is to increase the number of successful technology-based companies originating in, developing in, or relocating to the Hampton Roads area.

The **Lewis Incubator For Technology (LIFT)** <<http://www.liftinc.org>>, managed by Enterprise Development, Inc., provides outstanding resources for technology and support to businesses in the Ohio region. Its primary objectives are to create businesses and jobs in Ohio and to increase the commercial value of NASA knowledge, technology, and expertise. LIFT offers a wide range of services and facilities to the entrepreneur to increase the probability of business success.

The **Mississippi Enterprise for Technology** is sponsored by NASA and the Mississippi University Consortium and Department of Economic and Community Development, as well as the private sector. The mission of the Enterprise is to help small businesses utilize the scientific knowledge and technical expertise at the Stennis Space Center. A significant part of this effort is Stennis' Commercial Remote Sensing Program (CRSP), which was formed to commercialize remote sensing, geographic information systems, and related imaging technologies.

The **NASA Commercialization Center (NCC)** <<http://www.nasaincubator.csupomona.edu/home.htm>>, run by California State Polytechnic University, Pomona, is a business incubator dedicated to helping small businesses access and commercialize Jet Propulsion Laboratory (JPL) and Dryden Flight Research technologies.

The **NASA Illinois Commercialization Center (NICC)**, is the newest addition to NASA's technology transfer network. Serving the Chicago region, the NICC is a partner of the Glenn Research Center and GLITeC aimed at assisting companies with the use of NASA technology, as well as establishing new companies in Illinois built from NASA technology.

The **UH-NASA Technology Commercialization Incubator** <[http://www.research.uh.edu/otm/inc/UH\\_inc\\_home.html](http://www.research.uh.edu/otm/inc/UH_inc_home.html)> is a partnership between NASA's Johnson Space Center and the



*Employees of a NASA/Florida Business Center company, Netlander, Inc., discuss their product.*

University of Houston. The incubator is designed to help local small and mid-sized businesses commercialize space technology. The University of Houston houses the program and provides the commercialization and research expertise of its business and engineering faculties.

Other organizations devoted to the transfer of NASA technology are the **Research Triangle Institute (RTI)** and the **MSU TechLink Center**.

**RTI** <<http://www.rti.org>>, located in Research Triangle Park, North Carolina, provides a range of technology management services to NASA. RTI performs technology assessments to determine applications and commercial potential of NASA technology, as well as market analysis, and commercialization and partnership development. RTI works closely with all of NASA's Commercial Technology Offices.

The **MSU TechLink Center** <<http://techlink.msu.montana.edu>>, located at Montana State University-Bozeman, was established in 1997 to match the technology needs of client companies with resources throughout NASA and the federal laboratory system. TechLink focuses on a five-state region that includes Idaho, Montana, North Dakota, South Dakota, and Wyoming. Working closely with public, private, and university programs, TechLink provides ongoing support in the process of adapting, integrating, and commercializing NASA technology.

Affiliated Organizations, Services, and Products To compliment the specialized centers and programs sponsored by the NASA Commercial Technology Program, affiliated organizations and

services have been formed to strengthen NASA's commitment to U.S. businesses. Private and public sector enterprises build upon NASA's experience in technology transfer in order to assist the channeling of NASA technology into the commercial marketplace.

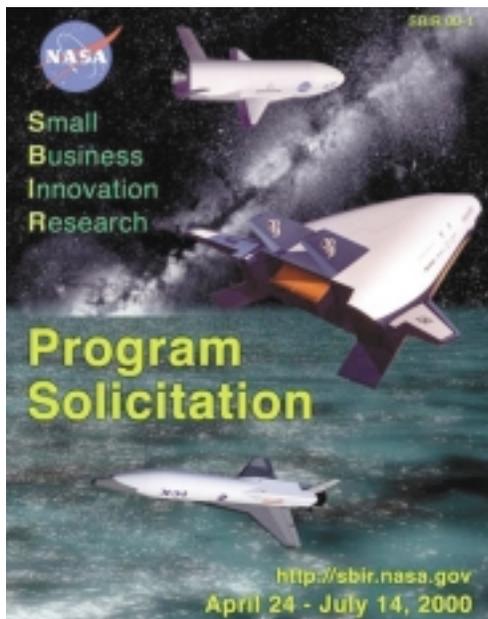
The **NASA Small Business Innovation Research (SBIR) Program** <<http://sbir.nasa.gov>> provides seed money to U.S. small businesses for developing innovative concepts that meet NASA mission requirements. Each year, NASA invites small businesses to offer proposals in response to technical topics listed in the annual SBIR Program Solicitation. The NASA field centers negotiate and award the contracts, and monitor the work.

NASA's SBIR Program is implemented in three phases:

- **Phase I** is the opportunity to establish the feasibility and technical merit of a proposed innovation. Selected competitively, NASA Phase I contracts last six months and must remain under specific monetary limits.
- **Phase II** is the major research and development effort, which continues the most promising of the Phase I projects based on scientific and technical merit, results of Phase I, expected value to NASA, company capability, and commercial potential. Phase II places greater emphasis on the commercial value of the innovation. The contracts are usually for a period of 24 months and again must not exceed specified monetary limits.
- **Phase III** is the process of completing the development of a product to make it commercially available. While the financial resources needed must be obtained from sources other than the funding set aside for the SBIR, NASA may fund Phase III activities for follow-on development or for production of an innovation for its own use.

The SBIR Management Office, located at the Goddard Space Flight Center, provides overall management and direction of the SBIR program.

The **NASA Small Business Technology Transfer (STTR) Program** <<http://sbir.nasa.gov>> awards contracts to small businesses for cooperative research and development with a research institution through a uniform, three-phase process. The goal of Congress





## Commercial Technology Network and Affiliations *(Continued)*

in establishing the STTR Program was to transfer technology developed by universities and federal laboratories to the marketplace through the entrepreneurship of a small business.

Although modeled after the SBIR Program, STTR is a separate activity and is separately funded. The STTR Program differs from the SBIR Program in that the funding and technical scope is limited and participants must be teams of small businesses and research institutions that will conduct joint research.

The **Federal Laboratory Consortium (FLC) for Technology Transfer** <<http://www.fedlabs.org>> was organized in 1974 to promote and strengthen technology transfer nationwide. More than 600 major federal laboratories and centers, including NASA, are currently members. The mission of the FLC is twofold:

- To promote and facilitate the rapid movement of federal laboratory research results and technologies into the mainstream of the U.S. economy.
- To use a coordinated program that meets the technology transfer support needs of FLC member laboratories, agencies, and their potential partners in the transfer process.

The **National Robotics Engineering Consortium (NREC)** <<http://cronos.rec.ri.cmu.edu>> is a cooperative venture among NASA, the city of Pittsburgh, the state of Pennsylvania, and Carnegie Mellon's Robotics Institute. Its mission is to move NASA-funded robotics technology to industry. Industrial partners join the NREC with the goal of using technology to gain a greater market share, develop new niche markets, or create entirely new markets within their area of expertise.

The road to technology commercialization begins with the basic and applied research results from the work of scientists, engineers, and other technical and management personnel. The **NASA Scientific and Technical Information (STI) Program** <<http://www.sti.nasa.gov>> provides the widest appropriate dissemination of NASA's

research results. The STI Program acquires, processes, archives, announces, and disseminates NASA's internal, as well as worldwide, STI.

The NASA STI Program offers users such things as Internet access to its database of over three million abstracts, on-line ordering of documents, and the NASA STI Help Desk for assistance in accessing STI resources and information. Free registration with the program is available through the NASA Center for Aerospace Information (CASI).

For more than three decades, reporting to industry on any new, commercially significant technologies developed in the course of NASA research and development efforts has been accomplished through the publication of *NASA Tech Briefs* <<http://www.nasatech.com>>.

The monthly magazine features innovations from NASA, industry partners, and contractors that can be applied to develop new or improved products and solve engineering or manufacturing problems. Authored by the engineers or scientists who performed the original work, the briefs cover a variety of disciplines, including computer software, mechanics, and life sciences. Most briefs offer a free supplemental Technical Support Package (TSP), which explains the technology in greater detail and provides contact points for questions or licensing discussions.

*Aerospace Technology Innovation* <<http://nctn.hq.nasa.gov/innovation/index.html>> is published bimonthly by the NASA Office of Aeronautics and Space Transportation Technology. Regular features include current news and opportunities in technology transfer and commercialization, aerospace technology and development, and innovative research.

*NASA Spinoff* <<http://www.sti.nasa.gov/tto/spinoff.html>> is an annual print and on-line publication featuring current research and development efforts, the NASA Commercial Technology Program, and successful commercial and industrial applications of NASA.

# Commercial Technology Network



**T**he NASA Commercial Technology Network (NCTN) extends from coast to coast. For specific information concerning commercial technology activities described below, contact the appropriate personnel at the facilities listed or go to the Internet at <http://nctn.hq.nasa.gov>. General inquiries may be forwarded to the National Technology Transfer Center.

To publish your success about a product/service you may have commercialized using NASA technology, assistance, or know-how, contact the NASA Center for AeroSpace Information or go to the Internet at:

<http://www.sti.nasa.gov/tto/contributor.html>.

- ▲ **Field Center Commercial Technology Offices**  
Represent NASA's technology sources and manage center participation in technology transfer activities.
- ▼ **National Technology Transfer Center (NTTC)**  
Provides national information, referral, and commercialization services for NASA and other government laboratories.
- **Regional Technology Transfer Centers (RTTC)**  
Provide rapid access to information, as well as technical and commercialization services.
- ★ **Research Triangle Institute**  
Provides a range of technology management services including technology assessment, valuation and marketing; market analysis; intellectual property audits; commercialization planning; and the development of partnerships.

## ▲ FIELD CENTERS

### **Ames Research Center**

National Aeronautics and Space Administration  
Moffett Field, California 94035  
Chief, Commercial Technology Office:  
*Carolina Blake*  
Phone: (650) 604-0893  
Email: cblake@mail.arc.nasa.gov

### **Dryden Flight Research Center**

National Aeronautics and Space Administration  
4800 Lilly Drive, Building 4883  
Edwards, California 93523-0273  
Chief, Public Affairs, Commercialization, and  
Education Office:  
*Jennifer Baer-Riedhart*  
Phone: (661) 276-3689  
Email: jenny.baer-riedhart@dfrc.nasa.gov

**Glenn Research Center** at Lewis Field  
National Aeronautics and Space Administration  
21000 Brookpark Road  
Cleveland, Ohio 44135  
Chief, Commercial Technology Office:  
*Larry Viterna*  
Phone: (216) 433-5398  
Email: larry.a.viterna@grc.nasa.gov

### **Goddard Space Flight Center**

National Aeronautics and Space Administration  
Greenbelt, Maryland 20771  
Chief, Commercial Technology Office:  
*George Alcorn, Ph.D.*  
Phone: (301) 286-5810  
Email: galcorn@pop700.gsfc.nasa.gov

### **Lyndon B. Johnson Space Center**

National Aeronautics and Space Administration  
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Acting Director, Technology Transfer and  
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*Charlene E. Gilbert*  
Phone: (281) 483-0474  
Email: charlene.e.gilbert1@jsc.nasa.gov

### **John F. Kennedy Space Center**

National Aeronautics and Space Administration  
Kennedy Space Center, Florida 32899  
Chief, Technology Programs and  
Commercialization Office:  
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Email: jim.aliberti-1@ksc.nasa.gov

### **Langley Research Center**

National Aeronautics and Space Administration  
Hampton, Virginia 23681-0001  
Director, Technology Applications Group:  
*Samuel A. Morello*  
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### **George C. Marshall Space Flight Center**

National Aeronautics and Space Administration  
Marshall Space Flight Center, Alabama 35812  
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Email: sally.a.little@msfc.nasa.gov

### **John C. Stennis Space Center**

National Aeronautics and Space Administration  
Stennis Space Center, Mississippi 39529  
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*Kirk Sharp*  
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Email: kirk.sharp@ssc.nasa.gov

### **Jet Propulsion Laboratory**

4800 Oak Grove Drive  
Pasadena, California 91109  
Manager, Commercial Technology Program Office:  
*Merle McKenzie*  
Phone: (818) 354-2577  
Email: merle.mckenzie@jpl.nasa.gov

## ▼ NATIONAL TECHNOLOGY TRANSFER CENTER (NTTC)

Wheeling Jesuit University  
Wheeling, West Virginia 26003  
*Joseph Allen, President*  
Phone: (304) 243-2455  
Email: jallen@nttc.edu

■ **REGIONAL TECHNOLOGY TRANSFER CENTERS (RTTCs)**

1-800-472-6785

You will be connected to the RTTC in your geographical region.

**Far West**

Engineering Technology Transfer Center

3716 South Hope Street, Suite 200

Los Angeles, California 90007-4344

*Kenneth Dozier, Director*

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Email: [kdozier@mizar.usc.edu](mailto:kdozier@mizar.usc.edu)

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**Mid-Continent**

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Texas Engineering Extension Service

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College Station, Texas 77843-8000

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**NASA CENTER FOR AEROSPACE INFORMATION**

**Spinoff Project Office**

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