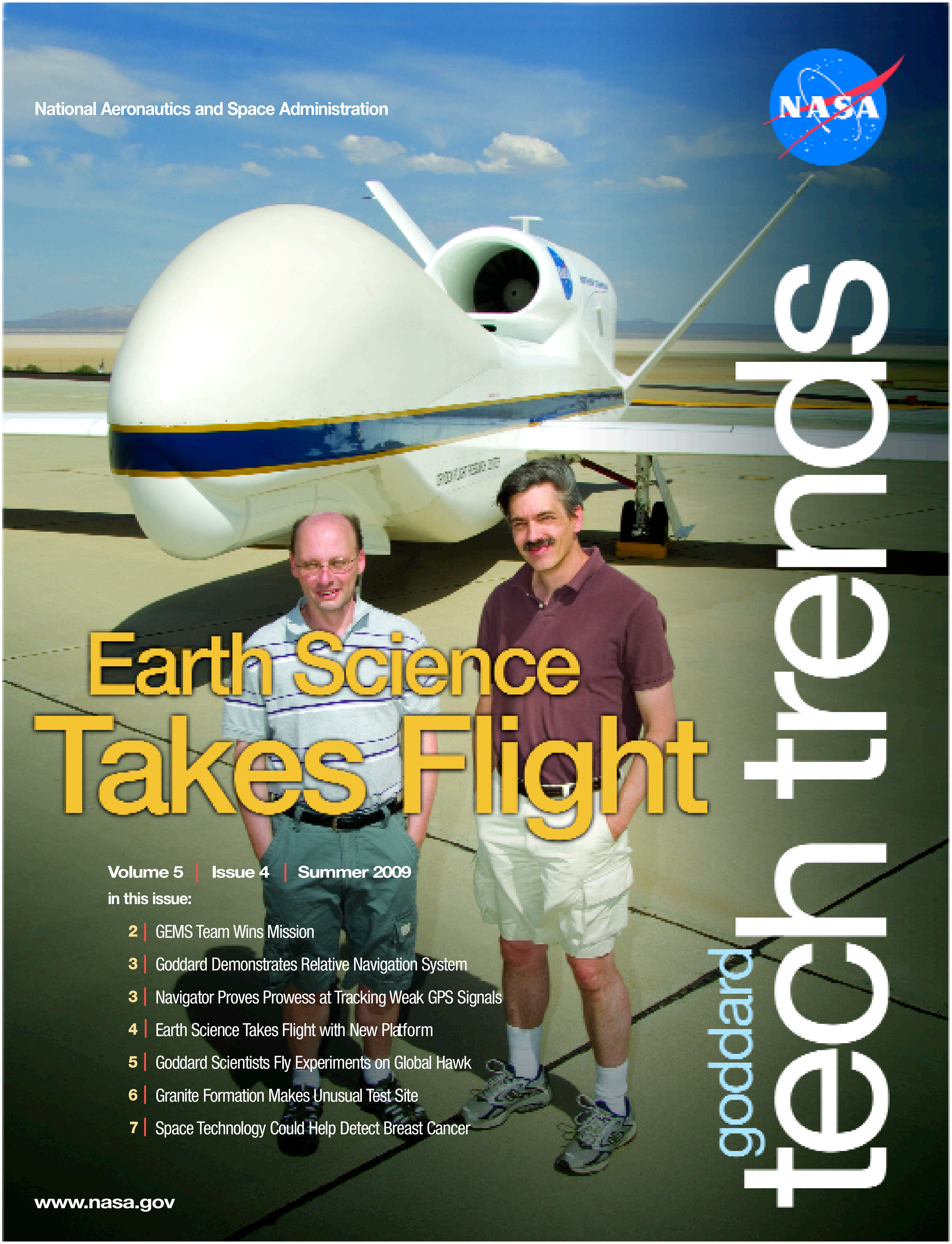
National Aeronautics and Space Administration

goddard tech trends



Earth Science Takes Flight

Volume 5 | Issue 4 | Summer 2009

in this issue:

Opening the Frontier of X-ray Polarimetry

GEMS Win Attributed in Part to R&D Funding

NASA selected Goddard's Gravity and Extreme Magnetism SMEX (GEMS) team to build one of the Agency's two Small Explorer missions, capping a multi-year effort that included significant R&D investments in the development of a new instrument needed to measure the polarization of X-ray light.

Led by Principal Investigator Jean Swank, GEMS will open a new window on the universe through X-ray polarimetry The observatory will provide never-before-obtained measurements of how fast black holes spin and how their spin rates affect the curvature of space-time. It also will study what powers pulsars and magnetars, how cosmic rays accelerate in supernova remnants, and whether a black hole at the center of our Milky Way was active in the recent past (*Goddard Tech Trends*, Summer 2008, Page 2).

Photo Credit: Chris Gunn

Principal Investigator Jean Swank is pictured here with two of her colleagues on the winning GEMS team, Keith Jahoda (left) and Kevin Black (right).

Answers to these questions will revolutionize scientists' understanding of strong field gravity and magnetism and change the way they view the universe, the GEMS team said.

GEMS will answer these questions through pioneering X-ray polarimetry measurements. Until now, obtaining these measurements was not possible because of poor instrument sensitivity and difficulty capturing enough X-ray photons. With support from Goddard's Internal Research and Development (IRAD) program, however, Goddard scientists developed the world's first time-projection chamber polarimeter.

"Winning this mission shows the value of sustained, focused R&D investments addressing the most critical technologies," said Goddard Chief Technologist Peter Hughes, whose IRAD program began funding polarimeter technology six years ago. "Our investment made a difference and resulted in the team winning this important new mission." ◆

About The Cover:

NASA's new Global Hawk aircraft is making its maiden scientific flight in mid-August, heralding a new era for Earth scientists who will now have access to another high-altitude platform on which to perform their experiments. The Global Hawk Pacific mission, managed by Goddard scientist Paul Newman, will make between four to five flights — each lasting about 24 hours in duration — to gather data over the Pacific and Arctic regions to validate Aura measurements. Two Goddard scientists, Matt McGill (left) and Scott Janz (right), are flying payloads on the flight.

Photo Credit: Tom Tschida, Dryden Flight Research Center

Goddard Engineer Demonstrates Relative Navigation During Hubble Servicing Mission

Goddard engineer Bo Naasz successfully demonstrated the Relative Navigation System (RNS) during the Hubble Servicing Mission. He is pictured here with RNS, which was installed inside the Shuttle cargo bay.

A team of Goddard technologists has demonstrated that spacecraft can operate in close proximity to one another with little or no human intervention — an important navigational capability for future science and exploration efforts.

While astronauts carried out the task of rendezvousing with, grappling, and then redeploying the bus-sized Hubble Space Telescope during the recent servicing mission, Goddard engineer Bo Naasz and his team simulated the same exacting maneuvers using the Relative Navigation System (RNS). The team's feat of engineering prowess advances the Agency's ability to execute these precision navigational tasks in future missions, Naasz said.

Cargo Bay Berth

Flown in the cargo bay of Space Shuttle Atlantis, RNS included three cameras with varying optical ranges, electronics to capture the camera images, the Goddard-developed Navigator GPS receiver (see related story below), and a hybrid computer system called SpaceCube that provides 15 to 25 times the processing power of a typical flight processor (*Goddard Tech Trends,* Summer 2008, Page 3).

As the Shuttle approached the Hubble, the cameras gathered real-time imagery and Navigator provided GPS data. Both data streams were fed into SpaceCube, which executed two algorithms — one developed by Goddard engineers — to calculate the position and orientation of the observatory relative to the Space Shuttle.

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Navigating in Low-Signal Environments

Goddard's Navigator Technology Successfully Tested

GPS navigational devices are as ubiquitous as cell phones, freely used by commercial and government users alike to determine location, time, and velocity. These tools, however, are only as good as the signals they receive.

Thanks to a team of engineers from Goddard's Component Hardware Systems Branch, even those platforms operating in weak-signal areas — such as geosynchronous or highly elliptical orbits — will be able to acquire the precise GPS radiowave signal to determine their location. As a result, constellations of next-generation satellites will be able to fly in formation and unmanned spacecraft will be capable of autonomous navigation.

During the recent Hubble Servicing Mission, engineers demonstrated for the first time the Navigator GPS receiver, a technology Goddard engineers had begun developing six years ago with Internal Research and Development funding. During a test of the Goddard-developed Relative Navigation System (RNS), the Navigator proved highly effective at quickly finding, acquiring, and tracking weak GPS signals — contributing to the overall success of the RNS experiment, said Greg Heckler, a member of the Navigator team.

The team's work doesn't stop with the first on-orbit demonstration, however.

According to Heckler, Honeywell is commercializing the technology specifically to build a receiver for the Orion spacecraft. His team provided a Navigator test unit to the GOES-R program and is now building receivers for the in-house Global Precipitation Measurement mission. The Magnetospheric Multiscale mission, a constellation of four identically outfitted

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Cover Story: Earth Science Takes Flight

Global Hawk to Make Maiden Scientific Mission

When the Global Hawk aircraft takes off from an airstrip at the Edwards Air Force Base in the high desert of Southern California this summer, the event will herald a new era for Earth scientists who now have access to an unpiloted, high-altitude platform on which to fly their experiments.

Goddard scientist Paul Newman (left) and NOAA scientist Dave Fahey (right) share project management responsibilities for Global Hawk's maiden scientific flight.

It also culminates months of planning — especially for three Goddard scientists who are participating in the maiden scientific flight of NASA's first unmanned aircraft system, which is capable of flying for longer intervals than piloted scientific aircraft, thereby increasing the amount of data scientists can collect.

Over the next few weeks, the Northrop Grumman aircraft will make between four to five flights — each lasting about 24 hours in duration — to gather data over the Pacific and Arctic regions. The principal goal is gathering data to validate measurements by Aura, an A-train satellite that Goddard developed to study Earth's ozone, air quality, and climate, said Goddard's Paul Newman, who is serving as the project scientist for the Global Hawk Pacific (GloPac) mission.

With its suite of 12 instruments — provided by scientists from Goddard (see related story, page 5), the Jet Propulsion Laboratory, the National Oceanic and Atmospheric Administration (NOAA), Denver University, and the Ames Research Center — the mission also will address trace gases in the upper troposphere and lower stratosphere from the mid-latitudes into the tropics. In addition, the mission will sample the developing winter stratospheric polar vortex, volcanic plumes, and aerosols and measure dust, smoke, and pollution that originate from Asia and Siberia and cross the Pacific.

Science, however, is not the only objective.

"This is the maiden science flight. We've never tried to do this before and we're trying to figure out how to do this well," said Newman, who is sharing project management responsibilities with Dave Fahey, a scientist with NOAA's Earth System Research Laboratory, and Mike Craig, a mission expert with the Ames Research Center. "This is a complex aircraft system," Newman added.

The Global Hawk unmanned vehicle makes its maiden scientific flight in mid-August. The flight includes two experiments developed by Goddard scientists.

Developed originally for the U.S. Air Force to gather intelligence and surveillance data, the Global Hawk is remotely piloted. Before a flight begins, the crew chief starts the aircraft from a laptop and then transfers control to the pilot who works from an operations center at Dryden Flight Research Center, located on the Edwards Air Force Base.

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Earth Science... Continued from page 4

During the GloPac mission, which will run for about six weeks beginning in mid-August, the mission's 12 principal investigators will work from an adjoining room where they will activate their instruments and begin gathering data as the Global Hawk ascends to its operational altitude of 65,000 feet (nearly twice as high as a regular commercial airliner). Throughout the mission, principal investigators will have immediate access to their data and will be able to command their instruments from their computer consoles.

"In many respects, the Global Hawk is more like a satellite than an airplane," Newman said.

The addition of the Global Hawk to NASA's fleet of research aircraft affords scientists a new capability, he added. The aircraft, which is distinguished by its bulbous nose and 116-foot wingspan, can travel 10,000 nautical miles for up to 31 hours, carrying 2,000 pounds of instrument payload. In contrast, NASA's manned research aircraft, the ER-2, can fly for only eight hours. Furthermore, researchers do not have access to their data until after the ER-2 aircraft lands.

NASA decided nearly a decade ago to begin transitioning to unmanned aircraft. In 2007, the Air Force gave Dryden two of its seven Global Hawk Advanced Concept Technology Demonstrators built as part of the Advanced Concept Technology Demonstration program sponsored by the Defense Advanced Research Projects Agency. Last year, Dryden entered into a Space Act Agreement with Northrop Grumman to share in the use of the aircraft. In exchange, Northrop Grumman provides support for each flight.

Referring to the new platform, Newman put it this way: "This will be cool." ◆

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Two Goddard Scientists Fly Experiments on Global Hawk

For Goddard scientist Matt McGill, the maiden flight of NASA's Global Hawk unmanned aircraft system "was a long time coming."

Four years ago, McGill asked a very simple question shortly after NASA announced that it would transition aircraft-based scientific investigations to unmanned systems: Did NASA even have any instruments that could fly on these platforms? Not content to wait for an answer, he competed for and received Internal Research and Development and Headquarters funding to modify his Cloud Physics Lidar to fly on an unmanned platform (*Goddard Tech Trends*, Winter 2007, Page 7).

He now gets his first chance to fly.

During the Global Hawk Pacific (GloPac) mission, McGill's instrument will gather cloud and aerosol measurements to validate Aura data. It is the first time that McGill has collected this type of data over the Arctic, he said. The instrument functions like the original. However, McGill modified the mechanical interface to make it compatible with the Global Hawk's payload area. He also installed an Ethernet-based downlink capability so that the instrument could download data as it received it.

Another Goddard scientist, Scott Janz, will be measuring nitrogen dioxide, dust, smoke, and ozone with his Ultraviolet-Visible Spectrometer, again to help validate Aura measurements. But he has other reasons for flying on GloPac as one of 12 experimenters.

Photo Credit: Tom Tschida, Dryden Flight Research Center

Goddard scientist Matt McGill used Internal Research and Development funds to modify his Cloud Physics Lidar for use on an unmanned aircraft system.

His experiment covers some of the science topics important to the proposed Geostationary Coastal and Air Pollution Events (GEO-CAPE) mission, which the National Research Council has recommended for the 2015 timeframe. Janz would like to use lessons learned from the GloPac experience to build a next-generation instrument that might be suitable for GEO-CAPE, he said.

"This mission will help us refine science requirements," he said. "We're getting data at higher spatial resolution that will help bound the requirements." The next step would be to build another aircraft-based instrument that might serve as the prototype for a future satellite mission. ◆

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The Formation in the Field

Scientist to Begin Testing Instrument Prototype

Why are granite slabs stacked incongruously in the middle of an open field four miles from Goddard? Could it be a half-finished monument or simply a storage area for unused construction materials?

Despite its remarkable lack of technological sophistication, the granite formation is actually a test site. Goddard scientist Ann Parsons plans to use it in the coming months to test an instrument she hopes NASA will one day land on the Moon, Mars, Venus, or even the rocky moons of the outer planets to survey the elements found as much as a foot beneath their surfaces — without ever digging or displacing one gram of material.


Photo Credit: Chris Gunn

Ann Parsons (center) and her team pose with the granite formation, Goddard's newest test site. From left to right: Sam Floyd, Richard Starr, Jack Trombka, Julia Bodnarik, Parsons, Min Namkung, Tim McClanahan, Larry Evans, and Lucy Lim.

Her instrument, the Pulsed Neutron Generator-Gamma-Ray and Neutron Detector, combines different technologies to achieve this measurement feat. First, a generator pulses neutrons into a sample area. When the subatomic particles interact with an element's nucleus, the nucleus becomes excited and emits a gamma ray, which a spectrometer then detects to reveal the identity of the element. The instrument also includes a neutron detector, which is effective for determining surface density and the presence of hydrogen atoms.

"The nice thing about neutrons is that they go deep into the soil — a meter (nearly three feet) on average," Parsons said. "To get a full elemental survey, the approach is effective down to about a half meter." Her instrument also can measure over a relatively broad area — within a meter radius — making it ideal for inventorying resources and determining, for example, the location of potential water beneath the surface, she said. "The ability to make measurements at about 30 to 50 centimeters below the surface without having to drill is a revolutionary capability," she said.

Parsons and her team, which includes Jack Trombka, a long-time Goddard scientist and recognized expert in gamma-ray instrumentation, has received Goddard Internal Research and Development and Headquarters funding to advance the concept.

Why Granite?

So why the granite placed in the middle of a field several hundred feet away from the road and the nearest building on the grounds of Goddard's Geophysical and Astronomical Observatory?

It was a matter of necessity, Parsons said. Initially, she tested her instrument concept at a private research facility in New Jersey, but soon discovered that the generated neutrons interacted with "everything," making the test results difficult to interpret. "The lesson learned from this experience led to the conclusion that the best way to perform these experiments is to have a very large, well-characterized test sample placed outdoors well away from other buildings and people."

Granite, as it turns out, is ideal for testing the sensitivity of her instrument because it does not contain hydrogen and it does not absorb water like other potential test materials. This characteristic is important because it is hard to control the amount of moisture contained within most materials placed outdoors during a Maryland summer.

When she begins her tests in the next few weeks, she will place the neutron generator and detectors on top of the granite formation and pulse neutrons into the material. Through this testing, she hopes to advance the flight readiness of her instrument and in the future find a berth on a landed mission to another solar system body.

In the meantime, the granite formation will host other experimenters.

"Now that the facility is getting ready, we're being asked by groups to test their instruments," Trombka said. In a few months, the team will test and calibrate the Russian-built Dynamic Albedo of Neutrons instrument, which is flying on the Mars Science Laboratory. The team also could assist in calibrating a version of the Gamma-Ray and Neutron Spectrometer flying on the MESSENGER mission to Mercury.

"It's going to be an amazingly busy summer," Parsons said. ◆

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Space Technology Could Help Early Detection of Breast Cancer

Using the same instrument to detect life on Mars and cancer lurking inside the human body isn't as far-fetched as one might think. Just ask Goddard technologist Stephanie Getty. She is now developing a technology platform that might be able to do both.

Technologist Stephanie Getty is applying spaceflight technology to develop a platform that might be able to detect breast cancer.

Under a grant with the National Institutes of Health (NIH), Getty is collaborating with the University of Maryland, Catholic University, and the National Cancer Institute (NCI) to develop a nano-scale detector that would locate specific biomarkers linked to breast cancer. The hope is that the NanoBioSensor Initiative will result in an instrument that physicians could use in a clinical setting to detect the presence of cancer biomarkers or predict the prognosis of a patient developing the disease.

Getty, who joined the Center nearly five years ago to pursue nano-technologies for spaceflight applications, also is receiving Goddard Internal Research and Development funding to advance her instrument concept. The same detector technology, which she calls ChemFET, could be used to detect organic molecules that may indicate the presence of past or current life on Mars, Titan, and other solar system objects.

NASA also might be able to use a modified version of the technology to detect specific genetic sequences to assure that terrestrial organisms have not contaminated samples collected on Mars or the Moon or to screen astronauts for cancer due to over-exposure to the Sun's harmful radiation during long-term stays on the Moon, Getty said. "This is a unique opportunity to leverage funding," Getty said. "It really is a dual-use technology."

But even Getty concedes that due to the long-range nature of NASA's exploration initiatives, it may take years before her instrument concept actually flies in space. That's why she pursued other funding avenues to help advance her ChemFET platform, she said.

Winning an NIH grant to help fund her work, she said, was fortuitous, a matter of being in the right place at the right time. "Actually, I was trying to find clean room space" when she met Robert Rashford, a systems engineer with the James Webb Space Telescope project, she said.

During a conversation with him, she discovered that he knew an NCI researcher who was interested in developing a miniaturized diagnostic tool that would replace an existing approach called DNA microarray technology, which allows scientists to examine thousands of genes at a time to study patterns of activity in cells.

Some people have a greater chance of developing certain types of cancer if a mutation occurs in specific genes. The presence of such a change is sometimes called a risk marker, indicating that cancer is more likely to occur. Tumor markers, on the other hand, are substances produced by tumor cells and are found in blood, urine, and tumor tissue. To date, researchers have identified more than a dozen substances that express abnormally when some types of cancer are present. Breast cancer is one.

Although DNA microarray technology is a powerful tool for identifying the presence of these biomarkers, the technique is currently confined to research laboratories due to time-consuming sample preparation, intensive data analysis, and cost, Getty said. ChemFET, however, offers a viable solution to the cancer-detection challenge because it uses nano-components and a fully electronic detection method. Both are compatible with miniaturization and rapid data analysis.

"We have proved the concept," she said. "Now we need to make it easy for a company to manufacture it. The point is we want to create a tool so that anyone could come into a clinic to be tested for breast cancer more rapidly." ◆

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Relative Navigation...

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The goal was demonstrating that space-qualified flight hardware could estimate the position of Hubble, a capability that would advance NASA's ability to carry out these tasks autonomously using an unmanned vehicle. "I'm ecstatic we were able to acquire and track the telescope so well," Naasz said. "SpaceCube made it possible to do the relative-navigation processing onboard and in realtime."

Bright Future

Now that he has proved the viability of autonomous navigation, Naasz said the future looks bright.

It is possible that NASA will have to return to the observatory with an unmanned spacecraft at the end of the observatory's operational lifetime to carry out a safe de-orbit — a maneuver that would require the abilities demonstrated by RNS. RNS also is a good candidate for future sample-return missions, spacecraft autonomous rendezvous, and other robotic servicing missions, Naasz said.

Work Began in 2003

Efforts to build such a capability began in 2003 when former NASA Administrator Sean O'Keefe canceled the Shuttle servicing mission, directing Goddard's Hubble Development Project to instead investigate the possibility of executing the same repairs robotically.

While laying the groundwork for the robotic servicing, Goddard engineers realized that developing an autonomous system to estimate Hubble's position and attitude in relation to the servicing vehicle would be difficult and would require a demonstration flight. Although former NASA Administrator Michael Griffin canceled the robotic mission two years later in favor of the tried-and-true crewed servicing mission, engineers used the technology they created to assemble the RNS experiment.

"It has been an interesting epic journey," Naasz said. "Our experiment positions us well to do autonomous or semi-autonomous navigation in the future." ◆

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Low-Signal Environments...

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spacecraft that will fly in formation to explore the interaction of Earth's magnetic field with the solar wind, also will fly units to help maintain the constellation's alignment.

"I am lucky I was here in the beginning," Heckler said. "I was able to see this technology advance from TRL (technology readiness level) one to seven, from Matlab to actual flight hardware." ◆

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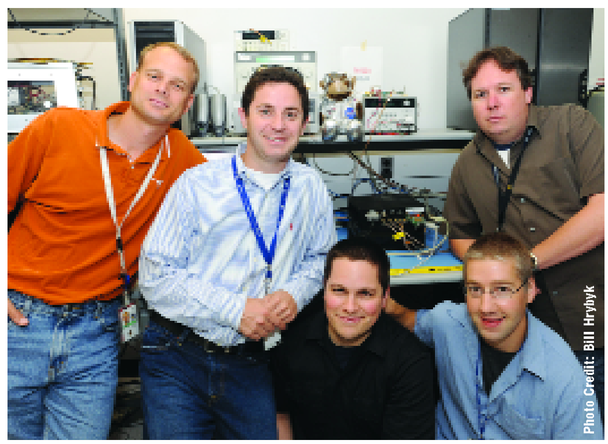

The Goddard Navigator team includes (from left to right): Bill Bamford, Steve Sirotzky, Greg Heckler, Luke Winternitz, and Rick Butler. Gerald — the team's space monkey — is perched on the shelf.

Goddard Tech Trends

Goddard Tech Trends is published quarterly by the Office of the Chief Technologist at the Goddard Space Flight Center in Greenbelt, Maryland. The newsletter describes technology developments at Goddard and explains how they are helping NASA to achieve its missions. If you want more information about Goddard technology, contact the Chief Technologist. If you wish to be placed on the newsletter distribution list, contact the editor. NP-2007-10-853-GSFC (revised 7/09)

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