National Aeronautics and Space Administration

# Cutting edge

Goddard's Emerging Technologies

# Laser Comm:

## Data Rides the High-Speed Rail

Volume 8 | Issue 1 | Fall 2011

## in this issue:


2 New Look, New Name

3 Goddard Wins 'Paradigm-Shifting' Laser Mission

3 Technology Overcomes Laser Challenges

4 Solving the Carbon Conundrum

5 Science in a Suitcase

6 Hitching a Ride on a Falcon

7 Opportunity Knocks, Scientist Answers

8 Turning Science Fiction into Reality

12 Tribute to Dan Powell and a Tenacious Spirit


www.nasa.gov

# New Look, New Name, Same Insightful Content

In 2004, the Goddard Office of the Chief Technologist debuted its first issue of *Goddard Tech Trends* to inform Goddard employees and stakeholders of the technology trends at the center. It's been a good run. But times are changing and so must this publication — particularly with the funding of NASA's new Space Technology Program and the Agency's renewed focus on technology development through its Office of the Chief Technologist.

The technology-development program at the Goddard Space Flight Center isn't simply developing or changing in a general direction, as was the case when we began publishing our quarterly magazine. It's increasingly become more focused on early-stage, emerging technologies that could lead to revolutionary leaps in capability — in essence the definition of cutting edge. That's why we decided to rebrand our quarterly magazine and change its name to *CuttingEdge.* We believe the new name reflects our focus and the types of information you can expect to find in this publication.

In this debut issue, we pay special tribute to a technologist who personified the "can-do" spirit that made NASA great and highlight Goddard's recent win of a space-based laser-communications demonstration project funded by the NASA Office of the Chief Technologist under its Space Technology Program. Optical communications will allow NASA to transmit and receive data 10 to 100 times faster than by current radio-frequency systems — truly a leap in capability for space missions that are currently data constrained.

We also feature articles about a new carbon-measuring technique, a miniaturized instrument that will study gamma-ray bursts in the upper atmosphere, and a NASA Innovative Advanced Concepts-funded study looking into whether "tractor beams" — truly the stuff of science fiction — could one day be used to gather extraterrestrial samples. Some are early stage and others are farther along in the development cycle. All, however, are forward reaching and represent the increasingly cutting-edge nature of our technology program.

In closing, welcome to our rebranded publication. Though we've changed the name and its design, we are proud to offer this magazine focused exclusively on strategic and emerging technologies at Goddard and how they can provide NASA with the technological solutions needed for exploration and scientific discovery in the future.

Peter M. Hughes
Goddard Chief Technologist

## About the Cover

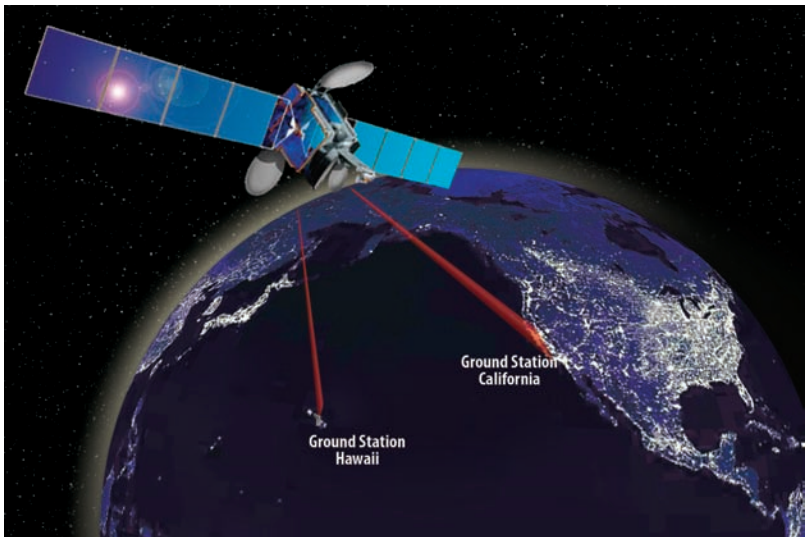
Principal Investigators Dave Israel and Bernie Edwards are leading a new NASA-funded effort to demonstrate space-based laser communications. The Laser Communications Relay Demonstration is expected to launch in 2016 and operate at least two years. Scientists heralded the award as a step in the right direction, giving them what they've long wanted: High-speed data rates and the potential streaming of high-definition video from distances beyond the Moon.

Cover Photo Credit: Chris Gunn

# Goddard Wins 'Paradigm-Shifting' LaserComm Mission

*Scientists Call Mission 'Long Time Coming'*

Goddard technologists have won millions of dollars in NASA funding to demonstrate a space-based optical communications system that could make today's radio-frequency systems look as passé as dial-up Internet and give scientists what they've long wanted: High-speed data rates and the potential streaming of high-definition video from distances beyond the Moon




*This artist's rendition shows the mission concept of the Laser Communications Relay Demonstration project that NASA recently selected.*

"We always dreamed of having laser communications, which could increase data rates by anywhere from 10 to 100 times," said Goddard Chief Scientist Jim Garvin, a long-time proponent of the technology, reacting to news of the Goddard win. "We've been waiting for more than a decade."

The Laser Communications Relay Demonstration (LCRD) project will demonstrate this long-awaited capability. One of three projects selected by NASA's Office of the Chief Technologist (OCT) for a trial run, the demonstration involves a hosted payload on a commercial communications satellite developed by Space Systems/Loral, of Palo Alto, Calif., and two specially equipped ground stations in California and Hawaii. The demonstration is expected to launch in 2016 and operate two to three years.

*Continued on page 9*

# Technology to Overcome Laser Challenges

The Laser Communications Relay Demonstration (LCRD) project promises to dramatically increase data rates, but achieving these speeds will be technically challenging — particularly when transmitting and collecting these tight, data-packed laser beams and then compensating for distortions that occur when the light travels through a turbulent or cloudy atmosphere.

To understand the challenges, it's best to first understand the technology's advantages, the most significant being that optical wavelength bands are very small — 100 times smaller than the width of a human hair — and therefore can be encoded to carry dramatically more information. The antenna collecting the signal, therefore, also is smaller, another advantage to spacecraft developers who must pack a great deal of hardware into a relatively small space.

The challenge comes in making sure the antenna, which is only 10 centimeters wide and looks more like a telescope, receives this narrow band of light and accurately transmits the signal back to a ground-based receiving station. This requires a highly precise pointing-and-tracking system.

The LCRD team plans to deploy a new technology developed by Applied Technology Associates, of Albuquerque, N.M., under a NASA Small Business Innovation Research grant. Its optical Magneto-Hydrodynamic Reference Unit incorporates a pointing mechanism into the transmitter or receiver telescope. The unit also senses the angle of the spacecraft's motion. "The technology device puts all this stuff together into one device. It senses the angle of the spacecraft motion and moves the telescope to keep the pointing aligned," said Mike Krainak, a Goddard laser expert involved in LCRD.

*Continued on page 10*

# Solving the Carbon Conundrum

*Progress Made on State-of-the-Art Carbon–Measuring Instrument*

Scientists know the global levels of carbon dioxide in the atmosphere. They know how much is produced through natural processes and the burning of fossil fuels. But the numbers don't jibe; the budget doesn't balance. More carbon dioxide is produced than what shows up in the atmosphere. So where precisely does the carbon go and will the "sinks" that remove it from the environment continue doing so?

A state-of-the-art carbon-measuring instrument currently under development at Goddard promises to provide a more complete picture of the carbon issue and perhaps solve the conundrum, scientists believe.

*A few CO2 Sounder Lidar team members are shown here inside a DC-8 during the 2010 field campaign demonstrating the instrument's capabilities. From top left (clockwise): Haris Riris, Jim Abshire, Bill Hasselbrack, and Mike Rodriguez.*

Begun several years ago under Goddard research and development programs, the CO2 Sounder Lidar is a strong candidate for a next-generation carbon-monitoring mission, the Active Sensing of CO2 Emissions over Nights, Days, and Seasons (ASCENDS). Led by Principal Investigator Jim Abshire, the new measurement technique is proving in aircraft demonstrations that it can meet the ASCENDS criteria of providing global around-the-clock measurements with unprecedented precision and resolution, regardless of the season.

For scientists, the data couldn't come too soon.

"We know the background levels of carbon dioxide very well. We have a global average," said Randy Kawa, a Goddard atmospheric scientist involved in the sounder's development. Scientists also know Earth's oceans and vegetation remove and store carbon. "However, half of what we're emitting isn't showing up in the atmosphere," Kawa added. "That's why we need details of the processes. We need to know where the sinks are and how well they will operate in the future." This is especially important since the carbon dioxide produced by coal-burning plants and vehicle emissions increases each year, he said.

Currently, a Japanese-built satellite, IBUKI or GOSAT (Greenhouse Gases Observing Satellite), is making global measurements of carbon dioxide. NASA, too, plans to launch its first-ever mission dedicated to carbon measurements in 2013. This mission, the Orbiting Carbon Observatory-2 (OCO-2), will fulfill the objectives of its predecessor, which was destroyed during a launch failure in 2009. NASA is planning another OCO mission from the International Space Station after 2015.

## Sounder Provides 24-Hour Coverage

Although IBUKI and OCO were developed to characterize and map the locations of carbon sources and sinks and monitor how they change over time, neither one can provide around-the-clock coverage. That's because they are equipped with "passive" instruments that rely on reflected sunlight to gather carbon measurements. The instruments, therefore, do not work at night, high latitudes during winter, or on partially cloudy days.

In sharp contrast, the CO2 Sounder Lidar carries its own light source — a pair of tunable laser transmitters — and a two-wavelength laser-absorption spectrometer that measures both carbon dioxide and oxygen. Although laser light cannot penetrate thick clouds, it can measure through thin clouds and particles, which prove troublesome for passive systems.

*Continued on page 5*

## Conundrum, *continued from page 4*

"What we do is bounce a laser beam off Earth's surface," explained Abshire. Like all atmospheric gases, carbon dioxide and oxygen absorb the light in narrow wavelength bands. By tuning its lasers across those absorption lines, the instrument can determine the levels of both gases in that vertical path. "The more carbon-dioxide molecules in the path, the deeper the absorption lines," Abshire said. Measuring oxygen is important, he added, because it reveals atmospheric pressure and helps scientists discern the mixing ratios of both gases.

Efforts also are afoot to develop a similar laser capability to measure methane, another greenhouse gas. Led by Goddard scientist Haris Riris, the addition would further enhance the sounder's usefulness, said Bob Connerton, who oversees Earth science-related technology-development efforts at Goddard.

### Aircraft Demonstrations

To demonstrate its viability as a space-based instrument, Abshire and his team began flying the sounder on high-altitude aircraft in 2008 — a field campaign supported by NASA's Earth Science Instrument Incubator Program. These demonstration flights have occurred every summer since. In July, his team once again packaged the sounder inside a DC-8 and carried out seven separate flights collecting data over California, Nevada, British Columbia, Iowa, Minnesota, Wisconsin, and New Mexico.

"The sounder worked quite well," Abshire said. "We recorded strong lidar signals and clear absorption lines for both carbon dioxide and oxygen at all altitudes and surface types. The instrument's measurements clearly separated the laser signal scattered from the atmosphere and ground surface, as needed for a space mission."

Though pleased with his instrument's performance, he's not declaring victory yet. NASA plans to compete the ASCENDS space instrument, and the Jet Propulsion Laboratory and the Langley Research Center are developing competing approaches. "Of course, I think our chances are very good because we have a really strong team. Our approach is also the most scalable to space and provides more information about carbon dioxide." ❖

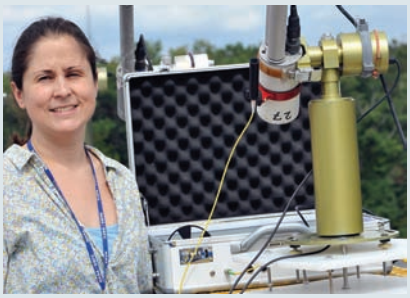
**CONTACT**

James.B.Abshire@nasa.gov or 301.614.6081

# Science in a Suitcase

Goddard scientist Emily Wilson Steel is building an inexpensive instrument that can measure three important carbon-cycle gases — carbon dioxide, methane, and carbon monoxide — all from a small suitcase.

The laser heterodyne radiometer is composed of commercially available telecommunications components and is competitive as a greenhouse-gas ground-validation instrument. Currently, the only ground-based network that measures carbon dioxide and methane in the atmospheric column is the Total Carbon Column Observing Network. However, only two of its 16 sites are in the U.S., Steel said. Furthermore, it's expensive and its instruments are so large they occupy small buildings.



Steel's instrument overcomes those disadvantages, she said. Packaged literally inside a suitcase, users could easily deploy the instrument on the ground or even in an aircraft. "With this technology, we want to establish the largest ground network of carbon-gas measurements in the world," she said.

Her goal could become a reality. She has partnered with NASA's AERONET, a Goddard-run network of more than 450 aerosol-monitoring instruments worldwide. In fact, she specifically designed her instrument to piggyback on an AERONET device that tracks sunlight — a necessary ingredient for measuring greenhouse gases. Her device determines how much light carbon and methane absorbs: The deeper the absorption lines, the greater the concentration.

"With our AERONET partner and the instrument's low cost, we could conceivably fill in the sparse network of carbon- and methane-measuring instruments," Steel said. ❖

**CONTACT**

Emily.L.Wilson@nasa.gov or 301.614.6155

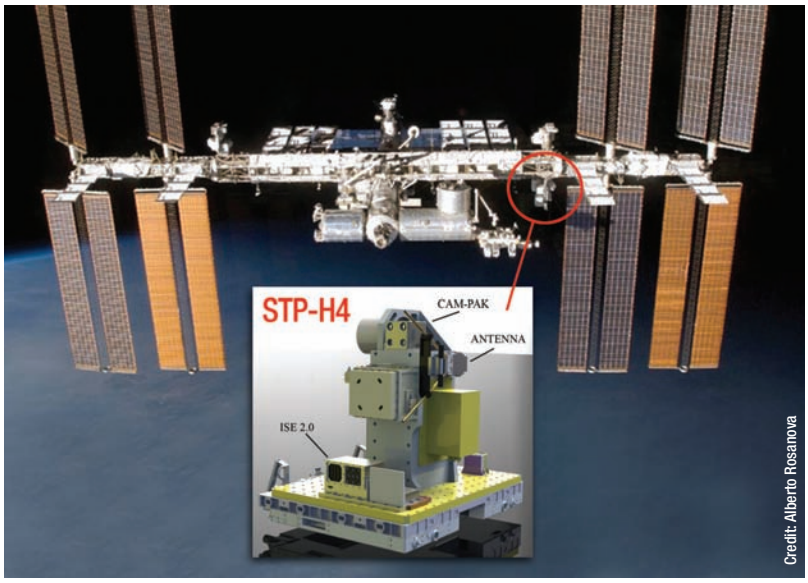
# Hitching a Ride on a Falcon

*Four Technologists to Fly Experiments on STP-H4*

The U.S. Air Force had room on a table-sized experiment pallet and four Goddard technologists needed a ride on a space-orbiting platform to demonstrate their technologies and further advance their space-flight-readiness levels.

Now, all are getting what they want.

The Goddard technologists have brokered a deal with the Naval Research Laboratory (NRL) and the Air Force Space Test Program (STP) to secure berths on STP-H4, a military-sponsored experiment pallet that STP plans to deploy on the International Space Station in 2013. The technologists must deliver their instruments to STP by spring 2012 for integration onto a Falcon launch vehicle.




*This composite shows one of the Goddard-developed payloads flying on a military-sponsored experiment pallet and its planned location on the International Space Station.*

"The Space Test Program told me they had room on the pallet and asked me how much space and power I needed," said Goddard technologist Tom Flatley, who helped arrange the flight opportunity for one of the two Goddard-developed experiments demonstrating four different technologies. "I asked for twice the amount I needed, understanding that I would then have excess power to include other technologies on the experiment. Frankly, I was just trying to get as much cool stuff as I could on that pallet."

## Two Separate Experiment Payloads

Flatley's contribution is SpaceCube 2.0, a more robust, next-generation onboard processor that is 25 times faster than current state-of-the-art technology. The technology has flown before in space. A first-generation model, SpaceCube 1.0, flew on the Hubble Servicing Mission and again on the NRL-sponsored MISSE 7 experiment pallet deployed on the International Space Station mainly to demonstrate its special algorithms that correct for radiation-induced upsets (*Goddard Tech Trends*, Spring 2010, Page 7).

With STP-H4, however, the more robust follow-on will demonstrate its processing prowess by crunching actual science data collected by Firestation, a miniaturized heliophysics instrument developed by Principal Investigator Doug Rowland to study the most powerful natural particle accelerator on Earth — lightning (see related story, page 7).

Rounding out the SpaceCube experiment is the electrohydrodynamic (EHD) thermal-control experiment, which Goddard Principal Investigator Jeff Didion demonstrated for the first time during a sounding rocket flight in the spring (*Goddard Tech Trends,* Winter 2011, Page 2). Unlike traditional cooling technologies that rely on mechanical pumps and other moving parts, EHD uses electric fields to pump coolant through tiny ducts inside a thermal cold plate. The approach would ultimately decrease the weight and size of cooling systems. EHD will sit below SpaceCube on the pallet to prevent the processor from overheating during its airless stay aboard the space station.

## WINCS Rounds Out Goddard Experiments

The other experiment occupying real estate on STP-H4 is the Winds-Ion-Neutral Composition Suite (WINCS), developed by Goddard scientist Fred Herrero and his partner, Andrew Nicholas, of NRL (*Goddard Tech Trends,* Summer 2011,

***Continued on page 11***

# When Opportunity Knocked, Scientist Answered

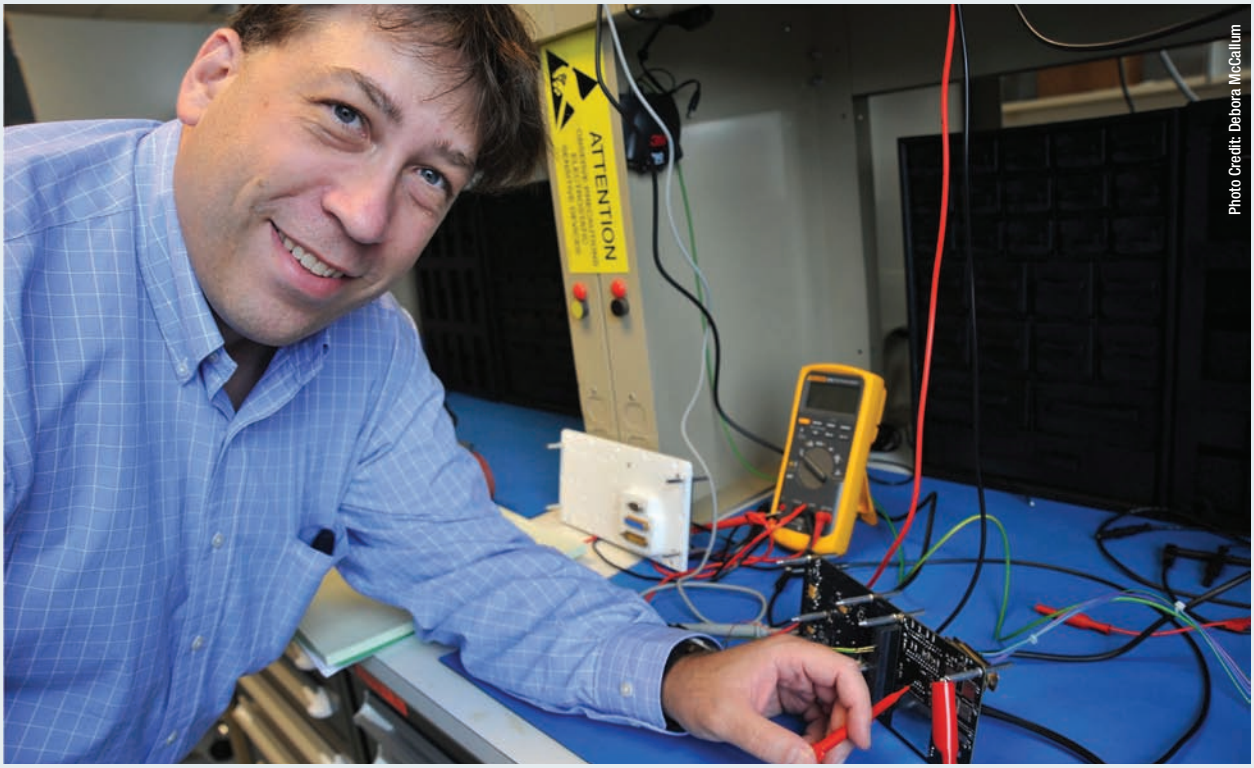



Photo Credit: Debora McCallum

*Heliophysicist Doug Rowland poses with the engineering unit of Firestation's interface board. The instrument will gather data about a little-understood phenomenon first discovered by scientists nearly two decades ago.*

When opportunity knocked, heliophysicist Doug Rowland answered. He and his team recently secured another flight opportunity for a pint-sized instrument studying lightning in Earth's upper atmosphere and now are bracing for a veritable "fire hose" of data about a little-understood phenomenon first discovered by scientists nearly two decades ago.

The instrument, Firestation, is one of four experiments manifested to fly on an experiment pallet the Department of Defense plans to deploy on the International Space Station in 2013 (see related story, page 6). It's a near duplicate of Firefly, which Rowland and his team began developing more than three years ago to fly on an emerging class of tiny satellites called Cubesats sponsored by the National Science Foundation. That mission also may launch in 2013.

Having secured a berth on the pallet, Rowland and his university partners must complete Firestation by spring 2012 for integration onto the pallet.

That shouldn't be an issue, Rowland said. Firestation is a knock-off of Firefly and, in fact, will be cobbled together from Firefly's spare parts. "We're basically ready," Rowland said. "We benefited from the fact that we had completed Firefly and had spare parts on hand. The only thing we need to do is develop a new housing appropriate for the pallet."

## Mystery Flashes

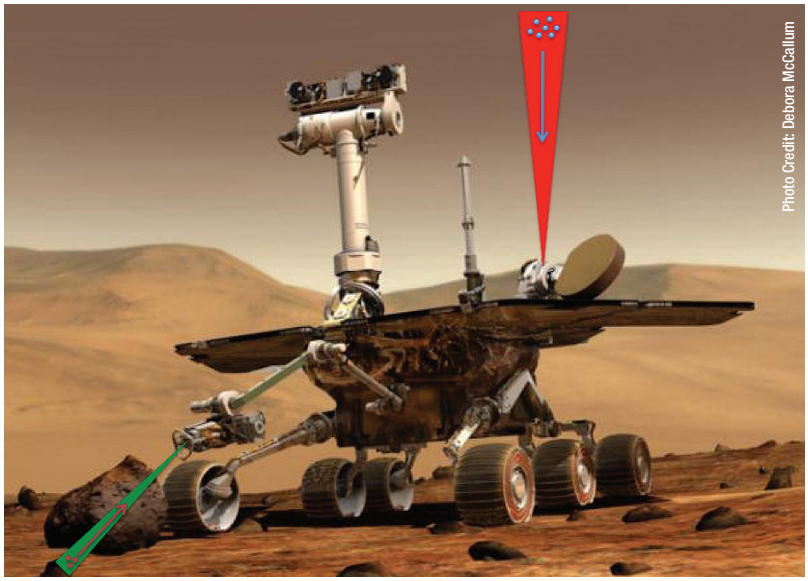
Although the instruments are closely related, they are different in key areas. Firestation covers a wider measurement range. It will take advantage of a camera, also onboard the pallet, to snap photos of lightning flashes so that researchers can precisely locate where they are occurring. Furthermore, Firestation will enjoy a data rate that is about 3,000 times larger than Firefly's, which means the team will be able to sample every lightning stroke, instead of Firefly's carefully selected sample.

But perhaps the biggest difference is in mission duration. Firefly is expected to remain in low-Earth

*Continued on page 11*

# Turning Science Fiction into Reality

Tractor beams — the ability to trap and move objects using laser light — are the stuff of science fiction, but a team of Goddard scientists has won NASA funding to study the concept for remotely capturing planetary or atmospheric particles and delivering them to a robotic rover or orbiting spacecraft for analysis.




*Goddard technologists are studying different techniques for corralling particles and transporting them via laser light to instruments on rovers and orbiting spacecraft.*

The NASA Office of the Chief Technologist (OCT) has awarded Principal Investigator Paul Stysley and team members Demetrios Poulios and Barry Coyle $100,000 to study three experimental methods for corralling particles and transporting them via laser light to an instrument — akin to a vacuum using suction to collect and transport dirt to a canister or bag. Once delivered, an instrument would then characterize their composition.

Though a mainstay in science fiction, and Star Trek in particular, laser-based trapping isn't fanciful or beyond current technological know-how, Stysley said. The team has identified three different approaches for transporting particles, as well as single molecules, viruses, ribonucleic acid, and fully functioning cells, using the power of light.

"The original thought was that we could use tractor beams for cleaning up orbital debris," Stysley said. "But to pull something that huge would be almost impossible — at least now. That's when it bubbled up that perhaps we could use the same approach for sample collection."

With the Phase-1 funding from OCT's recently re-established NASA Innovative Advanced Concepts (NIAC) program designed to spur the development of "revolutionary" space technologies, the team will study the state of the technology to determine which of the three techniques would apply best to sample collection. OCT received hundreds of proposals, ultimately selecting only 30 for initial funding.

## Replace Current Sample-Collection Methods

Currently, NASA uses a variety of techniques to collect extraterrestrial samples. With Stardust, a space probe launched in 1999, the Agency used aerogel to gather samples as it flew through the coma of comet Wild 2. A capsule returned the samples in 2006. NASA's next rover to Mars, Curiosity, will drill and scoop samples from the Martian surface and then carry out detailed analyses of the materials with one of the rover's many onboard instruments, including the Goddard-built Sample Analysis at Mars instrument suite.

"These techniques have proven to be largely successful, but they are limited by high costs and limited range and sample rate," Stysley said. "An optical–trapping system, on the other hand, could grab desired molecules from the upper atmosphere on an orbiting spacecraft or trap them from the ground or lower atmosphere from a lander. In other words, they could continuously and remotely capture particles over a longer period of time, which would enhance science goals and reduce mission risk."

## Team to Study Three Approaches

One experimental approach the team plans to study — the optical vortex or "optical tweezers" method — involves the use of two counter-propagating beams of light. The resulting ring-like geometry confines particles to the dark core of the overlapping beams. By alternately strengthening or weakening the intensity of one of the

*Continued on page 10*

## 'Paradigm-Shifting', *continued from page 3*

"We want to take NASA's communications capabilities to the next level," said LCRD Principal Investigator Dave Israel, who is leading the multi-organizational team that includes the Jet Propulsion Laboratory and Lincoln Laboratory at the Massachusetts Institute of Technology (MIT). Although NASA has developed data-compression technologies and other techniques to boost the amount of data that its current systems can handle, the Agency's capabilities will not keep pace with the projected data needs of advanced instruments and future human exploration, Israel added.

"Just as the home Internet user hit the wall with dial-up, NASA is approaching the limit of what its existing communications network can handle," he said, likening the emerging capability to land-based fiber-optic systems, such as Verizon's FiOS network, which have allowed the high-speed delivery of telecommunications, data, and voice. "In a sense, we're moving FiOS to space."

No one expects laser communications to completely replace NASA's radio-frequency network, which includes a fleet of tracking and data relay satellites and a network of ground stations. Furthermore, the transition to optical systems will take years to complete, but the eventual payback will be very large increases in the amount of data NASA can transmit.

"Right now, exploration beyond Earth is data-starved," Garvin said. "We have to be so careful about every bit of data we collect because our current systems cannot accommodate increased data collection. This is a long-awaited step in the right direction."

### First Step

To demonstrate the new capability, the Goddard team will encode digital data and transmit the information via laser from ground stations to an experimental payload hosted on the commercial communications satellite.

The payload will include telescopes, lasers, mirrors, detectors, a pointing-and-tracking system, control electronics, and two different types of modems. One modem is ideal for communicating with deep-space missions or tiny, low-power smallsats operating in low-Earth orbit. The other can handle much higher data rates, particularly from Earth-orbiting spacecraft, including the International Space Station. "With the higher-speed modem type, future systems could support data rates of tens of gigabits per second," Israel said. Once the payload receives the data, it would then relay it back to the ground stations.

The multiple ground stations are important for demonstrating a fully operational system, Israel said. Cloud cover and turbulent atmospheric conditions impede laser communications, requiring a clear line of sight between the transmitter and receiver. If bad weather prevents a signal from being sent or received at one location, the network could transfer the responsibility to one of the other ground stations or store it for later retransmission (see related story, page 3).

### Follow-On to LADEE Experiment

The project isn't NASA's first foray into laser communications. NASA hired the MIT-Lincoln Laboratory to develop a laser communications payload for the Lunar Atmosphere and Dust Environment Explorer (LADEE), which the Agency plans to launch in 2013. The main goal is proving fundamental concepts of laser-based communications and transferring data at a rate of 622 megabits per second, which is about five times the current state-of-the-art from lunar distances.

However, the LADEE payload is equipped with only one modem, the lower-speed model best suited for deep-space communications. In addition, LADEE is a short-duration mission. The experiment is expected to operate for only 16 days of the LADEE mission, not enough time to demonstrate a fully operational network, Israel said.

LCRD isn't NASA's first attempt at demonstrating an operational system, either. Before LADEE, NASA had begun developing the Mars Telecommunications Orbiter, but canceled the project in 2005 because of budget constraints. Had it launched in 2009, it would have exhibited high-speed data rates between Earth and several Mars landers and orbiters for as long as 10 years.

With the new NASA commitment to finally field a demonstration, scientists say they could not be more pleased. "This is really a potential paradigm shifter," Garvin said. "It will lower risks, enable smarter spacecraft, and in short provide better value for the taxpayer. It means we have our foot in the door to provide a capability NASA has long needed." ❖

**CONTACT**

David.J.Israel@nasa.gov or 301.286.5294

## Laser Challenges, *continued from page 3*

Earth's atmosphere also presents challenges. Unlike radio waves that travel through clouds, gases, and particulates, laser light is easily scattered when encountering these atmospheric conditions. As a result, one of the demonstration's main goals is determining how many ground-receiving stations the system would need so that at least one can communicate with orbiting spacecraft or a deep-space probe at all times. Team members also will experiment with interrupting transmissions midstream to see if they can resume data transmission once the clouds move.

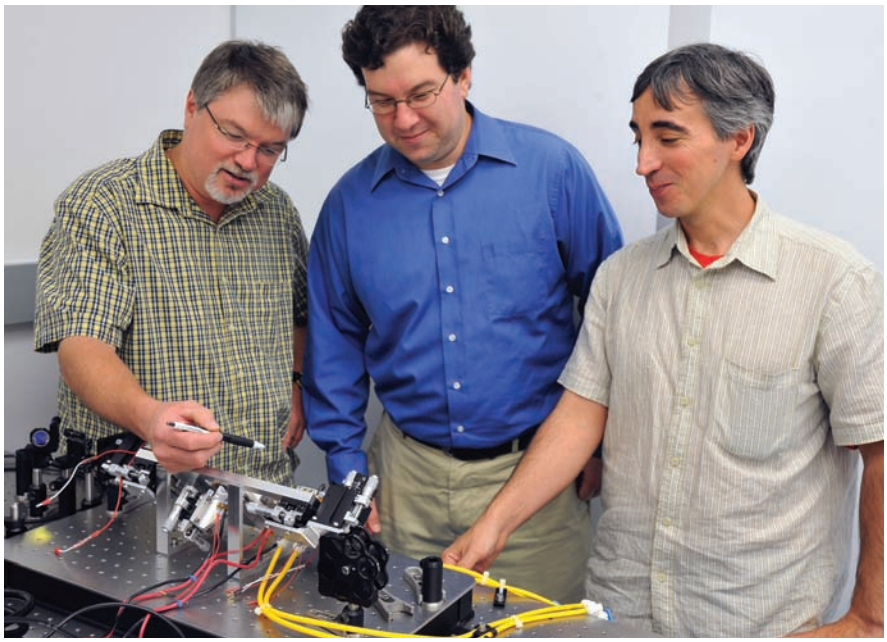
Even in relatively clear skies, turbulence in the air enlarges or moves the spot of light. To compensate for this problem, LCRD will employ high-speed adaptive optics that will detect the light and tweak its path to compensate for atmospheric movement, thereby keeping the light focused on the target.

"The whole point of LCRD is demonstrating its viability and showing how you would build an operational system," said LCRD Principal Investigator Dave Israel. "This, of course, includes showing the technological solutions for overcoming the obstacles." ❖

## Reality, *continued from page 8*

light beams — in effect heating the air around the trapped particle — researchers have shown in laboratory testing that they can move the particle along the ring's center. This technique, however, requires the presence of an atmosphere.

Another technique employs optical solenoid beams — those whose intensity peaks spiral around the axis of propagation. Testing has shown that the approach can trap and exert a force that drives particles in the opposite direction of the light-beam source. In other words, the particulate matter is pulled back along the entire beam of light. Unlike the optical vortex method, this technique relies solely on electromagnetic effects and could operate in a space vacuum, making it ideal for studying the composition of materials on one of the airless planetary moons, for example.



*Goddard laser experts (from left to right) Barry Coyle, Paul Stysley, and Demetrios Poulios have won NASA funding to study advanced technologies for collecting extraterrestrial particle samples.*

The third technique exists only on paper and has never been demonstrated in the laboratory, Poulios said. It involves the use of a Bessel beam. Normal laser beams when shined against a wall appear as a small point. With Bessel beams, however, rings of light surround the central dot. In other words, when seen straight on, the Bessel beam looks like the ripples surrounding a pebble dropped in a pond. According to theory, the laser beam could induce electric and magnetic fields in the path of an object. The spray of light scattered forward by these fields could pull the object backward, against the movement of the beam itself.

"We want to make sure we thoroughly understand these methods. We have hope that one of these will work for our purposes," Coyle said. "Once we select a technique, we will be in position to then formulate a possible system" and compete for additional NIAC funding to advance the technology to the next level of development. "We're at the starting gate on this," Coyle added. "This is a new application that no one has claimed yet." ❖

**CONTACT**

Paul.R.Stysley@nasa.gov or 301.614.5863

## Hitching a Ride, *continued from page 6*

Page 4). Ted Finne, also of NRL, developed the instrument's mechanical design.

Now in demand among scientists studying the ever-changing dynamics of Earth's upper atmosphere, WINCS originally was developed for use on Cubesats. The idea was to deploy the instruments on an armada of these tiny, relatively inexpensive satellites to gather multipoint measurements important for understanding and predicting space weather.

The ability to predict space weather — the atmospheric disruptions caused by energy racing through space by solar wind — is currently about 50 years behind weather prediction, said Nicholas, the WINCS principal investigator on STP-H4. "The models are really data starved."

Goddard technologists currently are integrating and testing seven WINCS units for already-planned Cubesat missions. Just a few weeks ago, the team received an order for another to study Earth's exosphere. The data from all eight will help feed the models. However, Herrero believes STP-H4 will be the first time WINCS actually is deployed in space.

"I commend these guys," said Goddard Chief Technologist Peter Hughes, who provided seed funds for all four technologies through Goddard's Internal Research and Development program. "To truly advance technologies, you need a flight opportunity. They are leaving no stone unturned in their quest to demonstrate their instruments in space, which is precisely what they need to do to show that their technology is viable for future missions." ❖

**CONTACT**

Thomas.P.Flatley@nasa.gov or 301.286.7029
Federico.A.Herrero@nasa.gov or 301.286.9118

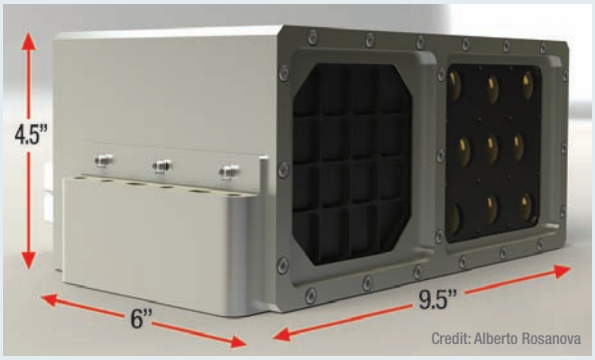
## Opportunity Knocked, *continued from page 8*

orbit for roughly a month, compared with Firestation's one-year sojourn aboard the space station. As a result, Rowland expects Firefly to gather only a tiny fraction of the science data that its sibling will collect. "This represents orders of magnitude better coverage," he said.

Their mission, however, remains the same. With their suite of sensitive photometers to measure lightning flashes, radio antennas to measure the strength of the lighting, and a combined gamma-ray electron detector, both instruments will gather data to find out whether lightning triggers Terrestrial Gamma-ray Flashes (TGFs), a little understood phenomenon first discovered by NASA's Compton Gamma-Ray Observatory in the early 1990s.

Although no one knows why, it appears these flashes of gamma rays that were once thought to occur only far out in space near black holes or other high-energy cosmic phenomena are somehow linked to lightning.

"The fact that they exist at all is amazing," said Rowland, who expects his instruments to observe up to 50 lightning strokes per day, at least one TGF every few hours, and a large TGF every couple days. "The electron and gamma-ray energies seen in TGFs are usually the domain of nuclear explosions, solar flares, and supernovas, not our relatively peaceful atmosphere."




*The Firestation experiment shown here is one of several technologies flying on the International Space Station. Goddard scientists originally developed the technology for a Cubesat mission.*

In particular, Rowland and his colleagues, including the Universities Space Research Association in Columbia, Md., and Siena College, located near Albany, N.Y., hope to find out if lightning triggers TGFs or if they trigger lightning. Could they be responsible for some of the high-energy particles in the Van Allen radiation belts, which damage satellites?

"We'll be getting a fire hose of data, which we think will help answer those questions — 20 million times as much data as a matter of fact, given the higher data rate and longer mission duration. It's going to be a little crazy." ❖

**CONTACT**

Douglas.E.Rowland@nasa.gov or 301.286.6659

# Dan Powell: Tribute to a Tenacious Spirit

In everything that he tackled, Goddard technologist Dan Powell demonstrated the rare ability to inspire, persevere, and overcome what his colleagues thought impossible. He "truly inspired me. He never gave up. He just wouldn't take no for an answer," his colleague, Ted Swanson, recalled.

On September 5, Powell lost his battle to complications caused by pneumonia and died at Johns Hopkins University Hospital in Baltimore, surrounded by his family and friends.

Powell, who began his career at Goddard in 2002 as a structural analyst in the Mechanical Systems Analysis and Structures Branch, championed the use of applied nanotechnology for spaceflight applications. He served as the principal investigator for a flight experiment involving carbon nanotube (CNT)-enhanced polymers and radiation-hardened memory. The memory board successfully flew aboard the Hubble Space Telescope Servicing mission in May 2009 — a groundbreaking demonstration of a CNT-based device in space.

In addition, he cofounded the Greater Washington Nanotechnology Alliance and served as the chairman of the Inter-Organization Nanotechnology Council. An expert in the development of metallic and organic-matrix composite structures, Powell received multiple patents for his work.

The news of his death stunned his Goddard colleagues, who remembered his seemingly unquenchable zest for life and unstoppable drive to make the impossible, possible. During his 36 years — 20 of them spent confined to a wheelchair because of a paralyzing injury he suffered at the age of 16 during a flag football game at a Boy Scout camp — he accomplished so much, his colleagues said. "Despite his physical disability, Dan was bound and determined to move forward. He took a positive spin on everything," Swanson said.

Indeed, during an interview with this publication many years ago, the California native talked about the accident that changed his life. He explained that had it not been for his injury, he probably would have never focused on developing his mind and applying his vast intelligence to developing technologies that would make life better for everyone. In fact, he always continued learning, whether it was pursuing graduate studies in mechanical engineering or collaborating with colleagues from across government and industry on new nanotechnology applications.

"He brought a vitality to the nano program at Goddard. In fact, he put it on the map," said Goddard Chief Technologist Peter Hughes, who worked with Powell closely over the years to fund nanotechnology-development efforts. "I cannot express how he will be missed. Dan was an inspiration to us all. He taught us that nothing, and I mean nothing, can or should stop a man or woman from achieving great things."

His wife, Lori, his mother, Connie, siblings, Holly and Coleen, and his trusted assistant, Ron, survive Powell. ❖

Cutting edge Goddard's Emerging Technologies

***CuttingEdge*** is published quarterly by the Office of the Chief Technologist at the Goddard Space Flight Center in Greenbelt, Md. Formerly known as *Goddard Tech Trends*, the publication describes the emerging, potentially transformative technologies that Goddard is pursuing to help NASA achieve its mission. For more information about Goddard technology, visit the website listed below or contact Chief Technologist Peter Hughes, *Peter.M.Hughes@nasa.gov*. If you wish to be placed on the publication's distribution list, contact Editor Lori Keesey, *ljkeesey@comcast.* NP-2007-10-853-GSFC (revised 10/11)