National Aeronautics and Space Administration

THE CRITICAL PATH

A FLIGHT PROJECTS DIRECTORATE PUBLICATION ■ 2023 SPRING ISSUE

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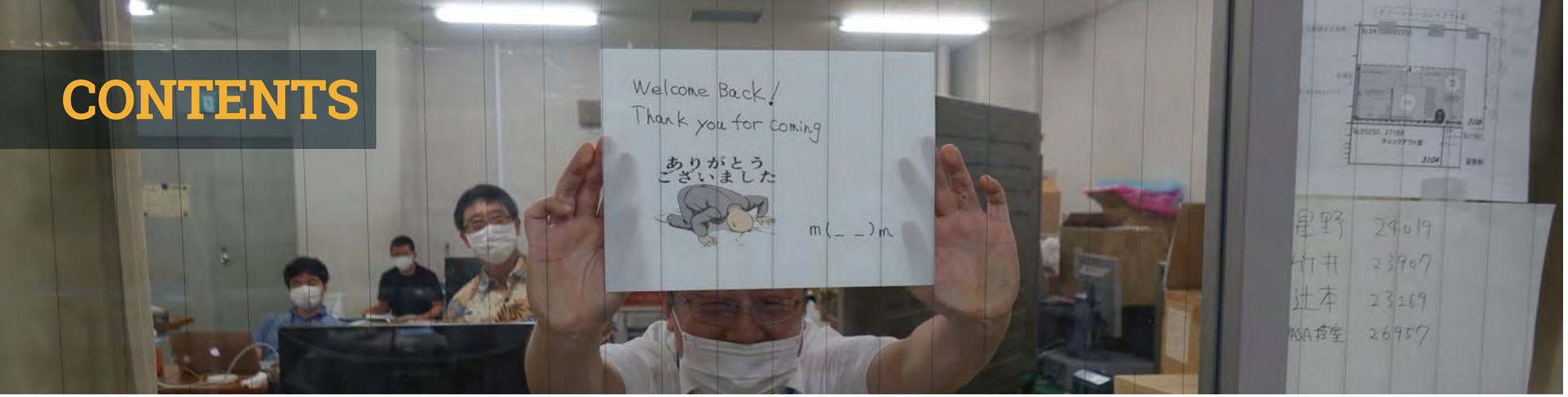

The NASA XRISM team received a warm welcome from their JAXA colleagues when they arrived in Japan in July 2020 after COVID travel restrictions were partially lifted. CREDITS: NASA/JAXA

THE CRITICAL PATH
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PUBLISHED BY THE FLIGHT PROJECTS DIRECTORATE

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Welcome Dr. Lystrup!

The Flight Projects Directorate (FPD) joins the rest of Goddard Space Flight Center in welcoming our new Center Director, Dr. Makenzie Lystrup. Dr. Lystrup will make history as the first female center director at Goddard.

Before joining our NASA family, Dr. Lystrup was vice president and general manager of Civil Space at Ball Aerospace, where she was responsible for the company's portfolio of civil space systems that span all science fields, operational weather and Earth observation, and advanced technologies development objectives. In this role, she led Ball's contributions to several NASA missions, including the James Webb Space Telescope, Imaging X-ray Polarimetry Explorer (IXPE), Landsat 9, and the Nancy Grace Roman Space Telescope.

WHAT'S UP WITH OUR Flight Projects Development Program

The Flight Projects Development Program's (FPDP) spring workshop was held at the Goddard Information and Collaboration Center (GIC2) April 11-13. Workshop attendees from all NASA centers toured Goddard's facilities and participated in two days of informative and engaging presentations, team-building activities, and networking.

Acting Center Director, Cynthia Simmons, gave an overview of Goddard and spoke about project management challenges. CREDIT: ESTHER KIM

FPDP 2023 Spring Workshop Participants. CREDIT: DESIREE STOVER/NASA

FPDP workshop attendees traveled around Goddard by tour bus. CREDIT: ESTHER KIM

X-Ray Investigations: XRISM Launch Promises to Deliver Much-Anticipated X-ray Science

The Explorers and Heliophysics Projects Division's (EHPD; Code 460) X-Ray Imaging and Spectroscopy Mission (**XRISM**, pronounced "kris-um") is one of NASA's long-standing partnerships with the Japan Aerospace Exploration Agency (JAXA). The mission also includes participation from the European Space Agency (ESA). XRISM will fly on a JAXA H-IIA rocket with JAXA's lunar landing probe, Smart Lander for Investigating Moon (SLIM), from Tanegashima Space Center in Japan. The launch window for XRISM/SLIM is scheduled to open no earlier than August 2023, pending the results of the recent JAXA H-III failure investigation. XRISM is the latest in a series of missions that have attempted to answer vital questions in astrophysics through the use of X-ray spectroscopy and imaging.

The science data gained from XRISM will advance our knowledge of the formation and structure of the universe, supernova remnants, outflows from galaxy nuclei (generated by supermassive black holes), and dark matter. While several similar missions have preceded XRISM, none were completed. Now, XRISM is poised to build on the lessons learned from previous attempts and deliver on a decades-old promise to explore the cosmos in a brand-new way.

The first attempt of a similar X-ray astronomy mission, ASTRO-E, was lost during launch in February 2000. The second mission, ASTRO-E2 (later named Suzaku), successfully launched in July 2005 but suffered a series of cooling system malfunctions that shut down the spacecraft's primary instrument, the onboard X-ray Spectrometer. The third attempt, ASTRO-H (Hitomi), overcame development obstacles following the strongest earthquake in Japan's recorded history (and the associated tsunami) in 2011. Hitomi finally launched in February 2016 and was able to begin initial operations before the spacecraft was lost a month into its mission due to an operational mishap that led to a control system stabilization failure.

However, the preliminary data provided by Hitomi during the short period of time it was operational proved invaluable. The Hitomi spectrum of the Perseus Cluster demonstrated the power of the state-of-the-art microcalorimeter X-ray spectroscopy, dramatically improving on the previous best X-ray spectrum of the cluster obtained with the Suzaku observatory.

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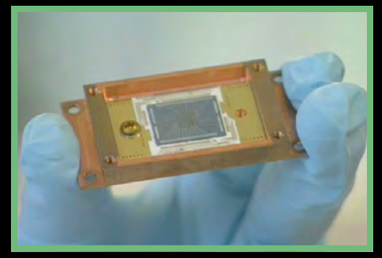
XRISM team members with the CSI in a clean room at NASA's Goddard Space Flight Center. From left: Bryan James, Mike Sampson, Tomomi Watanabe, Pete Barfknecht, Scott Porter, and Sinclair Douglas. CREDIT: LARRY GILBERT/NASA VIA NASA'S SCIENTIFIC VISUALIZATION STUDIO

In 2017, NASA announced that XRISM (initially called the X-ray Astronomy Recovery Mission, or XARM) would pick up where Hitomi left off. Based on the ASTRO-H development effort, this mission was considered "build-to-print" with minimal changes based on prior lessons learned to mitigate risks to mission success. NASA and JAXA leadership agreed to set up the NASA-JAXA partnership with a new organizational structure to enhance coordination and communication between the two agencies at all levels. This architecture also focused on an improved path for issue resolution, if needed. In addition, NASA responsibilities included high-level reviews and systems engineering advisory activities, which are not traditionally included in partnerships with other space agencies.

XRISM is now the fourth mission slated to perform this type of science, featuring the most advanced soft X-ray instruments to date. It remains one of NASA's top priorities in its most recent Decadal Survey for Astrophysics.

As a strategic Explorers program astrophysics project, XRISM will resume much of the science capability of the previous Hitomi mission, specifically the study of soft X-ray bands. To accomplish this, Goddard was tasked with developing the Resolve instrument and the X-ray Mirror Assemblies, while also operating XRISM's Science Data Center and administering its Guest Observer Program.

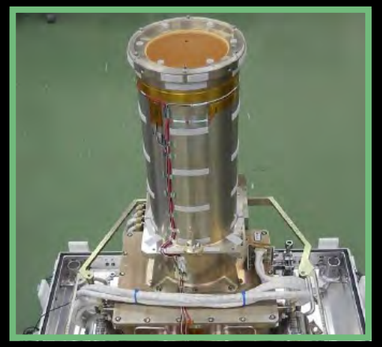
XRISM features two science instruments. The first was built in-house at Goddard: the **Resolve** detector is a microcalorimeter spectrometer array housed in the Calorimeter Spectrometer Insert (CSI) contained in a refrigerator-sized dewar of liquid helium.



The Resolve detector, a microcalorimeter spectrometer array, prior to being housed in the CSI. CREDIT: NASA/XRISM

The second is **Xtend**, a wide-field X-ray imager built by JAXA. Specifically, Xtend is an X-ray Charge-Coupled Device (CCD) camera that captures images over a wide wavelength that features the largest viewing area of any X-ray imaging satellite yet. Xtend will complete simultaneous observations with Resolve, providing complementary images with approximately arcminute spatial resolution.

XRISM also features two identical X-ray Mirror Assemblies (XMAs), one for Resolve and one for Xtend, both developed by Goddard.



Xtend, an X-ray CCD camera that captures images over a wide wavelength range. CREDIT: JAXA

Lillian Reichenthal serves as NASA's project manager, with Dr. Richard Kelley as the mission's Principal Investigator. Dr. Kelley, along with many of the science, engineering, and cryogenic leads, were alumni from the previous Astro missions with JAXA. Tasked with managing the XRISM project and responsible for the instrument hardware contributions from NASA to JAXA, Reichenthal brought with her a wealth of experience working with international partners and JAXA specifically. Together with the instrument manager, they immediately began building a team of experts, old and new, from across the Center to tackle the effort.

By early 2020, NASA completed delivery of the key components for the Resolve instrument to JAXA. The team was in Japan in February 2020, preparing for the upcoming instrument integration and test campaign with JAXA when they began to notice a sharp uptick in mask wearing among the general public there. This was followed by news of a large cruise ship, the *Diamond Princess*, being quarantined off Yokohama. Shortly after the team returned to the United States, COVID-19 was declared a worldwide pandemic. Undaunted, the team was determined to make the best of the situation, taking hurdles in stride and using them as springboards for learning and growth.

Lift and integration of the Resolve X-ray Mirror Assembly onto the top of the XRISM spacecraft at the Tsukuba Space Center in October 2022. From left: Marcellus Ajiboye and Steven Kenyon. CREDIT: NASA/JAXA

They wouldn't have to wait long for their next opportunity – in March 2020, a superfluid helium leak was observed in the guard vacuum of XRISM's flight dewar during instrument testing. The leak was below the sensitivity of existing hardware to detect at room temperature, which made location and repair extremely difficult. By the end of March 2020, XRISM's on-campus work at Goddard was paused and all planned travel to Japan was prohibited due to the pandemic. At both NASA and JAXA, the XRISM team had to quickly adapt and develop a path forward. They pioneered what were, at the time, novel workarounds to remotely collaborate and connect with the work in the cleanroom and the instrument data in Japan before the offices were shut down.

Beginning in March 2020 and continuing through April 2021, the NASA team helped JAXA isolate and identify the source of the dewar leak. The Goddard cryogenics team provided investigative leadership in coordination with JAXA with additional support from the X-ray astrophysics group and the Resolve systems team.

De-integration of the Resolve instrument due to the dewar leak by NASA team, beginning with the removal of delicate filters from the Aperture Assembly at the ISAS/JAXA facility in Japan. Left: Samuel Moseley, right: Steven Kenyon. CREDIT: NASA/JAXA

Re-integration of the CSI at the Niihama, Japan Sumitomo Heavy Industries (SHI) facility. NASA team members: front left – Michael Dipirro, center left – Tomomi Watanabe, directly behind dewar – Michael Sampson. CREDIT: NASA/JAXA

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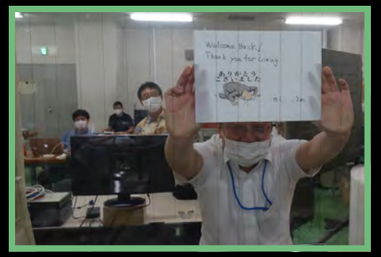


A warm welcome from JAXA colleagues when the NASA team arrived in Japan in July 2020 to remove the NASA hardware from the JAXA dewar and begin the leak investigation. CREDIT: NASA/JAXA

Collectively, the XRISM team delivered phenomenal work under immense pressure

By July 2020, NASA's XRISM team again began periodically traveling to Japan, though recurring lockdowns continued to present further challenges. This required long travel durations due to the extreme quarantine restrictions. Simultaneously, the rest of the team in the United States supported the work in Japan remotely.

By July 2021, the dewar was re-integrated and cooled to very low operational temperatures to confirm that the leak had been fixed. After all of this, the team had not only repaired the leak, but had also made the dewar more robust and strengthened XRISM's capabilities for the additional low-temperature tests required prior to launch.

In the end, XRISM not only survived, but thrived in spite of the pandemic and with limited resources. After delivery and integration with the spacecraft, XRISM completed the spacecraft environmental test program in January 2023.

Post-spacecraft environmental electrical tests confirmed excellent Resolve instrument performance on the spacecraft, comparable to the performance seen on ASTRO-H. Extensive testing between the instrument and spacecraft also eliminated residual concerns from ASTRO-H regarding interference from spacecraft components to the Resolve instrument.

XRISM is now set up for a successful launch to accomplish a high volume of great science with relatively limited funding, and is fast approaching its next programmatic milestone. The team is prepared to support these activities abroad including all critical operations and commissioning.

The XRISM science team continues to make excellent progress toward the Performance Verification phase (after commissioning), including through work on the X-ray Guest Scientist program and coordinating observations with other X-ray observatories. To date, 21 XRISM Guest Scientists have been competitively selected from the United States and Canada.

Along the way, NASA's XRISM team has overcome language and cultural barriers throughout the project's development lifecycle. Over the years, the team has gained immense experience effectively communicating with international partners and has demonstrated how to succeed within the specific work culture of Japan. Throughout this, NASA's XRISM team discovered techniques to bridge those communications gaps that could be applied to other groups including between contractors, other NASA centers, or academic institutions. This successful organizational structure could be leveraged to set up future international partnerships for success.

XRISM acoustic test at JAXA's Tsukuba Space Center in December 2022. CREDIT: JAXA

XRISM vibration test at JAXA's Tsukuba Space Center in December 2022. CREDIT: JAXA

In XRISM's case, this included adding project-level and Headquarters-level communications input and oversight in addition to other programmatic changes.

In addition to NASA's work in the United States, the XRISM team around the world has continued to deliver. JAXA's contributions to XRISM also include (but are not limited to) providing the Xtend instrument, the spacecraft and launch vehicle, and on-site integration and test facilities in Japan. ESA provided several components for XRISM, including loop heat pipes for the Resolve instrument as well as filter wheel mechanisms and electronics. XRISM is also supported by more than 100 astrophysicists, engineers, and other experts from universities and research institutes around the world.

XRISM's success means more than just the success of one mission, however long-anticipated. As Reichenthal sees it, Goddard's expertise in project management and instrument builds coupled with lessons learned were critical to getting to launch. Today's achievements can also be traced to the accomplishments of the ASTRO-E, ASTRO-E2, and ASTRO-H projects that XRISM has built on.

XRISM's progress to this point is due to the diligent efforts of diverse stakeholders working toward one shared goal to deliver on the long-standing promise of a next-generation, state-of-the-art soft X-ray science exploration satellite. Despite the mishaps of previous missions, a worldwide pandemic, and geographic barriers, the XRISM team has persevered. XRISM represents a triumph in international collaboration. The entire team's work to-date stands as an example of what innovation, dedication, and a considerate approach to challenging problems can accomplish. ■

J. Titus Stupfel / Code 460
Senior Technical Writer, Explorers and Heliophysics Projects Division

Thermal vacuum testing of the XRISM spacecraft at JAXA's Tsukuba Space Center. CREDIT: *@XRISM_JP on Twitter, August 22, 2022*

Goddard Comm & Nav Community Empowers Artemis I

On November 16, 2022, the Artemis I mission launched into space. NASA Goddard Space Flight Center's Communications and Navigation community played a critical role in this historic mission, helping the agency begin a new era of lunar exploration.

The Near Space Network provided the Space Launch System (SLS) rocket and Orion spacecraft with comprehensive communications services from the launch pad through their early orbit phases.

From Goddard's Near Space Operation Control Center in Maryland, the Launch Communications Segment in Florida and Bermuda, and the White Sands Complex in New Mexico, network experts synthesized services from both direct-to-Earth antenna systems and a constellation of relay satellites.

The Near Space Network's Launch Communications Segment (LCS) was responsible for direct-to-Earth communications support to Artemis I. LCS comprises two ground stations on the coast of Florida and one ground station in Bermuda that were designed to meet the specific needs of the SLS launch vehicle and Orion spacecraft. Network engineers coordinated support between all elements to ensure that the network met the mission's requirements.

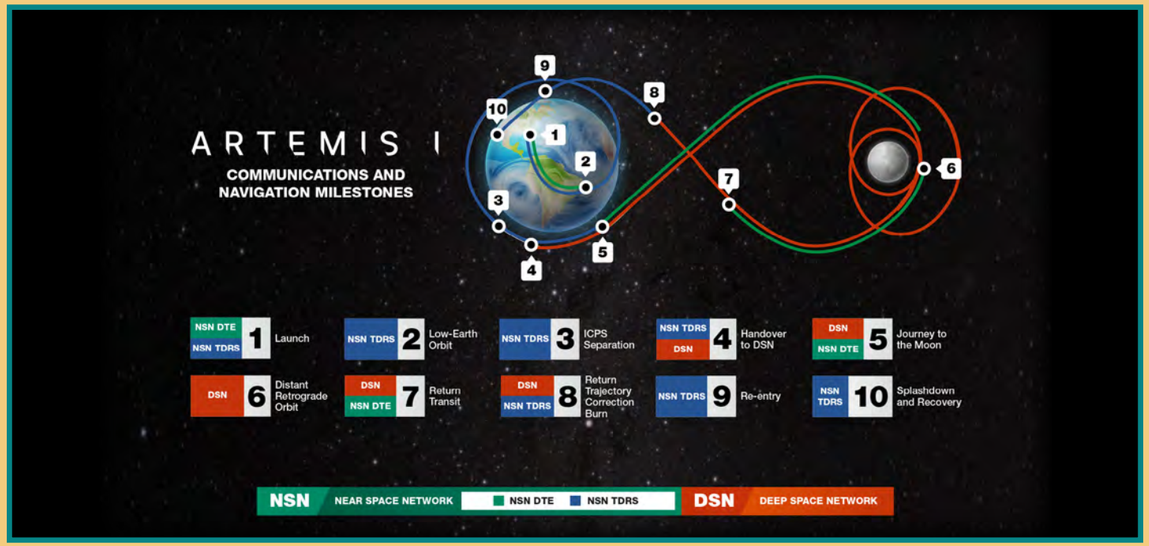
During ascent, the Florida-based LCS stations provided uplink and downlink communications between Orion and mission controllers. In the final phases of ascent, the Bermuda-based LCS station downlinked high-rate telemetry from SLS.

After the Orion spacecraft separation, the capsule received services from the network's constellation of Tracking and Data Relay Satellites (TDRS) – relays located in geosynchronous orbit that provide near-constant communications services. Near Space Network personnel at NASA's White Sands Complex in Las Cruces, New Mexico, coordinated TDRS support, ensuring the Orion spacecraft was communicating critical tracking and telemetry data.

Once Orion flew outside of the TDRS coverage zone, the Near Space Network handed over to its sister network, the Deep Space Network, operated out of NASA's Jet Propulsion Laboratory in Southern California. The Deep Space Network is the mission's primary communications provider at the Moon. However, future missions may see the Near Space Network covering lunar missions.

Network mission managers and engineers at the Goddard Near Space Operations Control Center during the Artemis I launch.. CREDIT: NASA

> "The Near Space Network supports a diverse set of missions, including launch vehicles, robotic satellites, and human spaceflight missions within 2 million kilometers of Earth. As NASA launches more missions into the near-space region, we are evolving our capabilities to support new missions. Additionally, we are preparing the network to off-load the Deep Space Network's lunar support, so our sister network can focus on servicing deep space missions beyond the Sun-Earth LaGrange Points 1 and 2."
>
> *Vir Thanvi, Near Space Network Project Manager*

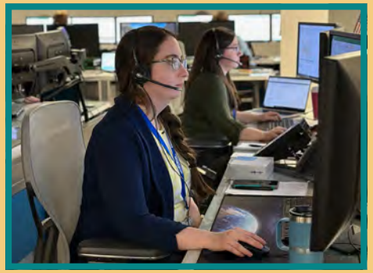


The NASA Artemis I mission received robust communications and navigation services from the Near Space Network and Deep Space Network. CREDIT: NASA / DAVE RYAN

Upon re-entry, both communications and navigation services switched back to the Near Space Network's TDRS fleet, which maintained contact with the spacecraft until splashdown.

Goddard's Flight Dynamics Facility (FDF) also played a critical role in tracking the SLS rocket and Orion capsule. Using data from both the Near Space Network and Deep Space Network, the facility tracked the mission from launch through its entire journey around the Moon and back.

Throughout Artemis I's journey, the FDF analyzed data from the Near Space Network's ground stations in Chile and South Africa, as well as data from the TDRS constellation for use in maneuvers and course corrections. Closer to the Moon, the facility relied on data from the Deep Space Network's three global ground stations in California, Spain, and Australia, to track the spacecraft.



Members of the Flight Dynamics Facility team tracking the Artemis I mission during the Space Launch System rocket launch. CREDIT: NASA

> "We're able to provide real-time updates to tracking as the mission's trajectory changes based upon data from SLS and the two networks, ensuring connection with Orion throughout its flight. We're also poised to provide backup navigation support to NASA's Johnson Space Center for Orion."
>
> *Sam Schreiber, Flight Dynamics Facility Operations Director*

To prepare for the mission, the FDF team conducted Abort-Once-Around (AOA) analyses to ensure the safe return of the Orion spacecraft in case of the unlikely event of a launch abort scenario, where Orion did not make it to orbit and could only circle the Earth once before splashing down.

To accomplish this, the team created new tools and processes from scratch – including processing thousands of potential trajectories to characterize the impact to service of a potential abort.

"Thanks to comprehensive testing of flight and ground systems, contingencies are unlikely – but they must be planned for," said Schreiber. "Efforts like the Artemis I AOA analyses demonstrate that NASA is putting safety first as we prepare to send humans to the Moon, Mars, and beyond."

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Cody Kelly, Mission Manager for National Affairs for the NASA Search and Rescue Office, on the USS Portland during Artemis I splashdown. CREDIT: NASA

Rosa Avalos-Warren, Near Space Network Human Spaceflight Mission Manager for Artemis I and Network Director for Launch Vehicles and Robotics, on-console at the Near Space Operations Control Center. CREDIT: NASA

"It is absolutely amazing to be a part of this historic mission that will create a more permanent presence in lunar orbit, and to know we played a critical role."

Rosa Avalos-Warren, Near Space Network Human Spaceflight Mission Manager for Artemis I

Goddard's Search and Rescue (SAR) team, who design and test emergency beacons for air, land, sea, and space, also contributed to Orion's safety.

On December 11, 2022, after a roughly 25-day journey to the Moon and back, the Orion capsule re-entered Earth's atmosphere. Upon splashdown in the Pacific Ocean, Orion's search and rescue beacons activated. On the USS Portland naval ship, members of the Goddard Search and Rescue team operated the newly developed SAR Intelligent Terminal (SAINT) application, which provided precise location data to the capsule recovery team.

"During recovery, we used our SAINT application operationally for the first time," said SAR National Affairs Manager, Cody Kelly. "This mission provided us an opportunity to test our Advanced Next-Generation Emergency Locator (ANGEL) beacons, which will be on astronaut life vests during future crewed Artemis missions."

The uncrewed Artemis I mission provided an opportunity for the Near Space Network, Flight Dynamics Facility, and Search and Rescue office to test new technologies and capabilities for future crewed missions. All groups are based at NASA's Goddard Space Flight Center in Greenbelt, Maryland, but have team members across the globe, dedicated to advancing capabilities for future exploration efforts. ■

Katherine Schauer / Code 450
Technical Writer, Exploration and Space Communications

The Next Generation of ESPD

Two new Earth Science Projects Division (ESPD) missions successfully passed Key Decision Point-A and entered Phase A in the last few months. Landsat Next is the newest and "super-spectral" iteration of the long-standing Landsat program. The Atmosphere Observing System (AOS) is poised to improve our understanding of severe weather and climate change. While these two projects continue development on a similar timeframe and blaze the path as the next generation of directed Earth missions with over $1.5 billion in cost apiece, each has a unique and revolutionary approach to their purpose.

Landsat Next

Landsat Next is the tenth chapter of the Landsat book, continuing the longest space-based record of Earth's land surface. While Landsats 8 and 9 were similar in design, Landsat Next is wildly different and will transform the depth of information available to users. It will continue to assist with agriculture, water use and quality, wildfire burns, climate change effects, and urban studies like its predecessors but with new and improved imaging and repeat cycles.

Landsat Next's mission concept will include a constellation of three observatories, launched on the same vehicle, with the combined capability to capture images from the same location on Earth every six days. This is significant when compared to Landsat 9's 16-day revisit. The mission will also include increased spectral and spatial resolution. This allows Landsat Next the ability to capture fast-changing processes on Earth such as crop growth and algal blooms.

The mission concept has strong dependence on the underlying heritage of Landsat 8 and Landsat 9 missions. In fact, many Landsat 9 team members have returned to work on Landsat Next but with new perspectives to develop this remarkable new project. While Landsats 8 and 9 measured 11 spectral bands, Landsat Next will have 26 bands, thus enabling new Landsat applications such as surface water quality, cryospheric science, geology, and agricultural applications including crop management and water consumption. Landsat Next provides step function gains in superspectral coincident visible and shortwave infrared + thermal infrared (VSWIR + TIR), by providing simultaneous superspectral VSWIR and TIR observations at improved spatial resolution. Most, if not all these gains are accomplished simply by implementing a "triplets" architecture – three identical observatories equally spaced in orbit. Each of the three satellites will be able to detect all 26 wavelengths of light and thermal energy. This architecture emphasizes the key priorities of existing Landsat users:

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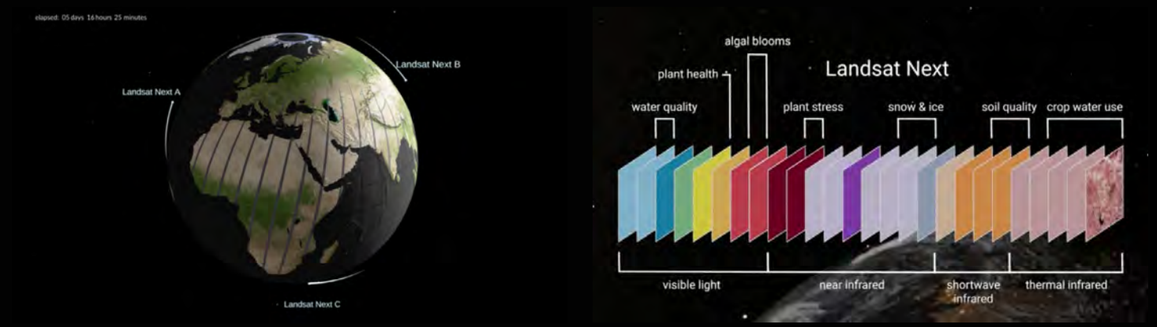


Landsat Next will be a trio of smaller satellites that can each detect 26 wavelengths of light and thermal energy. (top) Landsat Next will be "super-spectral" adding 15 new bands to support emerging user applications—for a total of 26 spectral bands. (bottom) CREDIT: NASA

improved temporal frequency of multispectral observations, higher spatial resolution, and additional spectral information for existing and emerging applications. Landsat Next will collect 20 times more data than Landsat 9. This data is critical to monitoring and managing Earth's natural resources.

Goddard will serve as the system integrator across all elements of the Landsat Next project and lead the mission system engineering and mission assurance efforts through the on-orbit checkout period. The project will coordinate with the Launch Services Program at Kennedy Space Center to secure access to space. Launch is planned for late 2030. As with previous Landsat missions, the U.S. Geological Survey will be responsible for developing the associated ground systems, operating the on-orbit spacecraft, and collecting, archiving, processing, and distributing Sustainable Land Imaging system data to users.

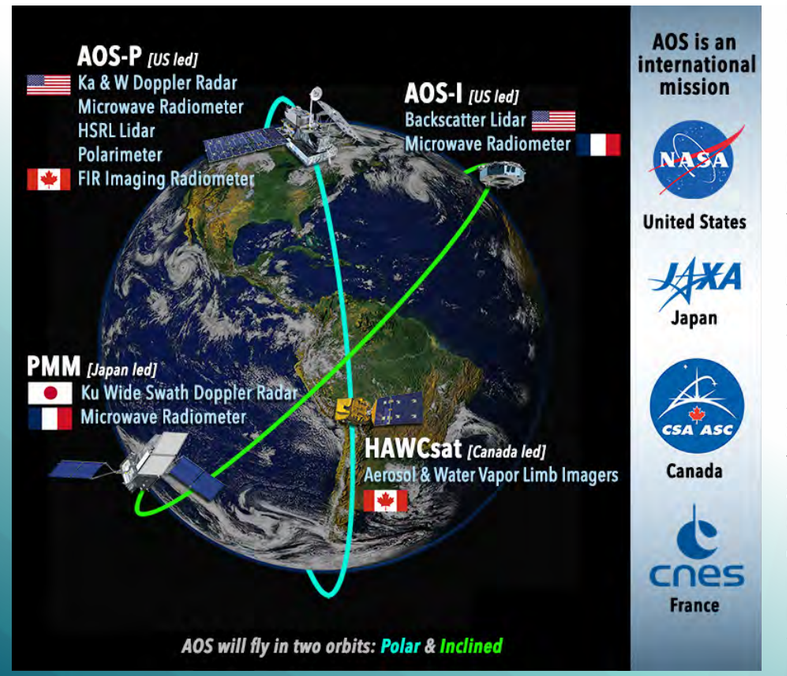
AOS

The AOS mission will examine links between aerosols, clouds, atmospheric convection, and precipitation to provide improved data on weather forecasts, air quality, and climate change. Four spacecraft will fly in two orbits – two on a polar orbit and two on an inclined orbit – to make the first-ever global measurements of vertical air movements and cloud convection. This data will provide critical insight into how natural and human-made aerosols affect cloud formation and weather patterns all around the world. AOS will also include a suborbital program to collect measurements that cannot be adequately measured from space. The mission will gather data from every step of cloud formation with the suborbital program providing data from ground stations and the air, via aircraft and balloons, in order to better understand the role aerosols and vapor play in the complex chain of processes and potentially creating extreme weather, thus improving weather forecasting.

To accomplish these goals, AOS has partnered with multiple NASA centers and four other space agencies: the Japan Aerospace Exploration Agency (JAXA), National Centre for Space Studies (CNES), Canadian Space Agency (CSA), and the German Aerospace Center (DLR). They have also partnered with universities both in the U.S. and abroad. NASA leads the development of both the AOS-Inclined (AOS-I) and AOS-Polar (AOS-P) spacecraft, while JAXA leads the development of the Precipitation Measuring Mission (PMM) spacecraft and CSA leads the High-altitude Aerosol Water vapor Clouds satellite (HAWCsat). AOS-P and HAWCsat will travel in a polar orbit while AOS-I and PMM will travel in a 55-degree inclined orbit with each spacecraft carrying a specific set of instruments designed to measure how atmospheric systems interact with each other.

The mission's design will provide improved and more frequent measurements of the aerosols in Earth's atmosphere and the vertical air motion that creates clouds and precipitation. With the four spacecraft in constant orbit, AOS can take measurements over the course of minutes to hours to days and reveal the distribution of aerosols and their links to the weather. Providing these continuous measurements helps meet the urgent need to better understand our dynamic atmosphere and improve forecasting of severe weather events.

AOS-I plans to launch in 2028 and AOS-P plans to launch in late 2030. The mission, in addition to Landsat Next, will generate such high-data-volume that the Earth Science Data and Information Systems program is implementing a new strategy to develop and operate multiple components of the Earth Observing System Data and Information System (EOSDIS) in a commercial cloud environment to meet the demands. Moving to cloud data increases flexibility and cost effectiveness for both EOSDIS and data users, making the incredible data that AOS and Landsat Next generate even more accessible.



AOS Constellation Image Partners CREDIT: NASA

Project Manager Spotlights

Jason Hair,
AOS Project Manager

Jason Hair is at the helm for AOS. Prior to AOS, Jason was the flight project manager for the Geostationary Extended Observations (GeoXO) mission to continue and extend the Geostationary Operational Environmental Satellite observation of the Earth's weather and environment. Before GeoXO, he was the project manager for Landsat 9's Thermal Infrared Sensor-2 (TIRS-2), overseeing the development and delivery of the instrument to Landsat 9 both on schedule and under budget.

Jason was also the project manager for the Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx) Visible and near-Infrared Spectrometer (OVIRS). OVIRS flew on the OSIRIS-REx spacecraft to survey the asteroid Bennu to locate and map minerals and molecules on the surface and help inform the sample site location. His first project management role was for the Solar and Lunar for Absolute Reflectance Imaging Spectroradiometer (SOLARIS) for the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission. SOLARIS concepts were developed to meet mission measurement requirements during pre-formulation activities.

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Jim Pontius
Landsat Next Project Manager

Landsat Next is led by Project Manager Jim Pontius. He previously served as project manager for the Landsat 9 Evolved Expendable Launch Vehicle Secondary Payload Adapter Flight System (L9 EFS). Jim was responsible for all aspects of delivering the fully integrated L9 EFS with up to 18 secondary payloads for launch aboard an Atlas V rocket from Vandenburg Space Force Base and stacked underneath the Landsat 9 primary mission. This first-of-its-kind interagency pathfinder partnered NASA and the U.S. Air Force together for developing, integrating, testing, and deploying to orbit a variety of CubeSats supplied from many different developers across the aerospace community. Jim also served as the Global Ecosystem Dynamics Investigation (GEDI) project manager. Jim took the project from inception at Phase A, through in-orbit commissioning and into Phase E operations. Before GEDI, Jim served as the Astro-H Soft X-ray Spectrometer Instrument project manager on an international partnership with the JAXA Hitomi mission. ■

Heidi Leach / Code 420
ESPD Technical Writer

2022 AGENCY HONOR AWARDS

Code 400 Awardees

Congratulations to all of the 2022 Agency Honor Award (AHA) recipients! Thank you to our nominators for their work recognizing our FPD teams and individuals for their exceptional achievements. Please use the link below to view the award recipients.

The AHA ceremony will be held on May 24th at 10 a.m. in the Building 8 auditorium on the Greenbelt campus. It will be a live ceremony and broadcast to the other Goddard campuses.

2022 AHA AWARD RECIPIENTS

LENGTH OF SERVICE PERSPECTIVES FROM THE DIRECTORATE

NASA, Goddard, and the Flight Projects Directorate pride themselves on the dedication of our exceptional workforce. Please join us in congratulating the seven civil servant employees who reached career milestones over the past year. These team members have devoted substantial portions of their career to the Federal Government and their perseverance and commitment enables NASA's mission.

Robert Connerton, 407

Technology Development Manager, **40 YEARS**

Reflecting, what has been the best part of working at NASA/GSFC/FPD?

When people asked me about what I liked about working at GSFC and at NASA, I told about one day where I was meeting with Dr. John Mather on large telescopes in the morning and in the afternoon I was meeting Dr. Jim Hanson from GISS on polarimeters and improving climate measurements. When asked which days that was I tell them the truth. It was a Tuesday or maybe a Thursday. It just another day at GSFC. Every day I had the opportunity to work with wonderful people and be a part of some amazing projects and missions.

- **Andrea Poulin, 435**
  Payload Manager
  25 YEARS
- **Bradley Teall Hill, 450.2**
  Deputy Office Chief
  10 YEARS
- **Benjamin Anderson, 450.2**
  Mission Manager
  35 YEARS
- **Brandon Bethune, 457**
  Deputy Project Manager Technical
  10 YEARS
- **Camille Thurston, 457**
  Provider Integration Manager
  25 YEARS
- **Jennifer Baldwin, 457**
  Secretary
  35 YEARS

KNOWLEDGE MANAGEMENT
Insights

Lessons Learned Requirement

There has been a lot of competition for mindshare the past few years. I thought this would be a good time to provide a reminder about NASA's lessons learned requirement. To comply with this requirement, I'll address NPD 7120.6A, list opportune times to capture project knowledge and suggest techniques for collecting lessons learned.

NPD 7120.6A – Knowledge Policy for Programs and Projects

NPD 7120.6A is the mandatory requirement for employees to collect project lessons. NPD 7120.6A applies to every NASA center yet permits a federated approach to compliance. Each NASA center has the autonomy to determine how to capture lessons learned in a way that aligns with that center's project management approach.

There are multiple reasons to capture knowledge in the form of lessons learned. The directive lists some of those benefits:

- Effectively manage the Agency's technical and program and project management knowledge to cultivate, identify, capture, retain, utilize, and share knowledge to continuously improve the performance of NASA in implementing its mission.
- Mitigate the impacts of attrition and other workforce demographic trends or program and project closeouts on knowledge loss and close anticipated knowledge gaps to benefit future knowledge users.
- Enhance awareness of Agency knowledge management resources, such as the Academy of Program/Project and Engineering Leadership (APPEL) Knowledge Services website where NASA's technical workforce can find knowledge needed to support project learning and mission success.

Lessons Learned Opportunities

Some project teams capture lessons during the project lifecycle. Other projects comply with lessons learned requirements during project closeout. This can turn out to be a hurried exercise when recall is no longer fresh, or team members have moved on to other projects. The longer a project runs, the greater the difficulty there will be in collecting comprehensive lessons at the end of the project.

With some planning, project teams can leverage opportunities during the project lifecycle to capture relevant and timely lessons. Opportune times include any of the following events:

- Project milestones (e.g., Key Decision Point (KDP) A, KDP B, Preliminary Design Review (PDR), KDP C, Critical Design Review (CDR), KDP D, 60 days within launch)
- Joint lessons learned sessions with follow-on project teams
- Lessons learned capture at the request of a senior leader
- New engineering, technology, and/or science paradigms
- Changes in project leadership
- Retrospective lessons learned at project completion
- Project continuation review
- Project cancellation

Three Learning Components

A meaningful strategy can enhance project success by learning from past projects' successes and failures. This strategy encompasses the following:

"Most of us work in industries where today's common knowledge will not solve the problems of tomorrow. Organizations must continually reinvent and update their common knowledge."

- NANCY DIXON

1. Learn Within the Project

Schedule Pause and Learn sessions for the project team at key milestones.

- Benefits: Continuous project improvement; consolidate team learning
- Outputs: Identify insights, lessons learned, and recommendations

2. Learn From Other Projects

Conduct joint lessons-learned session with follow-on project team to observe the discussion. Encourage all participants to engage in the group discussion.

- Benefits: Connect to those with relevant interests; timely value of shared lessons learned
- Outputs: Project lessons; continuous engagement and peer support

3. Share Project Lessons

Submit lessons learned to the Flight Projects Directorate (FPD); write a case study, develop a lessons-learned presentation, teach lessons at the Road to Mission Success program or for an APPEL course.

- Benefits: Leverage the investment of time and energy that went into gaining the knowledge; increase organizational learning; support development of future project leaders and team members.

Knowledge Capture Methods

1. After Action Review

Another term for the After-Action Review is 'Hot Wash'. This brief 15-minute exercise can be useful for the improvement of iterative processes.

2. Pause and Learn (PaL)

The Pause and Learn, an adaptation of the After-Action Review, was created by Dr. Ed Rogers, Goddard's former Chief Knowledge Officer. The PaL is a widely used assessment conducted during and after a project or major activity to capture lessons learned. This is a group discussion that enables employees and leaders to reflect upon, discuss, and discover (learn) what happened and why.

3. Knowledge Transfer Between Projects

In a project-based organization, one of the most effective ways to share lessons is a direct knowledge transfer between projects. The time value of shared lessons and their immediate applicability can lead to improved project performance.

4. Lessons Learned Report

A lessons learned report is an analytical report that provides insight into the successes and areas for improvement in a completed project. How the report is written depends upon the purpose for the report and the intended audience. Gathering insights, lessons, and recommendations can be conducted through Pause and Learns, one-on-one interviews, and/or group interviews.

Facilitated Lessons Learned Sessions

If you would like a facilitator for a lessons-learned session please contact me, **Judith.E.Dickinson@nasa.gov**. I am also available to train those employees who would like to lead Code 400 lessons learned sessions for their respective programs or projects. ■

Judy Dickinson / Code 400
FPD Knowledge Management Lead

References

- NASA NPD 7120.6A – Knowledge Policy for Programs and Projects
- APPEL Knowledge Services
- After Action Review
- The Pause and Learn
- Project to Project Knowledge Transfer

Susan Breon

Total and Spectral solar Irradiance Sensor–2 (TSIS-2)/Code 424
Project Manager

Born Pottsville, PA

Education BS in Nuclear Engineering, Pennsylvania State University

MS and PhD in Nuclear Engineering, University of Wisconsin—Madison

Life Before Goddard

Susan grew up in a small town in Pennsylvania. Work in the area consisted of factory jobs and farm work—both of which she did for short stints. Her parents encouraged Susan and her siblings to attend college for greater opportunities, so after high school she headed off to Penn State. Susan has played piano since she was six and briefly debated majoring in music. But she had a passion for science and math that was nurtured by her high school teachers. She decided it was better to be a professional engineer and an amateur musician than the other way around.

While studying nuclear engineering at Penn State, an accident at the Three Mile Island nuclear facility resulted in a melt-down of one of the reactors. As the nuclear power industry struggled to regain its footing, Susan changed her career path and headed off to graduate school. She obtained a research assistantship to study cryogenics, a discipline in demand for development of fusion energy. For her thesis, she studied boiling phenomena in superfluid helium. Little did she realize that her research would dovetail with work going on at NASA—developing liquid helium dewars to cool detectors like the ones on the Cosmic Background Explorer (COBE).

Life at Goddard

Susan started working at Goddard in the Cryogenics, Fluids, and Propulsion Branch in 1986, first as a Swales employee, then converting to civil service about a year later. COBE was a major focus for the Branch and she performed some supporting analyses, but her primary work was to develop the cryogenic system for the X-Ray Spectrometer (XRS). She was responsible for the procurement of a helium dewar that would include then-new cryocoolers to achieve the required lifetime. Susan also supervised the team developing the first-ever flight adiabatic demagnetization refrigerator (ADR) capable of cooling detectors down to 60 milliKelvin. This was an exciting time in cryogenics as her team reinvented standard laboratory techniques to withstand the rigors of spaceflight and explored the use of newly discovered materials such as high temperature superconductors. Susan became the lead for the XRS in-house development of the helium dewar for the Japanese ASTRO-E mission. The work was very demanding and rewarding. Unfortunately, Susan and her team learned one of the hard lessons of spaceflight when the launch failed.

Susan remained in the Cryogenics and Fluids Branch for about 25 years, becoming Branch Head in 2004. She had an oversight role in subsequent rebuilds of XRS, which is a story in itself. The Branch continued to advance the development of aerospace cryocoolers and ADRs, while maintaining expertise in cryogenic fluids for space applications and cryogenic testing. She led a small team to qualify low-cost cryocoolers for use on the Alpha Magnetic Spectrometer, an external astrophysics payload on the International Space Station. She also began preliminary concept development for the Robotic Refueling Mission 3 (RRM3), a flight demonstration of liquid methane transfer in zero-g. Members of her Branch provided cryogenic expertise for development of the James Webb Space Telescope (JWST).

In 2012 Susan became Associate Division Chief of the Mechanical Systems Division, Code 540. Her duties included managing the MSES IIA Bridge support service contract and setting up the follow-on MIST contract. In addition to managing institutional responsibilities for the Division, she worked on several strategic initiatives to improve communication and customer service.

Susan moved to Code 490 in 2016, becoming the Instrument Project Manager for the Resolve instrument on the X-ray Imaging and Spectroscopy Mission (XRISM). Resolve has significant heritage from XRS. After formulation efforts on Resolve, she moved to Code 480 to manage the cryogenic development and test for RRM3, which launched on December 5, 2018.

Following the launch of RRM3 Susan became Project Manager for TSIS-2. TSIS-2 continues a four-decade long measurement of the Sun's total power input to Earth as well as more recent measurements across the solar spectrum for use in climate models. TSIS-2 is Goddard's first observatory built as a Class D mission. It is also the first mission to procure launch services through the new Venture-Class Acquisition of Dedicated and Rideshare (VADR) contract set up by the Launch Services Program at KSC. Being "first" has given the team its share of challenges but has also given them the opportunity to pave the way for missions to follow. TSIS-2 is scheduled to launch in February 2025.

Life Outside Goddard

Susan and her daughter, Kathryn, have enjoyed travelling over the years. Susan adopted Kathryn from China as a baby, and they returned some years ago to help Kathryn connect with her roots. Kathryn recently got married, leaving her mom with two dogs and a cat. Susan is involved with her church and various local musical theater groups, especially Goddard's Music and Drama Club. She is very pleased to produce Goddard's first post-pandemic in-person show to be performed on Center this June. ■

Clockwise from left: Susan at KSC for the RRM3 launch; Breon family roadtrip; Susan and Kathryn in Paris; Susan with JWST mirror; Susan and Kathryn in Barcelona, CREDIT: ALL IMAGES COURTESY OF SUSAN BREON.

Kelly Catlett

Earth Science Projects Division, Code 420

PAAC Integrated Program Team Lead (IPTL), General Business Co-lead, and FMP Lead & ESPD Information Technology (IT) Manager

Born Silver Spring, MD

Education Bachelor of Science, Computer Information Science, UMUC

Master of Science, E-Commerce, UMUC

Project Management Professional from Project Management Institute

Life Before Goddard

Kelly grew up in Mayo, Maryland with a strong family connection to Goddard. Her grandfather was responsible for the development of the Hubble Space Telescope ground systems and operational organization, having a long career as an engineer and senior executive at Goddard and NASA Headquarters. Her mother also worked at Goddard, so Kelly often visited family on center and was always excited about NASA missions.

As a child, Kelly excelled at math and science. She didn't necessarily know what she wanted to do while career planning but had determined that computer science would be a fruitful path as an up-and-coming discipline at the time. She had always been organized, focused on doing even the smallest chores efficiently, which naturally lent itself to the IT field. While earning her undergraduate degree, she worked at Swales Aerospace building computers and servers as well as providing IT support. She transitioned to Marriott International, learning more about application support for all of their in-house databases and tools.

She later joined US Internetworking, Inc., an application service provider out of Annapolis, MD, where she focused on client application databases and other off-the-shelf tools with a customer relationship management focus. As her career progressed, she was elevated to a lead technical position providing expertise in the design, deployment, and maintenance of a highly available, multi-site Microsoft Exchange system. Kelly provided project management within the messaging environment, creating project plans, risk analyses, change management, and leading virtual teams across development phases.

Life at Goddard

Although Kelly was not looking for a position at the time, when she saw an open Goddard project manager position that required email migration experience, it seemed her work experience and history with Goddard had aligned. She onboarded in 2007 supporting the Information Technology and Communications Directorate (ITCD) as the implementation manager for NASA's Operational Messaging and Directory Service (NOMAD) Migration Project. Kelly facilitated the Center's NOMAD migration implementation schedule, including notifications and technical assistance to all new NOMAD users. She also developed NOMAD policies, procedures, and documentation for Agency and local system administrators, the NOMAD project team, and end users.

In 2010, Kelly was highly encouraged to consider an opening on the Global Precipitation Measurement (GPM) project. She was excited for the opportunity to dive further into project management and build her experience with flight projects. Kelly thoroughly enjoyed her time as the project support manager for GPM. She was selected to serve as a PAAC IPTL in 2012 while continuing her leadership on GPM for the project support

Clockwise from left: GPM launch in 2014; GPM Team at Tanegashima Space Center; Enjoying life on the water; Kelly, Kevin and Kayla.
CREDIT: ALL IMAGES COURTESY OF KELLY CATLETT

team, ultimately managing all logistics and support aspects of a very complex, dynamic launch campaign from the Tanegashima Space Center in 2014.

When GPM concluded in 2015, Kelly transitioned to Landsat 9 as Project Support Manager while training other staffers to eventually take on the role. In 2017, she joined ESPD, which aligned with her IPTL duties as well as managing IT across the division. In this role she leads the team supporting 1,000 end users across 10 project teams while also managing more than 60 employees spanning all PAAC disciplines across ESPD and the Space Weather Observations Program. Kelly's emphasis in both roles is to focus on her customers, proactively implementing sustainable, cost-effective solutions. Her dedication to these efforts also assists with anticipating the training needs and improved support for the entire general business community.

During her time on PAAC and at Goddard, Kelly recognizes an outstanding culture and work environment. From her experience, much of that revolves around the many mentors and peers that have helped her along the way. As a result, one of Kelly's greatest passions is developing her team and those who seek growth to ensure job satisfaction and joy in their careers. She was one of the primary developers of PAAC's Functional Mentorship Program (FMP) and is now responsible for program management. The program is in its sixth session, providing participants functional and technical training of their choice via selected mentors. Kelly's leadership of the FMP allows her to support PAAC team members to focus within their discipline or even transition between disciplines to meet their personal development and growth goals. She is excited to see the entire Directorate's focus on mentorship and coaching continue to evolve and grow.

Life Outside Goddard

Kelly and her husband, Kevin, and daughter Kayla, reside in Mayo, Maryland in Kelly's renovated childhood home. She enjoys spending time with family and her second family at the West River Yacht Club. She is most at home on the water and spends most of her time off boating throughout the Chesapeake Bay and beyond. Her passion for travel peaks when enjoying the beautiful water of the Caribbean. Kelly also loves to cook, garden, practice yoga, and hike. ■

Coming and Goings

October 1, 2022 through February 2023

Comings

Bashaer Zaki (External) to 457/ Near Space Network Project (NSN)

Morgan Van Arsdall (External) to 441/ Hubble Space Telescope (HST) Operations Project

Susanne Strege (583) to 401/Project Formulation and Development Office (PFDO)

Robert Vik (ARC) to 450.3/ Search and Rescue (SAR) Mission Office

Denise Lawless (802) to 401/Project Formulation and Development Office (PFDO)

Paul Markie (224) to 401/ Project Formulation and Development Office (PFDO)

Goings

Christy Hansen (400) to HQ

Kent Gaylor (457) Retirement

Nidhin Babu (452) Resignation

Andy Mitchell (423) to HQ

Shar Etemad (401) Retirement

Pam Millar (407) Retirement

Jeanne Behnke (423) Retirement

Keith Opperhauser (427) Retirement

Reassignments/ Realignments Details within Code 400

Miquel Moe (401) to 465/ Geospace Dynamics Constellation (GDC)

Robert Estep (497) to 427.1/ Ocean and Color Instrument (OCI)

Caleb Noblitt (460) to 465/Geospace Dynamics Constellation (GDC)

Brooke Hsu (418) to 401/ Project Formulation and Development Office (PFDO)

Betsy Park (421) to 430/ Planetary Science Projects Division (PSPD)

Andre Gondouin (418) to 425/ Atmosphere Observing System (AOS)

Nita Pszcolka (435) to 436/ Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging (DAVINCI) Project

Jerry Mason (457) to 401.1/ Rapid Spacecraft Development Office (RSDO)

Tim VanSant (4911) to 493/ Space Weather Next L1 Series Project

Param Nair (472) to 465/ Geospace Dynamics Constellation (GDC)

Caitlin Kohli (422) to 426/ Landsat NeXt

Jesse Lewis (426) to 425/ Atmosphere Observing System (AOS)

Sergey Krimchansky (431) to 418/Geostationary and Extended Orbit (GEO-XO)

Karen Rogers / Code 400
Administrative Officer

OUT & ABOUT

LIFE'S HIGHLIGHTS OFF CAMPUS

Congratulations to George Rankin (372/459) and his wife, Jennifer, on the birth of their son, Ethan Thomas. He was born on January 31, 2023, weighing 7.2 lbs., and measuring 21" long.

Best wishes to Mr. and Mrs. Ramon and Jacqueline (Seymore) Johnson (400) who were married on November 11, 2022, in Ochos Rios, Jamaica.

Cheers to Paige (460) and Jordan McKinley, who were married on November 12, 2023 in New Windsor, MD. Paige is the daughter of Paula Wood (460) and the sister of Pamela Merkel (155.7).

Continued on page 26

Share your news!
Weddings, births, interesting travel experiences...we want to know!

Please send your inputs to Paula Wood. Include your **name, phone number** to:

paula.l.wood@nasa.gov
Code 460
Ext. 6-9125

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Begoña Vila selected as Honorary Ambassador

Begoña Vila, the James Webb Space Telescope (JWST) Instrument Systems Engineer, was awarded the Embajadores Honorarios de la Marca España (Honorary Ambassador for the Spanish Brand) for Science and Innovation. The award was presented by King Felipe VI and Queen Letizia of Spain on March 15, 2023 at the Palacio de El Pardo and was followed by a reception with them.

Begoña said, "I was so honored and happy to be selected as an Honorary Ambassador for 'Marca España' (Spain Brand) on the Science and Innovation Category for my career and my work on JWST. It was a special event for me for sure – it's always wonderful to know your work is appreciated, but working and living abroad it is special to be remembered at home.

I was so touched and proud they believe me a good 'honorary ambassador' for Spain and I hope to continue to be so. It was an unforgettable experience that I was lucky to be able to share with my mum and sisters – I was very lucky they could come and share this special day with me."

The accreditation of the Honorary Ambassadors of the Spain Brand is an initiative of the Forum of Renowned Spanish Brands (FMRE) whose purpose is to offer public recognition to individuals, natural or legal, of Spanish nationality, who, in the FMRE's opinion, have contributed significantly to the generation and strengthening of a positive image of Spain abroad. The Honorary Ambassadors of Spain project was launched in 2005 and there are seven categories, including Science and Innovation, Sports, Tourism and Gastronomy, Culture and Communications, Social Action, Corporate Management, and International Relations.

For more information, go to:

https://brandsofspain.com/spain-brand-ambassadors/

https://www.casareal.es/ES/Actividades/Paginas/actividades_actividades_detalle.aspx?data=15663

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JWST Team Wins Prestigious Award

Members of the James Webb Space Telescope (JWST) Project team, along with members of its prime contractor team from Northrop Grumman received the Dr. Robert H. Goddard Memorial Trophy on March 10, 2023 at the Washington Hilton. The prestigious award was the highlight of the National Space Club and Foundation's 66th annual event, presenting its highest honor for "outstanding individuals for accomplishments in spaceflight, engineering, science, management and education. The premiere award, the Goddard Trophy, is presented to an individual, group or program deemed to have made the most significant contribution to space activity in the previous year."

In addition to the National Space Club award and Begoña Vila's honorary ambassadorship, the JWST team was also recognized with the National Air and Space Museum's 2023 Michael Collins Trophy for Lifetime and Current Achievements.

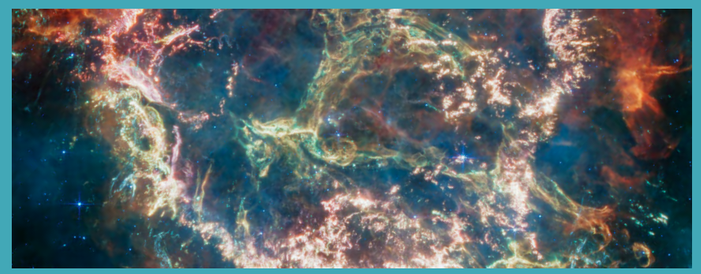
(left to right): Keith Parrish (Observatory Manager), Mike Menzel (Mission Systems Engineer), John Durning (Deputy Project Manager), Begoña Vila (Instrument Systems Engineer), Laura Betz (Outreach Lead), Scott Willoughby (NGAS Program Manager)
CREDIT: NASA

(left to right): Paul Geithner (Deputy Project Manager-Technical), Lee Feinberg (Optical Telescope Element Manager), Juli Lander (OTIS Deputy Manager), Mike McElwain, Jane Rigby (Observatory Project Scientists), Begoña Vila, Keith Parrish
CREDIT: NASA

JWST Captures Stunning New Images of the Universe

In case you missed it, 60 Minutes recently featured a segment called "The Origin of Everything" on the latest awesome discoveries from JWST.

https://www.youtube.com/watch?v=dC1-qgR7YO0



Hubble, JWST win Webby Awards!

The 2023 Webby award for Best Video, Science and Education was won by the Hubble Space Telescope. JWST was recognized with two "People's Voice" awards and their social media program was honored as one of the best on the internet.

Click here for more information.

THE LATEST SAR SAVES

NASA'S SEARCH AND RESCUE (SAR) OFFICE CONTINUES ITS EFFORTS TO DEVELOP AND IMPROVE ON LIFE-SAVING DISTRESS BEACON TECHNOLOGIES.

Each icon on this map represents one rescue event, though multiple saves may be involved with each event. The Search and Rescue Satellite Aided Tracking (SARSAT) system is able to detect three types of beacons:

Personal Locator Beacons (PLBs)

Used primarily by hikers and outdoor enthusiasts

Emergency Position Indicating Radio Beacons (EPIRBs)

Used by commercial and recreation ships

Emergency Locator Transmitters (ELTs)

Used by civilian aircraft

COSPAS-SARSAT rescues from September 2022 through April 2023 are shown above.

Loving Day - June 12:

"An annual celebration that commemorates the anniversary of the 1967 United States Supreme Court decision Loving v. Virginia which struck down the remaining anti-miscegenation laws in the United States".

Loving v. Virginia: 1967 & Supreme Court Case - HISTORY - HISTORY

DID YOU KNOW..?

We want to be in the know!

If you have something to share, send it to Jacqueline Johnson. Include your **name, phone number** and send it to:

Jacqueline.seymore@nasa.gov

Flight Project Diversity and Inclusion Committee

Ext. 6-6307

FLIGHT PROJECTS
LAUNCH SCHEDULE 2023

FALL / WINTER 2023

XRISM

GUSTO

ILLUMA-T