National Aeronautics and Space Administration

NASA Goddard Space Flight Center

FY 2006 Internal Research and Development Program

R&D Achievements

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R&D Achievements

Contents

Mars Global Surveyor

In an important development for laser-based communications, Goddard innovators demonstrated for the first time a one-way laser transmission from Earth to Mars, specifically to the Mars Global Surveyor pictured here. The transmission distance was 80.1 million kilometers — three times the distance of the previous longest laser transmission to a spacecraft traveling to Mercury. The Center's Internal Research and Development program funded the effort.

About the Cover

The images on the cover show some of the technologies advanced under the FY 2006 Internal Research and Development program, including laser communications, microcalorimetry, and vacuum pyrolysis.

Message from the Chief Technologist

Cultivating Technological Competitiveness

In FY 2006, the Goddard Space Flight Center's Internal Research and Development (IRAD) program supported 42 research proposals, which involved 235 Goddard employees, including principal investigators. I'm grateful for the enthusiastic support of Center Director Ed Weiler and Deputy Center Director-Technical Dolly Perkins. Both understand the value of the IRAD program.

I'm also grateful to the New Opportunities Office, Directors, Branch Heads, the investment area leads, proposal reviewers, and, of course, Goddard's most innovative technologists — the people who submitted IRAD proposals. Working together, we made the program more focused and more likely to achieve the results needed to keep Goddard on the cutting edge.

As with any high-risk endeavor, R&D is not a sure bet. Although the purpose of the IRAD program is to fund technologies that will give the Goddard Space Flight Center the advantage in new mission or instrument opportunities, sometimes the research does not yield expected results or outcomes. We do not view these as failures. We view these as learning opportunities. And in many respects, they are as important as the obvious successes. Knowing the pitfalls of a particular technical application can prevent someone from making the same mistake. This, of course, saves time and money — valuable commodities in an era of budget uncertainties.

This report highlights some of the progress we made in FY 2006, explains the management changes in R&D funding in 2006, and details plans for the future. I'm happy to report that many of our funded investigators made major strides, others more incremental. What they all did, however, was perform strategically aligned research in areas that are important to the Center.

I'm excited about what we accomplished in FY 2006 and look forward to a more vibrant program and the important results it creates in the coming years. ◆

Peter M. Hughes
Chief Technologist

The Purpose of R&D Funding

Investing in innovative technology is critical for ensuring long-term competitiveness and ultimately winning new work. The Goddard Space Flight Center's Internal Research and Development (IRAD) program has strived to ensure just that. Since its creation in 2000, the program has invested in specific technologies that can leverage external funding in the near-term to position the Center to win major proposal efforts in the future.

If history is a guide, the Center's relatively conservative investment in its FY 2006 IRAD program should ultimately translate into millions of dollars in new awards in the years to come.

In FY 2005, for example, the Goddard New Opportunities Office reported the award of 26 new proposals. Sixty-five percent of the awardees attributed their success to having previously received Goddard technology-development funding. In an informal survey also carried in FY 2005, principal investigators reported winning an additional $11.5 million in new business. This brought the total of new business awards attributable to previous Goddard technology investments to about $187.5 million. This is the type of return that the program seeks.

Strategic Investment Areas
FY 2006

Advanced Sensors, Instruments, and Supporting Technologies

Telescopes and Large Observing Systems

In-Space and Extraterrestrial Robotic Assembly, Maintenance, and Inspection

Exploration Systems Technology

Space Communications and Navigation

Information Systems, Modeling, and Computation Technology

New Awards and Developments

Although the New Opportunities Office did not report significant new NASA contracts in FY 2006, due in part to delays in some Agency Announcements of Opportunity, Goddard did win a few awards due to IRAD-funded work. An example was a 3-year, $720,000 Astronomy and Physics Research and Analysis grant to develop technologies for space-based ultraviolet/optical interferometers. Other IRAD investigators reported that:

❖ *Several new IRAD-funded technologies had advanced to the point where they are now available for use by existing missions.*

The "Navigator Global Positioning System (GPS) Receiver" provides a case in point. This technology will provide greater direction-finding accuracy than existing GPS systems — particularly for missions in high-Earth orbits. The Hubble Servicing Mission-4 and the Magnetospheric Multiscale mission are expected to use the technology.

❖ *Several new technologies were offered in proposals still pending before NASA.*

A good example was the next-generation unmanned aerial vehicle (UAV)-based lidar sensor. Progress enabled the principal investigator to submit a proposal to NASA Headquarters to integrate the instrument onto a UAV and begin test flights.

❖ *Scientific questions that could affect NASA's ability to carry out its ambitious Vision for Space Exploration were answered.*

The work of one Goddard scientist provides a good example. He demonstrated and verified the existence of several classes of "frozen orbits" around the Moon — important findings given that perturbations in the Moon's non-uniform gravitational field and the relative location of the Earth can pull spacecraft in different directions and alter their orbits. Frozen orbits, on the other hand, allow spacecraft to maintain a low-lunar or highly elliptical orbit almost indefinitely. This minimizes or eliminates the need for periodic boosts from onboard rockets.

What follows is a summary of the program's other notable achievements.

Notable Achievements *(Pages 3 - 10)*

Thanks to IRAD funding, Goddard principal investigators reported several outstanding achievements in FY 2006. Many could result in Goddard being selected in the future to build an instrument or mission or to help NASA achieve its ambitious exploration goals.

Robotics

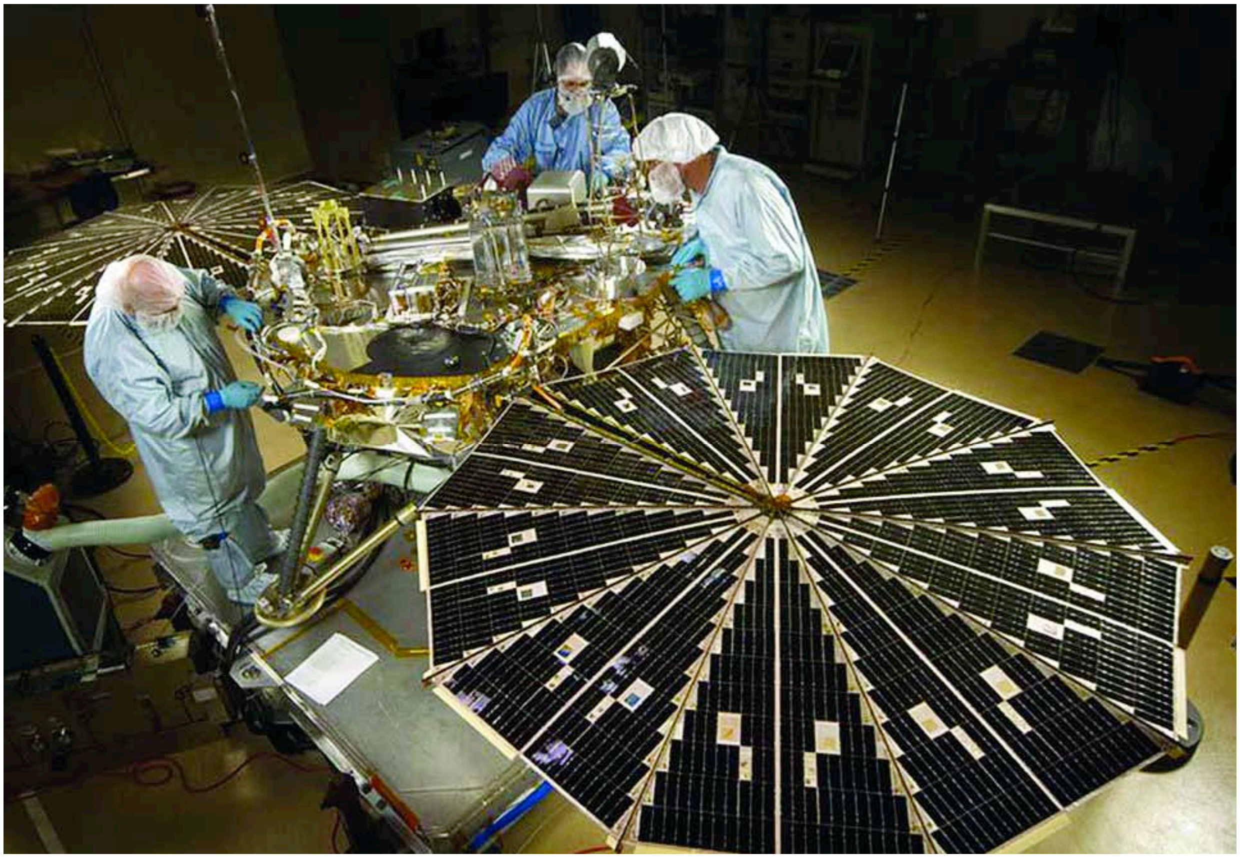
❖ Advanced important technologies for the 12-TET Walker, an innovative robot made up of 12 tetrahedral (TET) units, each with variable length struts that allow the robot to reconfigure itself into a great variety of shapes so that it can navigate difficult terrain. The effort resulted in two NASA patented systems: a synthetic skeletal-muscular system and a synthetic neural system. The advances have attracted the attention of the Naval Sea Systems Command, which is interested in TET "kits" to dispose of explosives. TET robotics has potential applications across all NASA enterprises, including astronaut habitats and multi-functional tools and structures. *(Principal Investigator: Steve Curtis, Code 695)*

❖ Developed major components, including overall system software, motion-planning algorithms, and a distance-measurement system, for a unique covering or "virtual skin" that would allow robotic arms to detect potential obstacles and avoid collisions with spacecraft and other surrounding objects. The system directly targets NASA's exploration tasks and would benefit robot manipulators doing space assembly and Lunar Reconnaissance Orbiter-type planetary explorations. *(Principal Investigator: Vladimir Lumelsky, Code 588)*

❖ Demonstrated the remaining "unproven" technology for a non-mechanical, three-dimensional laser imager, which included completing — with support from a small photonics company in Bozeman, Montana — the development of a proprietary device with electro-optic properties. In addition, the principal investigator proved for the first time that a laser beam could be deflected in the X- and Y-axes, with high speed, high accuracy, and large scalability. By merging this technology with existing in-house surface lidar instrument software, algorithms, and laser transmitters, real-time, three-dimensional imaging is now possible. *(Principal Investigator: Barry Coyle, Code 601)*

❖ Transformed a design and analysis tool used during the Hubble Robotic Servicing and De-orbit Mission effort into a general tool for advanced mission design. With this real-time simulation and visualization capability, called Freespace, Goddard is now well positioned to analyze and test many complex mission needs, including robotics, relative navigation, contact

This is an early prototype of the 12-TET Walker, an innovative robot that can reconfigure itself into a great variety of shapes. Advances made in FY 2006 attracted the attention of the Naval Sea Systems Command, which is interested in using the technology to dispose of explosives.



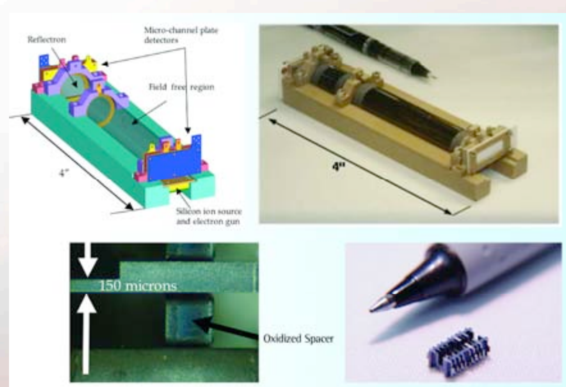
IRAD-funded research showed that hydrazine from thrusters did not decompose amino acids and, therefore, would not skew analyses of soil samples on the Martian surface. The findings may have benefited the Phoenix mission (shown above). The mission had gone to great lengths to cant its thrusters away from its sample site.

dynamics, and machine vision for automated rendezvous and control. Designed to be better than other industry- or government-operated facilities, Freespace is in the process of becoming an integral part of Goddard's existing test infrastructure. Over the past year, the Global Precipitation Measurement, Magnetospheric Multiscale, and Natural Image Feature Recognition experiment have adopted Freespace to meet their requirements. *(Principal Investigator: Steve Queen, Code 595)*

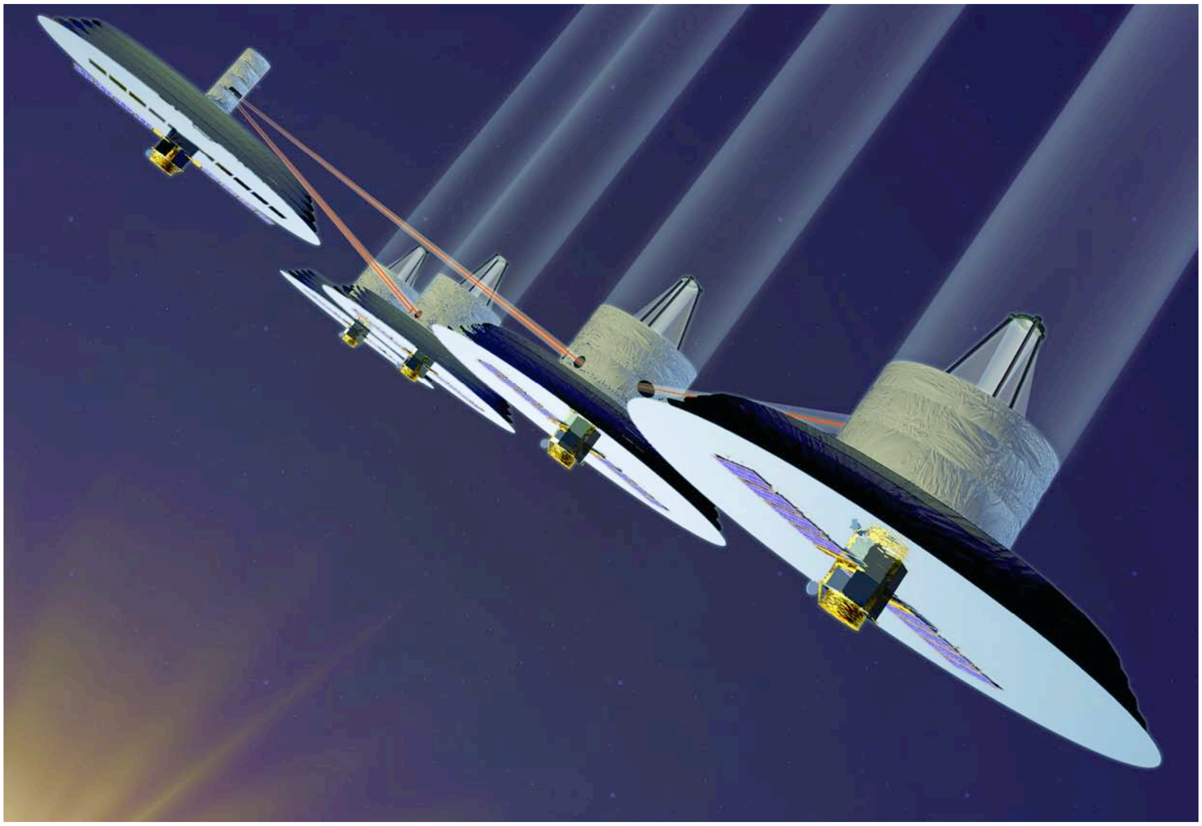
Exploration

❖ Found that hydrazine from thrusters does not decompose amino acids, which eases concerns that this widely used propellant would contaminate organic compounds and skew analyses of soil and other materials on the Martian surface and other solar system bodies. Results of this study will be used in the development of OSIRIS, a Goddard-managed Phase A Discovery mission. OSIRIS will perform follow-up studies. *(Principal Investigator: Jason Dworkin, Code 691)*

❖ Constructed a prototype of core elements of a miniaturized mass-spectrometer system. This work will help maintain the Center's position as world leader in space-flight mass spectrometry and associated science. The instrument's targeted mass and power are projected to be less than 1 kilogram and 1 watt of power, while maintaining the sensitivity and resolution needed for current planetary targets. *(Principal Investigator: Brian Jamieson, formerly with Code 553; Paul Mahaffy, Code 699, currently is the principal investigator)*



IRAD funding allowed researchers to develop core elements of a miniaturized mass spectrometer needed for future missions.



FY 2006 IRAD investments advanced the readiness of various technologies needed to carry out challenging missions in the future, including the proposed Terrestrial Planetfinder pictured here. These technologies also are applicable to nearer-term opportunities.

❖ Field tested a Gamma-Ray/Neutron/Cosmic-Ray Spectrometer and proposed the instrument as part of a Goddard Mars Scout proposal, Borealis Explorer. The compact spectrometer has important applications in both exploration and science, and could possibly be used on a robotic lunar mission, such as future lunar sortie missions. *(Principal Investigator: Jacob Trombka, Code 691)*

❖ Continued the development of large-format avalanche photo-diode arrays sensitive in the near infrared and suitable for use in three-dimensional, imaging laser-radar systems. To make these detectors suitable for use in space, the principal investigator emphasized high reliability and a compact design, partnering with AdTech Optics (array fabrication), Apeak Electronics (readout electronics), and the University of Maryland-Baltimore County (characterization, testing, and detector physics). *(Principal Investigator: Peter Shu, Code 553)*

Telescopes and Large Optical Systems

❖ Completed the Subscale Cryo-Thermal Test, which will improve engineers' ability to design and test future large cryo missions more accurately and less expensively. The new capability will put the Center in good position for future large space telescopes and other cryogenic missions. *(Principal Investigator: Mike DiPirro, Code 552)*

❖ Added 1024-actuator MEMs deformable mirrors to the Asymmetric Dual Michelson Interferometer to evaluate whether such a device is suitable for wavefront correction. This work increases Goddard's knowledge about this technology and, if successful, provides the Center with a proven instrument concept that it can apply to future, high-contrast astronomy applications. Testing continues. *(Principal Investigator: Charles Bowers, Code 667)*

❖ Produced an end-to-end mission simulator — known as SISSI — for future far-infrared/submillimeter space interferometers, an effort that directly supports the development of the Origins Probe SPIRIT. With SISSI, Goddard will be able to demonstrate the feasibility of interferometers and, based on simulations, help refine mission design and engineering. *(Principal Investigator: Stephen Rinehart, Code 665)*

❖ Developed and demonstrated in a software simulation environment (the Formation-Flying testbed) micrometer-level formation-flying algorithms and successfully performed nanometer-level, closed-loop optical control of two mirrors in a 7-element sparse array in the Fizeau Interferometer testbed. The work is critical for developing the Stellar Imager Pathfinder and other future sparse aperture/interferometric missions. *(Principal Investigator: Ken Carpenter, Code 667)*

❖ Showed through the modeling of the Fourier-Kelvin Stellar Interferometer testbed that the interferometer can detect and characterize the atmospheres of up to 40 of the known extra-solar giant planets. A major milestone in the effort involved reducing path-length jitter to less than 15 nm rms. The research increases Goddard's competitiveness on exoplanet search missions, such as the long-range Terrestrial Planetfinder. *(Principal Investigator: William Danchi, Code 667)*

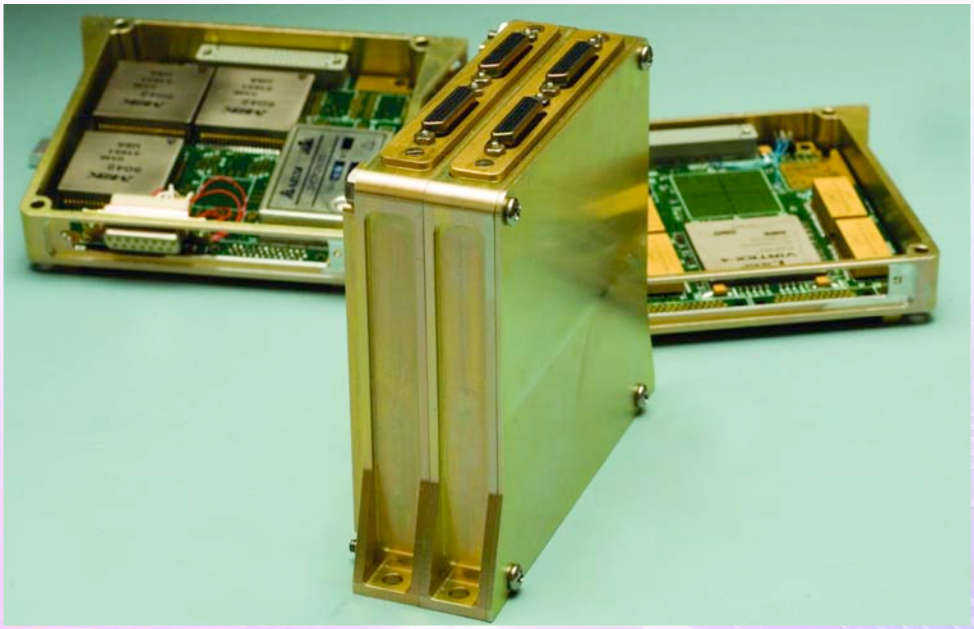
Information Systems

❖ Reported significant developments in the Core Flight Executive (cFE) program, an effort to provide a "plug and play," platform-independent system that offers reusable software to all types of missions. The Magnetospheric Multiscale mission plans to use cFE and the port to the coldfire processor, also developed by the project. Additionally, the Lunar Reconnaissance Orbiter mission and the relative-navigation sensor on the Hubble Servicing Mission-4 will employ cFE. *(Principal Investigator: Alan Cudmore, Code 582)*

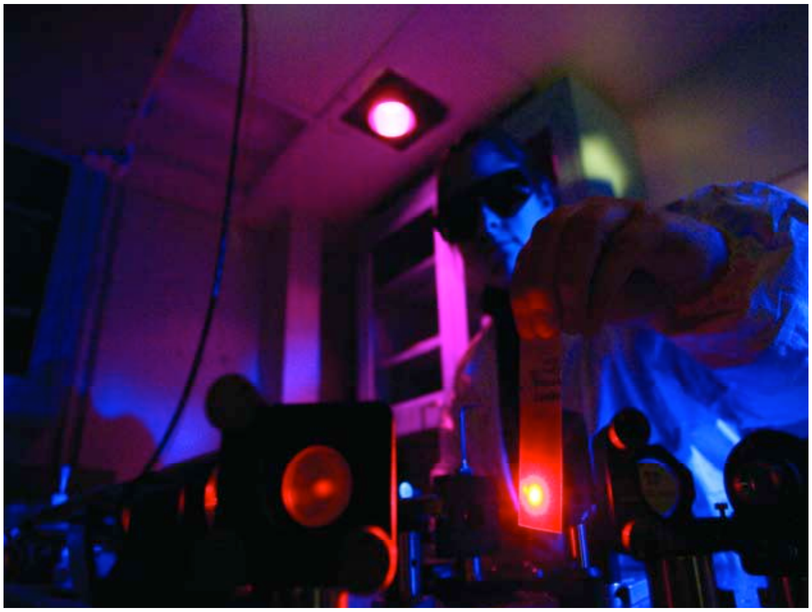
Space Communications and Navigation

❖ Completed the design of Space Cube, a high-performance, user-reconfigurable subsystem intended for spaceflight applications that require significant processing power. Space Cube will be used on the Express Logistics Carrier (ELC), an un-pressurized aluminum carrier for International Space Station science experiments and orbital-replacement hardware. In particular, Space Cube will provide communications and control between the station and external devices on the ELC. So far, the developers have fabricated and delivered 10 copies of the breadboard to the ELC development team. They also have successfully ported high-level software, including the Linux operating system, and Goddard's Core Flight Executive. *(Principal Investigator: John Godfrey, Code 561)*

❖ Analyzed fast receiver acquisition techniques for de-spreading signals used in Tracking and Data Relay Satellite System links and implemented digital signal-processing modules for test and evaluation in a field programmable gate array. These modules can be incorporated into a fully digital receiver, and can be ported to various software-defined radio platforms. Fast de-spreading is required for receivers that could support range-safety applications. Investigators showed acquisition times of less than 1 second. *(Principal Investigator: Steve Bundick, Code 569)*



The Space Cube, a next-generation command, data, and handling system, is faster than the current state-of-the-practice. Technologists advanced the technology through IRAD funding.



Goddard technologists continued research vital to advancing laser technologies necessary for range determination and communications.

❖ Built a prototype instrument capable of both precise range determination and communications using a photo-counting receiver — capabilities important to the Lunar Precursor and Robotic Program, Mars Scout, the Tracking and Data Relay Satellite System, and deep-space communications. *(Principal Investigator: Michael Krainak, Code 554)*

❖ Studied the feasibility of using low-cost, commercial-off-the-shelf cable equalizer integrated circuits to improve signals degraded by distortions in satellite ground terminals. This becomes an issue at rates in the hundreds of megabits per second. Tested with a 5-meter, Ka-band terminal at Wallops Flight Facility, the equalizer circuit showed significant improvements. *(Principal Investigator: Steve Bundick, Code 569)*

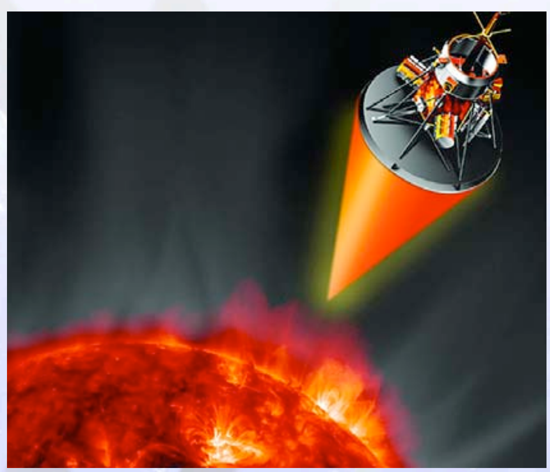
❖ Designed and tested the "Navigator Global Positioning System (GPS) Receiver" that will provide greater direction-finding accuracy than existing GPS systems — particularly for missions in high-Earth orbits. The Hubble Servicing Mission-4 and the Magnetospheric Multiscale mission are expected to use the technology. *(Principal Investigator: Luke Winternitz, Code 596)*

❖ Carried out a complex analysis of lunar trajectories, demonstrating and verifying the existence of several classes of "frozen orbits" around the Moon — important findings given that perturbations in the Moon's non-uniform gravitational field and the relative location of the Earth can pull spacecraft in different directions, altering their orbits. Frozen orbits allow spacecraft to maintain a low-lunar or highly elliptical orbit almost indefinitely, minimizing or eliminating the need for periodic boosts from onboard rockets. This fuel mass savings then can be used for onboard instruments. The research allowed Goddard to support and provide communications expertise for several lunar architecture studies managed by Headquarters. (Principal Investigator: David Folta, Code 595)

❖ Demonstrated a one-way laser transmission from Earth to Mars, specifically to the Mars Global Surveyor, at a distance of 80.1 million kilometers. This is three times the previous longest laser transmission distance to a spacecraft traveling to Mercury. *(Principal Investigator: James Abshire, Code 690.5)*

Sensors, Instruments, and Supporting Technologies

❖ Designed and began testing a plasma-wave antenna that could fly on a Solar Probe to gather in-situ measurements of the plasma-wave environment in the Sun's corona. The design is made up of three antenna booms capable of withstanding 3,000 suns. The IRAD-funded work has initiated an effort that will give Goddard a major advantage over competing teams for the award of a Solar Probe instrument, which is needed to better understand solar-wind acceleration. *(Principal Investigator: Edward Sittler, Code 673)*



Using IRAD resources, Goddard scientists designed and began testing a plasma-wave antenna that researchers hope will one day fly on a Solar Probe to investigate the environment in the Sun's corona.

❖ Advanced the Center's quest to develop a practical continuous Adiabatic Demagnetization Refrigerator by creating three different refrigerants that cool below the target temperature of 10 mK. The technology is important to future far-infrared astronomy missions that will probe the faintest and most distant objects in the universe using cooled detectors. *(Principal Investigator: Peter Shirron, Code 552)*

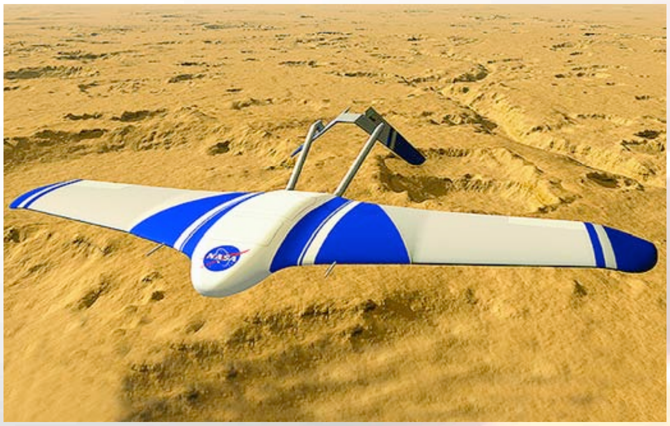
Principal Investigator Peter Shirron, shown here with the Adiabatic Demagnetization Refrigerator (ADR), created three different refrigerants that cool the ADR below the target temperature of 10 mK — important to future far-infrared astronomy missions.

❖ Designed the ISPACE polarimeter-spectrometer and developed algorithms needed to simultaneously retrieve aerosol amounts and absorption, plume heights, and radiance leaving the surface. The resulting imaging polarimeter-spectrometer, which is designed specifically for missions in low-Earth orbit, will have the capability to perform both atmospheric and surface science far better than existing imaging spectrometers. *(Principal Investigator: Jay Herman, Code 613.3)*

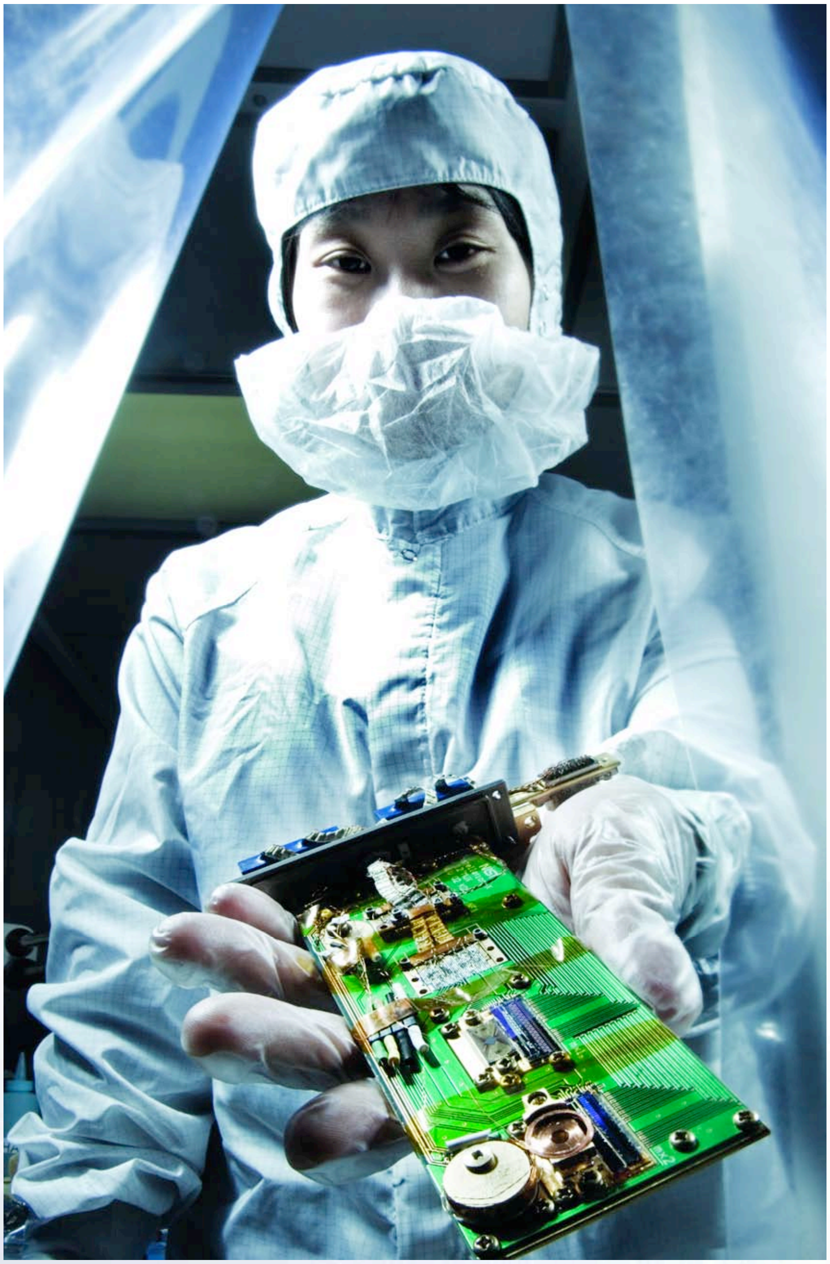
❖ Evaluated the integrity of diode attachments and carried out thermal characterization tests using thermal-impedance measurements. These measurements are aimed at increasing the technical-readiness level of submillimeter-wave radiometry, which will put the Center in a better position to propose missions like the Submillimeter Infrared Radiometer Ice Cloud Experiment. *(Principal Investigator: James Wang, Code 614.6)*

❖ Built and delivered a lower-mass, lower-cost mass spectrometer, which offers the additional benefit of consuming less power. It is expected to fly in the nose compartment of the HADD-II, an upper atmosphere demonstration flight slated for sometime in 2007. The R&D effort gave the principal investigator an opportunity to try new technical approaches that he can use in other instrument applications. *(Principal Investigator: Paul Mahaffy, Code 699)*

❖ Advanced the Digital Beam-Forming Synthetic Aperture Radar (DBSAR) technology so that it can be tested for the first time on the RadSTAR's airborne L-Band Imaging Scatterometer when it flies aboard the NASA P3 aircraft in the summer of 2007. DBSAR offers significant advantages over conventional synthetic aperture radar because it provides fine spatial resolution over larger areas — important to planetary missions searching for water and other resources. *(Principal Investigator: Rafael Rincon, Code 614.9)*



IRAD funding resulted in the development of a low-mass, low-cost mass spectrometer that would have flown in the "ARES Mars Plane" pictured above had NASA selected the Mars Scout proposal. The instrument has other uses.



Goddard researchers assured the Center's continued leadership in X-ray microcalorimetry by procuring a cryogen-free dewar to test and develop the next-generation technology shown here.

❖ Procured a cryogen-free dewar to test and develop next-generation X-ray microcalorimeters for medium-class Explorer mission opportunities and the proposed Constellation-X, thus assuring the Center's leadership in this important technology. *(Principal Investigator: Richard Kelley, Code 662)*

❖ Studied and designed a single-photon asynchronous laser transponder capable of ranging to orbiting satellite corner cube arrays using laser-ranging facilities at the Goddard Geophysical and Astronomical Observatory. This effort is expected to result in an operational capability that will enable laser tracking/ranging to lunar and planetary spacecraft with an accuracy of 1 centimeter (per second) and nanosecond-level clock correction. This capability will improve orbit determinations for precision mapping and provide new insights into planetary motion and relativistic effects. *(Principal Investigator: Philip Dabney, Code 694)*

❖ Acquired all optical and mechanical components needed to build a next-generation unmanned aerial vehicle (UAV)-based lidar sensor and began the instrument's opto-mechanical assembly. Progress enabled the principal investigator to submit a proposal to NASA Headquarters to integrate the instrument onto a UAV and begin test flights. The proposal is still pending. *(Principal Investigator: Matthew McGill, Code 613.1)*

❖ Improved the Center's ability to propose sensitive large-format photon counters by demonstrating individual photon counting using existing e2v L3 CCDs and completing the design and layout of the first fully depleted p-channel charge multiplying CCDs. These detectors are important enabling technologies for planned low-background astronomical missions, including imagers and spectrographs for the Joint Dark Energy Mission and the Extrasolar Planetary Imaging Coronagraph. Compared with e2v L3 CCDs, thick fully depleted p-channel charge multiplying CCDs are likely to be more radiation tolerant. They also offer compelling advantages for studying objects that emit light in the 800-1050 nm range. *(Principal Investigator: Bernard J. Rauscher, Code 665)*

❖ Developed a functioning breadboard of a low-power, low-mass Fourier Transform Spectrometer, a possible successor to the highly successful Goddard-built Composite Infrared Spectrometer that flew on Cassini to measure infrared emissions from Saturn and its rings and atmosphere. The next-generation instrument is ideal for characterizing Mars methane (and elucidating its origin) from an orbiter, studying Titan pre-biotic chemistry from an aerover, and studying Enceladus cryo-volcanoes and surface thermal features from a Saturn orbiter. The development puts Goddard in good position to compete on future NASA Announcements of Opportunity. *(Principal Investigator: John Brasunas, Code 693)*

❖ Made significant progress advancing the technical readiness and overall feasibility of a wide-swath, full-waveform, spaceborne imaging lidar. Derivatives of the technology were offered in two Mars Scout proposals and as part of a ROSES Lunar Sortie Science Opportunities study proposal. *(Principal Investigator: Bryan Blair, Code 694)*

Langley/Goddard Collaborative IRAD

❖ Made important technical progress in the development of a system that would extract oxygen and reduce oxides and metals from lunar soil. A small-scale vacuum pyrolysis chamber is now being developed as a potential instrument for the Lunar Precursor and Robotic Program. In addition, the principal investigators are collaborating with Pratt & Whitney/Rocketdyne to further develop the vacuum pyrolysis technique. *(Principal Investigators: Eric Cardiff, Code 597, Goddard; and Karen Taminger, Code 188A, Langley)*

❖ Conducted initial tests of important components to reduce the risk of using fiber-laser technology in future Earth System Science Pathfinder missions, such as ACCLAIM. The effort further leverages the working relationship between Goddard, the Langley Research Center, and ITT Industries. Furthermore, it enables a new class of reliable active measurement concepts. *(Principal Investigators: Melanie Ott, Code 562, Goddard; and Ed Browell, Code E303, Langley)*

❖ Collaborated with the Langley Research Center to develop and demonstrate a novel method for efficiently capturing information from circularly symmetric images, such as output from a Fabry-Perot Inteferometer and two-dimensional polar imagery. Langley designed and built the conical mirror and cylindrical detector system and Goddard modified an existing lidar testbed instrument to accept the Langley system. NASA could apply the technology to both science and exploration missions. *(Principal Investigators: Matthew McGill, Code 613.1, Goddard; and William Cook, Code 468, Langley)*

Under his IRAD award, Principal Investigator Eric Cardiff built a prototype system to test a technology called vacuum pyrolysis. The technique is aimed at ultimately extracting oxygen from lunar soil.

Focus on New Priorities

Given the heavily competitive nature of research funding and the declining number of new opportunities, the Office of the Chief Technologist initiated the first steps in FY 2006 to streamline the way that the Center solicited and selected R&D proposals. It achieved this by issuing the first-ever integrated call for proposals involving all of the Center's technology-investment programs — IRAD, Core Capabilities, and the Director's DiscretionaryFund (DDF).

Technologists end their funding year by sharing research results at the annual "IRAD Poster Session."

This step paved the way for a more thorough reorganization of Goddard's R&D funding later in 2006 when the Center's leadership consolidated IRAD, Core Capabilities, and DDF into one all-encompassing internal investment program, known as IRAD.

The New IRAD Program

The new consolidated program that the Office of the Chief Technologist rolled out in 2006 affects awardees in FY 2007. It features two primary elements — a "top-down" directed program that targets near-term competitive opportunities and a more traditional call for proposals that solicits proposals for technology-development concepts that support Goddard's strategic business areas.

Through the "directed" portion, leads identify technologies and capabilities necessary to win anticipated Announcements of Opportunity or to capture other strategically important work. About half of the integrated investment program falls under this category. The competed program, on the other hand, is managed more like a traditional solicitation for proposals. Technologists submit proposals that support Goddard's lines of business as well as innovative, high-impact investments for near- to mid-term opportunities.

The Future

For the past six years, the IRAD program has evolved so that it is more strategically aligned with future opportunities important to Goddard. This alignment should bode well for the Center. According to research conducted by private organizations, the most successful R&D programs demonstrate two common characteristics:

❖ They **identify priority areas**. Instead of spending scarce research dollars on "blue-sky" ideas, successful organizations identify the most promising technologies and focus on them. As previously mentioned, the FY 2006 IRAD program focused only on strategic research areas.

❖ Program participants also **collaborate with others**. With the FY 2006 program, administrators made collaboration a priority and gave partnerships special consideration when awarding research dollars. The three IRAD principal investigators who teamed with researchers from the Langley Research Center provide an example of this.

The steps taken in FY 2006 laid a foundation for more comprehensive changes in the FY 2007 program. The combined IRAD program is expected to strengthen the Goddard Space Flight Center's investment in important technologies and assure that the Center wins new work in the future.