Bringing Space Technologies Down to Earth

When John Glenn returned to space on October 29, 1998, a variety of NASA Goddard Space Flight Center technologies went with him—the three-dimensional roller locking sprag, a cryogenic turboalternator, and capillary pumped loop technology. These technologies, like all other Goddard-developed innovations, may one day be used on Earth as well as in space.

Since its inception, Goddard has pursued a commitment to technology transfer and commercialization. For every space technology developed, Goddard strives to identify secondary applications, which can increase our nation's global competitiveness. These efforts are based in the Technology Commercialization Office.

The goal of Goddard's technology transfer and commercialization program is to provide technology, expertise, and facilities to U.S. companies, universities, and government agencies. This report presents new and transferred technologies, as well as other Technology Commercialization Office activities in 1998.

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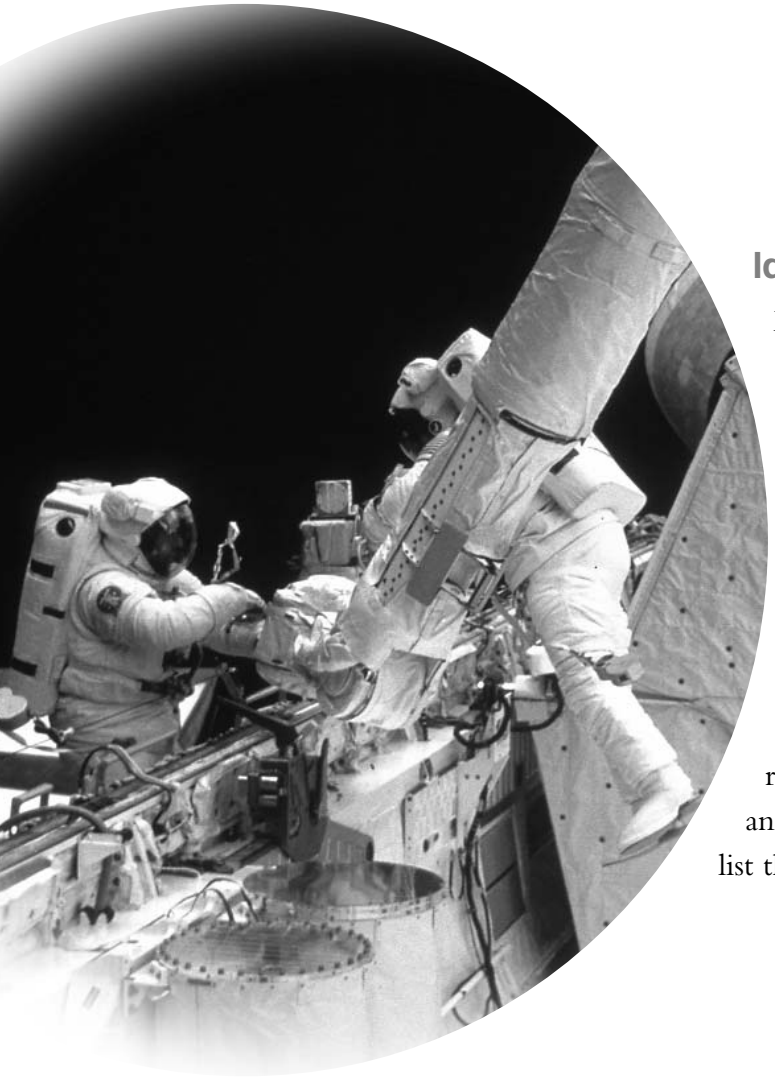
Technology Commercialization at Goddard Space Flight Center

NASA Goddard Space Flight Center's challenging and technologically demanding Earth Science and Space Science missions generate a wealth of advanced technology. Goddard's inventions, expertise, and facilities are a national asset that can be used to develop new products and processes that benefit the U.S. economy. The products and processes developed by transferring technology to U.S. industry increase the nation's competitiveness, create jobs, improve the balance of trade, and enrich the lives of its citizenry.

Goddard's Technology Commercialization Office seeks out Goddard research and development that has the potential of being successfully transferred to meet industry and national needs. Then, using its technical, legal, business, and marketing expertise, the office works with researchers and industry to transfer technologies to the marketplace.



Identifying a Technology

Each year, scientific and technical staff working at Goddard develop dozens of advanced technologies that may have the potential for successful transfer to a variety of areas. Once identified, these technologies become part of an inventory maintained by the Technology Commercialization Office. To encourage researchers to identify these technologies for possible transfer, the Technology Commercialization Office operates an extensive inreach program. Inreach program activities include ongoing consultation with technical researchers, employee development programs, colloquia, and new technology recognition programs. Pages 22–24 list the technologies reported in 1998.

Assessing Commercial Viability

Once a new technology is reported, the Technology Commercialization Office undertakes a technical, business, and legal assessment to determine commercial potential. This assessment involves identifying possible applications and markets, considering cost and pricing information, and estimating market size and trends. The technologies described in this report received a full assessment and were determined to have commercial viability.

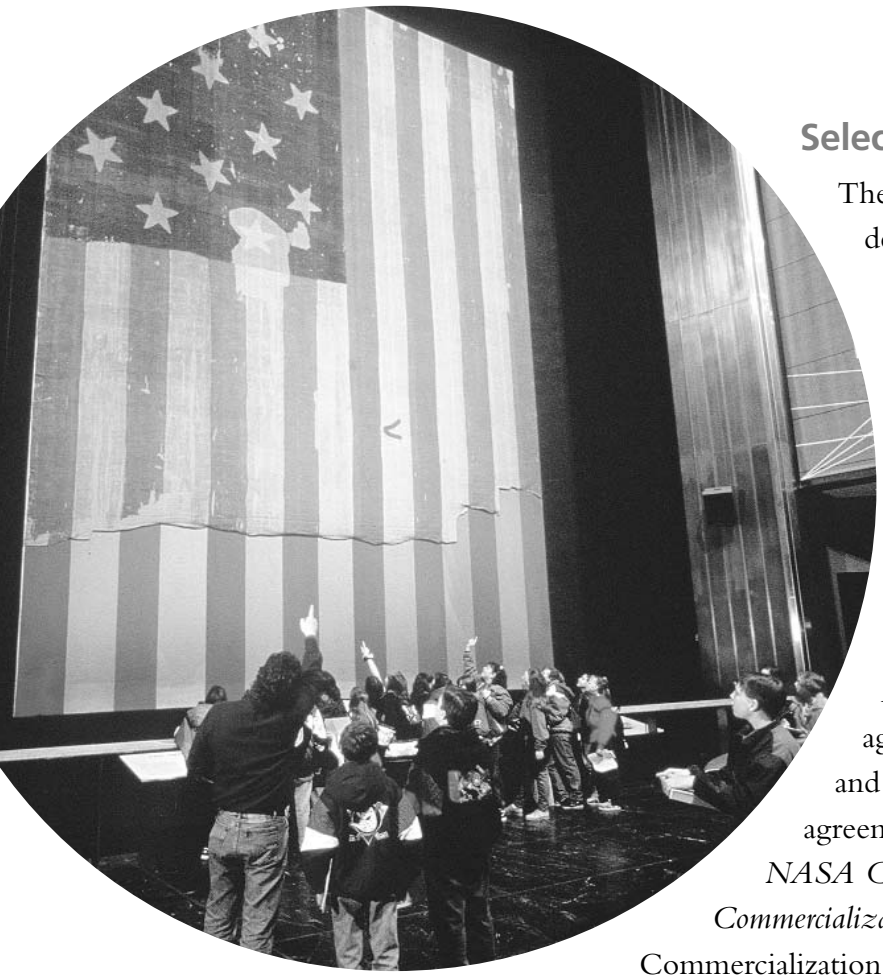
Building Commercial Interest

Once a technology is determined to have commercial potential, the Technology Commercialization Office undertakes a variety of outreach efforts to communicate its availability and possible applications. The office publishes various materials, including one-page descriptions highlighting technologies available for commercial transfer. By hosting and attending commercialization workshops and trade conferences, the office has the opportunity to demonstrate available technologies and build interest among industry and entrepreneurs.
(See page 27.)

Small Business Outreach

Extra efforts to involve smaller businesses are made under the auspices of the Small Business Innovation Research (SBIR) program. The SBIR program offers grants to small businesses to meet federal research and development needs. A similar program—the Small Business Technology Transfer (STTR) program—involves teams of small businesses and research institutions conducting research jointly. For more information on either of these programs, call the SBIR program manager at (301) 286-5836.

A new addition to Goddard's small business outreach effort is the Small Business Incubator program. This program was designed to nurture start-up enterprises that are undertaking efforts to commercialize NASA technologies. Under the incubator program, businesses receive a variety of benefits, including low-cost office space, planning assistance, and legal and financial advice.

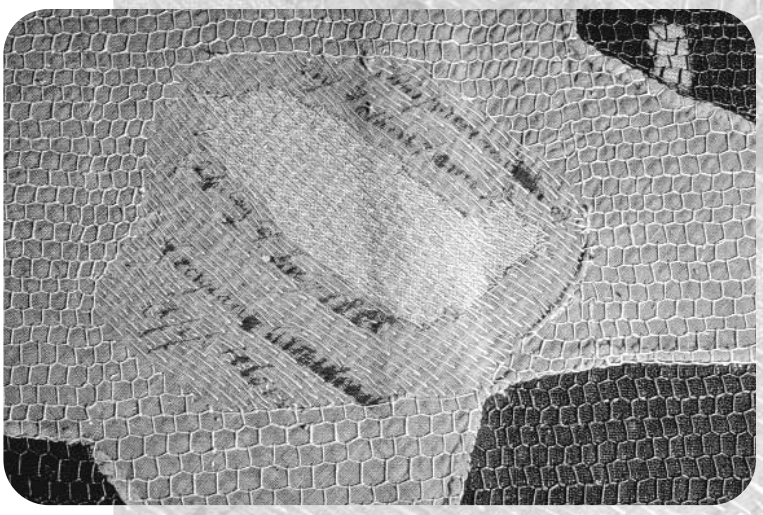


Selecting a Partner

The Technology Commercialization Office has devised a series of steps to ensure a fair and equitable process for selecting a commercial partner for its technology. After candidate companies receive information through Goddard's various outreach efforts, prospective partners prepare and submit proposed commercialization plans. After reviewing the submissions, the Technology Commercialization Office selects the best proposal and negotiates a patent or copyright license and/or a Space Act Agreement with the selected partner. These agreements undergo legal review by general and patent counsel. More information on these agreements is provided in the publication *Working with NASA Goddard Space Flight Center: The Technology Commercialization Process,* available from the Technology Commercialization Office.

Success

Through their partnerships with Goddard, U.S. companies are improving existing products, developing new products and markets, and saving time and money with improved processes. In turn, Goddard benefits through royalties and partnerships. All of this aids the U.S. economy through job creation and helps to improve the nation's quality of life.



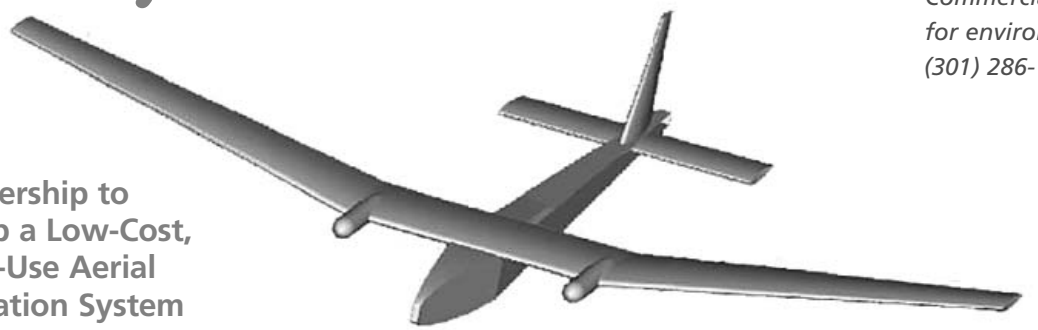
A Goddard-developed technology is used to preserve the Star-Spangled Banner. A magnified image is shown at right. *(See story on page 15.)*

1998 Technology Opportunities and Successes

Goddard scientific and technical staff are continually discovering technologies to achieve space mission goals. These technologies—whether for environmental systems; sensors and detectors; guidance, navigation, and control; optics; thermal and cryogenics; or information systems—may offer benefits outside the aerospace industry. The technologies summarized here have been determined to have commercial potential, and some have achieved commercialization success.

Environmental Systems

For more information on these technologies, call the Technology Commercialization Office's contact for environmental systems at (301) 286-1098.



A Partnership to Develop a Low-Cost, Easy-to-Use Aerial Observation System

Goddard's partnership with a commercial aerospace company is expected to realize the airborne electric remote observation system.

In 1998, Goddard partnered with BAI Aerosystems, Inc., of Easton, Maryland, to develop a prototype vehicle for the airborne electric remote observation system (AEROS). The 6-pound, 8-foot wingspan AEROS includes a miniature video camera and transmitter to provide real-time aerial observation for natural hazard damage assessment, fire fighting, law enforcement, ranch or farm patrol, and videography.

Launched from a tethered or free-flying helium balloon, AEROS requires only a small propulsion system, which reduces the aircraft's weight, complexity, and cost. Constructed of hobby-type wood and fabric, AEROS uses small, efficient, quiet, environmentally friendly motors powered by rechargeable batteries. Operating at an altitude of 500 feet, AEROS can fly for 10 minutes at 20 miles per hour. A maximum endurance of 20 minutes may be possible. During flight, video data are transmitted to a receiver that provides real-time video images.

Goddard and BAI are working together and sharing costs to realize the commercial potential of this technology. Extensive design efforts took place in 1998, and fabrication and flight trials are planned for early 1999.

New Instrument for Measuring Cloud Top Height

Goddard is developing an instrument that combines three techniques to improve cloud top height measurement accuracy.

Cloud height information is essential for studying Earth's climate system and thunderstorms as well as for weather forecasting and aircraft operation. Researchers at Goddard are developing an instrument to improve cloud top height measurement accuracy. The new spectrometer/radiometer combines three techniques—the thermal infrared (IR) technique, the molecular oxygen A-band technique, and the technique using the Fraunhofer line filling-in effect. This unique combination allows each technique to compensate for the inherent shortcomings of the other two.

Goddard and FEMA to Work Together for Public Safety

The two federal agencies formed a partnership to transfer space technologies to improve emergency management.

Goddard and the Federal Emergency Management Agency (FEMA) have signed an agreement to facilitate the transfer of technologies to improve public safety. The agreement links Goddard's technology transfer goals with FEMA's mission to reduce the impact of a broad spectrum of natural and man-made disasters by improving hazard mitigation, emergency preparedness, incident response, and disaster recovery.

FEMA currently is interested in Goddard's Earth Alert system. Earth Alert combines a new emergency notification system with an existing communications infrastructure—personal pagers. The system is designed to feed weather data from several sources into a centralized emergency response center. The response center interprets incoming warnings and issues an alert via cellular communications towers. Earth Alert-equipped pagers and fixed receivers located in schools, hospitals, businesses, churches, and other facilities can receive the warning message. Integrating the system with a global positioning system (GPS) and wireless Internet links allows Earth Alert to provide maps indicating the relative location of the danger.

As their partnership continues, the two agencies may identify other Goddard technologies that can enhance FEMA's ability to warn citizens of natural disasters, acts of terrorism, and other emergencies.

The single, compact instrument consists of a single-grating spectrograph that uses three grating orders simultaneously with bandpass and order sorting filters. The device images 11-μm radiation from the zeroth order of the grating onto an IR detector with an IR filter and lens assembly. The bandpass filters separate first-order 750–780 nm radiation (for the A-band absorption) from second-order 390–400 nm radiation (for the Fraunhofer line filling-in effect).

A proof-of-concept instrument has been built and tested in Goddard laboratories, and a provisional patent was filed in September 1998. Goddard seeks partners to further develop this technology.

Spotlighting Success

A New Agreement for Advances in Satellite Data Analysis

Goddard establishes a new Regional Application Center to find practical uses for satellite data.

In 1998, Goddard and the University of Puerto Rico agreed to establish a Regional Application Center (RAC) at the university's Mayagüez campus. Designed to foster the use of environmental and Earth resource data from satellites and other sources, the RAC program allows participating institutions to receive and manipulate data effectively, inexpensively, and on a routine basis.

To participate, universities must have adequate computer systems expertise, remote sensing applications, user constituency, and supporting equipment. These capabilities are essential for receiving, cataloguing, storing, and manipulating NASA satellite, ancillary, and in situ data. As an RAC, the institution supports the calibration and validation of satellite data, and its research results are incorporated into shareable global environmental knowledge bases.

The University of Puerto Rico is prepared to devote portions of its Laboratory for Applied Remote Sensing and Image Processing, other facilities, and a multidisciplinary team of researchers toward accomplishing a variety of objectives. One goal is the visualization of information by overlaying satellite data onto images supplied by the university's commercial partner, Caribbean Pictometry, Inc. When possible, resulting applications will be commercialized.

Weather Anywhere

Goddard is working with commercial partners to further develop a hand-held weather information device and server system.

Goddard and its commercial partners, Global Science and Technology, Inc., and Aeptec Microsystems, Inc., have made considerable progress in developing the Weather Anywhere technology. Weather Anywhere was designed to provide real-time, location-specific weather information via cellular communications. The technology consists of a hand-held computer and display system with GPS capabilities. This device communicates with a weather data acquisition system and Web-based server information subsystem.

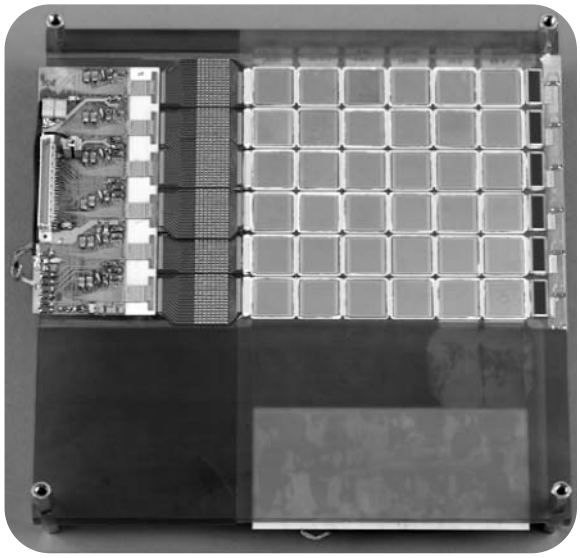
In 1998, Goddard and its commercial partners tested the real-time acquisition of satellite data. Researchers also explored using neural networks to process temperature sounding data, which indicate instabilities that can cause severe weather and wind fields. Neural networks make statistical decisions based on historical data. By "training" the neural network using infrared images from the GOES satellite, researchers can obtain atmospheric profiles for weather forecasting.

To date, the neural network has been verified and trained using data products from the National Oceanic and Atmospheric Administration. A display unit was selected, and testing of the system design is set to begin in early 1999.

Goddard seeks companies interested in participating in either transmitting data or forecasting weather products using these high resolution atmospheric profiles.

Sensors and Detectors

For more information on these technologies, call the Technology Commercialization Office's contact for sensors and detectors at (301) 286-5979.



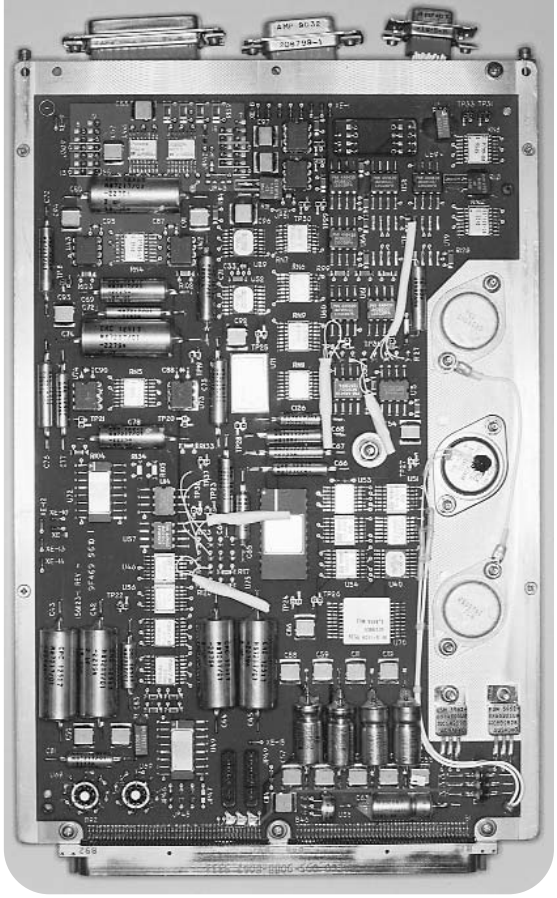
A Successful Wire Bonding Technique for CZT Strip Detectors

Goddard's advances result in highly reliable, small, light, thin detectors for a wide variety of applications.

Extensively used in infrared applications, cadmium zinc telluride (CZT) recently has been used in place of silicon in X-ray and gamma-ray devices. Although CZT allows for higher detection efficiency and thinner detectors, it is more brittle than silicon, often leading to craters and failures during wire bonding. Goddard has devised a fabrication technique that solves these problems by using ultrasonic and other semiconductor-based bonding methods to connect the electrical wires to CZT strips.

Goddard's highly reliable wire-bonding technique uses an ultrasonic wedge bonder with soft aluminum wire, low ultrasonic power, a thick (2–3 μm) layer of gold over the bonding pads, and a large bonding pad area. The innovation allows CZT to be used successfully in strip detectors, small- and medium-size arrays, and pixellated detectors.

CZT detectors can be used in a variety of applications. For example, the University of Arizona plans to use a CZT array to demonstrate novel nuclear medical imaging techniques. Other uses include nondestructive evaluation, oil well logging, X-ray astronomy, airport baggage scanners, nuclear weapons surveillance, environmental monitoring, and geological surveying. Goddard is seeking a partner interested in furthering the CZT detector manufacturing technology and helping to transfer it to commercial applications.



A Differential Current Source

This device produces output current proportional to the input control voltage regardless of variations in load impedance and common-mode voltages on the load.

Goddard researchers have devised a voltage-controlled current source circuit with high-impedance floating differential output that can be maintained even in the presence of common-mode voltages. The device's collection of operational amplifiers and their associated input and feedback resistors work in concert to produce an output current that depends only on the control input voltage and the resistances in the circuit.

The first amplifier-resistors set provides the positive-terminal output voltage that helps to drive the output current through a load impedance. The second set acts as a unity-gain inverter to produce the negative-terminal output voltage. The next two amplifiers are connected as voltage followers to isolate the reference resistors from the low impedances of the final amplifier-resistors set. This last set acts as a unity-gain differential voltage-summing circuit. In situations where low noise is essential, the connected amplifiers should be low-noise junction field-effect-transistor devices.

Goddard's innovation is ideal for instrumentation systems where common-mode voltages can cause errors in precision measurements. Its low-cost design, made with commercial off-the-shelf components, could improve the accuracy of some instrument measurements for a relatively small increase in cost.

A Highly Accurate, Low-Frequency, RF-Induced Current Dosimeter

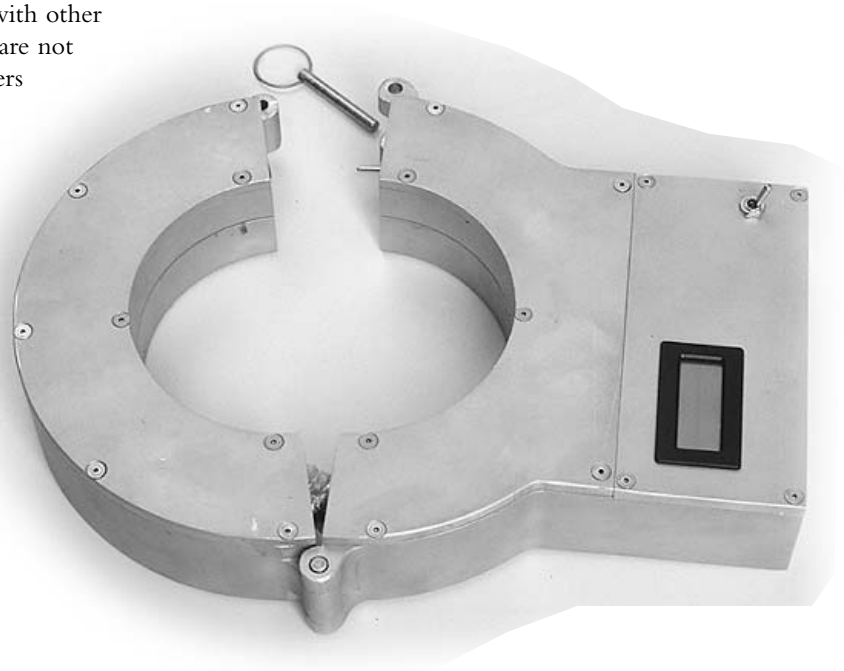
This device improves occupational safety by accurately measuring the body currents created by exposure to nonionizing electromagnetic radiation.

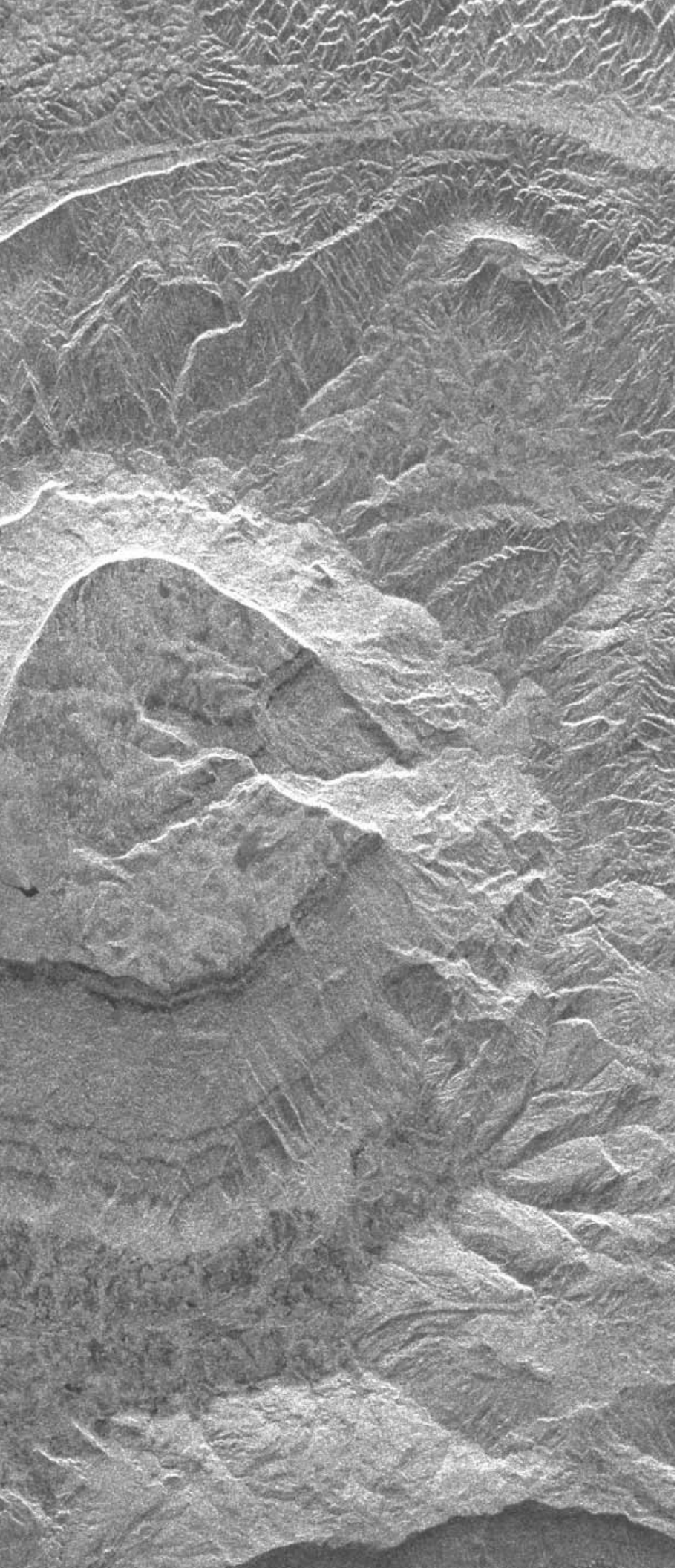
Working with Florida International University, Goddard developed a prototype nonferrous electromagnetic dosimeter technology that can be used to protect workers in a variety of radiofrequency (RF) applications. The RF dosimeter provides a direct, noninvasive measurement of currents induced in the human body by nonionizing electromagnetic radiation. These RF-induced currents can result in pain, shocks, and burns.

Because body size, grounding, body orientation, and contact with other objects greatly affect the current, field strength measurements are not sufficient for occupational safety. Workmats and stand-on meters act as antennas and create currents. Wearable ferrous meters are heavy and offer insufficient accuracy.

Goddard's nonferrous technology is worn around the arm or leg. This lightweight device provides accurate rate readings in any body orientation without significantly perturbing the field. The device can be used by occupational safety and health personnel; systems developers; technicians; and equipment operations in broadcasting, manufacturing, medicine, and the military.

In late 1998, the Technology Commercialization Office held a technology briefing to describe its patented technology to industry. Commercialization plans have been accepted, and a decision is pending regarding partnership.





Spotlighting Success

Further Developments to Sensors for Remote Sensing of Agriculture

Goddard and its commercial partners further advanced the capabilities of LEISA sensors.

Goddard's partnerships with Boeing Commercial Space Company and Resource21 yielded bold advances to the linear etalon imaging spectral array (LEISA) sensor technology. Originally developed for a NASA space mission, the LEISA sensor uses an etalon wedge filter to create hyperspectral images of Earth's atmosphere and surface features.

In 1998, researchers developed a second-generation LEISA sensor that uses three 256-by-256 indium gallium arsenide arrays. Conceived as a "bolt-on" sensor to perform atmospheric correction and improve high-spatial resolution, multispectral Landsat-type images, the LEISA/Atmospheric Corrector (LEISA/AC) will also provide a unique hyperspectral view of terrestrial processes. The field of view has been expanded to 15° (an 185-km swath for a 700-km orbital altitude), and the wavelength range is now 0.8–1.6 μm. The sensor operates at room temperature, which is another significant achievement. LEISA/AC can provide simple, compact, and robust hyperspectral imaging capabilities for a wide variety of applications. The sensor will be flown aboard the Earth Orbiter-1, scheduled for launch in late 1999.

Goddard and its commercial partners are working to develop LEISA further in 1999. In addition, Goddard is considering transferring LEISA to international governments, which could use the technology to monitor coastal erosion, volcanoes, forest fires, or other surface features.

Guidance, Navigation, and Control

For more information on these technologies, call the Technology Commercialization Office's contact for guidance, navigation, and control at (301)-286-2198.

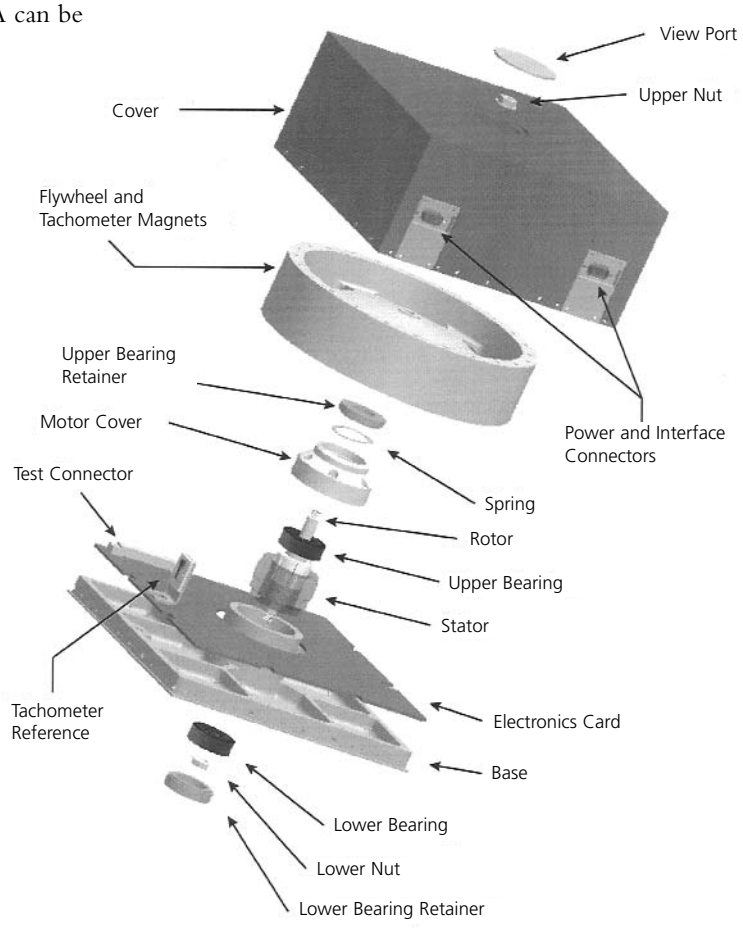
Partnership Sought for Integrated Reaction Wheel Assembly

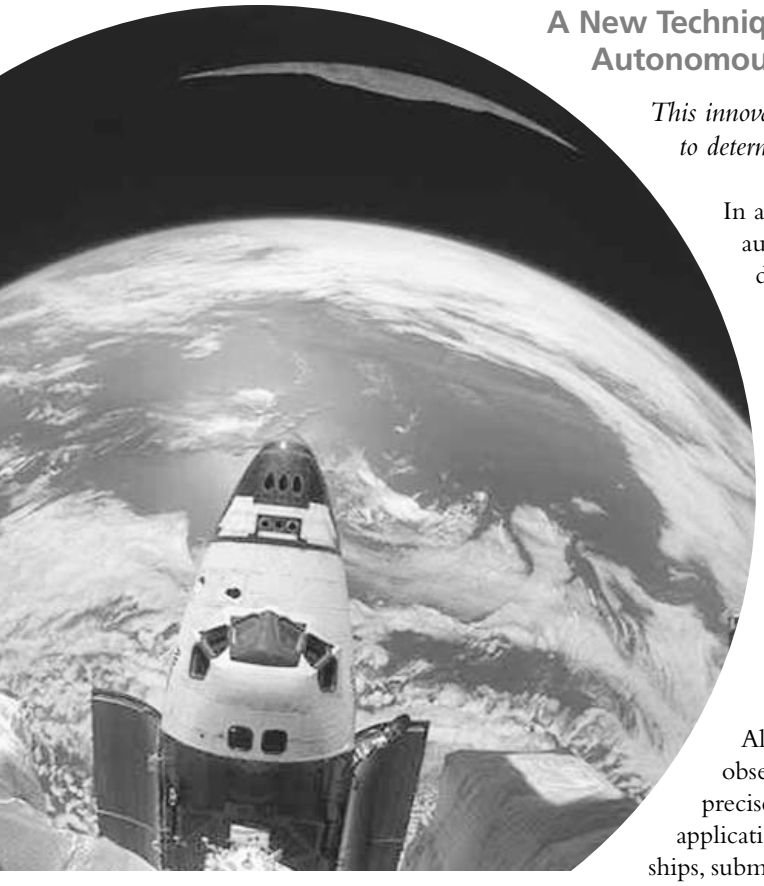
This flywheel technology was explained to potential partners at a 1998 technology briefing.

Goddard is continuing its efforts to commercialize its Integrated Reaction Wheel Assembly (IRWA). This device provides attitude control to spacecraft. Adding or removing energy from the flywheel applies torque to a single axis of the spacecraft, causing it to rotate (reaction). Maintaining flywheel rotation (momentum) stabilizes a single axis of the spacecraft. IRWA can be operated with a current (torque) controller or speed (momentum) controller.

Originally developed for the Small Explorer (SMEX) program, IRWA's design offers many benefits. The flywheel, motor, and all required electronics are housed in one small, easily mounted package. Its unsealed design reduces the weight and cost associated with complex o-ring seal designs. Hybrid ceramic ball/conventional race bearings provide long life, low noise, and low vibration. Its modular interface enables the use of various communication standards.

In 1998, Goddard hosted a technology briefing to review IRWA's design and capabilities with prospective partners. License applications are due within 60 days of performance testing, which will be completed in early 1999. Readers interested in obtaining the performance testing results or more information on IRWA are encouraged to call Goddard's Technology Commercialization Office.





A New Technique for Autonomous Spacecraft Orbit Determination

This innovation uses magnetic field and attitude information to determine a spacecraft's orbit up to 1,000 km above Earth.

In an effort to reduce recurring operations costs by having spacecraft autonomously determine their own orbit, Goddard researchers developed a device that calculates spacecraft navigational data in real time. The position-finding magnetometer processes data from a three-axis magnetometer and star tracker/sun sensor to determine attitude and orbit.

The magnetometer's algorithm relies on the spherical harmonic nature of the core geomagnetic field. It begins by making a first guess and then corrects it with a combination of successive substitutions and Newton-Raphson iterative schemes. The magnetometer minimizes computing requirements, allowing orbit solutions to be provided in roughly 5 seconds, with accuracy of better than 50 km. More accurate solutions can be obtained—to about 1 km—at locations sufficiently far (in latitude) from the geomagnetic field equator and the South Atlantic Anomaly.

Although the technology's accuracy is not sufficient for most ground-observing satellites, the invention can benefit missions that do not require precise fixing accuracy, such as solar and stellar observers. In addition to its applications in space, the magnetometer can be used on aircraft, balloons, ships, submarines, and land-based vehicles.

Spotlighting Success

Company Licenses GPS Enhanced Orbit Determination Experiment Software

By licensing GEODE software, Goddard enhances a U.S. company's global economic competitiveness and obtains valuable data for further technology improvements.

Goddard successfully negotiated a license agreement with Orbital Sciences Corp. (OSC) for the use of Goddard's GPS Enhanced Orbit Determination Experiment (GEODE) software. Headquartered outside of Washington, D.C., and with operations across the country, OSC offers a variety of space and ground infrastructure systems, satellite access products, and satellite services.

Designed to be hosted on either the GPS receiver's digital receiver/processor unit or the primary spacecraft computer, GEODE's navigation algorithms provide real-time spacecraft position and velocity data. These data are sufficiently accurate to meet the high-precision instrument pointing and state prediction requirements of future spacecraft. Accuracy levels are better than 20 m/sec for total position and 0.03 m/sec for total velocity at an altitude of 520 km. GEODE's navigational performance is not dependent on continuous visibility and can withstand loss of contact with the GPS space vehicles for several hours without undergoing a significant degradation in accuracy.

The arrangement with OSC includes a flight performance data clause, which allows Goddard to obtain the data from future OSC flight missions. With these data, Goddard will be able to perform validation analyses of GEODE and verify its capabilities.

Optics

For more information on these technologies, call the Technology Commercialization Office's contact for optics at (301) 286-2642.

Optical Fiber Cable Chemical Stripping Fixture

Goddard's fixture provides a highly reliable, repeatable, and accurate method for stripping coatings from optical fibers.

Researchers have developed a device for safely and effectively stripping the coatings off of optical fibers. Goddard's chemical fiber stripping device is used in combination with a chemical bath to remove a predetermined length of coating from a fiber prior to component assembly. The stripping fixture ensures that the optical fiber is stripped to a precisely controlled length (within 0.01 inches). The remaining fiber coating has a sharp, well-defined interface with the stripped region. This versatile fixture can use a variety of chemical solutions on many types of coatings and optical fibers.

This innovation is an excellent alternative to traditional stripping methods that can weaken or damage the optical fiber. For example, mechanical stripping can damage fibers by nicking or scratching the glass. With the appropriate chemical solution, Goddard's fixture can safely and reliably strip away polyimide, acrylate, or other coatings without damaging the fiber. The technology is ideal for fiber-optic assemblies used in the telecommunication, cable television, military, and aerospace industries. It is particularly well-suited to high-reliability applications.

Goddard is in the process of negotiating a license agreement with a fiber-optic component supplier. Other fiber-optic component suppliers who would like more information about the stripping fixture are encouraged to contact Goddard's Technology Commercialization Office.

Spotlighting Success

Using a Space Technology to Help Diabetics

Goddard is establishing a commercial partnership with a medical research company to develop a noninvasive blood glucose monitor using Goddard's laser diode-based spectrometer technology.

Recognizing a common bond between NASA's need to monitor astronauts' physiological health while in space and the need for diabetics to monitor their blood glucose levels, NASA, the Juvenile Diabetes Foundation International, and Research Triangle Institute hosted a technology workshop in 1998 to help solve these needs together. Over 150 scientists, engineers, physicians, and advocates met to consider more than two dozen technologies that might further the noninvasive or minimally invasive measurement of physiological analytes, including blood glucose.

Goddard is establishing a partnership with a commercial company to develop a blood glucose monitoring system that uses technology originally developed for atmospheric measurements. Goddard's fiber grating spectrometer uses laser diodes, tunable fiber Bragg gratings, and optical amplifiers. These technologies, respectively, keep the spectrometer small, highly selective of spectral wavelengths, and stable while providing sufficient laser output power. The commercial company plans to use this technology to develop a method for measuring blood glucose without having to use a pin prick to obtain a blood sample.

NASA Helps Preserve the Star-Spangled Banner

An infrared camera originally developed to explore Mars is helping preserve a national treasure.

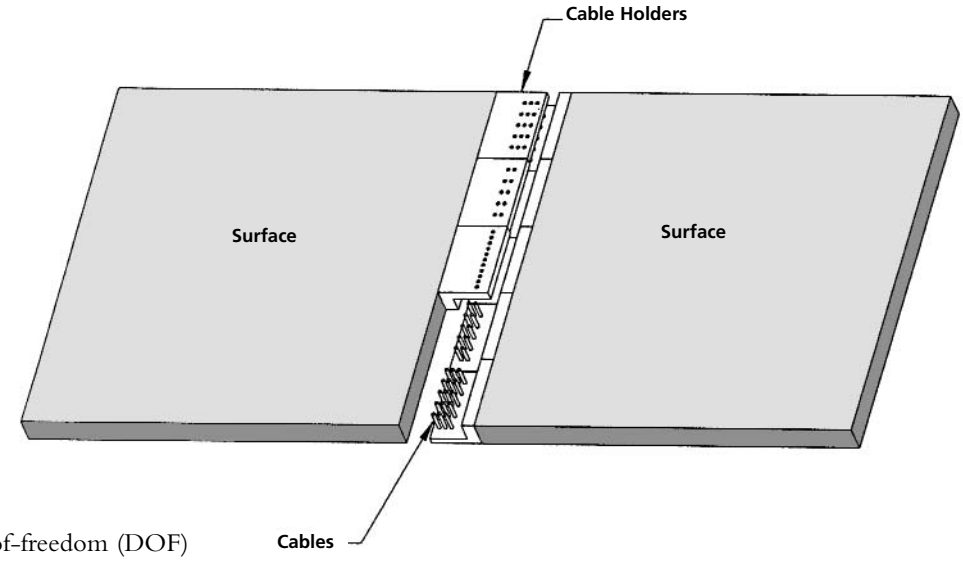
When Francis Scott Key awoke that September morning in 1814 to find the American flag still flying over Fort McHenry after a night of battle, he was prompted to write the poem that became our national anthem. But decades of exposure to light, air pollution, and temperature fluctuations have taken a toll on the artifact. So Smithsonian researchers have begun a three-year project to preserve the historic flag.

In this preservation effort, the acousto-optic imaging spectrometer (AImS), originally developed at Goddard to explore Mars played a key role. Unlike thermal infrared cameras, which make images based on differences in radiated heat, AImS uses reflected infrared light. A team of researchers from Goddard, the University of Tennessee at Knoxville, and New Mexico State University used the camera to make 72 image sets comprising 35 infrared wavelengths. These image sets formed a mosaic of the massive flag, revealing deteriorated and soiled areas not visible to the naked eye.

AImS can be used in examining other works of art and prehistoric cave paintings. Goddard also has a cooperative agreement with Swales and Associates, Inc., and Georgetown University Medical Center to explore the use of AImS in skin cancer research.

Thermal and Cryogenics

For more information on these technologies, call the Technology Commercialization Office contact for thermal and cryogenic systems at (301) 286-5169.



A High-Strength, Heavy-Duty Hinge with Four DOF

This hinge allows movement in four planar and rotational directions while inhibiting movement in the other two.

Originally developed for the U.S. Navy to join barges at sea, Goddard's four degrees-of-freedom (DOF) compliant hinge uses an array of parallel cable segments to connect two normally coplanar surfaces. Fabricated of stranded or woven material (e.g., stainless steel, other materials under consideration), the cable segments are perpendicular to the connected surfaces. The hinge prevents planar motion along the *z*-axis and rotational motion about the *x*-axis while allowing some movement in the other DOF for the purpose of force reduction or compliance. By allowing minute but critical deflections in the other DOF, the hinge adapts to external forces.

It also offers dampening capability and redistributes loads evenly, prolonging the life of the joint. This high-strength hinge can be adjusted for varied stiffness or flexibility. Its ability to handle heavy loads makes it ideal for railroad couplings, linking sections of causeways or pedestrian walkways, bridge expansion joints, industrial conveyor belts, and jet thrust deflectors. It also could be used for wheelchair ramps or transport systems. Finally, it may offer benefits as a prosthetic device.

Goddard seeks partners interested in transferring the four DOF compliant hinge to commercial markets.

Spotlighting SBIR Success

Improving Air Conditioning and Refrigeration Systems

SBIR funds to a Florida company have resulted in a new product that boosts the performance of refrigerator/freezer and air conditioning systems.

At the 1998 International Air Conditioning, Heating, and Refrigeration Exposition, Mainstream Engineering Corp. introduced its newest product—QwikBoost. This unique, low-cost additive to increase the performance of air conditioners, heat pumps, refrigerators, and freezers stemmed from a Goddard Small Business Innovation Research contract to develop heat rejection systems for spacecraft.

Circulating through a refrigeration system, QwikBoost increases the cooling capacity of refrigerants, such as liquid hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs). QwikBoost has a significant solution heat when mixed with HFCs and HCFCs. This solution heat increases the available cooling capacity (latent heat) of the refrigerant during evaporation, increasing system performance. Once the QwikBoost additive is introduced into the system, it remains active for the life of the system and does not need to be replaced.

QwikBoost is currently available for automotive air conditioning systems for faster cool-down and more cooling on hot days. Potential NASA applications for the invention include vapor-compression thermal control systems for spacecraft, air conditioning and refrigeration systems at facilities, and vehicle fleet air conditioning systems.

SBIR Technologies Fly Aboard Space Shuttle

The capillary pumped loop technology and the miniature turboalternator flew successful missions in 1998.

Two cryogenic technologies that were developed under the auspices of the SBIR program accompanied John Glenn on his return to space in October 1998. Funding had been provided to Cullimore & Ring Technologies of Littleton, Colorado, for development of the capillary pumped loop (CPL) technology and to Creare, Inc., of Hanover, New Hampshire, for development of the miniature turboalternator.

The CPL uses surface tension forces developed in a fine-pore wick to circulate a working fluid/vapor through pipes or tubing. An evaporator placed near a heat source turns the working liquid into vapor, which is transported through the tubing to a condenser where the heat is removed. The resulting liquid is then returned to the evaporator. During the Space Shuttle experiments, the loop sustained high parasitic heat gains and continued to operate in the microgravity environment.

Developed for a miniature cryocooler for space missions, the turboalternator uses a miniature electrical generator to avoid conductive heat leak, a radial in-flow turbine to decrease bearing loss and allow cryogenic operation, and gas bearings that do not wear out. This technology enables the construction of small, efficient, vibration-free cryocoolers. Data on the turboalternator's performance aboard the Space Shuttle are forthcoming.

These space technologies may have applications on Earth as well as in space. CPLs may be used in medicine, the military, fire and rescue, and recreation. Future commercial applications for the turboalternator may include brushless DC motor-driven circulators, pumps for liquid cryogens, or MRI detectors used in medicine.

Information Systems

For more information on these technologies, call the Technology Commercialization Office contact for information systems at (301) 286-0561.

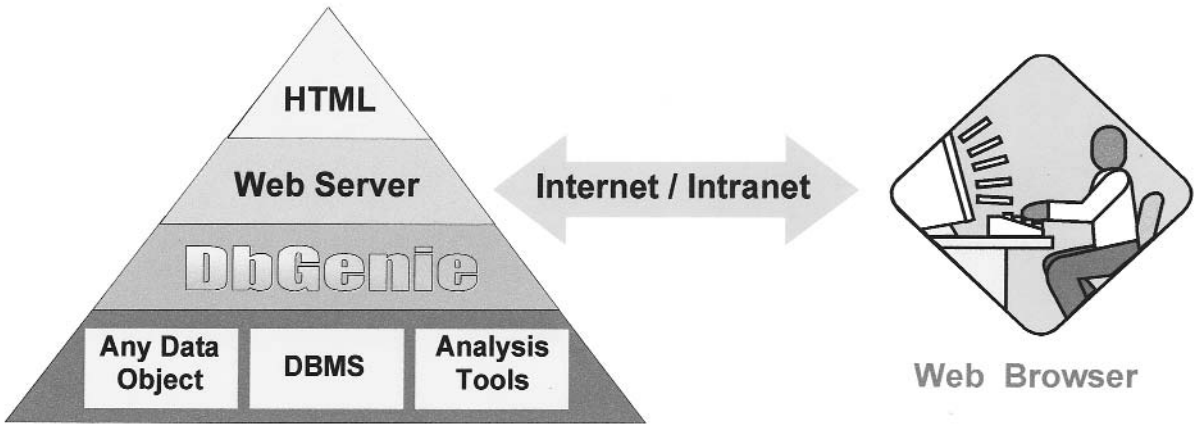
Segmented Cold Cathodes for Large Flat-Panel Displays

This technology replaces cathode ray tube technology to allow for large, multicolor displays with minimal depth that offer comparable brightness in a simpler design.

Goddard has developed an innovative technology that uses segmented cold cathodes to greatly improve multicolor flat-panel display capabilities. This technology consists of segmented photocathodes set orthogonal to an array of control grids. The display panel's resolution is defined by the number of control grids (horizontal resolution) and the number of segmented photocathodes (vertical resolution). The photocathodes and control grids are housed between an input window and an equipotential mesh grid.

Displays made with this segmented cold cathode technology will have 1 mm^2 pixels, which is sufficient resolution for large-screen home entertainment systems, public message boards, network control room displays, flight simulations, video games, and other large displays. The technology also creates a video image that is brighter than active matrix liquid crystal and comparable to cathode ray tube displays. Displays made with this technology are less than 10 cm deep. Researchers estimate that a commercial system running 2-m wide and 1-m tall could be produced for less than $2,000 in mass production.

Goddard seeks partners interested in developing the cold cathode technology further and transferring it to commercial markets.



Improving Intensive Information Distribution through Electronic Handbooks

NASA SBIR funding gave a small company in Vienna, Virginia, the seed money needed to develop a Web-based information systems tool.

As part of NASA's Small Business Innovation Research program, Goddard researchers have worked with Virginia-based REI Systems, Inc., to develop Electronic Handbooks (EHBs). The easy-to-use EHBs are designed to manage complex, distributed information-intensive processes in a Web-based environment.

A key element of this interactive tool is the Database Genie (DbGenie), developed by REI Systems. DbGenie helps information system developers to create the appropriate user interface. Driven by a series of "fill-out form" templates, DbGenie performs database searches, data manipulations, and other operations. An access control module provides a role-based security system that ensures confidentiality, integrity, accountability, and availability.

Not only was this technology developed with SBIR funding, but it also has been applied to the program's processes. EHBs currently service approximately 35 percent of NASA's new contracts on-line—the largest end-to-end use of the Internet in the government to date. Time and cost savings have been dramatic. The time needed to process SBIR proposals has been reduced by one-third, and costs have been cut by $300,000.

In 1998, REI Systems hired 16 additional staff members to implement EHB technology. The company also received a five-year Phase III SBIR contract award to provide electronic support to the NASA SBIR/STTR programs. In addition, REI Systems is teaming with commercial firms to establish other, nongovernment EHB applications.

Spotlighting Success

Companies and Government Benefit from Administrative Software

Formerly known as the Paperless Office, the Omni Tool Set automates many administrative functions.

Seeking to reduce administrative costs, several government and commercial organizations obtained the source code for the Goddard-developed Omni Tool Set software program in 1998. This efficient, cost-saving, Web-based technology allows for paperless processing of several administrative functions.

Set up on an intranet, Omni is accessible only to employees. Authorized personnel access the system by selecting their user ID and entering their password. Once the employee is logged in, the system provides Web pages of automated administrative functions, such as time and attendance systems, leave slips, facility scheduling, and flexible work schedule management.

Goddard makes this technology available to businesses and government agencies at no cost. In 1998, NASA Kennedy Space Center's Launch and Landing Division and the U.S. Navy's Inventory Control Point requested copies of the Omni Tool Set source code. In the commercial sector, the software was recently acquired by ManTech Systems Engineering Corporation of Seabrook, Maryland, and AI Solutions of Lanham, Maryland.

Software Telemetry Processing System Used by Businesses Nationwide

Several companies have found Goddard's technology for Reed-Solomon correction useful.

The Goddard-developed Software Telemetry Processing System (STPS), which uses Reed-Solomon (RS) encoding and decoding to improve data transmission, was transferred at no cost to several businesses in 1998. Manufacturers of satellites and computer chips, telemetry data processors, and data decompression researchers have found STPS useful. Other applications include the transmission of compressed audio, video, data, and images via satellite, local area networks, the Internet, or modem—particularly modems using noisy phone lines.

RS codes normally are used with synchronous data and fixed-length block sizes. If variable-length packets need to be transmitted, traditionally they are broken down into nearly equal blocks, and packet fill (i.e., information that will not be used) completes the block length. This method, however, is not an efficient use of bandwidth. Goddard's STPS eliminates the transmission of packet fill, allowing more data to be transmitted per second. In addition, variable-length packets/frames can be transmitted as a single unit rather than separate blocks. STPS thus provides simpler implementation and better transmission of real-time audio/video.

The following organizations began using Goddard's STPS software in 1998: GenCorp Aerojet of Azusa, California; Omitron of Greenbelt, Maryland; Aydin Telemetry, Inc., of Newton, Pennsylvania; Honeywell, Inc., of Clearwater, Florida; and the Applied Physics Laboratory at Johns Hopkins University.

1998 Technology Commercialization Office Activities

Goddard's Technology Commercialization Office undertakes a variety of activities to promote technology transfer within Goddard and among commercial industries. These include tracking new technologies, attending conferences and symposia, and recognizing the contributions of Goddard's scientific and technical staff to the technology commercialization process. This section outlines the office's activities in 1998.

New Technologies Reported

NASA Goddard Space Flight Center has amassed a wealth of advanced technologies with the potential to be transferred to a variety of institutional and commercial industries. In addition to the technologies highlighted in this report, these pages list all of the transferable technologies reported to the Technology Commercialization Office in 1998. For more information about any of these technologies or facilities, call the Technology Commercialization Office contact number listed with each category.

Environmental

Contact: (301) 286-1098

Facilities include Terrestrial Physics, Atmospheric Sciences, and Hydrospheric Processes Laboratories.

Airborne Water Vapor Micropulse Differential Absorption Lidar Digital Aerial Camera System

Efficient Representation of Geolocation Data for Environment Images

ESO and GSFC Aladdin Camera

Exploring Technology with Satellite Imagery

HDF-EOS Datablade

Imaging System with Time Delay and Integration Using a Plane Two-Axis Scan Mirror in Object Space

Microshutter with Large Fill Factor

Miniature Motorized In-Line and Right Angle Bellow High-Vacuum Valve

Modular Vibration Isolation and Precision Pointing Device

Noise Reduction for ASE Source

Raman Water Vapor Microlidar

Trash Lure

Ultra-Long Life, High-Reliability Check Valve Using a Neutral Buoyancy Stainless Steel Hollow Poppet

Vacuum Damper Investigation and Performance Evaluation Robot

Sensors and Detectors

Contact: (301) 286-5979

Facilities include the Detector Development Laboratory.

Barium-Barium Ion Inductively Coupled White Light Source

Closed Loop IFOG Demodulator

Conformable Meanable Winding Magnetometer Sensors and Grid Measurement Methods

DMD Illumination Coupler

End-Point Detection in Reactive Ion Etching of Polysilicon

Fabry-Perot Interferometer with Broad Spectral Coverage

High-Rate User Ka-Band Phased Array Antenna

Improved Electrical Contract to High-Bandgap III-N Semiconductors by Use of Reduced Bandgap Semiconductor Layers

Ion Source for Mass Spectrometers and Other Applications

Microfabricated Structures with Electrical Isolation and Interconnections

Multiloop Symmetric SQUID

Off-Axis A1203 Substrates for Growth of GaN and Related Materials

Off-Axis Sapphire Materials

Phased Array Calibration by Orthogonal Phase Sequence

Printed Circuit Ironless Stator Motor

Programs for SAR Interferometry and Automatic DEM Generation

Real-Time Lossless Digital Imaging and Video System

Redundant Waveguide Switch

Surface Trace Electrical Feedthru

Quatratran: A Superconducting Transistor Based on Quasiparticle Trapping

Times-8 GaAs MESFET Frequency Multiplier

Two-Stage SQUID Amplifier

Guidance, Navigation, and Control

Contact: (301) 286-2198

Facilities include a Global Positioning Systems Laboratory.

Active Magnetic Bearings Incorporating Self-Sensing of Transverse Rotor Displacement in Linear and Magnetically Saturated Regimes

Automating Human Operations in Control Centers

Clutch/Brake with Rectangular-Area-Contact 3D Locking Sprags

Dual Mass Vibratory Rate Gyroscope with Suppressed Linear Acceleration Response

Generation of Mechanical Oscillation Applicable to Micromachined Gyroscope

Hexapod Airborne Instrument Pointing System

High-Rate Telemetry Acquisition System Prototype

Highly Stable Lateral Transfer Retroreflectors

Image Correlation Tracker-Based Instrument Pointing System

Low-Cost Airborne Telemetry Station

Low-Cost TDRS User Antenna Technology

Low-Loss Pole Configuration for Multipole Homopolar Magnetic Bearings

Microaltimeter

Mobile Range Control System

Modular GPS Receiver

Orbital Debris Mitigator

PC-Based Telemetry and Command System Handling 4800 Bits

Real-Time Attitude Determination System Using Java Technology

Remotely Operated Bakeout Box Shutter

Solar Array Drive

Solar Pressure and Aerodynamic Drag

Spacecraft Component Design Frameword

Spacecraft Environment Modeling Tools

Spacecraft On-Board Momentum Control System for Reduction of Reaction Wheel-Induced Pointing Jitter

Using the GPS System to Determine Attitude Rates Using Doppler Effects

Optics

Contact: (301) 286-2642

Facilities include the Diffraction Grating Evaluation Facility, Surface Metrology Laboratory, Optical Coating Facility, Vacuum UV Optical Measuring Facility, Laser and Electro-Optic Laboratory, and the Cryogenic Optical Test Facility.

Continuous Optical Modulation with Discrete Level or Other Noncontinuous Light Modulating Arrays

Dual Polarization Acousto-Optic Tunable Filter

Fabrication and Evaluation of a Compound Refractive Lens for Hard X Rays

High-Quality Optically Polished Surfaces on Bare Aluminum Substrates

Highly Efficient High-Power Amplifiers for Optical Communication

Laser Beam Scanning in Elliptical Patterns

Monolithic Optoelectronic Integrated Circuit Using Selected Epitaxy

Radiation-Tolerant 12-Channel Fiber-Optic Receiver and Transmitter Designs

Reflection Optics Reference Beam Telescope

Reflector-Based Off-Axis Optical System for Holographic Storage

Shaft Position Optical Sensor

Tunable Compact Waveguide Termination

Visible Laser Diodes Operating from 0.45 to 0.7 μm

Wide Tuning Range Acousto-Optic Tunable Filter

Thermal and Cryogenics

Contact: (301) 286-5169

Facilities include the Cryogenics Laboratory, Thermal Engineering Coating Facility, Cryocooler Test Bed, and Cryogenic Research and Integration Facility.

120 VDC Heater Controllers

Advanced Composite Heat Sink

Automated Liquid Helium Transport System

Flat Panel Radiant Cooler

Flexure Nuts

Gap Welding Preform

Gas Film Bearings for Reverse Brayton Cryocooler

Glass Cure Plate for Composite Materials Fabrication

Low-Cost Joggled Composite Panel Fabrication

Polyimide Insulation Coating of Kapton Flexible Circuits

Pump and Earth-Testable Spacecraft Capillary Heat Transport Loop Using Augmentation Pump and Check Valves

Radial Flow Heat Exchanger

Scan Mirror Remote Temperature Sensing System and Method

SolarPanel

Structure Attachment Device Allowing Thermal Expansion and Contraction Differences

Visible and Infrared Callibration Target (or Source)

Information Systems

Contact: (301) 286-0561

Facilities include the Fiber Optic Interconnect Laboratory, Electromagnetic Test Facility, Large Area Pulsed Solar Simulator Facility, and Battery Test Facility.

Adaptive Scheduler

AgentBuilder

Application Launcher

Communications Analysis Graphical Environment

Data and Information Access Link

Data Aquisition System at 1 Gigahertz and 8 Bits

Data Trending and Analysis System

Dedicated, Individual Web Servers as a Personal Web Presence

Desktop Satellite Data Processor Control Software

Direct Hard Disk Drive Interface for High-Speed, High-Capacity Data Storage

Electrical, Electronic, and Electromechanical Parts Information Management System and Web System

Ensuring Functional Performance of Distributed Software in the Presence of Incompatible Software Versions

File Relay Monitor

Forward Link Simulator Device Driver/API and PCI Card

Front End Data System/Digital History Data Storage

Image Transfer Protocol

Integrated Test and Operating System

Intelligent Data Management and Routing Software

Interleavers for Turbo-Codes

Java-based Spacecraft Web Interface to Telemetry and Command Handling

K-Latch: An SEU-Hard Flip-Flop Element

Knowledge Server Tools

Level-Zero Processing Software

Mass Storage Benchmarks

Modification of Gnu Cross-Compiler Configuration Files for UT69R000 Microprocessor

Modular Offshore Data Acquisition System

Modularization and Generalization of Web Form Processing Tools

Multiplexed Molecular Analysis System

Nascom Blocks Transmitted in Internet Protocol

New Technology Ground Support Equipment

Numeric Paging System

Online Prework Questionnaire

Parallel Adaptive Mesh Refinement Toolkit

Planning and Resource Reasoning Technology

Return Link Processor Card Digital UNIX Device Driver and PCI Card

Scientist's Expert Assistant

SEAWIFS Data Analysis System

Semantic DBMS for Storage of Satellite Data on Compact Media

Simple Automatic File Exchange

Structural Integrity Assessment of High-Density Microelectronic Devices and Components

TDRSS Internet Link Terminal

Vision 2000 Common Graphical User Interface

Visual Analysis Graphical Environment

Volumetric Display Driver

Web Implementation of SEAWIFS Bio-Optical Archive and Storage System

Innovator Recognition

Technology transfer would not be possible without innovators. The scientific and technical staff at Goddard must identify, document, and report their new technologies to the Technology Commercialization Office. These innovators also are deeply involved in other steps of the transfer and commercialization process. Goddard would like to extend its appreciation to the innovators who reported new technologies in 1998.

Thomas Ajlumi
Roger Alig
Heidi Anderson
Eric Anderson
Micheal Ando
B.D. Arkwright
Sean Arthur
Shahid Aslam
Karen Baith
James Baker
Donald Baker
Paul Baker
W. Balinski
Dan Ballard
A.E. Balogh
Craig Bearer
Edward Bedwell
Jeanne Behnke
Robert Benson
Ted Berman
Kenneth Blumenstock
John Bolton
Norman Booth
P. Bortfeldt
John Bowman
Matt Brandt
James Bremer
John Bristow
Thomas Brooks
Barbie Brown
James Busch
Ira Bush
Marie Bussman
Glenn Cammarata
Charles Campbell
Kyle Campbell
Robin Cantor
Armen Caroglanian
Charles Chalfant
Clinton Chan
I. Chang
Sue Chang
Renu Chaudhry
Engmin Chern
R. Choo
Linda Cingel
William Clark
L.M. Clark
Robert Cohn
Michael Comberiate
Darrel Conweay
Daniel Costello
E.A. Craig
Jack Craig
John Curry
Mark Cushman
George Daelemans
Andrew Daiber
Darush Darvani
Michael Darzi
Narash Das
Richard Davis
John Degnan
Greg Dell
Sandy Dempewolf
Joseph Deskevich
Jason Dowling
John Downing
James Duff
Chris Durachka
David Ebert
Mitchell Eggers
David Ehlers
Matthew Erb
Mary Farrall
Robert Fatland
Felix Fernandez
Jeffrey Ferrara
David Fisher
David Folta
Mark Ford
David Fout
Jeffrey Freedman
Harold Frisch
Gary Fu
Edward Gaddy
Mahendra Gharpuray
Parminder Ghuman
Terry Graessle
Mark Granoff
Trish Gravatt
Scott Green
Thomas Green
Greg Greer
Sandra Grosvenor
Richard Gummer
Richard Guritz
Claef Hakun
Daryl Halliday
R.S. Hanson
David Hardison
Puthugraman Hariharan
Elfrieda Harris
Jonathan Hartley
John Heanue
Greg Henegar
Michael Herriage
Stan Hilinski
Mark Hillyer
Bruce Hilman
Jill Holz
J.J. Horan
Ira Horowitz
David Israel
Clarence Johnson
Jeff Johnson
Chris Johnson
Jeremy Jones
Abhay Joshi
Linda Jun
Thor Juneau
George Kallarakal
Christos Karasiotos
Ramesh Karne
Richard Katz
E.A. Kawam
Karen Keadle-Calvert
Michael Keeler
Ben Keith
Gerald Klitsch
Benjamin Kobler
Lisa Koons
Stephen Koubek
Robert Kuntz
Hesselink Labertus
James Langston
Douglass Lankenau
Edward Larson
James Lawler
Orion Lawlor
Stephen Leake
Kevin Leath
Mark Lemkin
Shusun Li
David Linard
Thomas Logan
J.M. Lombardo
Edward Luczak
James Lyons
Jeffrey MacDonagh-Dumler
Peter MacNeice
Stephen Maher
Jo Major
Savyasachee Mathur
Matt McCoy
Kenneth McDonald
Mark McDonald
David McLean
Frederick McNair
John McQueen
Johnny Medina
David Mehuys
Joseph Mica
Joseph Miko
Chandru Mirchandani
Alfredo Moreu-Valentin
Samuel Moseley
Phil Myers
Michael Nahum
Nicholas Netreba
Willam Niemeyer
Brian Ottens
Edward Packard
Hongwoo Park
Eugene Parker
Robert Patterson
Vince Pell
Fernando Pellerano
J.W. Pellicotti
Fred Peng
William Plano
Coorg Prasad
Dean Price
Thomas Priest
David Puckett
Jerry Reddell
E.L. Regaldo
Victor Reinhadrt
James Repaci
Karen Richon
John Riley
Naphtali Rishe
A.D. Robinson
Trey Roessig
Linda Rosenberg
Lamont Ruley
Kit Ruseau
Thomas Rust
Steve Sabia
Brian Schieber
Greg Schmidt
Ginny Schmidt
Joseph Schmitz
Robert Schwenk
Jeannine Shirley
Wendy Shoan
Peter Shu
Amit Singh
Tim Singletary
Mary Smiley
Don Smith
Ronald Sorace
Nick Speciale
Robert Sperling
John Stachniewicz
Edward Stanford
Ruth Stapko
Michael Stark
Alphonso Stewart
W.J. Taft
Oscar Takeshita
Joel Ullom
S. VanKyk
John Vranish
Kenneth Wagner
Stephen Waterbury
Robert Waterman
Dave Welch
Keith Wichmann
Randy Wilke
Joel Williams
Kenneth Winiecki
Andrew Wolf
Michael Yachmetz
John Zaniewski

Award Programs

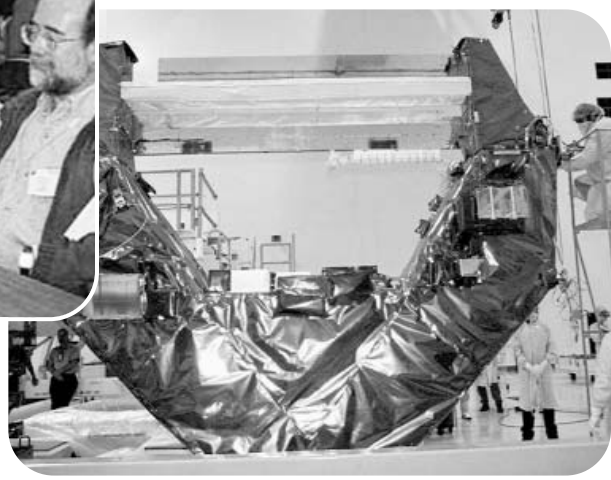
A number of award programs have been established to recognize the valuable participation of government employees in technology transfer. These awards are presented by Goddard, NASA, and other federal agencies.

Kerley Award

Named after the late James Kerley, a Goddard scientist who championed technology transfer and commercialization, the Kerley Award is presented annually to recognize a Goddard researcher's commitment to new technology reporting. The 1998 award was given to Geary Schwemmer, inventor of holographic optical element technology. The commercialization of this technology is expected to have a $40 million impact on the U.S. economy.

Government Technology Leadership Award

Sponsored by *Government Executive* magazine, the prestigious Government Technology Leadership Award recognizes projects that have boosted efficiency and effectiveness, lowered costs, and/or improved service to the public by finding innovative uses for technology. Goddard's Cooperative Satellite Learning Project (CSLP) was selected as one of the winners for 1998. By involving elementary and high school students in NASA scientific satellite missions, CSLP motivates children to pursue careers in science, engineering, mathematics, and other technical areas. Students who participated in this program have controlled a satellite's orbital operations and designed an experiment for a Space Shuttle mission.

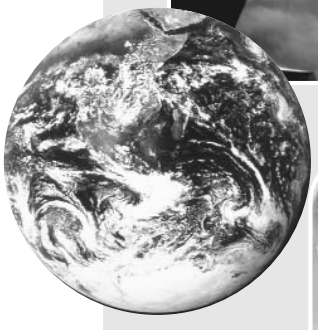


FLC Award for Excellence in Technology Transfer

This Federal Laboratory Consortium (FLC) award recognizes federal laboratory employees whose technology transfer efforts have been outstanding. Two Goddard scientists received this award in 1998. Frank Cepollina was honored for his efforts assisting the transfer of technologies from the Hubble Space Telescope Flight Systems and Servicing Project to the medical, semiconductor, tool, electric utility, and oil drilling industries. John Vranish received the FLC award for his involvement in the transfer of his three-dimensional sprag technology to household tools, pull starters on gasoline motors, automatic transmissions, and other applications in which a cog must only move in one direction.

Conferences, Briefings, and Symposia

NASA Goddard Space Flight Center disseminates information about its space technologies and potential commercial applications by hosting and attending conferences, briefings, and symposia. At these events, the Technology Commercialization Office demonstrates technology, distributes informative literature, and offers one-on-one counseling to industry about partnership and commercialization opportunities at Goddard. Through these events, Goddard successfully reached many small and large companies, academic institutions, and trade and professional organizations in 1998.



Goddard-Sponsored Programs

- AIAA Small Satellite Missions Symposium
- Community Day
- Integrated Reaction Wheel Assembly Commercialization Workshop
- Ka Band Workshop
- Law Enforcement Commercialization Workshop
- MIDEX Preproposal Conference
- Photon Satellite Project Presentation
- Technology Showcase

Air and Space

- Air Traffic Controller Association Conference
- Johnson Space Center's Inspection '98

Environment

- TechnoVentions
- U.S. Global Change Research Program Native Peoples/ Native Homelands Climate Change Workshop

Medicine

- Non/Minimally Invasive Measurement of Physiological Analytes Workshop

Computers and Electronics

- Bureau of Export Administration Conference
- Business Opportunity and Electronic Commerce Conference
- E-Gov
- EMC Harmonization Conference

Engineering and Manufacturing

- National Design and Engineering Show
- Society of Automotive Engineering

Small Businesses

- Blacks in Government Conference
- Goddard's Annual Small Business Conference
- NASA Technology and Business Conference
- Society for Advancement of Chicanos and Native Americans Conference

Technology Exhibitions

- Capitol Hill Technology Showcase
- High Technology Council of Maryland Technology Showcase
- Naval Post-Graduate School Technology Review Conference
- Technology 2008
- United Nations/United States International Conference on Spinoff Benefits of Space Technologies

How to Reach Goddard's Technology Commercialization Office

To best respond to inquiries, the Technology Commercialization Office has divided Goddard's assets into six areas of core competence. Readers interested in obtaining information on Goddard technologies, partnership possibilities, or the availability of facilities are encouraged to call the number in their area of interest.

Environmental Systems
Contact: (301) 286-1098

Guidance, Navigation, and Control
Contact: (301) 286-2198

Information Systems
Contact: (301) 286-0561

Optics
Contact: (301) 286-2642

Sensors and Detectors
Contact: (301) 286-5979

Thermal and Cryogenics
Contact: (301) 286-5169

Internet Addresses

Goddard Technology Commercialization Office
http://techtransfer.gsfc.nasa.gov

Goddard Space Flight Center
http://www.gsfc.nasa.gov

NASA Commercial Technology Network
http://nctn.hq.nasa.gov

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Internet: http://techtransfer.gsfc.nasa.gov