National Aeronautics and Space Administration

Innovator of the Year

goddard tech trends

Volume 6 | Issue 1 | Fall 2009

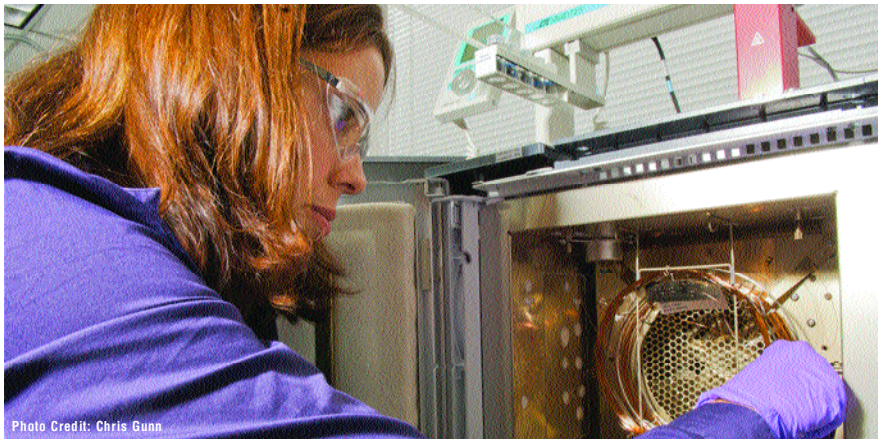
in this issue:

www.nasa.gov

Eigenbrode Earns Chief Technologist's Top Prize

Flatley Wins an Honorable Mention

The Office of the Chief Technologist has selected Goddard scientist Jennifer Eigenbrode to receive its 2009 "IRAD Innovator of the Year" award. Also being recognized is Thomas Flatley, whose contributions earned him and his team an honorable mention for advancing a hybrid computer system that provides 15 to 25 times the processing power of a typical flight processor.



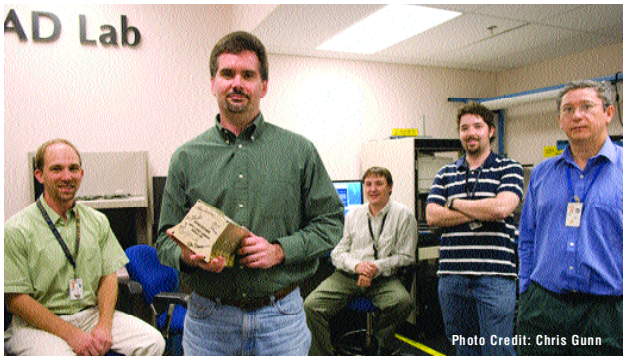
The Office of the Chief Technologist selected scientist Jennifer Eigenbrode as its 2009 "IRAD Innovator of the Year."

"We bestow the awards on IRAD principal investigators who advance NASA's missions and goals," said Chief Technologist Peter Hughes. 'Jennifer's work allowed Goddard to enhance the capabilities of the Sample Analysis at Mars (SAM) instrument. Tom, on the other hand, worked tirelessly to develop spaceborne science and operational capabilities for SpaceCube."

In R&D-funded testing, Eigenbrode demonstrated that thermochemolysis — the combination of heat and a specific chemical — would significantly enhance SAM's ability to analyze large carbon molecules if they are discovered on Mars (see related story, page 3). Her testing led to the inclusion of this alternate chemical processing on the instrument, one of 10 flying on the Mars Science Laboratory. "With the addition of Jennifer's chemical toolkit, the range of organic molecules that SAM can detect has been expanded with no hardware modifications. It provides a promising path to contribute to our understanding of the biological potential on Mars," said SAM Principal Investigator Paul Mahaffy.

SpaceCube, meanwhile, played a pivotal role in the relative navigation experiment carried out during the Hubble Servicing Mission earlier this year. As the Shuttle approached the telescope, SpaceCube ran behind the scenes to help simulate the exacting docking maneuvers. It calculated the position and orientation of the observatory relative to the Space Shuttle. The successful demonstration validated an important navigational capability for future science and exploration efforts (*Goddard Tech Trends*, Summer 2009, Page 3), Hughes said.

SpaceCube also benefits other NASA missions, added Deborah Amato, Goddard's crosscutting technology focus area lead. In November, SpaceCube will be attached to the International Space Station to demonstrate an innovative radiation-hardening technology. Flatley also is demonstrating SpaceCube on an upcoming Earth science flight opportunity in Spring 2012 and is collaborating with a number of industry vendors interested in commercializing the system. ◆



Thomas Flatley and his team received an honorable mention for their work advancing SpaceCube. Team members include (left to right): Dave Petrick, Thomas Flatley, Gary Crum, Alessandro Geist, and Manuel Buenfil.

About The Cover:

Goddard scientist Jennifer Eigenbrode shows the tools she used to validate a new experiment that will fly on the Sample Analysis at Mars (SAM) instrument — an accomplishment that earned her the FY 2009 "IRAD Innovator of the Year" award. Her experiment is expected to provide far more details about the molecular composition of organic compounds should SAM discover them when operations begin on the surface of Mars in 2012.

Photo Credit: Chris Gunn

New Experiment Enhances Ability to Find Life on Mars

Goddard scientist Jennifer Eigenbrode never dreamed that an experiment she developed for analyzing large organic molecules on an alien world would find a berth so quickly on a spaceflight mission. But that's exactly what has happened.

Her experiment has been incorporated into the Goddard-developed Sample Analysis at Mars (SAM) instrument, one of 10 flying on the Mars Science Laboratory. The car-sized rover will launch in 2011 to analyze dozens of samples scooped from the soil and drilled from rocks to assess whether Mars now or ever sustained life.

"Mars was a lot different 3-1/2 billion years ago. It was more like Earth with liquid water," Eigenbrode said. "Maybe life existed back then. Maybe it has persisted, which is possible given the fact that we've found life in every extreme environment here on Earth. If life existed on Mars, maybe it adapted much like life adapted here."

Should the mission find large organic molecules — potential precursors or artifacts of life that are made up of smaller molecules such as carbohydrates, lipids, proteins, and nucleic acids — Eigenbrode's experiment will reveal far more details about their evolution. "Our experiment preserves information on how these molecules formed," she said. "What we'll get are key observations that tell us about organic carbon sources and processing on Mars — shedding light on the planet's carbon cycle. Even if we don't detect signs of life, we might learn why not."

Eigenbrode secured the flight opportunity after successfully proving in a series of R&D-funded tests earlier this year that thermochemolysis — the combination of heat and a specific chemical — would significantly enhance SAM's ability to analyze large carbon molecules if they are discovered on Mars.

Complex Instrument

SAM is considered one of the most complicated instruments ever designed to land on the surface of another planet. Equipped with a gas chromatograph, a quadruple mass spectrometer, and a tunable laser spectrometer, SAM will carry out the initial search for organic compounds when the Mars Science Laboratory lands in 2012. To identify organic compounds, however, the instrument will have to prepare soil and rock samples before it can obtain measurements.

As planned, the rover's robotic arm will scoop up the soil and drill rock samples and a separate mechanism will deliver the samples to SAM's sample-manipulation system, a carousel-like device that contains two concentric rings holding 74 tiny tubes. Once the tubes are filled with the fine-grained samples, the carousel will rotate and insert the tube inside a pyrolysis oven. As the oven heats, the hermetically sealed sample will begin to break down, releasing gases that SAM's instrument will then analyze for potential biomarkers.

There is a catch, however. Although SAM will be effective at identifying organic compounds, heat breaks carbon bonds, resulting in fragmentation and the loss of molecular information. What was needed, Eigenbrode believed, were other ways to prep the samples to prevent fragmentation.

In her quest to find these techniques (*Goddard Tech Trends*, Summer 2008, Page 7), Eigenbrode used Internal Research and Development funds to investigate methods that would give a robotic laboratory operating millions of miles from home the same flexibility and capability of an Earth-based organic geochemistry laboratory. "Sample preparation is the forgotten science in Mars exploration,"

Continued, Page 7

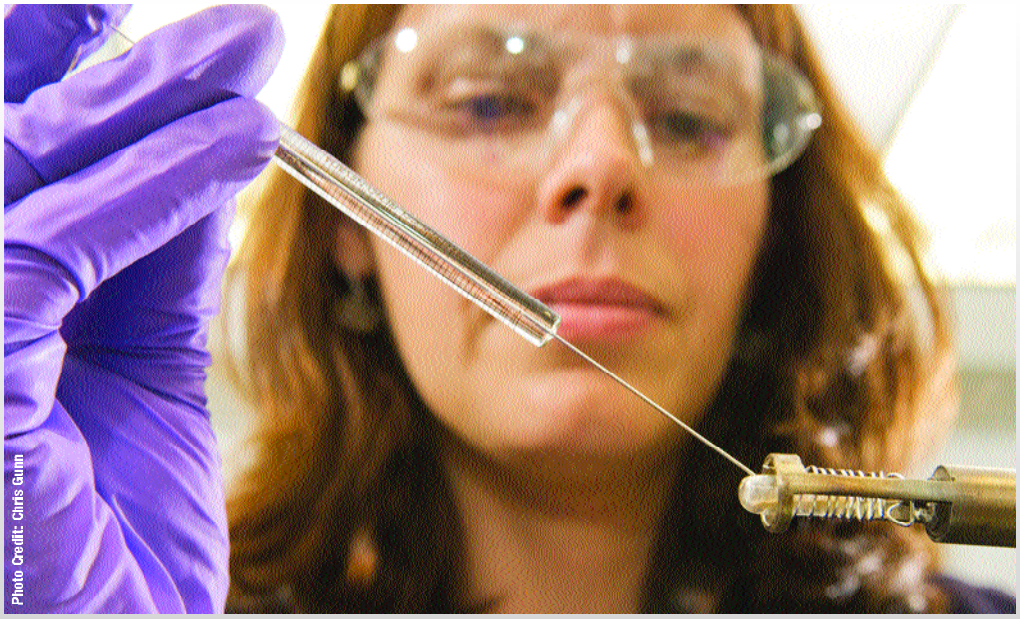


Photo Credit: Chris Gunn

As part of her R&D-funded research, Principal Investigator Jennifer Eigenbrode injected a chemical into a rock sample and then heated the test tube to determine whether the sample-preparation method preserved the sample's molecular structure. Her testing proved successful, ultimately leading to the experiment's inclusion on the Sample Analysis at Mars instrument.

Fast Track to Space

Three Goddard Scientists to Fly Experiments on New Micro-Satellite

Scientists usually follow a certain protocol before flying instruments in space, testing their concepts first in a lab and then as balloon-borne or sounding rocket payloads. Three Goddard scientists, however, have turned that process on its head, hitching a ride on a new NASA-developed micro-satellite that promises to advance space technologies faster and at a dramatically reduced cost.

John Keller, one of the scientists who helped Principal Investigator Michael Collier develop MINI-ME, is pictured here with the instrument before it was shipped to the Marshall Space Flight Center for integration into the FASTSAT spacecraft.

The scientists will be among the first to fly instruments on the Fast, Affordable, Science and Technology Satellite (FASTSAT), an experimental micro-satellite that the Marshall Space Flight Center developed with its industry partner, Dynetics, in just under 11 months. FASTSAT and three other satellites will fly aboard a Defense Department Minotaur IV launch vehicle, designated STP-S26, from Kodiak, Alaska, in mid-2010.

FASTSAT will be flying a total of six instruments, three of which were developed by Goddard scientists. The Defense Department's Science and Experiments Review Board approved all six.

"It is ironic," said Michael Collier, principal investigator on MINI-ME, one of the three Goddard-provided instruments. "Usually you use suborbital platforms to prepare instruments for satellites. But we're proving our concepts on a satellite."

The Instruments

The three Goddard-developed instruments each weigh about 3 kg (6.6 lbs.) and are designed to study different processes in Earth's upper atmosphere and the effects of solar activity in this region — an important scientific line of inquiry given the fact that intense solar activity can disrupt communications and navigation satellites and exert an aerodynamic drag on low-Earth-orbiting satellites and other space assets (see story, page 5, for a description of each).

"This is an area of intense interest to both NASA and the Defense Department," said Doug Rowland, principal investigator on the PISA instrument. "Both are seeking a greater scientific understanding of Earth's atmosphere and knowledge on how it affects technological systems like GPS and cell phone networks."

All instruments were developed with Goddard Internal Research and Development (IRAD) funding to advance their technology readiness levels. The ultimate goal is to fly these miniaturized, low-power instruments on a future NASA mission, said the principal investigators, who delivered their experiments to Marshall in August and early September. The instruments now are undergoing additional testing.

The micro-satellite is about the size of an exercise ball. It specifically was developed to carry Earth-observing and space science missions. And due to its relatively low cost at around $10 million — compared with hundreds of millions for a traditional satellite — the spacecraft is ideal for carrying technology-demonstration payloads.

Fortuitous Opportunity

The scientists called hitching a ride on the micro-satellite fortuitous. When the three scientists began work on their IRAD-funded instruments three years ago, they thought they would be flying on MidSTAR-2, a follow-on to the successful experimental satellite system developed by students at the U.S. Naval Academy (*Goddard Tech Trends*, Winter 2007, page 5). The Academy did not receive funding to build MidSTAR-2, forcing the trio to seek a different platform on which to integrate their instruments.

"The unique confluence of the development of the Goddard instruments, the FASTSAT spacecraft, and the availability of a Defense Department launch opportunity in exchange for experiment results allowed this mission to proceed and become a reality," said John Sigwarth, the principal investigator on the Thermospheric Temperature Imager.

'Real Feel-Good Success Story'

"Most space physicists don't get this type of opportunity in a career," Collier added. "This is a real feel-good success story. We could not have done this without the generosity of a lot of people," he said. "This is the way the IRAD program is supposed to work." ◆

Contact:

Michael.R.Collier@nasa.gov or 301.286.5256
Douglas.E.Rowland@nasa.gov or 301.286.6659
John.B.Sigwarth@nasa.gov or 301.286.0166

Goddard's FASTSAT Payloads

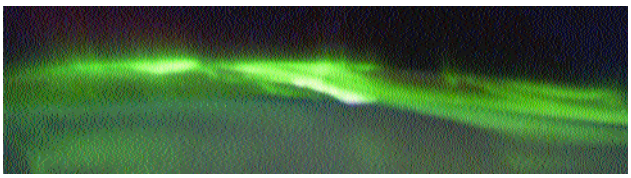
Here is a snapshot of Goddard's FASTSAT instruments:

MINI-ME (Miniature Imager for Neutral Ionospheric Atoms and Magnetospheric Electrons)
— Principal Investigator Michael Collier

MINI-ME, which weighs less than 3 kg. and is the smallest of the three Goddard-provided FASTSAT payloads, will look for neutral atoms flowing up from Earth's ionosphere and into the magnetosphere, the magnetic field that envelops the planet and protects it from the harmful effects of solar wind. In addition to flying on FASTSAT, MINI-ME will fly on a sounding rocket in January 2012 under a $1.6 million NASA award. Again, it will measure the ion population in Earth's upper atmosphere. "FASTSAT and the sounding rocket flight are a great start for this instrument concept," Collier said.

PISA (Plasma Impedance Spectrum Analyzer)
— Principal Investigator Doug Rowland

PISA will accurately measure electron density and temperature in Earth's upper atmosphere — data needed to understand the ways that solar wind produce complex structures and turbulence at high altitudes. These structures can scatter radio waves, disrupting communications with low-Earth-orbiting navigation and scientific satellites. The instrument will study what causes the disruptions and whether scientists can predict and monitor them. PISA is a proof-of-concept of a miniaturized instrument that the principal investigator hopes to shrink further to fit inside an even smaller micro-satellite that is expected to fly in 2012 (see story below).



All three instruments will study aurorae, nature's light show.

TTI (Thermospheric Temperature Imager)
— Principal Investigator John Sigwarth

This revolutionary imager will measure in near real-time the global temperature of Earth's thermosphere, which can heat up and expand during solar storms. Having an instrument that can provide these measurements is crucial for protecting low-altitude satellites. Skylab, for example, plunged to the Earth earlier than expected after a storm-heated atmosphere expanded and exerted an aerodynamic drag on the low-flying laboratory. ◆

Another Goddard Micro-Satellite Mission Under Development

Bigger is not always better, particularly if you're a technologist who needs relatively inexpensive access to space to test emerging new technologies for studying scientific mysteries.

Under National Science Foundation (NSF) funding, scientist Doug Rowland is leading an effort to develop a new nano-satellite mission to explore the relationship between lightning and the sudden releases of energy that occur everyday in the upper atmosphere. First discovered by the Compton Gamma Ray Observatory in the 1990s, these energy releases can be observed only from space.

Rowland's mission, called "Firefly," will explore which types of lightning produce the terrestrial gamma-ray flashes and how often they occur. The end result will be a better understanding of the effect that the millions of lightning flashes have on Earth's upper atmosphere and near-Earth environment.

Rowland expects to launch the experiment in August 2010 on an NSF-funded CubeSat, a tiny satellite that is about the size of a football. The cost to develop, launch, and operate Firefly during its three-year mission is expected to be less than $1 million.

Rowland has other plans for CubeSats. He hopes to further reduce the size of his Plasma Impedance Spectrum Analyzer (PISA) so that he can fly the instrument on a CubeSat sometime in 2012. PISA will make its debut flight on the Fast, Affordable, Science and Technology Satellite in 2010 (see related story, page 4). ◆

Scientist Doug Rowland is leading an effort to develop a new nano-satellite mission to explore the relationship between lightning and the sudden releases of energy that occur every day in the upper atmosphere. He is shown here with a model of the CubeSat spacecraft on which the experiment will fly.

Contact:

Douglas.E.Rowland@nasa.gov or 301.286.6659

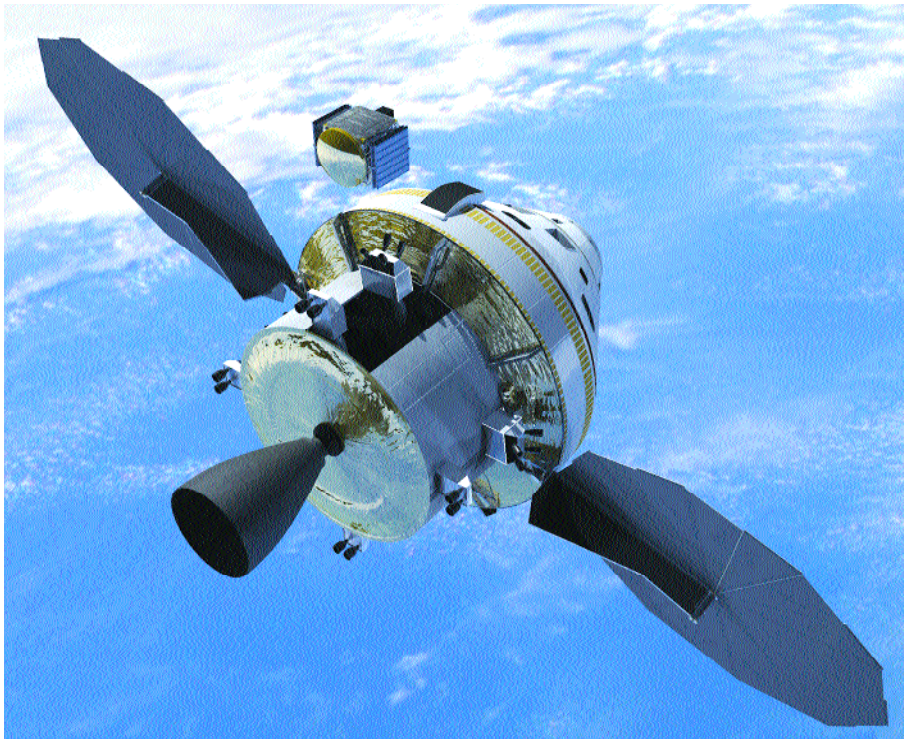
Wanted: A Free Ride into Space

Goddard to Develop Orion Payload Carrier

Goddard is laying the groundwork to provide technologists and scientists with something that they need the most — a free ride to low-Earth orbit.

The Center's Exploration Systems Projects Office recently received a green light to begin planning the development of an unpressurized cargo (UPC) capability that would accommodate science, technology, engineering, and education payloads on the Orion crew exploration vehicle.

"This is a technologist's dream," said Deputy Project Manager Neal Barthelme. "We're providing low-cost, quick access to space" — a capability now in short supply for technologists who need to test prototype components and instruments in space to assure their readiness for actual flight missions.



This artist's rendition shows the Orion crew exploration vehicle and Goddard's unpressurized cargo capability that would accommodate science, technology, engineering, and education payloads.

Flight opportunities formerly were available on the Space Shuttle through the Goddard-managed Shuttle Small Payloads Project (SSPP), which offered free flight opportunities on SSPP's Hitchhiker, Get Away Special, and Space Experiment Module. However, Shuttle cargo space once devoted to these experiments now is allotted to equipment and supplies needed by the International Space Station.

Baselined for Orion Service Module

Although NASA's Constellation Program includes multiple elements, including a lunar lander, for now the UPC capability is baselined for Orion — and more particularly the service module that is mounted directly below the cone-shaped crew module. The service module is large enough inside to accommodate propellant and other life-support necessities as well as a cargo carrier capable of ferrying 600 kg (1,300 lbs.) payloads into low-Earth orbit.

"There is nothing small about UPC," Barthelme added, comparing UPC's payload capacity with Hitchhiker's 600 lbs. "It's capable of carrying Small Explorer-class payloads."

Still in the planning stages, the Goddard team hopes to model the UPC much like the "one-stop shop" service offered by the SSPP. Goddard will build the carrier, work with users to assure compatibility, and integrate the experiments. Three different flight configurations are planned. The system could deploy a free-flyer into low-Earth orbit. It could deliver an extractable payload to the International Space Station. And it could fly experiments on a pallet that would remain affixed to the UPC for the length of the mission.

The pallet mode, however, is only useful to users who want to gather data since the service module is jettisoned just before Orion reenters Earth's atmosphere, preventing experiment recovery.

While users are assured a free ride into space, they would have to secure funds to build and test their experiments, Barthelme said.

Trailblazer Mission Sought

Goddard hopes to begin offering payload accommodations sometime in 2015, and in fact is looking for a "trailblazer" mission to demonstrate one of the UPC's three operational modes.

NASA's decision to make Goddard the lead development organization is a natural choice, added Project Manager Mike Weiss. "We're continuing our rich history of offering low-cost access to space." In addition to developing SSPP, Goddard managed the Apollo Scientific Instrument Module, which flew on three lunar missions.

Given past experience, Barthelme and Weiss are confident of the UPC's ultimate success. "We know that if we build UPC, they will come," Barthelme said. ◆

Contact:

Neal.F.Barthelme@nasa.gov or 301.614.5255

New Experiment...

Continued from page 3

Eigenbrode said. "An instrument is only as good as the sample, and there is no single method for identifying all molecular components."

In FY 2009, she tested rocks similar to those found on the red plant, prepping the sample with a small amount of tetramethylammonium hydroxide in methanol (TMAH), a derivatization chemical mixture used in laboratories for studying organic compounds. She then heated the sample to determine whether the TMAH not only preserved the sample's molecular structure, but also could survive the higher levels of radiation found on Mars. The testing proved successful.

No Technology Hurdles

The tests also proved that the addition of her experiment on SAM posed no technical challenges. Ten of the 74 carousel cups already were reserved for a "wet chemistry" derivatization experiment effective for analyzing free amino acids, the building blocks of proteins.

Seeing the benefit of adding Eigenbrode's sample-preparation method to the overall SAM mission, Principal Investigator Paul Mahaffy and scientists Daniel Glavin (see related story below) and Jason Dworkin agreed to donate two of the 10 cups for her experiment. Just a few weeks ago, the SAM team added and sealed the TMAH chemical inside the two cups.

"When I began working on my concept earlier this year, I thought it might be suitable for a future Mars mission, perhaps in 2016," Eigenbrode said. "I never thought that it would fly so soon on SAM. I believe we have really enhanced the capabilities of SAM should it find organic material. What I really want now is to find macromolecules on Mars." ◆

Contact:

Jennifer.Eigenbrode@nasa.gov or 301.614.5967

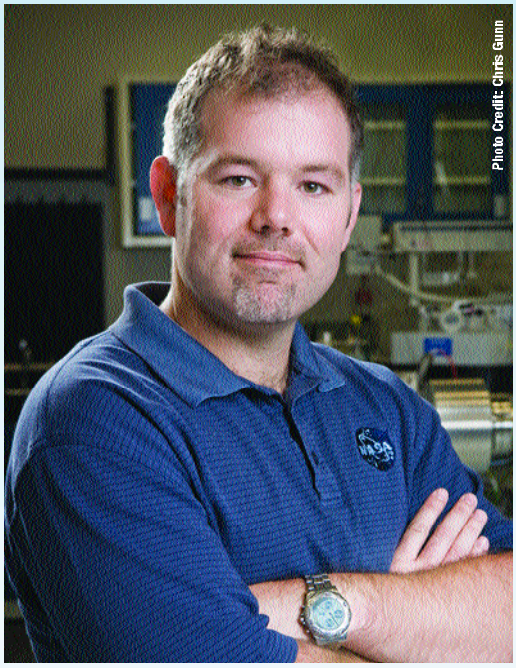
Another Notch on His Belt

Glavin Wins Prestigious Award

Astrobiologist Daniel Glavin, who received the Goddard "Innovator of the Year" prize two years ago because of his work developing a concept of a miniaturized pyrolysis mass spectrometer to analyze gases on other solar system bodies, has carved yet another notch on his belt for scientific achievement.

The Meteoritical Society awarded Glavin the 2010 Nier Prize, which the international organization bestows on young scientists for outstanding research in the field of meteoritics and planetary science. Glavin was recognized for his contributions in the field of extraterrestrial organic chemistry by investigating martian meteorites, carbonaceous meteorites, micrometeorites, and cometary samples, the organization said.

In March, Glavin and another Goddard astrobiologist, Jason Dworkin, published a paper in *Proceedings of the National Academy of Sciences* providing further evidence that the molecular orientation of compounds brought to Earth by meteorites could have determined the world's chemistry long before life began on Earth.



Scientist Daniel Glavin, a past winner of Goddard's "IRAD Innovator of the Year" award, continues to receive recognition for scientific achievement, winning the prestigious Nier Prize.

In particular, the team tackled the question of why living organisms use only the left-handed version of amino acids, the building blocks of all life that come in both left- and right-handed forms. Scientists have long wondered whether life's left-handed inclination arose because of random processes or whether meteorites may have seeded this propensity. To shed light on the mystery the team studied carbon-rich meteorites and found that the left-handed variety occurred more frequently. "Our research showed that meteorites seeding the early Earth could have jumped started life as we know it today," Glavin said recently.

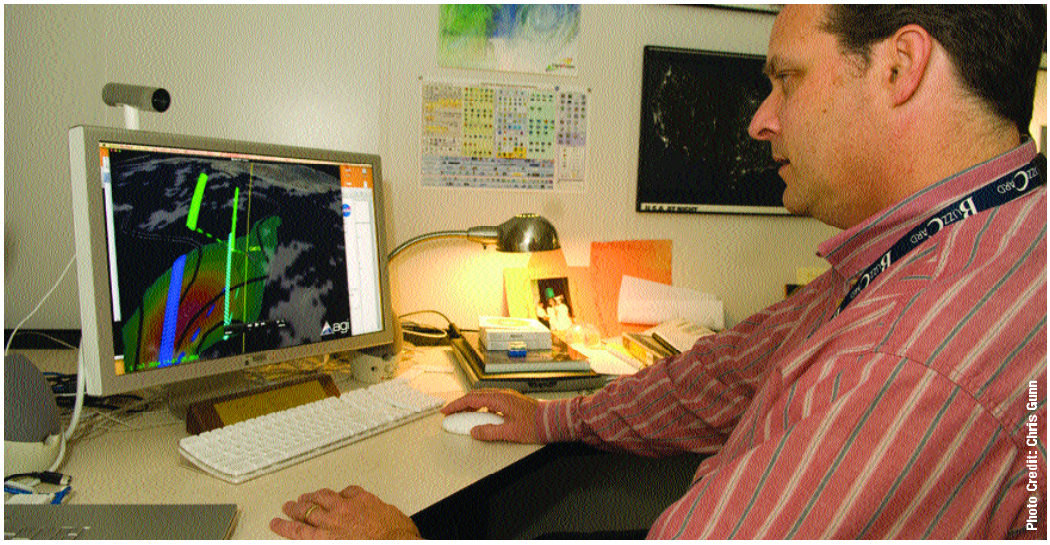
Glavin's knowledge of astrobiology has spilled over into all areas of his professional life. He now is developing a suitcase-sized mass spectrometer that NASA could land on the Moon, Mars, or another solar system body to analyze gases, including organic compounds found in the atmosphere or in rocks and soil. He also is working with a team of technologists building the Sample Analysis at Mars instrument suite that will fly on the Mars Science Laboratory rover. ◆

Contact:

Daniel.P.Glavin@nasa.gov or 301.614.6361

Sensor-Web Simulator Comes Online this Fall

Would sensor-web technology really improve the accuracy of Earth-observing data needed to predict, for example, the weather? That's a question a new prototype technology will help answer when scientists begin testing it this fall.



Technologist Michael Seablom demonstrates a computer modeling technology that he and his team developed to gauge the cost-effectiveness of a future sensor-web system. With sensor webs, scientists would be able to task various satellite and ground sensors to gather measurements where information is needed.

The "sensor-web simulator" will give scientists a powerful new computer tool to design future Earth-observing missions when the prototype system is delivered to the Earth Science Technology Office (ESTO) in November, said technologist Michael Seablom, who, along with his team, built the simulator from existing Goddard technology using research money provided by ESTO.

The question the simulator will help answer is the cost-effectiveness of sensor-web technology, a proposed capability that would allow scientists to task satellite sensors to take targeted measurements while working in concert with others. With current observing systems, scientists only get data when a satellite passes over a particular area, as opposed to where they really need the data, Seablom said.

Seablom and his team began developing the simulator about three years ago to improve the accuracy of weather models. The concept stems from a NASA Earth Science Vision study performed in 2000. Originally, the team set out to build a simulator to evaluate weather forecasters' multiple models and search for discrepancies in data. By knowing where discrepancies existed, scientists then could task various satellite and ground sensors to gather measurements where more information was needed.

"As we progressed, the concept evolved into a tool for gauging the cost-effectiveness of a sensor-web system," Seablom said. With additional ESTO funding, the team is fine-tuning the computer modeling technology and hopes to install a final version in 2012 at the Goddard Integrated Design Center.

"What scientists need to find out is whether sensor webs would provide us with better science, hopefully at a reduced price," Seablom said. "The simulator will help us decide." ◆

Contact:

Michael.S.Seablom@nasa.gov or 301.286.8580

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 11/09)**

Peter M. Hughes
Chief Technologist
301.286.2342
Peter.M.Hughes@nasa.gov

Lori J. Keesey
Editor
301.258.0192
ljkeesey@comcast.net