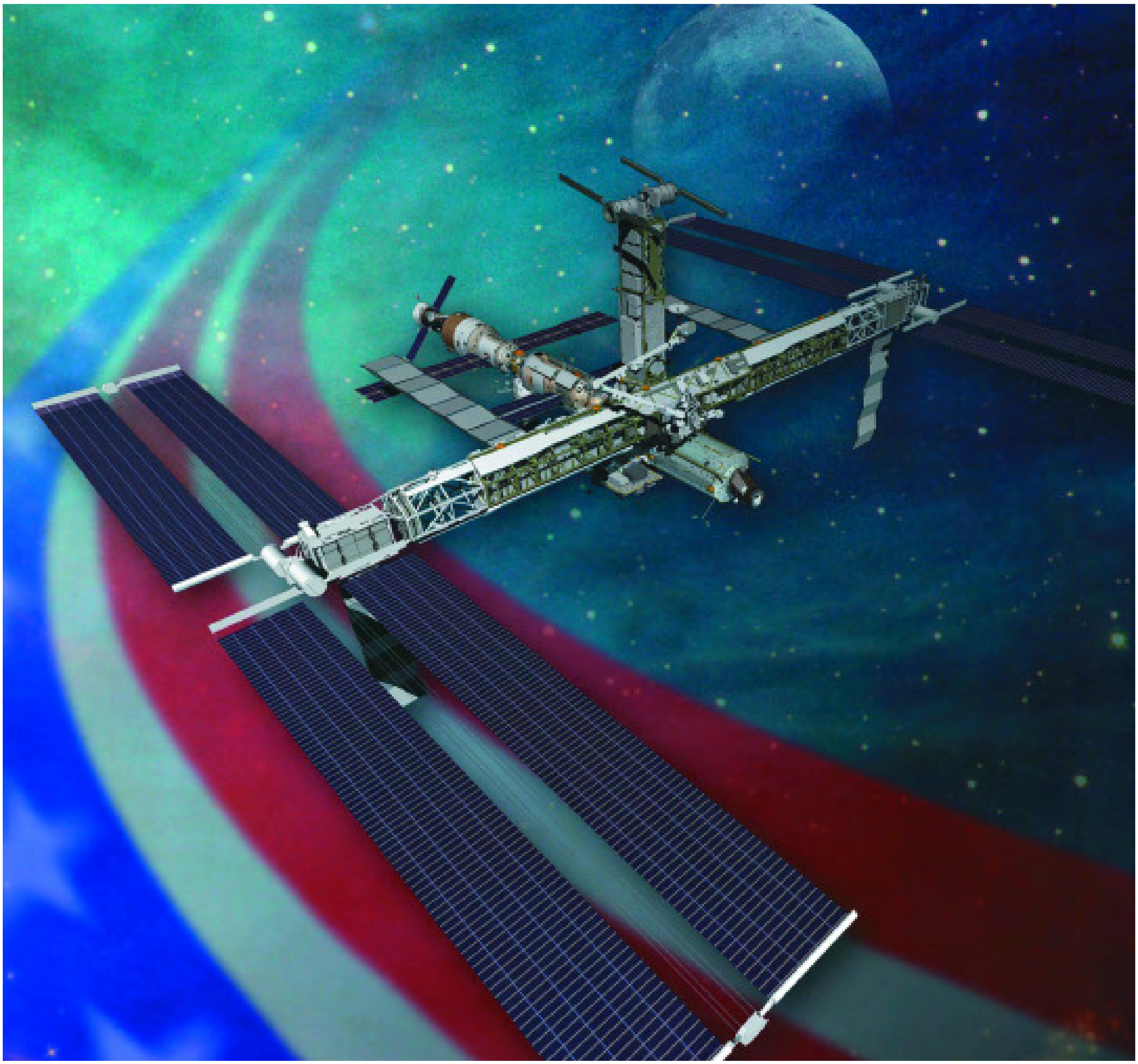
National Aeronautics and Space Administration

Lyndon B. Johnson Space Center

roundup



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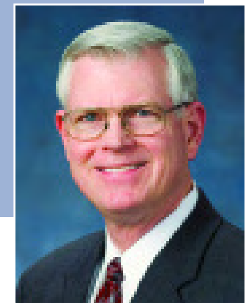


I need your creative ideas about how to be more creative here at JSC!

I've come to accept the fact that I'm not a particularly creative person, especially in comparison with the clever and technically elegant solutions our NASA engineers produce on a regular basis. For that reason I've learned to open my personal aperture and ask others, frequently in totally different lines of business, how and why they do their jobs the way they do. In what my wife calls my "relentless quest to find the most direct and efficient way to accomplish anything and everything," I'm not too proud to recognize and adopt a better mousetrap when I see it. But designing a better mousetrap is not one of my strong points. So I'm sensitive when the subject of creativity comes up.

People I respect have told me that "JSC is reluctant to consider new ideas and ways of doing business. A not-invented-here attitude tends to stifle creative thinking." One of the most difficult challenges we face in the space business in the dynamic world of the 21st century is how to be flexible, innovative and creative, while at the same time acknowledging and benefiting from the experience we've gained in human spaceflight over the last half century.

I want your ideas on how we at JSC can open our aperture and be more receptive to new ways of thinking. I have emphasized the value of diverse backgrounds and thought processes in every one of our organizations and teams, and I've tasked all members of the JSC Senior Staff to continually benchmark against similar activities outside JSC and outside NASA. The results to date have been even better than I expected, and future Roundup articles will describe those results. In the meantime, I need all of you to put on your creative thinking caps and give us ideas on how we can be more receptive and innovative here at JSC. Please don't be reluctant to send me e-mails or letters, stop me when I'm walking around or call for an appointment and let's talk.

Just be patient… I have a lot of questions, even about mousetraps.

"Every revolutionary idea evokes three stages of reaction: 1) It's completely impossible; 2) It's possible but not worth doing; 3) I said it was a good idea all along."

—Arthur C. Clarke

Human Spaceflight Transition Update

Evolving human space flight from current operations of the Space Shuttle Program; assembly, maintenance and utilization of the International Space Station and the development and flying of the new suite of vehicles in the Constellation Program is the largest undertaking in the agency's history. Future communications in the JSC Roundup will address the latest status of the goals of transition including 1) evolving the workforce, 2) efficiency in achieving multi-program objectives at the best value to the agency and center and 3) the efficient and safe fly-out of the Space Shuttle Program. Transition will impact the workforce, facilities and infrastructure, but every effort is being expended to address and mitigate any negative transition impacts. To be successful it is crucial that every available forum and medium be used to promote open and honest dialogue with the employees relative to transition activities ongoing at the center, in the programs and throughout the agency.

The Transition Leadership team members will continue to be proactive on transition communication to keep the JSC community involved and informed. The team members are:

Izella M. Dornell	*JSC Transition Manager*
Jon B. Olansen, PhD	*Space Shuttle Program*
Stephen J. Elsner	*International Space Station*
James R.Nise	*Constellation Program*

On the cover

Computer-generated artist's rendering of the International Space Station after Space Shuttle **Atlantis'** ***(STS-117/13A) undocking and departure. The image shows the addition of the second and third starboard truss segments with Photovoltaic Radiator and the deployed third set of solar arrays. The P6 starboard solar array wing and one radiator are retracted.***

TINY TECHNOLOGY COULD MEAN BIG THINGS FOR NASA

Pint-sized possibilities

by Kendra Phipps

A silicone-based adhesive is mixed with carbon nanotubes. Adding nanotubes to currently used repair and adhesive materials allows for rapid curing by hand-held microwave devices.

NASA/DeHoyos JSC2007E09902

For the uninitiated, the word "nanotechnology" might translate to "the hard drive inside an iPod Nano."

But for those in the know, nanotechnology represents an invisible world of nearly limitless potential. This world is a whole lot smaller than an MP3 player—and the possibilities go way beyond carrying 1,000 songs in your back pocket.

The prefix "nano" means "one billionth"—for example, a nanometer is one billionth of a meter. Nanotechnology experts typically work with materials that are between one and 100 nanometers in size. For comparison's sake, it would take approximately 10,000 nanometers to equal the width of a human hair.

With the help of some serious microscopes, Johnson Space Center teams are learning how to create and harness materials on this tiny scale, and then use them to further the Vision for Space Exploration. Or as Applied Nanotechnology Team Lead Leonard Yowell puts it, the experts "grow, manipulate and test nanomaterials in order to solve NASA's toughest technical problems."

Either way, JSC is using some really small technology to solve some really big challenges.

'Kind of *Star Trek*-y'

"It's a very tall order and it's kind of *Star Trek*-y in a way," said Neal Pellis, associate director of Science Management for the Space Life Sciences Directorate. JSC's nanotechnology work is a joint effort involving the Engineering and Space Life Sciences directorates, other NASA centers and academic partners.

The science fiction appeal of nanotechnology comes not only from the tiny size of those materials involved, but also from the extraordinary properties. Take carbon nanotubes, for example. Carbon atoms can be bonded together in row after row of hexagons, and when a "sheet" of these hexagons is rolled up, that sheet creates a carbon nanotube.

"There are several nanomaterials we are studying, but this particular form of carbon is extremely promising," said Sivaram Arepalli, the team's chief scientist.

continued on page 4

JSC's Applied Nanotechnology Team, left to right: Pasha Nikolaev, Mary Jane O'Rourke, Ram Allada, Peter Boul, R. Kelley Bradley, Team Lead Leonard Yowell, Michael Waid, Chief Scientist Sivaram Arepalli, Padraig Moloney, William Holmes, George Nelson, Edward Sosa.

Carbon nanotubes are 100 times stronger than steel at only one-sixth the weight. They conduct heat better than almost any other known material, and are excellent electrical conductors as well. "This makes nanotubes a very promising building block for a new generation of nanoelectronic chips, as well as power cables," said senior scientist Pasha Nikolaev, a former graduate student of Nobel Prize-winning chemist Rick Smalley.

Carbon nanotubes and other nanomaterials could be used in dozens, if not hundreds, of different ways in human spaceflight. They could reduce a spacecraft's mass and volume while increasing its strength. They could aid in protecting astronauts from radiation. They could dramatically miniaturize machinery in lunar outposts.

With so many possibilities, where should NASA start?

"We're taking technology that's fairly new and advanced, and we want to focus on the toughest problems first," said Padraig Moloney, the team's applications lead. "For human spaceflight, that includes advanced life support." Nanotechnology could play a role in crucial life-support activities such as carbon dioxide removal and water purification.

NASA already has carbon dioxide "scrubbers" on the shuttle and space station, but Moloney said that the devices will need to be "kicked up a notch" for long-duration missions outside of low-Earth orbit. Carbon nanotubes, after being chemically integrated into the devices, could boost the performance of the devices, reduce their mass and possibly make them reusable.

The agency will also need renewable, chemical-free ways to purify water to replace the current system, which uses toxic iodine. Carbon nanomaterials called fullerenes, discovered by Smalley, have been found to enhance the disinfection effects of ultraviolet light. This discovery could lead to safer water disinfection methods in space, and also to portable purification systems on Earth.

Keeping humans safe in space also means perfecting thermal protection systems (TPSs), the exterior spacecraft coatings that keep out heat. The shuttle's TPS, Reinforced Carbon-Carbon (RCC), can currently be repaired during a flight using a custom-designed paste-like substance. The paste is applied by an astronaut and hardens, or cures, during reentry. But the material could soon get a nanotechnology upgrade: scientists have found that after adding small amounts of nanotubes to the goop, it can be hardened with a handheld microwave device. This way, the crew and ground support teams can be assured that the material is set—and safe—long before reentry.

"Right now, they're trying to cook it in orbit but (are) not getting it to the level they would like," said Moloney about the ongoing RCC repair research. "So we're trying to get a more reliable cure."

JSC teams are also collaborating with Ames Research Center, the agency's lead TPS development facility, to improve the first-generation TPS material for the new Crew Exploration Vehicle. The material is called PICA (phenolic impregnated carbon ablator), and JSC is supplying Ames with functionalized carbon nanotubes that are "customized for the application," said Mike Waid, an engineer on the team.

"We're toughening PICA," he said. "It's amazing how a small amount of tiny nanotubes can have such a big impact on performance."

and you can put the medicine right where you want it—inside the tumor itself, rather than coursing through the patient's entire bloodstream.

'A very significant future'

The health-care industry isn't the only one looking into commercial applications of nanotechnology. While this tiny technology has enormous potential in the spaceflight world, it could soon also be a part of your everyday life. In fact, it might be already: a technology originally supported by NASA has found its way into America's pastimes.

"Carbon nanotubes are now being used in baseball bats, hockey sticks, golf clubs and bicycle frames to enhance their strength and flexibility," said Arepalli.

Pellis said that he sees big things for this small form of technology, both on and off the planet.

"There's a very significant future for nano approaches. We're only at the very, very thin part of the opening of the shell," he said. "I'm very convinced that if we can continue to support it as a country, we'll continue to make a difference—from our own transportation to the materials our homes are made of. It's very far-reaching when you think of it."

William Holmes (left) adjusts the optics that align and focus lasers for the production of nanotubes.

Chemist Peter Boul, assisted by R. Kelley Bradley (below), functionalizes carbon nanotubes. The nanotubes are suspended in solution and chemical groups are added to the nanotubes' walls, customizing the nanotubes for specific applications.

NASA/DeHoyos JSC2007E09897

Tiny health helpers

Of course, even with clean air to breathe, safe water to drink and a solid heat shield around them, people can still run into health problems. Nanotechnology is poised to help with medical technology, as well.

Pellis said that his team is looking for ways to use nanotechnology to monitor astronauts' health and to intervene when necessary.

"We look for ways in which we can noninvasively assess aspects of an individual's health state," he said. Those methods could include minimally invasive nano-sized implants, which would monitor vital signs and relay the information to Earth in real time.

"We also look at nanotech approaches for targeted delivery (of medicine): kind of the 'magic bullet' concept," said Pellis. He said that one of these approaches, the nanoshell, is being examined in the private sector as a possible cancer treatment. Nanoshells contain medicine as well as certain molecules that interact with components of tumors.

"Blood vessels in tumors have holes in them called fenestrations, which is just a root word for window," said Pellis. Get something small enough to fit through that window, he said, STS-117

Just do it *Again*

by Brandi Dean

STS-117 astronauts take a break from training to pose for the crew portrait. Scheduled to launch aboard the Space Shuttle Atlantis *are (from left) astronauts James F. Reilly II, Steven R. Swanson, mission specialists; Frederick W. (Rick) Sturckow, commander; Lee J. Archambault, pilot; Patrick G. Forrester and John D. (Danny) Olivas, mission specialists.*

If you missed either of the last two missions, now would be the time to catch up.

When *Atlantis* heads for the International Space Station this month, its mission may sound a little familiar. The crew will install a new truss segment, unfurl new solar arrays and fold up an old one—all tricky stuff that's been done on the past two missions.

"I jokingly call those flights the test flights for us," said Kelly Beck, lead space station flight director for STS-117.

And with two successful missions leading the way, those involved with this flight are hoping it will be the best yet.

"We're really fortunate that we have those guys to follow," *Atlantis*' commander, Rick Sturckow, said. "Almost everything went great on those missions, and the things that didn't go so well, we're able to learn from."

The new set of solar arrays that Sturckow's crew—pilot Lee Archambault and mission specialists Patrick Forrester, Steven Swanson, John "Danny" Olivas and Jim Reilly—will install on the starboard side of the station will be a mirror image of those installed on the port side in September. And like the crew that installed the port arrays, the STS-117 crew will be in charge of unfolding its arrays and preparing them to track the sun and generate power. It sounds straightforward, but the first time a set of solar arrays was unfolded in space in 2000, things didn't go quite as intended. The array panels stuck together, allowing cables meant to pull the arrays taut to come off their pulleys and leave the array slack.

The crew was able to fix the problem, but to avoid it altogether in the future, the unfolding technique changed when the second set of arrays was launched on STS-115. By unfolding them more slowly and during periods when the station flew in sunlight, the

The morning light spills through the open door of the Vehicle Assembly Building as Space Shuttle* Atlantis *begins rolling out to Launch Pad 39A. First motion was at 8:19 a.m. The 3.4-mile trip along the crawlerway took about six hours. The mission payload aboard Space Shuttle* Atlantis *is the S3/S4 integrated truss structure, along with a third set of solar arrays and batteries. The crew of six astronauts will install the truss to continue assembly of the International Space Station.

arrays were deployed without a hitch—a circumstance the *Atlantis* crew hopes to repeat in March.

"It takes a little bit longer to deploy, but it's done in a safer manner," said Cathy Koerner, shuttle lead flight director. "We'll be doing that again for STS-117."

But the crew also wants to learn from a problem its predecessors experienced in September. A 10-foot-wide rotary joint turns the solar arrays, allowing them to track the movement of the sun. But before it can be installed, the bolts that keep the joint from shifting during launch in the shuttle's cargo bay have to be removed.

That's where the STS-115 crew ran into trouble—it turned out the bolts were screwed in more tightly than expected. It took more than 20 minutes and two astronauts to loosen one of them. So this time, Sturckow said, Swanson and Forrester, the spacewalkers who will be removing the bolts during the mission's second spacewalk, will be prepared.

"They're working out every day," he joked.

In case that's not enough, however, they'll have a tool on hand that will give their elbow grease a little more oomph.

"We have a torque multiplier that we're bringing up that [the previous spacewalkers] didn't have," Sturckow said. "So if we do encounter the same difficulty with high torques that they had, we'll break out this tool. And we'll apply whatever torque it takes to break the bolt or back it out at the higher torque settings. So I don't have any doubt that we'll be able to remove those launch restraints."

And from STS-116's mission, *Atlantis*' crew is planning to learn from the problem *Discovery*'s crew encountered in retracting a solar array that was circling the Earth for more than six years. Like the arrays activated in December, the new arrays won't be able to rotate and track the sun until another set of arrays is retracted. And if STS-116 is any indication, it won't be easy. It took more than 71 tries and an extra spacewalk to neatly fold the array back into its box during that mission.

The original plan was for the arrays to be folded by ground command while all of the astronauts were inside the station. But flight controllers now are working on a plan that would have Forrester and Swanson ready to assist with the folding during the second spacewalk of the mission. And if that doesn't do it, Reilly and Olivas could give it a try during the third spacewalk.

"I think we're going to end up doing something totally new here," Sturckow said.

The space station program will be looking at the data gleaned from all those attempts to retract the arrays to decide how to change the flight plan. Even with less than three months to go, Koerner said, there's still plenty of time to make modifications.

"It's not like in the old days, where when you got within six months of flight [and] you pretty much knew what you were doing," she said. "When you're doing assembly operations, everything that you plan to do is contingent on the flight prior to you and the hardware that's already on orbit. In truth? The flight plan will be firmed up post-landing when we can turn around and look at what we've done and feel good about the success of the mission."

TEAMING UP FOR SPACE EXPLORATION

Aggies

They are bitter enemies on the athletic field, but when it comes to engineering and science fields, Texas A&M University and the University of Texas in Austin work as a cohesive team to advance space exploration goals.

Texas A&M team members, from left to right, Anne Lai, Mohamed Zebda, Amanda Howard, Agustin Mohedas and Rebecca Torres.

"I do not believe there is any petty rivalry," said Dr. Charles Lessard, faculty member of the Biomedical Engineering Department at Texas A&M. "Maybe in the sports arena, but not in the engineering workplace or community."

The two prestigious universities are partnered with NASA via a Space Act Agreement "for the purpose of promoting education that can benefit the NASA mission," said Doug Holland, Remote Image System Acquisition project lead at Johnson Space Center.

The resulting collaboration consists of two cutting-edge projects that will create software and technology capable of diagnosing the medical condition of crewmembers in space.

Texas A&M is spearheading the Remote Image System Acquisition (RISA) Telemedicine Software application. A Texas A&M team, comprised of students and faculty, is producing software that will aid in medical diagnosis for long-term spaceflight missions.

"Lists of medical conditions we [NASA] are concerned about have been provided to the team, and [its] task is to develop methods for the crew to perform a self-diagnosis with the equipment available on the spacecraft," Holland said. "Since the crew may not have a medical doctor available, crew members will need as much help as possible in determining the conditions that they may be experiencing."

"The RISA software will allow astronauts to diagnose several medical conditions without waiting for ground support from medical personnel. The software is easy to comprehend and requires minimal effort from the astronaut," said Rebecca Torres, a Texas A&M biomedical engineering student. "With the advancements in exploration, advancements in medical support are crucial. In order to sustain health on long-duration missions, astronauts will rely on support like the RISA software to quickly diagnose any problems before they become severe."

The University of Texas' RISA Space Camera 3, with the help of the Texas A&M's RISA software, will fulfill NASA's need for a high-reliability, multi-spectral imager for crew and vehicle health monitoring.

The RISA Space Camera 3 will employ the software developed at Texas A&M to gather images.

"The imager is intended to replace a wide variety of imaging capability currently in use by NASA human spaceflight systems. Given the limited

and Longhorns

by Catherine E. Borsché

University of Texas Austin team members, from left to right, Benafsha Irani, Louis Gianni, Nitin Udpa and Ramya Sankar.

space available in the Crew Exploration Vehicle, lower power solutions are required," Holland said. "Also, given the longer missions planned, a high-reliability system is required to avoid mission failures of critical functions. These are capabilities that currently do not exist in available flight hardware."

This camera will have a much broader use in terms of exploring the cosmos, with imaging capabilities for not only medical diagnoses but also vehicle, lunar and Martian surface applications.

"By allowing real-time, live images to be relayed to JSC, exploration will be far more interactive and in much higher quality," said Benafsha Irani, a University of Texas biomedical engineering student. "This camera is targeted for use on the surface of the moon and Mars. Being able to image things in space will allow faster results and conclusions on the composition of materials."

The health implications make these two projects impressive for future Vision for Space Exploration goals.

"The finalized RISA software will be able to detect various skin-related conditions, including cyanosis [and] changes in skin tone and hue, as well as conduct a basic, nail-bed capillary response test. These functions rely on the camera's ability to accurately and efficiently distinguish between colors under a variety of lighting conditions," said Agustin Mohedas, a Texas A&M University biomedical engineering student.

In addition, "The RISA imager is being designed to perform microscopy, basic checkups and exams. This will include imaging of the eyes, ears, mouth, throat and more. The design also allows for future additions, including x-rays and ultrasound imaging," said Louis Gianni, University of Texas biomedical engineering student.

The teamwork exemplified by both universities and JSC illustrates that the NASA family extends much farther than just the centers. And with such a successful joint effort underway to further the Vision for Space Exploration, the potential for reaching farther into the cosmos is much more attainable.

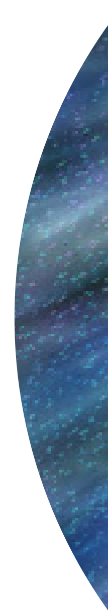
"In the past, we relied on commercial, off-the-shelf imagers that were not designed specifically for the space environment," Holland said. "We learned, through recent experiences with the Shuttle Program, how important it is to be able to accurately inspect our vehicles. The systems for exploration will have a much longer mission in a much harsher environment. The RISA project is aimed at high-quality, high-reliability monitoring of the crew and vehicle for exploration objectives."

The above image of the moon was taken with the second generation of the RISA imager, known as the Space Camera 2.

Connecting the dots

Stardust's heat shield performance has major ramifications for Constellation

by Catherine E. Borsché



As the Stardust spacecraft raced across the heavens on Jan. 15, 2006, producing a brilliant trail in its wake, the implications that it would have on exploration were still to be seen. But Karen McNamara, acting curator for space-exposed hardware and Stardust recovery lead, was there to ensure that the capsule would be perfectly maintained so that engineers could evaluate the heat shield's performance for future spaceflight testing.

"I flew out on the helicopter that night and was one of the first people on site to photo document the heat shield," McNamara said.

McNamara also noted that the scientists were very interested in documenting not only how it came back and where it was, but how the hardware was handled the entire time—where it was touched and the materials it came into contact with., The team took apart the Stardust spacecraft in a clean room in Utah to ensure that both the samples and the heat shield were uncompromised from outside contaminants.

This activity was part of a "Stardust observation campaign," John Kowal, Crew Exploration Vehicle (CEV) Thermal Protection System (TPS) manager, said. The campaign was made up of different components, which would help the Constellation Program learn more about the probability of using a similar heat shield for the CEV and the Crew Return Vehicle (CRV).

"We sponsored some airborne observations of the reentry, and there were some measurements taken of the radiation coming off of the vehicle to try to confirm the reentry environments," Kowal said. "The second part of it was the post-landing assessment of the TPS, and that's important to us because the heat shield material that was used on Stardust is the prime candidate right now for the heat shield for CEV. That material is called Phenolic Impregnated Carbon Ablator (PICA)."

"It [PICA] is actually one of the first materials that we have used that is a true ablator, which means that it actually dissipates heat by being consumed, or essentially burning," McNamara said.

In aerospace terms, it is what occurs when the protective outer surface of the spacecraft is eroded due to the immense heat caused by hypersonic-speed travel through the atmosphere during reentry.

"When [Constellation designers] did analysis on what they were going to use for the heat shield, they evaluated four or five materials," McNamara said. "They cited PICA as the most likely candidate. So the Ames Research Center is now working with Boeing to develop a potential heat shield for the CRV."

Stardust provided an excellent testbed for the heat shield of the future for many reasons.

"This [Stardust] we are looking at as sort of a flight test for the material, and we can use it with the post-flight assessments to confirm the models that are used to predict the thermal performance of the ablator," Kowal said. "We can look at how the ablator chars and recesses, and it also gives us insight into the performance of the material in the combined environments it is going to see during flight."

As Kowal noted, it is virtually impossible to replicate the reentry environment on the ground. You may get some of the elements right, such as the heat rate and pressure, but then the shear may be off. Stardust was able to show scientists how PICA would perform in true atmospheric conditions.

"Stardust was also the steepest, hottest reentry that we have ever done. My understanding is that the CRV will be as hot, if not hotter, so it is a good data point in comparing the temperatures and the actual angle of attack on reentry," McNamara said.

The Stardust heat shield was studied intensely so that engineers would be able to make accurate assessments of the PICA material.

"Stardust returned at 3 a.m., so you could see the trail across the sky as it came in. They actually did spectral analysis of that, looking at the chemical compounds that were burning off and the temperatures," McNamara said.

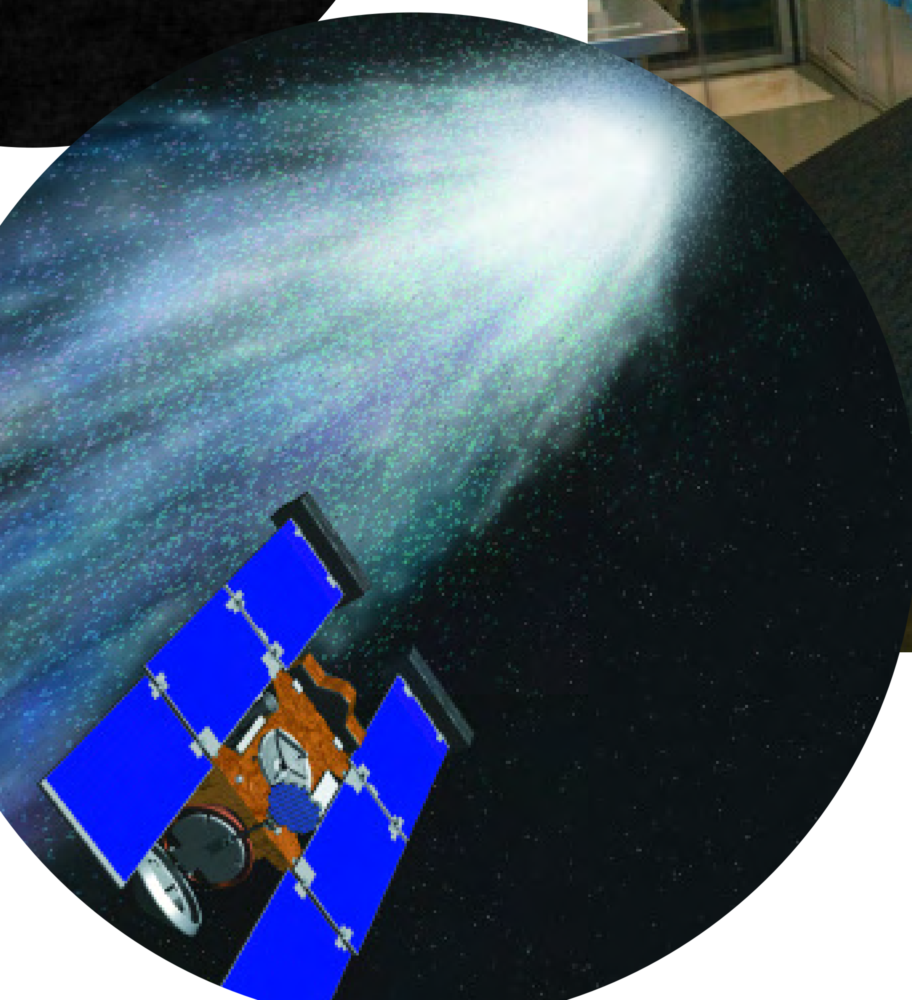
What NASA has learned about the heat shield could prove to be invaluable to exploration systems design.

"We've had groups come in to map and plot the recession of the heat shield, and how much of it actually did get consumed on reentry," McNamara said. "The interesting thing is that the ablation, or recession, really was quite less than what they thought it would be."

Because not as much of the heat shield burned off as originally predicted, engineers will be able to reduce the mass in the CRV design. Since saving room is so critical in space, this is an optimistic finding for Constellation.

Testing on Stardust's heat shield continues today; and, as time passes, NASA will learn more about the revolutionary material, PICA, and what impact it will have on future spaceflight.

"There is a lot of discussion about robotic missions versus [human] missions, as if the two aren't related. And they really are incredibly intertwined, and the technology to accomplish both is connected," McNamara said. "It's important for both programs to look towards the other for problems that have already been solved or information that can help them in advancing the technology. Stardust is a phenomenal example of that, where it's translating almost exactly to the CRV. That could be a great benefit to the [human] flight program. They aren't reinventing the wheel—they have hard data. It allows them to rethink their approach."



Clockwise from top center: ***Stardust capsule returning from space.***

Stardust researcher Miria Finckenor of the Marshall Space Flight Center examining the capsule with a magnifying glass.

An artist rendering of the Stardust Comet Wild-2 Encounter.

Astros visit JSC

In January, JSC was visited by four Houston Astros' ballplayers (pictured below): Roy Oswalt, Lance Berkman, Chris Sampson and Jason Lane. The players toured Building 5 and took a ride in the Motion Base Simulator before signing autographs in Building 3. Oswalt did such a good job "landing" the simulator that Center Director Mike Coats seemed ready to offer him a job. "Roy did that? I'm impressed," said Coats, watching the landing from the simulator's control room. "If it wasn't such a big cut in pay, we'd sign him up."

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