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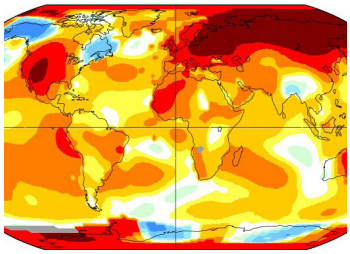
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TRENDING



Friends and Family Gather to See Webb Telescope One Final Time
Friends and family members of project staff for the James Webb Space Telescope came to Goddard on April 1 to see the observatory one last time prior to its departure for NASA's Johnson Space Center in Houston.

Second Warmest March on Record
March 2017 was the second warmest March in 137 years of modern record-keeping, according to a monthly analysis of global temperatures by scientists at the Goddard Institute for Space Studies. March 2016 was the warmest on record to date.





Roscosmos Executives Visit Goddard
Sergey Saveliev and Sergey Krikalev, executives from the Russian space agency Roscosmos, paid a visit to Goddard to learn more about the center's science, engineering projects and upcoming missions.

NASA Invites the World to Adopt the Planet
In celebration of Earth Day, NASA invites people around the world to "adopt" one of 64,000 individual pieces of our home planet as seen from space by visiting go.nasa.gov/adopt.



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On the cover: A solar flare (upper right edge) peaks on April 2, one of a trio of solar flares captured by NASA's Solar Dynamics Observatory from April 2-3.

Image credit: NASA/Solar Dynamics Observatory

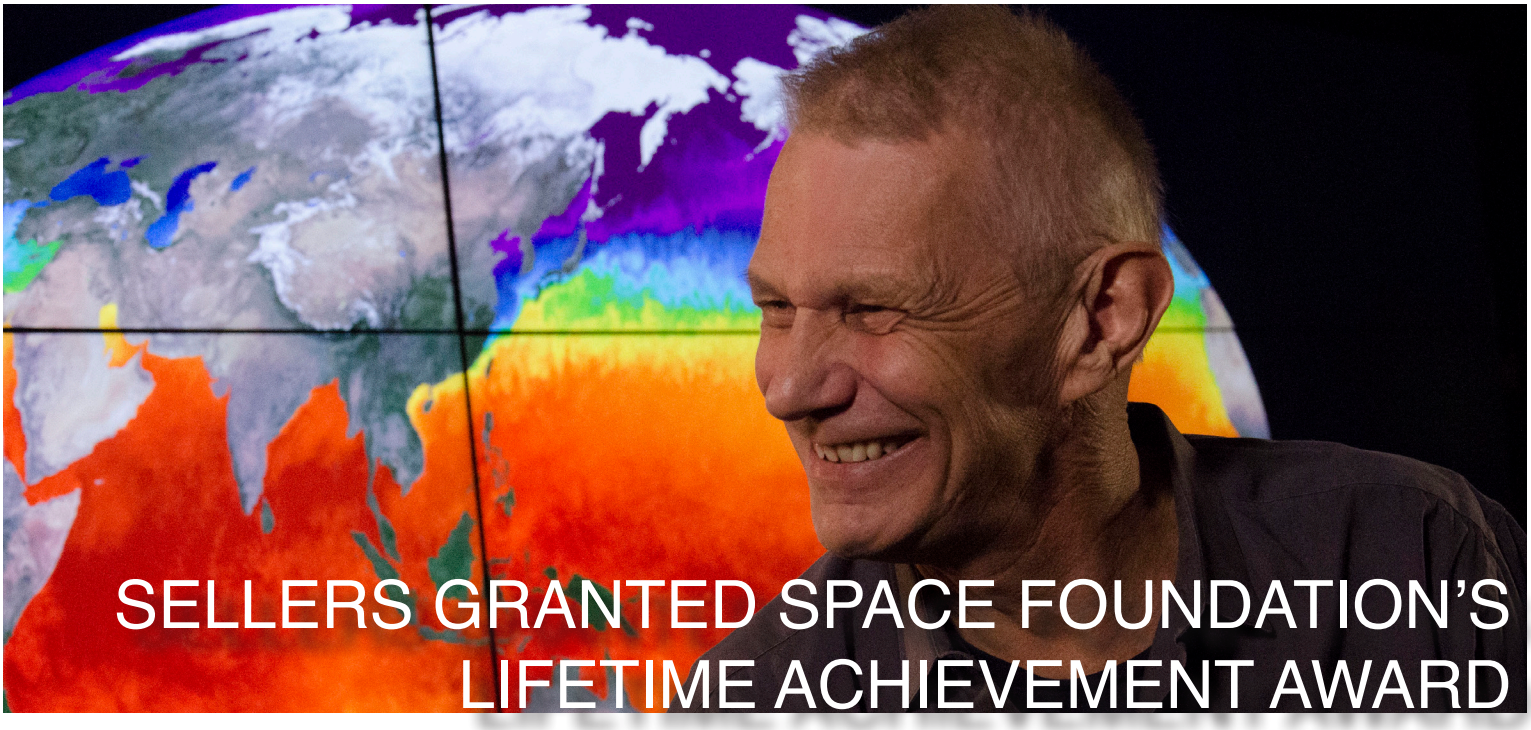
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GoddardView Info

Goddard View is an official publication of NASA's Goddard Space Flight Center in Greenbelt, Maryland. Goddard View showcases people and achievements in the Goddard community that support the center's mission to explore, discover and understand our dynamic universe. Goddard View is published by the Goddard Office of Communications.

You may submit story ideas to the editor at darrell.d.delarosa@nasa.gov. All contributions are subject to editing and will be published as space allows.

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SELLERS GRANTED SPACE FOUNDATION'S LIFETIME ACHIEVEMENT AWARD

Piers J. Sellers, the late NASA scientist and astronaut, was granted the Space Foundation's General James E. Hill Lifetime Space Achievement Award at the foundation's 33rd Space Symposium in Colorado Springs, Colorado, on April 5.

Sellers worked as a climate scientist at NASA's Goddard Space Flight Center in the 1980s and 1990s before joining NASA's astronaut corps in 1996. In 2011, after retiring as an astronaut, Sellers returned to science and worked in multiple leadership positions in the Goddard Sciences and Exploration Directorate.

Sellers died in December 2016, about a year after being diagnosed with pancreatic cancer.

Created in 2002, the Hill award is the Space Foundation's highest honor, named after the organization's late chairman, retired Air Force Gen. James E. Hill. It "recognizes outstanding individuals who have distinguished themselves through lifetime contributions to humankind through exploration, development and use of space."

Previous NASA recipients include astronauts Neil Armstrong, Sally Ride and Buzz Aldrin.

On Sellers' behalf, Colleen Hartman, Goddard director of sciences and exploration, accepted the award from retired Navy Adm. James O. Ellis Jr. – current Space Foundation chairman.

"I never met a single man, woman or child who didn't instantly fall in love with Piers," Hartman said. "He was a force of nature defending our fragile Earth. It is our American exceptionalism which demands that we make sure the Earth Piers defended remains a great place to live for the entire world."

Sellers was nominated for the honor by British space journalist and broadcaster Sarah Cruddas and was endorsed by British media personality Carol Vorderman and former NASA astronauts Garrett Reisman, Kenneth Ham, Michael Good and Gregory Johnson.

"Dr. Sellers is an incredibly optimistic man with tremendous faith in people and their ability to bring about positive change," said Ellis in a December 2016 statement announcing the award, released days before Sellers' death. "We are honored to have the opportunity to recognize him for his lifetime of achievement."

Born in Great Britain, Sellers studied ecology at the University of Edinburgh and earned a doctorate in biometeorology at the University of Leeds. He arrived at Goddard in 1982 and began research on the challenges of understanding and simulating the complex interactions between Earth's atmosphere and biosphere.

Sellers led the work that created the first realistic computer model of how the biosphere interacts with Earth's climate and helped lead major field campaigns to combine ground, airborne and satellite measurements of photosynthesis. ■

Above: Late NASA scientist and astronaut Piers J. Sellers, who was awarded the Space Foundation's General James E. Hill Lifetime Space Achievement Award.

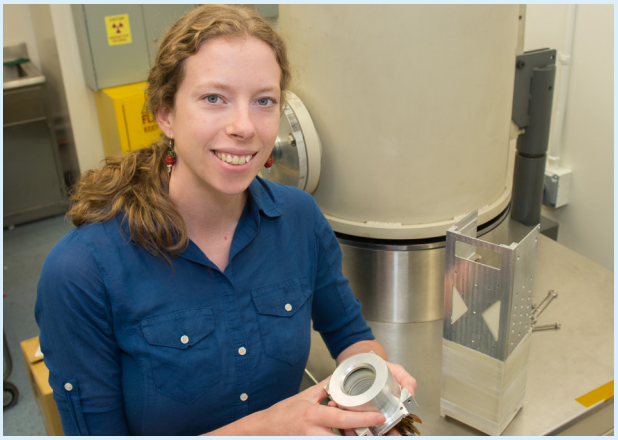
Photo credit: NASA/Goddard/Rebecca Roth

ALLISON EVANS:
BUILDS BOXES THAT FLY IN SPACE

By Elizabeth M. Jarrell

What do you do and what is most interesting about your role here at Goddard? How do you help support Goddard's mission?

I build boxes for a living. I build the boxes that enclose the brains of the spacecraft, the electronics boards, and I make sure that the boards do not shake apart during launch or get too hot or too cold in space. Recently, I have been building CubeSats which are tiny spacecraft about the size of a loaf of bread or a shoebox. The advantage of using CubeSats is that they cost much less to launch because there is so much less mass going up into space. I call CubeSats the cellphones of spacecraft because you have to miniaturize everything.



When did you know you wanted to become an engineer working on spacecraft?

When I was little, I read a lot of books about planets, spacecraft and the shuttle, but I always thought I would become an artist. In high school, my guidance counselor convinced me to take calculus. I loved it and was good at it. My calculus teacher suggested that I become an engineer. I then figured out that I could use my creativity to make engineering designs, so I could do both.

How do you combine your artistic vision with engineering design?

I mostly design structures. Trying to figure out how the pieces will fit with each other and align properly involves a lot of thinking about turning shapes around in your head. Envisioning how something will look when viewed from different angles requires an artistic eye. I try not to make things unnecessarily clunky. It saves mass as well.

What brought you to Goddard?

I came to Goddard as an intern while in college. I first interned at NASA's Langley Research Center in Hampton, Virginia, and then spent four more summers at Goddard first as an intern and later as a co-op. I worked two summers in the heliophysics area and two summers in the components and hardware branch where I now work full-time. These summers at Goddard gave me a chance to see what engineering is like as a career and also helped me make the connections that I needed later. Working with both scientists and engineers as mentors has given me a broader perspective.

What about your work on a balloon mission?

I worked on the Balloon Experimental Twin Telescope for Infrared Interferometry (BETTII). I designed and analyzed the exoskeleton, which is the structure that all of the bus components – such as the batteries and the communications equipment – sit on and to which the instrument itself is attached. BETTII will study astrophysics targets, such as star-forming regions of galaxies, and look at them in the infrared spectrum.

BETTII is the size of a bus and the exoskeleton is roughly the size of a car. It is the biggest thing I've designed so far. The design process is the same as for the tiny CubeSats, though!

Please tell us about your pending patent.

I am in the process of obtaining a patent, which is now officially patent-pending, on CubeSat thermal louvers. Thermal louvers are used for controlling the temperature of the components inside a spacecraft. Thermal louvers were designed for big spacecraft way back in the '70s, but did not yet exist for small spacecraft like CubeSats. My patent will be for miniaturizing the thermal louver technology. I hope CubeSats will eventually use my design. Goddard's Dellingr CubeSat, which is currently in the testing phase, will demonstrate my technology. Going through the process of patenting has been challenging, but I saw a need for more varied thermal control in the future of CubeSats and went for the opportunity.

What is your six-word memoir? A six-word memoir describes something in just six words.

Don't be afraid to be weird. ■

Center: Allison Evans

Photo credit: NASA/Goddard/Bill Hrybyk

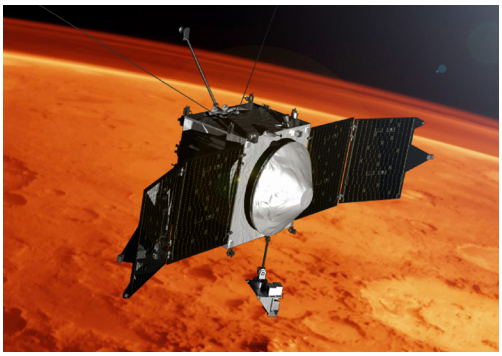
MAVEN REVEALS MARS HAS METAL IN ITS ATMOSPHERE

By Nancy Jones and Bill Steigerwald

Mars has electrically charged metal atoms – or ions – high in its atmosphere, according to new results from NASA's MAVEN spacecraft. The metal ions can reveal previously invisible activity in the electrically charged upper atmosphere – known as the ionosphere – of Mars.

"MAVEN has made the first direct detection of the permanent presence of metal ions in the ionosphere of a planet other than Earth," said Joseph Grebowsky of NASA's Goddard Space Flight Center. "Because metallic ions have long lifetimes and are transported far from their region of origin by neutral winds and electric fields, they can be used to infer motion in the ionosphere, similar to the way we use a lofted leaf to reveal which way the wind is blowing." Grebowsky is lead author of a paper on this research.

MAVEN, short for the Mars Atmosphere and Volatile Evolution Mission, is exploring the Martian upper atmosphere to understand how the planet lost most of its air, transforming from a world that could have supported life billions of years ago into a cold desert planet today. Understanding ionospheric activity is shedding light on how the Martian atmosphere is being lost to space.



The metal comes from a constant rain of tiny meteoroids onto the Red Planet. When a high-speed meteoroid hits the Martian atmosphere, it vaporizes. Metal atoms in the vapor trail get some of their electrons torn away by other charged atoms and molecules in the ionosphere, transforming the metal atoms into electrically charged ions.

MAVEN has detected iron, magnesium and sodium ions in the upper atmosphere of Mars over the last two years using its Neutral Gas and Ion Mass Spectrometer instrument, giving the team confidence that the metal ions are a permanent feature. "We detected metal ions associated with the close passage of Comet Siding Spring in 2014, but it didn't tell us about the long-term presence of the ions," said Grebowsky.

The interplanetary dust that causes the meteor showers is common throughout our solar system, so it's likely that all solar system planets and moons with substantial atmospheres have metal ions, according to the team.

Sounding rockets, radar and satellite measurements have detected metal ion layers high in the atmosphere above Earth. There has also been indirect evidence for metal ions above other planets in our solar system. When spacecraft are exploring these worlds from orbit, sometimes their radio signals pass through the planet's atmosphere on the way to Earth, and sometimes portions of the signal have been blocked. This has been interpreted as interference from electrons in the ionosphere, some of which are thought to be associated with metal ions. However, long-term direct detection of the metal ions by MAVEN is the first conclusive evidence that these ions exist on another planet and that they are a permanent feature there.

The team found that the metal ions behaved differently on Mars than on Earth. Earth is surrounded by a global magnetic field generated in its interior, and this magnetic field – together with ionospheric winds – forces the metal ions into layers. However, Mars has only local magnetic fields fossilized in certain regions of its crust, and the team only saw the layers near these areas. "Elsewhere, the metal ion distributions are totally unlike those observed at Earth," said Grebowsky.

The research has other applications as well. For example, it is unclear if the metal ions can affect the formation or behavior of high-altitude clouds. In addition, a detailed understanding of the meteoritic ions in the totally different Earth and Mars environments will be useful for better predicting consequences of interplanetary dust impacts in other yet-unexplored solar system atmospheres. "Observing metal ions on another planet gives us something to compare and contrast with Earth to understand the ionosphere and atmospheric chemistry better," said Grebowsky.

The research was funded by the MAVEN mission. MAVEN's principal investigator is based at the University of Colorado's Laboratory for Atmospheric and Space Physics in Boulder. The university provided two science instruments and leads science operations, as well as education and public outreach, for the mission. Goddard manages the MAVEN project and provided two science instruments. The University of California at Berkeley's Space Sciences Laboratory also provided four science instruments for the mission. Lockheed Martin built the spacecraft and is responsible for mission operations. NASA's Jet Propulsion Laboratory in Pasadena, California, provides navigation and Deep Space Network support, as well as the Electra telecommunications relay hardware and operations. ■

Center: Artist rendering of the MAVEN spacecraft.

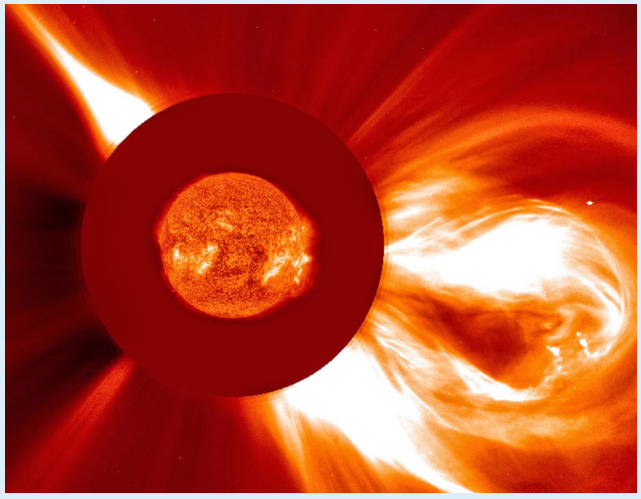
Image credit: NASA/Goddard

LIVING WITH A STAR: NASA AND PARTNERS SURVEY SPACE WEATHER SCIENCE

By Sarah Frazier

NASA has long been a leader in understanding the science of space weather, including research into the potential for induced electric currents to disrupt our power systems. Last year, NASA scientists worked with scientists and engineers from research institutions and industry during a pair of intensive weeklong workshops to assess the state of science surrounding this type of space weather.

Storms from the sun can affect our power grids, railway systems and underground pipelines through phenomena called geomagnetically induced currents, or GICs. The sun regularly releases a constant stream of magnetic solar material called the solar wind, along with occasional huge clouds of solar material called coronal mass ejections. This material interacts with Earth's magnetic field, causing temporary changes. These temporary changes to the magnetic field can create electric currents just under Earth's surface, which are GICs.



Long, thin metal structures near Earth's surface — such as underground pipelines, railroads and power lines — can act as giant wires for these currents, causing electricity to flow long distances underground. These electric currents can cause problems for all three structures, and they are especially difficult to manage in power systems, in which controlling the amount of electric current is key for keeping the lights on. Under extreme conditions, GICs can cause temporary blackouts, meaning that studying space weather is a crucial component for emergency management.

"We already had a pretty good grasp of the key moving pieces that can affect power systems," said Antti Pulkkinen, space weather researcher at NASA's Goddard Space Flight Center. "But this was the first time we had solar experts, heliospheric scientists, magnetospheric physicists, power engineers and emergency management officials all in a room together."

Though GICs can primarily cause problems for power systems, railroads and pipelines aren't immune.

"Researchers have found a positive correlation between geomagnetic storms and misoperation of railway signaling systems," added Pulkkinen, who is also a member of the space weather research-focused Community Coordinated Modeling Center based at Goddard.

This is because railway signals, which typically control traffic at junctures between tracks or at intersections with roads, operate on an automated closed/open circuit system. If a train's metal wheels are on the track near the signal, they close the electrical circuit, allowing electric current to flow to the signal and turn it on.

"Geomagnetically induced currents could close that loop and make the system signal that there's a train when there isn't," said Pulkkinen.

In power systems, the GICs from a strong space weather event can cause something called voltage collapse. Voltage collapse is a temporary state in which the voltage of a segment of a power system reaches zero. Because voltage is required for current to flow, voltage collapse can cause blackouts in affected areas.

Though blackouts caused by voltage collapse can have huge effects on transportation, health care and commerce, GICs are unlikely to cause permanent damage to large sections of power systems.

"For permanent transformer damage to occur, there needs to be sustained levels of GICs going through the transformer," said Pulkkinen. "We know that's not how GICs work. GICs tend to be much more noisy and short-lived, so widespread physical damage of transformers is unlikely even during major storms."

The scientists who worked on the survey, part of the NASA Living With a Star Institute, also created a list of unanswered questions in GIC science, mostly related to computer modeling and prediction. The members' previous work on GIC science and preparedness has already been used to shape new standards for power companies to guard against blackouts.

"We're really proud that our team members made major contributions to the updated FERC standards," said Pulkkinen. "It also shows that the U.S. is working to address GIC risk." ■

Center: Composite image of a coronal mass ejection as seen by the Solar and Heliospheric Observatory.

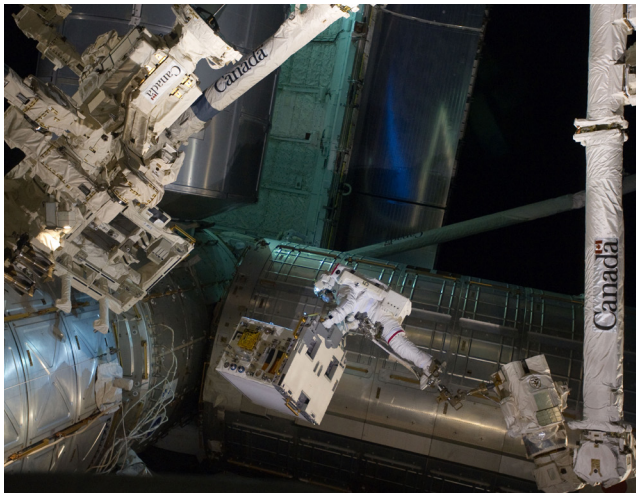
Image credit: European Space Agency, NASA/Solar and Heliospheric Observatory

ROBOTIC REFUELING MISSION DEPARTS INTERNATIONAL SPACE STATION

By Vanessa Lloyd and Peter Sooy

The International Space Station serves as an orbiting test and demonstration laboratory for scientific experiments. These experiments are inherently transient with typical life cycles ranging from one to five years. Once their test objectives are accomplished, they are removed to make way for new experiments.

On Feb. 19, one such experiment – a test module called Raven – was successfully launched and installed on the exterior of the station, where it will test autopilot technologies for spacecraft. As the Raven payload took its perch on the station, another Satellite Servicing Projects Division (SSPD) creation – the Robotic Refueling Mission (RRM) payload – departed. Aboard the SpaceX Dragon trunk in which Raven arrived, RRM made its way back to Earth on March 19.



RRM has a firm legacy in demonstrating satellite servicing capabilities and that in-orbit servicing is technologically ready for implementation. RRM launched in July 2011 aboard the final space shuttle flight and was the last payload to be removed from the shuttle cargo bay by an astronaut. It was subsequently mounted onto an Express Logistics Carrier built at NASA's Goddard Space Flight Center. RRM demonstrated and tested the tools, technologies and techniques needed to robotically refuel and repair satellites in space that were not designed for servicing.

"The Robotic Refueling Mission was an essential bridge between the manned servicing carried out in the Hubble Space Telescope servicing missions and robotic servicing that will be demonstrated in the upcoming Restore-L mission," said Ben Reed, SSPD deputy director. "Our team worked very hard to develop the suite of RRM tools and experiments and are extremely pleased to see what they accomplished. We are eager to apply the lessons learned from RRM to the Restore-L mission as well as future servicing efforts."

Planning for RRM began in 2010. The fourth Hubble servicing mission had just ended. The Space Shuttle Program was in its twilight, scheduled for retirement in 2011. Hundreds of Goddard engineers who supported Hubble servicing were not sure what a future without shuttle would hold. A team, led by former SSPD Associate Director Frank Cepollina – often called the "father of servicing" – began brainstorming how to continue servicing without shuttle. Cepollina's team determined that the future of servicing would rely on robotics, and the space station robotic arm was the best mechanism to test and develop robotic servicing techniques. Eighteen months later, RRM was in the cargo bay of space shuttle Atlantis, ready to launch and demonstrate that robotic servicing had come of age.

"The space station is on-orbit and already has a robot," said Cepollina. "Space station was tailor-made for RRM and worked beautifully as a test bed for servicing."

The washing machine-sized RRM payload housed four unique tools that were used by the station's twin-armed Canadian Dextre robot to accomplish the precise, complex tasks needed to refuel a satellite. In January 2013, RRM confirmed that current robotic technology could refuel a triple-sealed satellite fuel valve by transferring 1.7 liters of ethanol.

In separate launches in 2013 and 2014, two new task boards and a tool were sent to the space station as part of RRM Phase 2. The task boards further demonstrated activities vital to servicing free-flying satellites. Similarly, the new tool – the Visual Inspection Poseable Invertebrate Robot – exhibited state-of-the-art near- and mid-range inspection using an articulable, snakelike borescope tool.

Currently, the RRM team is developing and working to execute a third phase of RRM, which will continue to advance the technology necessary for robotic refueling. RRM Phase 3 will focus specifically on servicing cryogenic fluid and xenon gas interfaces which will support future scientific missions as humans extend exploration farther out in our solar system.

"Space station was a wonderful facility to test our technologies, and we know that RRM's departure will make room for another great experiment," said Jill McGuire, RRM project manager. "We are proud of what we accomplished with RRM and are excited to contribute to the next stages of enabling robotic satellite servicing." ■

Center: NASA astronaut Mike Fossum handles the RRM payload during its launch to the International Space Station in July 2011.

Photo credit: NASA



PUZZLES WITHIN PUZZLES

By Ellen Gray

Eugenia De Marco loves puzzles. Her face lit up and she grinned broadly when asked what it was like to figure out how to get NASA instruments that measure snow on the ground attached and running on a Naval Research Lab P-3 plane.

“These aircraft have deliberate holes where things kind of hang off of or look out of so we can get data. But all the holes are different sizes or in different locations in the aircraft,” she said as she described fitting aboard five unique instruments that have been designed to fit on several different types of aircraft. “These are all little puzzle pieces that you need to keep in mind when you design something.”

As a mechanical engineer at NASA’s Goddard Space Flight Center, De Marco is part of a team that designs science instruments for airborne missions that study Earth. Many of these instruments are early versions of what may one day fly on satellites. For the past year, she has been working with a program called SnowEx, a five-year airborne campaign that is trying to figure out one of the most challenging puzzles in Earth observation: How do you measure from the air the amount of water in snow that’s on the ground?

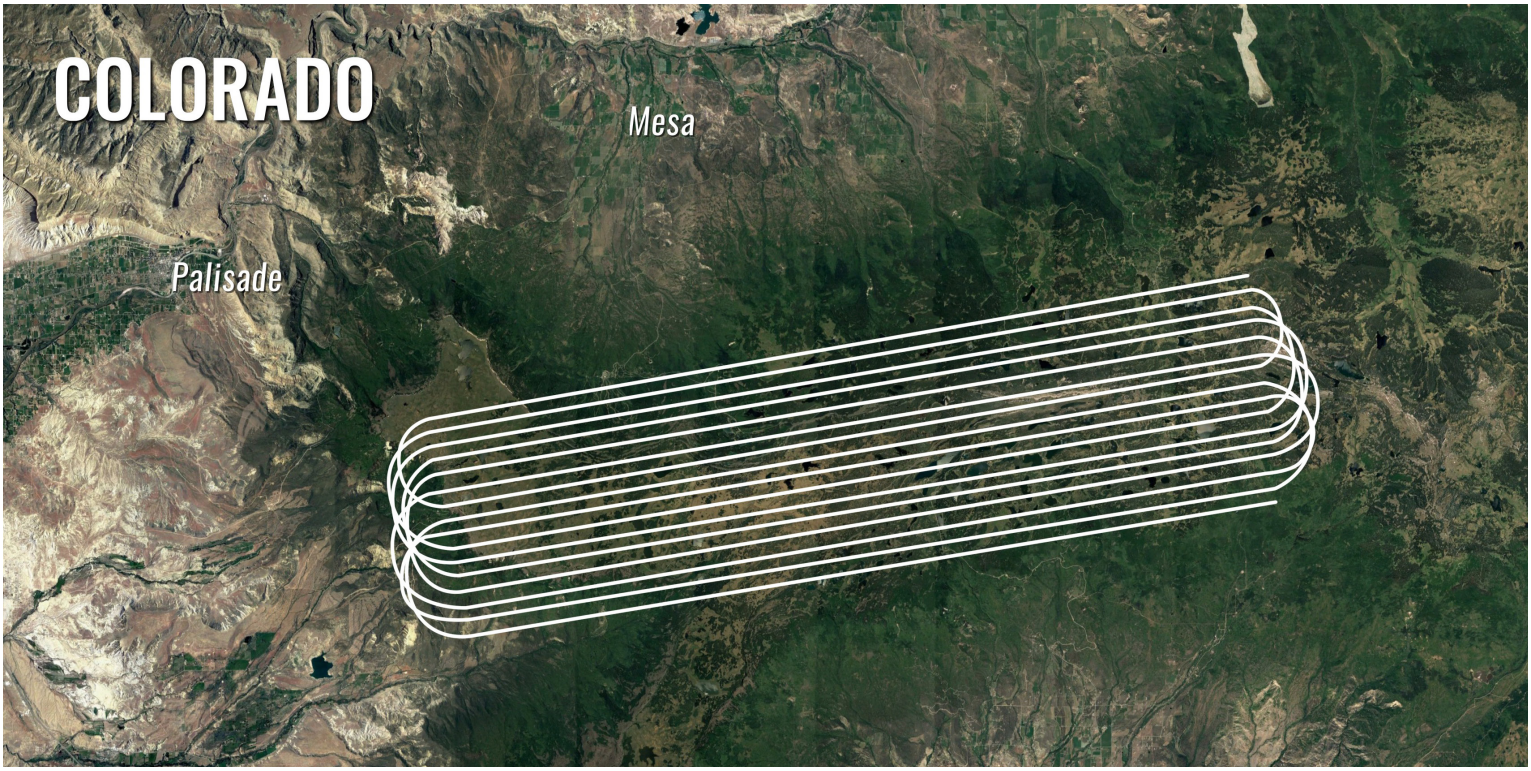
Snow on the ground is easy to observe from space or the air, but not so easy to measure how wet or dense it is, and thus how much water may flow downstream into reservoirs and agricultural fields when the snow melts in the spring. One instrument is unlikely to be able to give scientists the observations they need, especially on rugged mountain slopes whose steep angles can complicate things. But many instruments, whose observations fit together like puzzle pieces to illuminate the bigger picture, just might.

Five of those instruments were De Marco’s responsibility aboard the Naval Research Lab P-3 aircraft this February during SnowEx’s first trip to its test bed – the snow-covered Grand Mesa and Senator Beck Basin outside Colorado Springs, Colorado. As the lead integration engineer for the aircraft, her job during the flights was to coordinate with the pilots and the instrument scientists to make sure that each instrument collects the data it needs.

“The pilots will call down to me and usually, in general, to everyone, ‘We’re this close to our target,’ and then I make sure everybody’s ready to go and then science starts happening. In the meantime, I keep track of every time we hit the line and start and stop [data collection],” she said.

The “line” she mentions refers to the predetermined path the airplane flies along so that it will fly above ground stations set up by scientists below to measure snow directly. Dozens of researchers from a variety of universities and government agencies were camped out on Grand Mesa and in Senator Beck Basin, going out each day on snowmobiles, skis or snowshoes to dig snow pits or set up other sensors directly on the snow in the mountains.

“They’re doing that to compare what we’re seeing with our instruments,” De Marco said. “Our instruments will say,



‘Hey, we just saw 10 feet of snow,’ and the ground will say, ‘Yep, that was 10 feet of snow.’ It’s a data comparison-type deal.”

On a given flight, the P-3 aircraft flies 12 lines that last from three to 10 minutes each. One instrument that looks at how light scatters after bouncing off snow on the ground actually needs to fly in a circle around a ground station so it can capture all the angles. Sometimes problems with the instruments crop up, usually small glitches that can be fixed onboard, and De Marco will rejigger the flight pattern so when the instrument is ready to go again, they can still fly over that instrument’s line.

Weather, however, is the biggest thing that can impact a flight, said De Marco. Clouds get in the way of some instruments’ observations, so the plane may try to fly above or below them depending on the instrument. Choppy air can complicate flying over the lines. When planning flights, De Marco and the science team try to fly in good conditions, but with weather over the mountains difficult to predict, they often go out in less-than-ideal weather and adjust their flight plan as they go.

“I think the most exciting thing is when we land and we know that we hit those lines and everything was working well and the sky looked great and the weather was great,” De Marco said. “I mean that just feels really good and makes all that hard work totally worth it.” ■

Above (left): Goddard mechanical engineer Eugenia De Marco (left) consults with instrument scientist Alex Coccia during a SnowEx research flight aboard a Naval Research Lab P-3 aircraft. Photo credit: NASA/Goddard/Joy Ng

Above (right): The SnowEx aircraft flies in “lines” above field sites set up on Grand Mesa in Colorado. A satellite image of Grand Mesa in summer shows the topography with the flight lines superimposed on top. Image credit: NASA/Goddard/Joy Ng

Below: An aerial view of Grand Mesa in Colorado. Photo credit: NASA/Goddard/Joy Ng



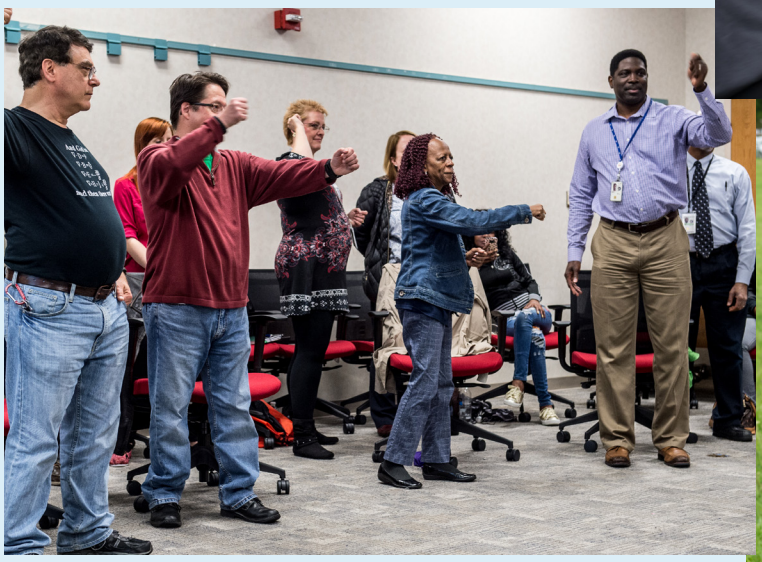
GODDARD ‘SPEAKS UP’: ‘ALL OPINIONS













MATTER' IN SAFETY AWARENESS CAMPAIGN













Photo credits: NASA/Goddard/Bill Hrybyk and Debora McCallum



EXPERIENCE THE 2017 ECLIPSE ACROSS AMERICA

AUGUST 21, 2017

http://eclipse2017.nasa.gov

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