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Goddard Tech Trends

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Laurie Leshin Speaks on Technology

As the Director of the Sciences and Exploration Directorate at the Goddard Space Flight Center, Laurie Leshin leads the largest science organization within NASA and is responsible for ensuring the scientific integrity of NASA's Earth-observing missions, space-based telescopes, and instruments exploring the Moon, Mercury, Mars, Saturn, comets, and other astronomical objects. Leshin began her career as a cosmochemist primarily interested in deciphering the record of water on solar-system objects. Recently, she talked with Goddard Chief Technologist Peter Hughes about technology development and her views on where it's headed.

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In your capacity as the director of NASA's largest science organization, how do you view technology development at Goddard?

What I'm impressed with about technology development here at Goddard is how well the scientists and engineers work together to solve technical problems. The engineers are oriented to solving big science questions and interested in moving science in the right direction. That is an absolute pleasure to see. It's a powerful combination.

What previous technology investments do you see as particularly valuable?

Certainly, our investments in laser technology continue to be very important for advanced communications and Earth and planetary sciences, including lunar exploration. In the area of astrophysics, I would say mirror development and microcalorimeters are among the most valuable. And, of course, metrology for LISA will really stretch our imaginations. There are real technical challenges there. Our investments in mass spectrometers are important to planetary science, as are sensor webs to heliophysics. Overall, however, miniaturization has to be a focus for us; it affects everything we do. To gain access to space, we must fly smaller and smaller payloads. Now, I'm sure I'm missing some important technologies, but these are some obvious ones that come to mind now.

Photo Credit: Chris Gunn

Is it important for Goddard to fund long-term, low technology readiness level (TRL) ideas, and if so, why and on what?

We always need to look for that next great revolutionary idea. However, because of tighter budgets, we'll have to continue our focus on shorter-term technologies. Do I think this is the optimum? No, I don't. Over the past 7 years, we've seen our low-TRL funding avenues whittled away. The question is how much of our seed corn are we eating? Though the current situation is not ideal, I think there's still a lot we can do with the technology investments we're making. But I think another issue is at play here, too. There's not a clear delineation as to what Headquarters should fund in terms of higher-risk, long-term technology development. Some low-TRL technologies Headquarters should fund. That's my position.

Photo Credit: Chris Gunn

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On The Cover:

As the Director of Goddard's Sciences and Exploration Directorate, Laurie Leshin leads NASA's largest science organization. In a recent conversation with Goddard Chief Technologist Peter Hughes, she discussed technology R&D at Goddard, describing some of the technologies that are important strategically to the Center, and forecasted where she thought investment spending was headed.

Photo Credit: Chris Gunn

Wavefront Sensing and Control Group Savors Success

JWST Enabling Technology Attracts the Interest of Others

It's been a good year for Goddard's Wavefront Sensing and Control Group, the band of technologists who delivered an advanced algorithm for aligning the James Webb Space Telescope's (JWST) multiple mirror segments so that they operate as a single mirror system once the observatory begins operations early next decade.

During a demonstration with Ball Aerospace's high-fidelity testbed telescope — a one-sixth scale model of JWST — the software performed as designed. As a result, JWST's end-to-end optics commissioning system achieved a technology readiness level of six (out of nine) under NASA's method for determining the maturity of new technologies. That means the software, called the Hybrid Diversity Algorithm (HDA), is ready for flight-qualification testing leading up to JWST's launch in 2013.

Members of Goddard's Wavefront Sensing and Control Group include (from left to right): Ron Shiri, Timo Saha, Chuck Strickland, Bruce Dean, Jeff Scott Smith, and David Aronstein.

Other Potential Users

In addition, the U.S. military and the National Radio Astronomy Observatory have expressed interest in using the technology for their applications, and market research conducted for Goddard's Innovative Partnerships Program Office by a North Carolina-based company revealed that the technology had excellent market potential across multiple industries. A private company already has contacted Dean about possible licensing, he said.

And just recently, the group won mid-year funding under Goddard's Internal Research and Development (IRAD) program to develop an enabling technology for laser-based communications. Although the group won't use its HDA technology directly in the effort, it likely will use it as a monitoring tool to insure that the laser technology is

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James Webb Space Telescope to Fly Other Ground-Breaking Technologies

When the James Webb Space Telescope (JWST) reaches its orbit about a million miles (1.5 kilometers) from Earth and begins studying the distant reaches of the universe, the event will mark an unprecedented triumph on several technological fronts.

Aside from its 21.3-foot (6.5-meter) primary mirror — the largest and lightest ever flown — JWST will fly a deployable multi-layer sunshade. This tennis court-sized structure will block sunlight and prevent the cold section of the observatory from exceeding -375° F (-233.3°C) — the temperature needed to detect faint infrared light from distant astronomical objects and reveal more about the formation of planetary systems.

The microshutters used on the observatory's Near Infrared Spectrograph also represent another technological breakthrough. They, too, achieved a technology readiness level rating of six following an important demonstration test earlier this year. Originally conceived with Goddard R&D funding, the microshutter array consists of 62,415 tiny shutters arranged in a waffle-like

silicon grid. Through the application of a magnetic force, these shutters — each about the width of a human hair — open or close to allow or prevent starlight from entering the spectrograph. This way, astronomers can gather light from only those objects they want to study.

JWST also is flying a super-cold mechanical cyrocooler to keep instruments cool and state-of-the-art infrared detectors. ◆

The ILIADS and Lunar Odyssey

Goddard and USA Join Forces to Create New Exploration Tool

It's June 2019. A remotely controlled lunar rover dispatched to collect water-ice samples from a site more than 12 miles (20 kilometers) from NASA's lunar outpost has encountered mechanical difficulties. A team of astronauts must now venture out to either repair the rover or, at the very least, retrieve the scientifically precious samples and bring them back to the outpost near the rim of Shackleton Crater on the Moon's South Pole.

Plunging temperatures colder than those on Pluto, the lack of sunlight, potentially perilous terrain, and razor-sharp microscopic dust grains that can be lofted high above the lunar surface and travel at hurricane-like speeds could make the trip difficult.

Consequently, mission planners on Earth will have to plot the astronauts' journey in excruciating detail — a task that will require a novel, all-in-one software package that provides easy access to both geographic and environmental data as well as mission-planning applications. Without this special software, it would be risky to launch a rescue mission of the multi-billion-dollar rover system.

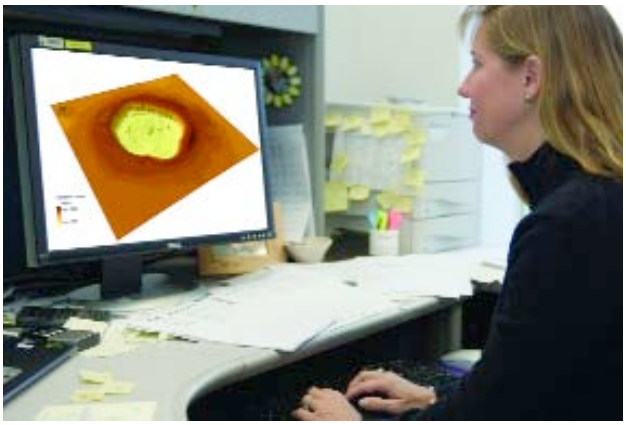
Collaborative Effort

That's precisely what technologists at the Goddard Space Flight Center and the United Space Alliance (USA) are developing under a collaborative effort that has attracted the attention of the NASA Exploration Systems Mission Directorate, which could use the software to select potential lunar landing sites in the near term and plan and carry out human sorties from the U.S. outpost in the long term.

The capability, which the partners recently demonstrated at a National Space Symposium conference in Colorado Springs, is actually a combination of two separate software tools that Goddard and USA originally developed under their own Internal Research and Development programs. They plan to complete a prototype by the end of the fiscal year, said Julie Loftis, the Goddard Principal Investigator.

The Goddard contribution is a geospatial information and analysis system named ILIADS. It will give users access to three-dimensional information about all aspects of lunar terrain on human scales, topographic contour maps that reveal rover-scale slopes, precise surface distance and elevation measurements, in-situ resource and terrain hazard maps, and other important environmental data about the Moon, including the dynamics of space weather and illumination. The USA portion is an extensible management and planning software tool that the Houston-based company developed for Space Shuttle operations.

The two teams decided to collaborate after discovering that their products could become more powerful as a single, all-in-one capability, Loftis said. "We were delighted to learn that not only were the products complementary, but the expertise of the two organizations was complementary, as well. Goddard can provide the applied scientific knowledge, which will be needed for lunar surface mission operations."



Principal Investigator Julie Loftis looks at the type of lunar geographic data that ILIADS could make available to NASA mission planners now and in the future. The ILIADS project is a joint effort with United Space Alliance.

Combined GIS and Mission Planning Capability

Late last year, team members received funding under Goddard's Innovative Partnerships Program Office to modify their products so that they would work together. Goddard is adjusting ILIADS so that its server, server interface, and datasets are available to USA's Questus™. USA, meanwhile, is modifying its software to support ILIAD's lunar environmental data. With these modifications, including a continuous zoom-and-pan function, users will be able to visually specify geographic areas on the Moon and quickly retrieve more specific data about those regions, and one day entertain "what if" scenarios involving human operations at such sites.

The team hopes to complete the integration in time for the NASA Lunar Reconnaissance Orbiter (LRO), a Goddard-led and developed mission that will spend a year mapping the Moon after its launch in late 2008.

"All LRO data will go to the competitively selected instrument principal investigators," said Goddard Co-Investigator Steve Talabac. "It will then be archived into the Planetary Data System. Using ILIADS, however, NASA mission planners and scientists will be able to access the data to choose landing sites and perform analyses. ILIADS will make the data easily useable for a new customer base that traditionally has not been able to use archived planetary data." ◆

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Where Dust Rules

Contamination and Coatings Engineering Branch to Build Dust Chamber

Although scientists and engineers can't physically go to the Moon or Mars to study the harmful effects of the severe dust conditions there, they will get access to the next best thing.

With funding from Goddard's Internal Research and Development program and the Exploration Systems Mission Directorate (ESMD), engineers with the Center's Contamination and Coatings Engineering Branch have teamed with Goddard's scientists to build a one-of-a-kind chamber that will simulate the harsh environments on both extraterrestrial worlds.

"Under the Vision for Space Exploration, we're tasked with getting instruments and mechanisms to work in these environments. We needed a facility to determine what these effects are," said Principal Investigator Sharon Straka, explaining the genesis of the project. "That way, we can do a better job of developing viable mitigation and protection solutions."

Opening this Summer

Slated to open this summer, Goddard's new Dusty Environmental Effects Particle (DEEP) Chamber to be housed in Building 4 will allow researchers to study and characterize the effects of lunar and Martian dust on spacecraft surfaces, including degradation-sensitive mechanisms, instrument surfaces, microshutters, optics, solar arrays, and thermal control and other coatings. It also will give scientists a venue for testing their theories on how dust travels and levitates, particularly on or near the lunar surface, she said.

Though unique, Straka said DEEP capitalizes on lessons learned from an existing dust chamber used by Goddard's Sample Analysis at Mars (SAM) instrument team, which is using a much smaller chamber to test valves and filters. SAM is flying on the Mars Science Laboratory a large mobile rover that will analyze soil and rock samples using the most advanced equipment ever used on the planet's surface. New exploration requirements, however, dictated that a much larger facility become available to test instruments and other larger components.

Larger Facility

As a consequence, Goddard's new facility — measuring 4 feet (1.2 meters) in diameter and 6 feet (1.8 meters) in length — is significantly larger than dust facilities operated at other NASA centers. Because of its size, it will be capable of accommodating everything from instruments and large components to space suits.

Straka also said it was purposively designed to handle a diverse set of experiments both at atmospheric pressures and in a vacuum. It will come equipped with external ports to accommodate manipulators, lasers, detectors, and other non-vacuum compatible laboratory equipment. While on the inside of the cylindrical-shaped chamber, a vacuum-compatible mechanical system will suspend the dust and a variable speed fan system will circulate the atmosphere. In addition, capabilities are being built into the chamber to simulate the lunar dust-charging environment.

After its opening this summer, the chamber will add new capabilities. Among those is a Lehigh University-designed payload translation table that will easily slide instruments and components inside the chamber. The chamber also will be available to intern students for basic research. ◆

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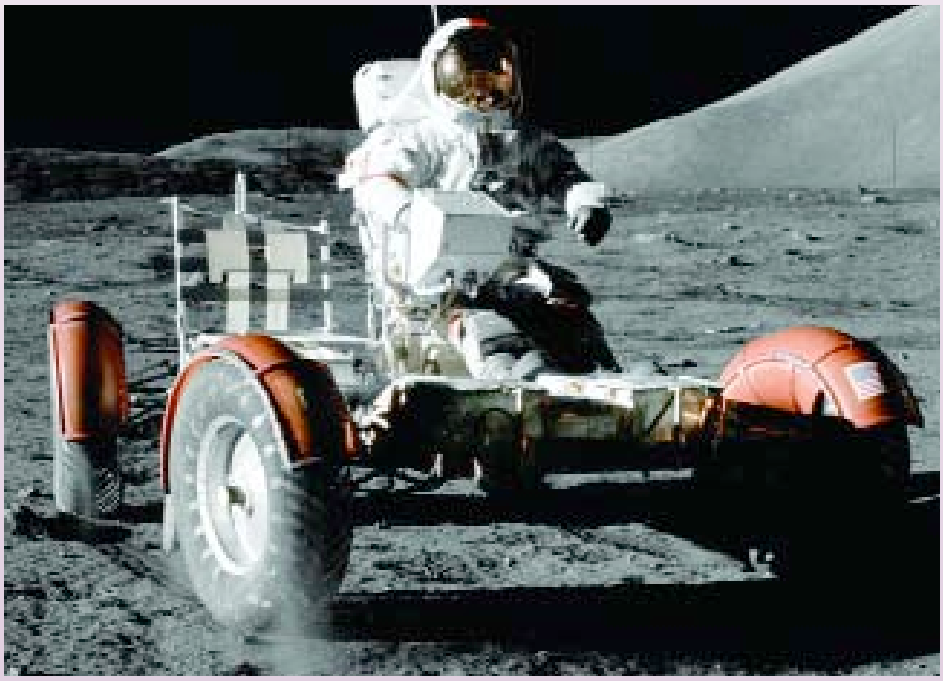

To mitigate the dust problem that proved troublesome for Apollo-era astronauts, NASA installed special bumpers on the lunar rover to keep dust from kicking up. A new dust chamber will help scientists to better understand the phenomenon.

Detector Technology Supports Human Spaceflight

Betsy Pugel, who works with Goddard's Ultraviolet Detectors Group, demonstrates her non-destructive and portable technique for testing candidate materials for thermal-protection systems on next-generation spacecraft.

A Goddard physicist working on ultraviolet detectors for Earth and space science purposes has morphed an existing measurement technique into an application not normally associated with ultraviolet detectors — human spaceflight.

Betsy Pugel, who works with Goddard's Ultraviolet Detectors Group, is now working with engineers at the Ames Research Center (ARC) and Johnson Space Center to test candidate materials for the thermal-protection system on NASA's next-generation transportation system, the Orion crew exploration vehicle. The themal-protection system will protect the conical-shaped crew module from friction-induced heat as it hurdles through Earth's atmosphere during reentry. It also overlays the spacecraft's pressure shell (see related page 7).

The approach she is using is a well-established technique innovatively applied to take spectroscopic measurements and ultraviolet images of resin-based composites and oxides to evaluate their degree of cure, variations, and defects, Pugel said. Unlike other testing methods, the approach Pugel is using is non-destructive, portable, and may be used in field tests, she said.

Expanding Detector Applications

The ultraviolet group got involved in human spaceflight after exploring alternative applications of their ultraviolet cameras and detectors. "A couple years ago, while considering other applications for these detectors, we discovered that we might have an application for the themal-protection systems used in spacecraft," Pugel recalled.

The technique was first tested during the Shuttle's Return to Flight effort. Collaborating with the Langley Research Center, Pugel examined foam-impacted reinforced carbon-carbon materials, which are used on the leading edge on the Shuttle wing. With this technique, she detected cracks and inhomogeneities in surface coatings without destroying or altering the material.

From Stardust to Orion

Pugel also applied the technique to determine how well the heat shield and back shell of NASA's Stardust Sample Return Capsule performed during the craft's reentry into Earth's atmosphere early last year. The spacecraft, which had collected cometary and interstellar particles, traveled at 28,900 mph (46,510 kph) — the fastest reentry speed ever achieved by a man-made object. *Continued, Page 7*

Detector... Continued from page 6

Examination of Stardust's thermal-protection system — phenolic impregnated carbon ablator (PICA) in the heat shield and super light ablator (SLA) in the backshell — showed chemical signatures corresponding to temperature changes in the heat shield material. From this, it was possible to conclude that the instrumentation inside the sample return capsule had not been exposed to temperatures greater than about 275°F (135°C) — a lot cooler than the 572-932°F (300-500°C) that was expected, Pugel said.

For this and other reasons, NASA selected the same materials for potential use on Orion's thermal-protection system and tasked Pugel with examining samples from ARC's Arc Jet testing facility, which simulates reentry conditions. In addition, Pugel will compare the PICA and SLA that are manufactured under different conditions and then evaluate them in the ultraviolet to look for variations in degree of cure on the materials' surfaces. ◆

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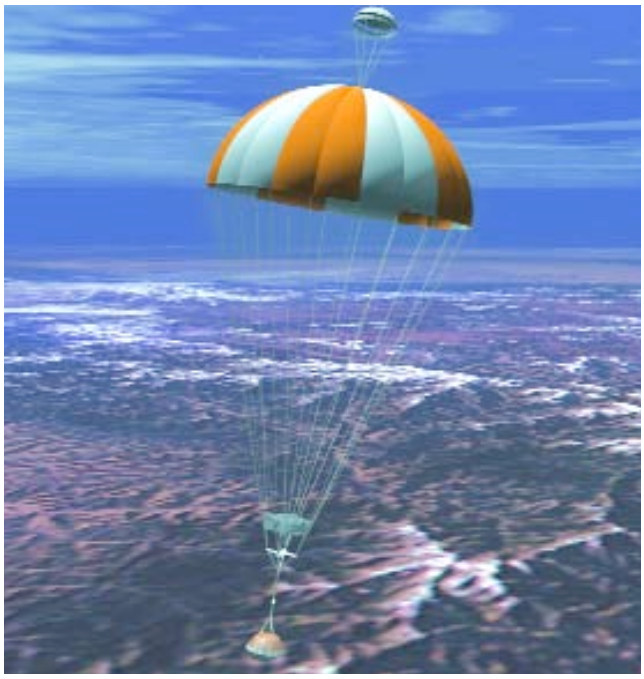

This artist's rendition shows the Stardust spacecraft as it returns to Earth. Goddard technologists tested its heat shield to see how well it performed during reentry.

Getting Experience

Tiger Team Designs Composite Crew Module Pressure Shell

They know their design won't fly, but that's not the motivation for 30 engineers who have begun meeting at the Goddard Space Flight Center to design and eventually test a full-size pressure shell of the Orion crew module made entirely of lightweight composite materials.

Their sole mission over the next 18 months is to get experience.

Chartered by the NASA Engineering and Safety Center, the team includes engineers from Goddard and other NASA centers, the Air Force Research Laboratory, and private industry — people specifically tapped because of their expertise in disciplines needed to design, assemble, and eventually test a carbon-graphite-epoxy pressure shell. The group has already created conceptual designs and expects to finalize one over the next 8 months.

Goddard, which has a long history in the area of composite materials, was chosen as the lead center because of its extensive experience in space-systems design, said Mike Kirsch, a Langley Research Center engineer who's heading the Composite Crew Module team. "At any one point, Goddard seems to have many active projects going on," he said. "It goes through the entire hardware design, build, and test process in a relatively short period of time. With only 18 months to start and finish this project, that type of the experience was needed," he said.

After a critical design review in October, the group plans to manufacture the conical-shaped capsule, which will measure about 12 feet (3.7 meters) in diameter and 10 feet (3 meters) in height, and begin tests at a still-undetermined location in the spring of 2008.

Last summer, NASA chose Lockheed Martin to build the Orion crew exploration vehicle. Although engineers have selected aluminum lithium as the primary construction material, the advantages of composites in some applications may be significant, said Jeff Stewart, a Goddard engineer who now serves as the team's Deputy Project Manager. It weighs less, offers more flexibility in design, and can cut down on the number of parts required to assemble a spacecraft.

"From this effort, we gain in-house expertise in advanced composites structures, which the Agency can then tap when it begins building other spacecraft needed for lunar exploration in the future, including lunar habitats," Stewart said. ◆

Savoring Success... Continued from page 3

working properly, said Bruce Dean, Group Leader for the Optics Branch Wavefront Sensing and Control Group.

While work ramps up on the new IRAD program, Dean and his team are still savoring the success of HDA, a patented technology he set out to develop 8 years ago as a NASA co-op student from West Virginia University. The algorithm solves one of NASA's biggest technological challenges: aligning JWST's segmented mirror so that it performs flawlessly after launch and deployment.

The JWST Challenge

Compared with other NASA observatories, JWST will fly the largest primary mirror ever deployed in space. Measuring 21.3 feet (6.5-meters) in diameter, it is significantly larger than HST's 7.8-foot (2.4-meter) primary mirror. The much larger size is needed to gather infrared light from the first galaxies formed after the Big Bang.

However, no rocket is large enough to hold a 6.5-meter mirror if it were flown in one large piece. Therefore, the JWST team is assembling the mirror in 18 segments, which will fold like a drop-leaf table and then unfold after launch.

To make sure the segments are perfectly aligned once they deploy, the observatory will take an image of a star and transmit it to the ground. Controllers will then analyze the image using eight different commissioning steps, each step handing off to the next, to determine how to properly position the individual segments to eliminate distortions in the observatory's vision. HDA is involved in four of these eight commissioning steps, including the last step to assure a sharp, clear image. Every couple weeks, the JWST team will then repeat the last step of this process to maintain the observatory's light-gathering prowess.

Cost-Saving Technology

"This is a real breakthrough," Dean said. "People would be amazed at what this algorithm accomplishes to save millions of dollars in flight-system development costs. In essence we replace hardware using software."

Nearly 2 years ago, Dean delivered the algorithm to Ball Aerospace, which adopted HDA as its primary commissioning software. During a recent demonstration, HDA proved to be the key software component that allowed JWST to achieve a technology maturity level of six, as determined by an independent review board, Dean said.

With that success, Dean says he's gearing up to apply the group's know-how to other technical challenges. "Having the opportunity to build a Wavefront Sensing Group from some of the best and brightest and to see these technologies further developed for missions like JWST has been an awesome experience," he said. ◆

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What other trends could affect technology development at Goddard?

Access to space is an issue. As I said earlier, we need to energize our creativity on miniaturization.

What advice can you give Goddard technologists?

Goddard technologists have to keep the end in mind. In addition to concentrating on cross-cutting technologies that will help multiple lines of business, they need to maintain their focus on meeting science needs. At the same time, our scientists need to focus on questions that have real scientific pull. They have to perform a reality check on what's viable.

What does the landscape look like from your perspective?

With continued budget pressures at the federal level and within the Agency, I don't see the outlook for funding technology changing significantly in the near future — we just need to continue to be focused and creative with the resources we've got. ◆

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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