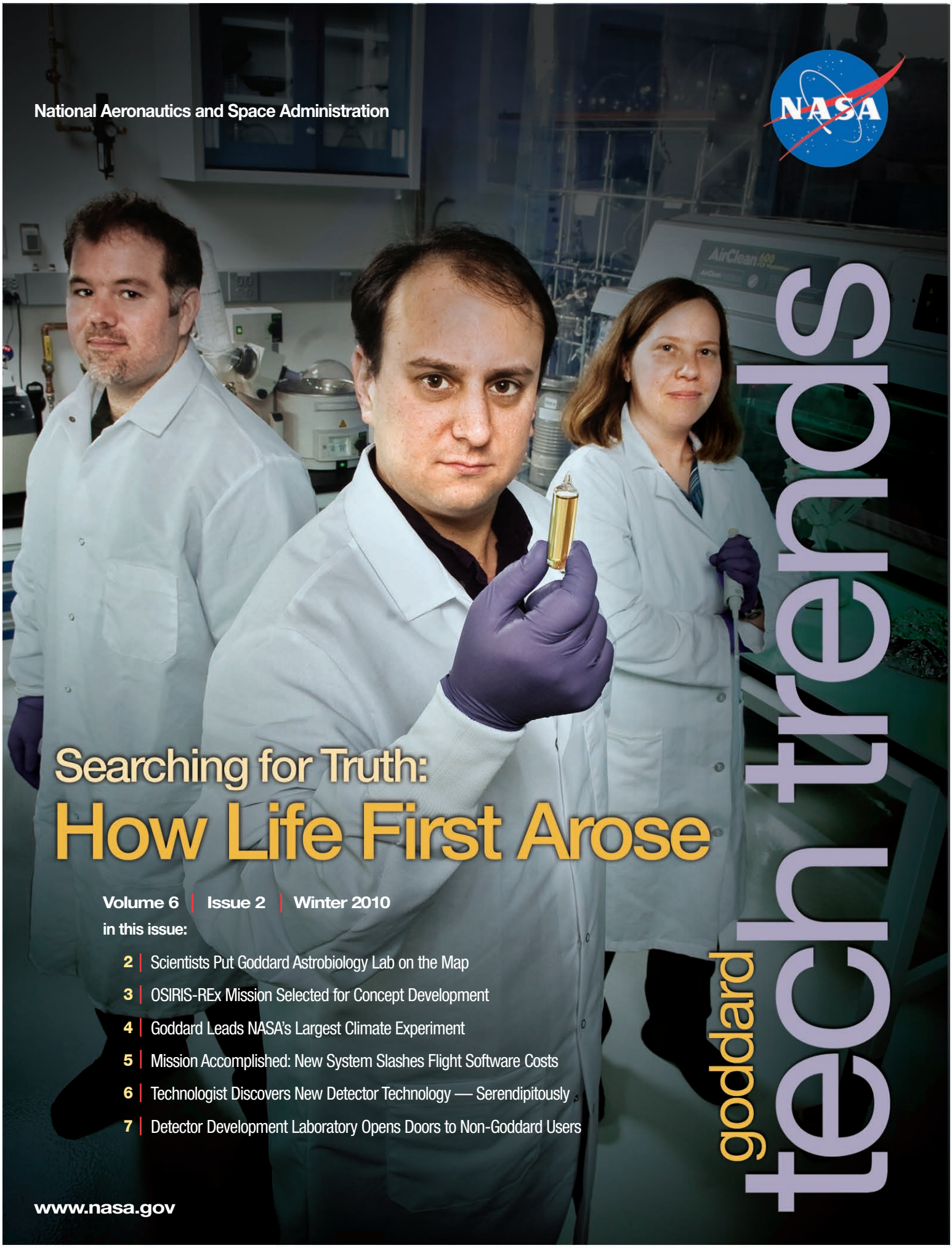

National Aeronautics and Space Administration

goddard tech trends

Searching for Truth: How Life First Arose

Volume 6 | Issue 2 | Winter 2010

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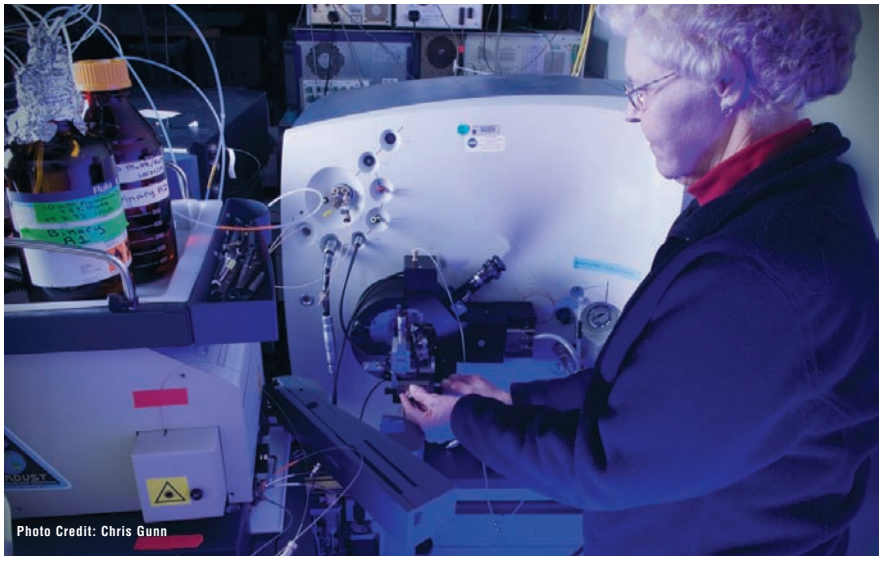
Goddard Scientists Put Astrobiology Lab on the Map

Brook Lakew knew his colleagues at the Goddard Astrobiology Analytical Laboratory had made the big time when he heard a group of academic scientists discussing on a popular radio program the scientific significance of NASA discovering glycine — a fundamental chemical of life — in a comet sample collected in 2004 during the NASA Stardust mission.

The radio interview was just one of thousands of reports aired or published in the national and international media following the announcement of the discovery last year by Goddard scientists Jamie Elsila, Daniel Glavin, and Jason Dworkin.



Technician Millie Martin adjusts an instrument before analyzing amino acids in interplanetary dust particles and cometary grains.

The three, who were instrumental in creating Goddard's astrobiology lab and its state-of-the-art analytical capabilities, studied the Wild 2 comet sample, ultimately finding the glycine through a variety of laboratory techniques. Their discovery is significant because it supports the theory that some of life's ingredients formed in space and were delivered to Earth long ago by meteorite and comet impacts.

"They received wide coverage, huge publicity," recalls Lakew, the associate chief for technology for planetary and lunar science. "What's interesting is the fact that they weren't supposed to evaluate the Stardust samples in the first place. They volunteered their services and little by little showed their capabilities. They ultimately got a share of the sample, which allowed them to make their discovery. In this case, the underdog prevailed."

The lab, and the three scientists who are putting the facility on the astrobiology map, certainly are on a roll.

OSIRIS-REx

Just before the new year, NASA selected the Goddard-managed Origins Spectral Interpretation Resource Identification Security-Regolith Explorer (OSIRIS-REx) as one of three finalists for the Agency's next space venture to another celestial body (see related story, page 3). The OSIRIS-REx team, which is proposing to build the first mission to return a pristine sample from an asteroid, will receive $3.3 million to conduct a 12-month mission-concept study. Should NASA ultimately select the mission as its next New Frontiers mission, Dworkin will serve as the deputy project scientist and organic analysis lead. Glavin will serve as the deputy instrument scientist for the mission's mass spectrometer.

Just as important, the Goddard Astrobiology Analytical Laboratory will get an agreed-upon allocation of the asteroid samples once they are returned to Earth, said Bill Cutlip, who oversees the OSIRIS-REx proposal effort within Goddard's New Opportunities Office.

Even if NASA chooses one of the other two competing New Frontiers missions, Dworkin and his team believe the lab, which moved into more spacious and better-equipped digs in Goddard's new science building last year, will continue to make its mark on the astrobiological community.

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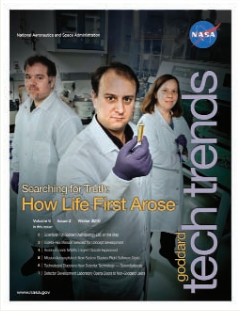


About The Cover:

Scientists Jason Dworkin (forefront), Daniel Glavin, and Jamie Elsila, through their groundbreaking research, have put the Goddard Astrobiology Analytical Laboratory on the map. Should NASA select a Goddard-proposed sample-return mission to an asteroid as its next New Frontiers mission, the lab will be among the first to analyze the sample to determine the source of life. The three are posed here in their new and better-equipped laboratory in the Center's new science building.

Photo Credit: Chris Gunn

OSIRIS-REx Mission Selected for Concept Development

Mission Could Advance Scientists' Understanding of the Origin of Life

The new year started off on a promising note for a team of Goddard scientists and engineers who are key members of a proposed mission that will for the first time in space-exploration history return a large, pristine sample of a carbonaceous asteroid to Earth for detailed analyses.

On December 29, NASA announced that it had selected the Origins Spectral Interpretation Resource Identification Security-Regolith Explorer mission, also known as OSIRIS-REx, as one of three finalists for the Agency's next New Frontiers mission. The other two proposals, managed by the Jet Propulsion Laboratory, include the Surface and Atmosphere Geochemical Explorer. It would gather clues to Venus's early history in part using a mass spectrometer developed by Goddard technologist Paul Mahaffy, who also is building a mass spectrometer for OSIRIS-REx. The third mission is MoonRise, a sample-return mission to the Moon's south pole.

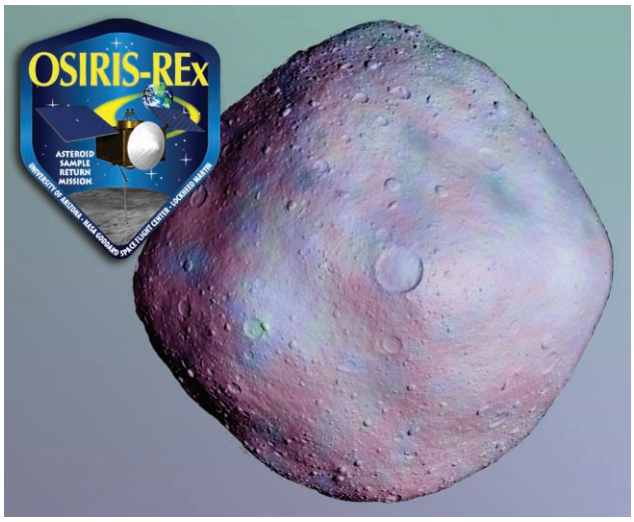
All three teams are receiving $3.3 million this year to conduct a 12-month Phase-A mission concept study. NASA then will select one of the three for full development. The selected mission must be ready for launch no later than December 30, 2018 and must not exceed $650 million, excluding the cost of the launch vehicle.

Goddard will manage OSIRIS-REx's overall development and provide systems engineering and quality assurance as well as the mass and infrared spectrometers, under the direction of Robert Jenkens. Michael Drake, director of the University of Arizona's (UA) Lunar and Planetary Laboratory, will serve as principal investigator and Lockheed Martin will develop the spacecraft, sampling mechanism, and sample-return capsule. In addition to Goddard and UA, Arizona State University and the Canadian Space Agency are providing instruments.

New Era of Planetary Exploration

If selected, OSIRIS-REx will usher in a new era of planetary exploration, said Bill Cutlip, who oversees the OSIRIS-REx proposal effort for the Goddard New Opportunities Office. "OSIRIS-REx's target asteroid is a time capsule from before the birth of our solar system. I can't emphasize enough the significance of this mission. This is going to be the first pristine sample from an asteroid — ever!"

As now conceived, the OSIRIS-REx spacecraft will rendezvous with an organic-rich asteroid after roughly three years of cruising through space. It will map and thoroughly characterize the object using a suite of scientific instruments, including a mass spectrometer provided by Mahaffy and an infrared spectrometer provided by Goddard scientist Dennis Reuter. It then will use its sample mechanism to collect up to 2 kg (4.4 lbs.) of regolith, which will be ferried back to Earth by way of a sample-return capsule that traces its heritage to NASA's highly successful Stardust mission.



The OSIRIS-REx mission would collect a sample from an asteroid similar to the one pictured here in this mathematically created rendition.

"This is a big step for exploration," Cutlip added. "We will be operating around an asteroid for more than a year. The spacecraft will be there sending imagery in near-real time."

Once the capsule lands at the Utah Test and Training Range, samples then will be curated at the Johnson Space Center and distributed to various laboratories for analyses that cannot be duplicated by spacecraft-based instruments or in-situ robotic rovers. The Goddard Astrobiology Analytical Laboratory (see related story, page 2) will be one of the first labs to receive the samples. It also will coordinate the worldwide analysis of samples and controls.

"You can't underestimate the value of a pristine sample," Cutlip added. Meteorites, pieces of asteroids that break away and plunge to Earth, are "toasted on their way through Earth's atmosphere," Cutlip explained. "Once they land, they then soak up the microbes and chemicals from the environment around them." With a pristine sample — especially one from an asteroid type not available in NASA's meteorite collections — scientists will learn more about the time before the birth of our solar system, the initial stages of planet formation, and the source of organic compounds available for the origin of life, said Joe Nuth, OSIRIS-REx project scientist.

Other Objectives

Sample return, however, isn't the only objective.

The mission's organizational structure directly supports NASA's goal to expand the pool of well-qualified principal investigators and program managers. Highly experienced individuals, who are assisted by capable younger deputies, fill all management positions. "Every role has a senior and junior person," said Daniel Glavin, who will assist Mahaffy in

Continued, Page 8

Goddard to Lead the Largest Climate Experiment NASA Has Ever Launched

The latest trend in information technology — tapping into idle computers worldwide to carry out complicated calculations normally reserved for supercomputers — will be showcased in an unprecedented climate experiment that Goddard scientists plan to roll out this spring.

"This is the largest climate experiment NASA has ever launched," said Robert Cahalan, a Goddard scientist who is overseeing the Climate@Home initiative in collaboration with several other government and academic organizations.

The climate experiment, a multi-directorate activity involving Goddard's science, engineering, and information technology organizations, is expected to launch in April when Goddard scientists begin recruiting volunteers worldwide to help quantify the accuracy of the Agency's global climate models. Volunteers will run the complex simulations on their computers and other computing devices. Never before have scientists attempted to recruit so many people to help perform research vital to forecasting the Earth's climate in the 21st century.

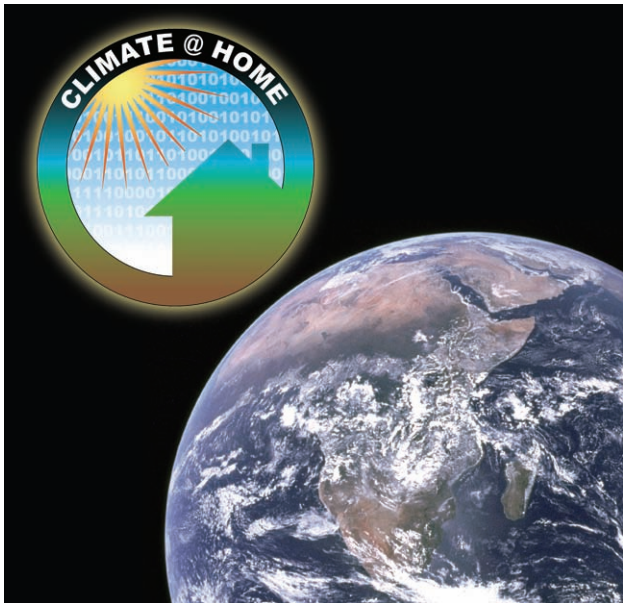
"We're reaching out to the public to help us explore how climate may change in the next century under a wide range of different situations," said Michael Seablom, a Goddard technologist who is managing the initiative's software and integration requirements. "By tapping into volunteers' computers, we will be able to increase our confidence in climate change predictions more than would ever be possible using the supercomputers currently available to scientists."

Testing Different Scenarios

To test the sensitivity and accuracy of these models, scientists run millions of calculations, each computing a different scenario or combination of circumstances — such as varying levels of chlorine or water vapor in the atmosphere. With these calculations, scientists are able to better understand the uncertainties in their climate model and its ability to forecast future climate.

Instead of using supercomputers, however, Goddard scientists want to create a virtual supercomputing network that would spread the data-processing chores across thousands of computers — an approach that technologists often refer to as "cloud computing." Such a task-sharing initiative would eliminate the need to buy additional supercomputers and reduce energy consumption. NASA believes the cost savings from tapping unused desktop computers could be as high as $5 million.

Participants will be able to obtain the necessary software and instructions from a NASA Web site soon to go online. The model will run automatically as a background process whenever computers are on, but are not being used to their full capacity.



Modeled After Other Projects

Although the project is new to NASA, the idea has been tried before. In fact, Climate@Home will have the option of using the same computer architecture developed for "SETI@Home," a scientific experiment that uses Internet-connected computers in the Search for Extraterrestrial Intelligence (SETI) program.

The initiative also is modeled after a similar project coordinated by the Oxford e-Research Centre in the United Kingdom. Launched in 2002, "climateprediction.net" has attracted nearly 45,000 participants worldwide to run calculations testing the sensitivity of a model created in the United Kingdom. NASA's program, however, is designed to test the accuracy of a model developed by the Goddard Institute of Space Studies in New York. Climate@Home also will explore the accuracy of other models.

"This way, we can get a lot done for a fraction of the cost because we are harvesting idle processors," Seablom said. "Our overarching goal is to execute a super-ensemble of climate forecasts by tapping into idle processors on thousands of desktop and other computing systems in homes, offices, and schools." ◆

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Mission Accomplished:

Goddard Fulfills Goal of Developing System to Slash Flight Software Costs

A band of Goddard technologists is about to fulfill a long-time Goddard ambition: Streamlining the arduous and costly process of developing software to handle routine spacecraft tasks and ultimately reducing mission costs and development time.

Within just a few weeks, Goddard's Flight Software Systems Branch plans to complete and roll out the last remaining component of its Core Flight Software (CFS) system, a mission-independent, reusable flight-software environment that the branch began creating more than five years ago in part with Goddard R&D funding.

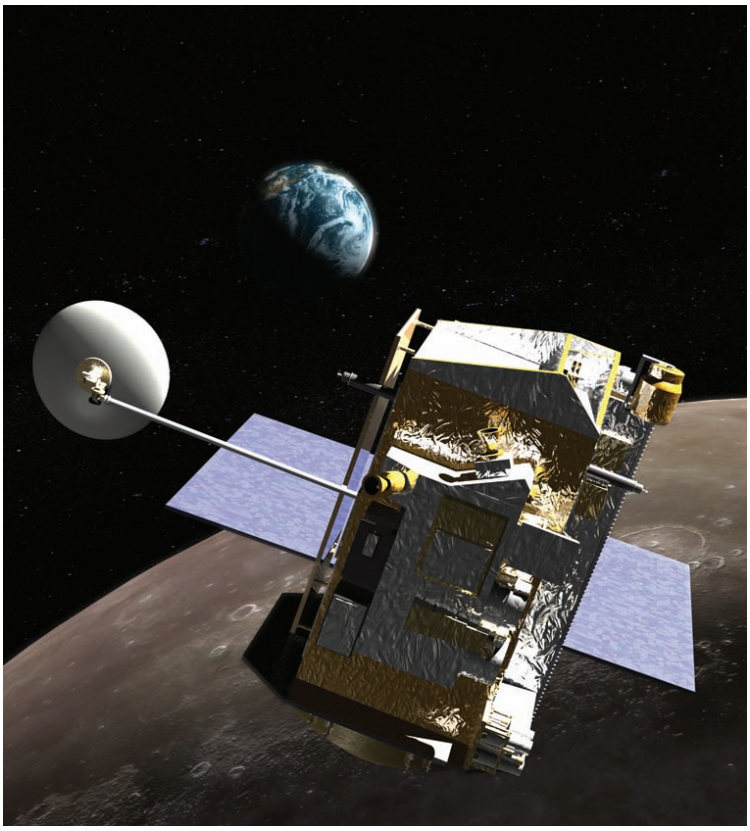
"We attempted to reuse flight software in the past, but only achieved limited success," said Barbie Medina, CFS lead, adding that users can enjoy a 30-percent reduction in software-development costs using the system. "I believe we've truly developed a technology that will help us go where we need to go."

CFS provides an automated system that offers proven software for such routine tasks as telemetry processing, health and safety monitoring, commanding, and data storage, just to name a few. The obvious benefit is that missions do not have to dedicate valuable resources to developing commonly reused software. Instead, they can use their resources to develop greater functionality onboard their spacecraft. Furthermore, systems can be up and running in just a few weeks, not months as was the case before. "If missions keep reusing software, the reliability ratings go up. This allows Goddard, and anyone using it, to be more competitive, particularly in proposal efforts," Medina added.

The branch initially released the Core Flight Executive (cFE) — the cornerstone upon which all CFS components sit — in 2005. It provides generic onboard software services. Because its internal workings are carefully layered, users enjoy a "plug-and-play" environment where they can swap or update software and hardware without shutting down the entire system.

Over the years, the branch made available an ever-growing library of flight-proven flight software as part of its CFS reuse library. With the addition of the final package in late February or early March, 11 commonly used flight software applications will be available to users.

Since the roll out of the capability, the CFS system has attracted a growing number of users. The Goddard-developed Lunar Reconnaissance Orbiter was the first to adopt cFE, followed by the Radiation Belt Storm Probes mission, managed by the Applied Physics Laboratory (APL).



The Goddard-developed Lunar Reconnaissance Orbiter mission was the first to use a new system that reduces flight software costs.

As the system became more robust with the addition of flight-proven software, it attracted more users. The Goddard-developed Magnetospheric Multiscale and the Global Precipitation Measurement (GPM) missions are using both the cFE and the flight software applications, as is the Ames Research Center, which is managing the Lunar Atmosphere and Dust Environment Explorer mission. In addition, Goddard's Innovative Partnerships Program office has established cFE usage agreements with APL and the Marshall Space Flight Center. The Langley Research Center, meanwhile, is evaluating cFE for use in a proposed Earth science mission.

The benefits to these missions already are clear. "Within two weeks of licensing the system, GPM had completed a substantial part of its command and data handling software," said Maureen Bartholomew, who originally served as the CFS product-development lead.

"We have proven to be the experts in flight software development," Bartholomew said. "CFS has distinguished Goddard as the lead." ◆

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SPECIAL REPORT: Detector Technology

For the past two decades, Goddard has established a considerable reputation for building technologies that allow scientists to sense natural phenomena, such as photons, and convert them into a representation of what the instrument saw at the spacecraft.

This investment in detector technologies has led to scientific discoveries literally across the electromagnetic spectrum. Here, Goddard Tech Trends showcases one of those technologies, including the laboratory that has made these advances possible.

A Serendipitous Discovery

Goddard Technologist Advances Microcalorimeter-Detector Technology

If you're the best in your business, how do you stay on top? To use a cliché, you build a better mousetrap.

Goddard technologist Wen-Ting Hsieh is attempting to do just that. While working to advance a new technology that senses X-ray photons, she and her team serendipitously discovered in 2009 yet another approach that could further revolutionize NASA's ability to build large-format, highly sensitive detector arrays that contain millions of pixels.

Goddard technologist Wen-Ting Hsieh serendipitously discovered another technology that could further revolutionize NASA's ability to build large-format, highly sensitive detector arrays that contain millions of pixels.

According to Hsieh, the discovery happened while she was fabricating a metallic magnetic microcalorimeter (MMC) under an Internal Research and Development (IRAD) program award — a discovery that could cement Goddard's sizeable expertise in microcalorimeter-detector technology.

Microcalorimeters, pioneered at Goddard and first flown on the U.S.-Japanese Suzaku mission, operate under a simple principle. When an incoming X-ray hits the microcalorimeter's absorber, the X-ray's energy is converted to heat that a thermometer then measures. The heat is directly proportional to the X-ray's energy, revealing much about the physical properties of the astrophysical objects emitting the radiation.

Instead of relying on more traditional thermometers — even the state-of-the-art transition edge sensors (TES) made of superconducting film — MMCs use magnetism to determine the photon's energy. The advantage is that heat does not dissipate the way it does with TES-based microcalorimeters. The significance of non-existent dissipation is that technicians can more easily increase the number of pixels in the MMC detector array.

"Scientists would like tens of thousands or even millions of pixels," explained Carl Stahle, the assistant chief for technology for the Instrument Systems and Technology Division, adding that more pixels mean higher-resolution images and spectroscopic measurements. MMC technology, which Hsieh is developing in collaboration with scientist Simon Bandler, currently offers the best hope for achieving these detector sizes, Hsieh said.

Hsieh discovered the new technology when she inadvertently applied too much niobium adhesive onto an MMC array. In subsequent tests and experiments, she and her team realized that they had produced a microcalorimeter that detected X-rays through the superconducting properties of a thick niobium layer — a different physical mechanism than originally intended.

That chance niobium coating has since led to another IRAD that broadens the scope of her MMC work. In addition to her original task, Hsieh is now developing a new type of spectrometer — the magnetic penetration depth thermometer (MPT), which is highly sensitive and suitable for large arrays. Although others have proposed the MPT technology, no one had proved the MPT could work — until Hsieh and her team made the identification.

"We still got great results with the planned MMC," Hsieh said. "I'm glad we made the mistake. This will take us to a new stage in detector-technology development." ◆

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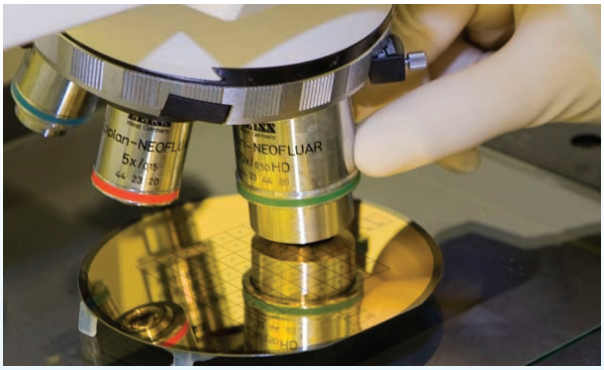
The Source of Goddard's Detector Excellence

Facility Offered to Non-Goddard Users

Why has Goddard established a reputation for excellence in detector development? Carl Stahle, assistant chief for technology for the Instrument Systems and Technology Division, believes much of the credit should go to one organization — the Detector Development Laboratory (DDL).

"The DDL's capabilities really are the engine," Stahle said. "If we didn't have this capability, we couldn't do what we do."

Since it opened its doors 15 years ago, the lab has served as the go-to facility for principal investigators building custom instrument-detector systems under Internal Research and Development program awards, NASA Research Announcements, and flight projects. "Most of what we do in the DDL is to develop custom detectors. It's our niche," Stahle added. As a result, the facility over the years has equipped the 24,000-square-foot lab with specialized machinery, tools, and cleanrooms that are especially ideal for prototyping and developing new detectors, micro-electro-mechanical systems, and nanotechnology devices.



A Goddard technologist uses an optical microscope to inspect a silicon wafer between detector fabrication steps at Goddard's Detector Development Laboratory.

Wearing a "bunny suit" and working on a clean-bench, a fabrication engineer inspects and selects silicon wafers for processing.

This wide-ranging capability is now being offered to non-Goddard users.

With support from Goddard's Innovative Partnerships Program Office, the lab has begun marketing its capabilities to U.S. companies, universities, and other government agencies, which could tap into the resource through a Space Act Agreement. "We're focused on getting companies and others to send their people to us for training," explained Thomas Stevenson, the primary point of contact for the lab. "Company personnel can carry out their work alongside our users." ◆

For more information, visit http://detectors.gsfc.nasa.gov/DDL/.

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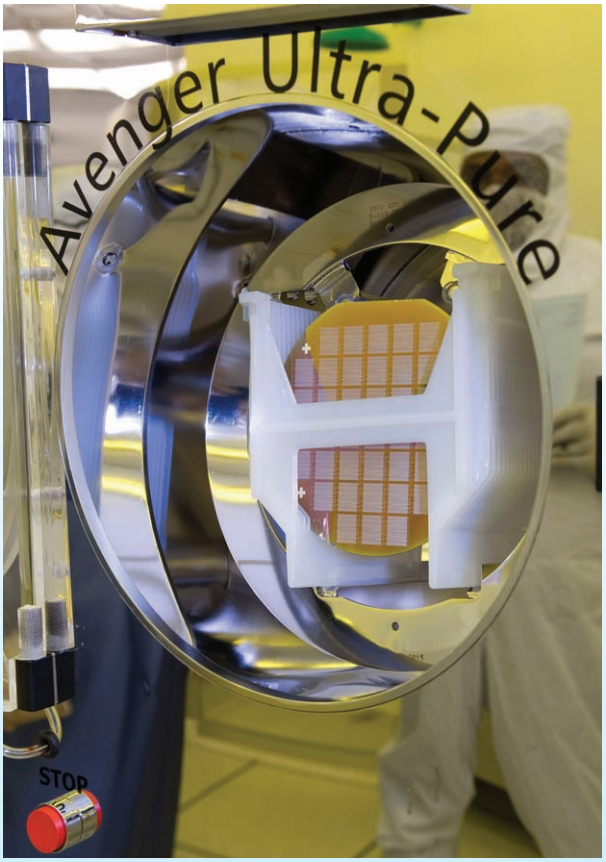
All photos by: Bill Hrybyk



Following a wet-processing step at the Detector Development Laboratory, technicians load a cassette holding silicon wafers into a spin-rinse dryer, which will flush away traces of chemicals with ultra-pure water and then dry the wafers with heated nitrogen gas.

Astrobiology Lab... Continued from page 2

The team was instrumental, for example, in identifying weaknesses in NASA's sample-storage procedures. The Agency has since adopted the lab's recommendation of using Mylar instead of nylon bags to assure contamination-free storage of any carbon-rich samples gathered from another celestial body. "Our lab is unique in NASA," Elsila agrees. Although other academic and private-sector institutions offer analytical capabilities, Goddard's facility offers "an assemblage of instruments that are dedicated to one purpose: Searching for clues of how life first arose," Dworkin adds.

Academic Reputation Grows

The lab is staying true to its mission. Earlier in 2009, Glavin and Dworkin, who both received Goddard R&D funding to advance instruments and techniques to study organic compounds, published a paper providing further evidence that the molecular geometry of compounds brought to Earth by meteorites could have determined the world's chemistry long before life began on Earth.

This announcement came on the heels of yet another important discovery. In 2008, Dworkin and Glavin, in collaboration with the Scripps Institution of Oceanography, Indiana University, Carnegie Institution of Washington, and the Universidad Nacionale Autónoma de México, used the lab to analyze samples involved in a famous experiment conducted in the early 1950s by Harold Urey and Stanley Miller. In the original Miller-Urey experiment, the renowned scientists showed that natural processes, like lightning, could have provided the energy for simple molecules to reassemble into more complex amino acids necessary for life. In Dworkin and Glavin's analysis of samples from the original experiment, the pair ultimately discovered 22 amino acids. Ten never had been found in any other experiment like this.

Dworkin, Glavin, and Elsila say more academic papers are in the pipeline. In fact, Glavin plans to present another paper involving a meteorite discovered in the Sudan at the Lunar and Planetary Science Conference in early March. Whether these research efforts generate the same level of worldwide acclaim remains to be seen. "We'll see," Glavin says.

In the near term, the lab will concentrate on advancing its considerable expertise in analyzing terrestrial analogues — samples collected from places on Earth that are similar in nature to those on Mars — and studying meteorites that have plunged to Earth, the scientists say. As Dworkin explains, the work helps the team refine which techniques to use when NASA carries out another sample-return mission — whether it's to another planet or an asteroid.

"It keeps us in practice. When that day comes, we'll be ready," Dworkin says. "No pun intended, but we do have the right chemistry with our people. We're here because we want to be here," Glavin added. ◆

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OSIRIS-REx... Continued from page 3

the development of the mission's mass spectrometer. "We want sustainability, which is especially important since the data will not be returned until 2023," Glavin said.

The OSIRIS-REx samples will be available to generations of future scientists, just as samples brought back from the Moon during the Apollo program are available to scientists today.

The mission also wants to make sure it is proposing the best possible team, Cutlip added. Drake will serve as principal investigator, with Dante Lauretta of UA as his deputy. Nuth, meanwhile, will serve as the Goddard project scientist, supported by Jason Dworkin, who also directs Goddard's Astrobiology Analytical Laboratory. In addition, Lockheed Martin has an unmatched legacy of success building robotic sample-return missions, including Genesis and Stardust, Cutlip added.

"If you're going to do sample return, this is the team to do it with," Cutlip said. ◆

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Goddard Tech Trends

Goddard Tech Trends is published quarterly by the Office of the Chief Technologist at the Goddard Space Flight Center in Greenbelt, Md. 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.

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