THE INNOVATION CATALYST

February 2023

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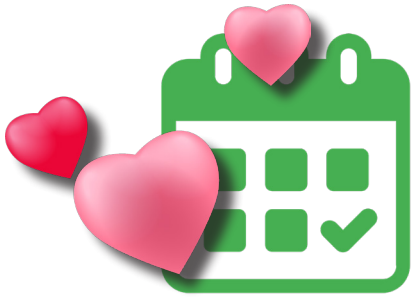
TECH TRANSFER TIP

with SBIR/STTR Center Lead Joseph Famiglietti:

Remember you can use SBIR/STTR (Small Business Innovation Research/Small Business Technology Transfer) Phase III Contracts to meet your project's goals! This streamlined process meets the sole source requirement ensuring deadlines are met. A Phase III contract can be awarded at any time, for any dollar amount and duration on a past Phase I or Phase II contract from any government agency.

UPCOMING EVENTS:



INNOVATOR HOUR

TUESDAY, FEBRUARY 14, 2023

1:00–2:00 P.M.

STRATEGIC PARTNERSHIPS OFFICE

NP-2023-1-006-GSFC

NASA Senior Leadership Lays Out Agency's Blueprint For Manned Missions to the Moon and Mars

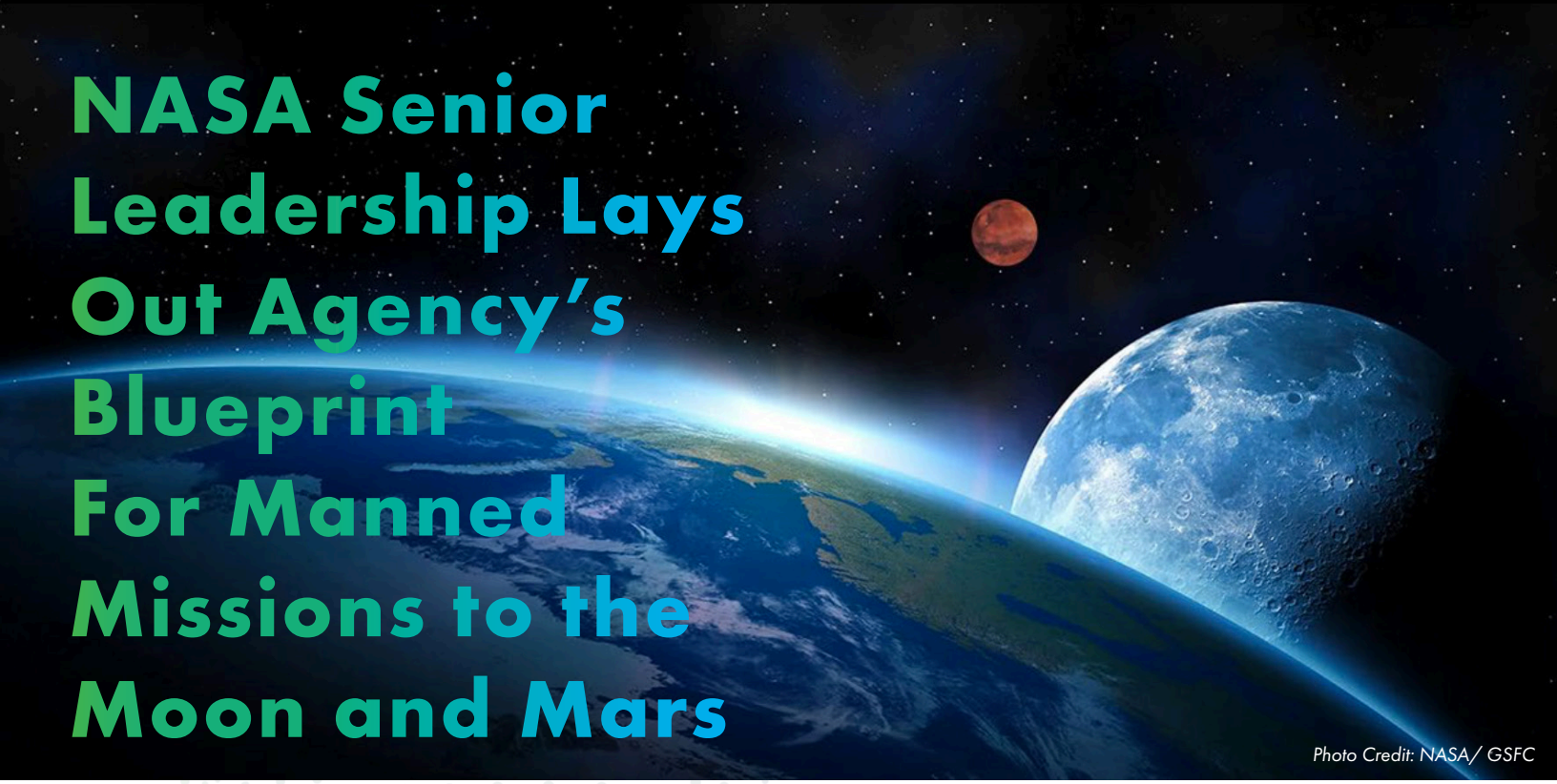


Photo Credit: NASA/ GSFC

Administrator Bill Nelson Proclaims NASA is in the "Golden Age"

When NASA's Artemis I mission rocket lifted off from the Kennedy Space Center, it marked the beginning of the historic return to manned missions to the Moon, Mars, and planets beyond. At the Goddard Town Hall on January 12, NASA Administrator Bill Nelson, NASA Deputy Administrator Colonel Pam Melroy (USAF Ret.), and agency senior leadership explained NASA's Moon to Mars mission objectives. To ensure the success of NASA's mission strategy and to outline Goddard's vital role, leadership shared the agency's blueprint for deeper exploration in the solar system, and the path forward to achieving that in the coming months and years.

Named after Apollo's twin sister, the Artemis mission hopes to revitalize some of the glory of NASA's previous moon-landings from over a half a century ago. Artemis I was the first of a series of increasingly complex missions aimed to build a long-term human presence on the Moon. The primary goal of Artemis I was to test that the heat shield on the Orion CM-002 spacecraft could ensure a safe re-entry, descent, splashdown, and recovery, prior to the first flight crew aboard Artemis II.

"We have a big world out there to explore," said Nelson to the capacity crowd in attendance. "And oh my, are you exploring it! It is an exciting time to be at NASA in what I describe as the 'Golden Age.' But this is only the beginning of a new beginning of the Artemis generation."

Sen. Bill Nelson, NASA Administrator, Photo Credit: NASA

To embark on the mission that Nelson describes as an effort to "explore the universe and create a sustained human presence throughout the solar system," NASA leadership outlined to the Goddard community precisely how, what

NASA Deputy Administrator Pam Melroy speaks at GSFC Town Hall, Photo Credit: NASA/GSFC/OCOMM

and why the entire agency will achieve this. Nelson and Melroy compared the present effort to the Apollo mission to the Moon.

"A lot of people ask me, 'why we are going to the Moon?'," said Nelson. "We were there 50 years ago. [But] we are not just going to the Moon, we are going to the Moon to live, to learn, to work, to invent, to create, in order to go to Mars and beyond."

"The same way I was inspired by Apollo, Artemis is going to create another tidal wave of engineers, scientists, aviators, and explorers who are excited about the future," added Melroy.

Melroy explained to the Goddard community that the mission began with the Biden-Harris Administration giving NASA the direction not to alter the goal of going from the Moon to Mars. But to do that, she said, "What we first needed to do is understand what the value is of going into space, not just human space flight but going into space itself."

The value of going into space, Melroy explained, was predicated on the convergence of what she called "three pillars" that include: science, inspiration, and natural posture or U.S international prestige. The example she gave was the James Webb Space Telescope.

"It's having a capability that could not be done here terrestrially," said Melroy. "There is so much science that cannot be done here because of the limitations of being on Earth. With the James Webb Space Telescope, we had to go to space to get that capability. Science is one of the founding principles [of going into space] that we bring. It is what gives us the foundational insights that lead to technology and capability breakthroughs later on and create technologies that benefit all of our country in many different industries."

Melroy went on to explain that NASA, through its investments in public-partnerships, has helped transform the commercial space industry in the last decade. She said, "We are the envy of the world with our U.S.-based commercial space industry because of the unique capabilities that [private industry] has obtained [through technology transfer]."

Now that NASA has defined why we want to go to the Moon and Mars, Melroy said we can begin look in more detail into what we will accomplish. For the past decade, NASA has been working on the Space Launch System rocket for heavy-lift payloads and the Orion spacecraft itself, which will carry humans to the Moon. The key she said to understanding the what NASA was hoping to accomplish, "was shifting gears from a capabilities-based approach to a goal or objective-based approach."

Melroy stated the goal of Moon to Mars is to "create a blueprint for sustained human presence and exploration throughout the solar system." Currently, NASA has plans

to launch astronauts to Mars within the next two decades. However, being able to effectively carry out those plans has been and will continue to be challenging. To succeed, she added, "we have to have the capability and the infrastructure in place that enables humans to stay in space for long periods of time. This is a whole agency thing that we are doing together."

As doing science on another planet is going to be new for NASA, Melroy said she asked the advice of the Federated Board (FB), a NASA-based organization that includes senior leadership from all the agency Mission Directorates. While not a decision-making body, the FB seeks to drive consensus, promote efficient conflict resolution, help interpret strategic guidance and expectations from agency leadership, and provide advice to NASA leadership. The FB provided Melroy with four bucket areas that NASA first needs to learn about, which include: science, infrastructure, transportation and habitation, and operations.

From left, Kurt "Spuds" Vogel, Joel Kearns and Cathy Koerner, Photo Credit: NASA

"This is the beginning of the 'what,'" explained Dr. Kurt "Spuds" Vogel, NASA's director of Space Architecture, who led the effort to formulate and synthetize the objectives of the four bucket items. "With science, we need to understand the origin of life in the solar system by identifying where and when potentially habitable environments exist. With infrastructure, we need to demonstrate technologies that support autonomous construction, precision landing, surface transportation, and industrial-scale manufacturing capabilities in support of continuous human presence. With transportation and habitation, we need to get [to the Moon or Mars] and get back and sustain ourselves. With operations, we are going further [in space] and staying longer [on the Moon or Mars] than anything in NASA's history, so we need to demonstrate technologies to live and work on a planetary surface other than Earth."

Vogel said the key to achieving the bucket items is what he called an agency-wide effort to have unity of purpose. "What we wanted to do," he said, "is get back into a unified approach with a constancy of purpose where everybody [at NASA] is communicating from the same sheet of music and we all have the same plan. Communications is the lifeblood of the entire strategy."

NASA's deputy associate administrator for the Exploration Systems Development Mission Directorate Cathy Koerner, Photo Credit: NASA

Cathy Koerner, NASA's deputy associate administrator for the Exploration Systems Development Mission Directorate presented on how NASA plans to execute these objectives and focused on the science, annual lunar surface missions, Mars missions, and effort to expand partnerships with private industry. Koerner explained how NASA has been working on future Artemis missions while it simultaneously prepared for the inaugural launch that occurred on November 16.

"We've got hardware on the shelves waiting to assemble, the spacecraft for Artemis II is in production, and some elements of the spacecraft and the rocket are already at the Kennedy Space Center," said Koerner, who is also manager of the Orion Program. "That's going to enable us to do the next crewed mission [on Artemis II], the test flight that will set up our annual cadence of surface missions to the Moon."

Koerner said the next phase of the Artemis program will be to send the first crewed capsule around the moon and back, without landing on the moon in 2024. Nelson estimated that NASA will announce the crew for this phase of the mission sometime before the end of this year. NASA then aims to use the Orion capsule to land astronauts on the moon for phase three of the program by 2025.

"We have learned so much from humans in low Earth orbit and have been tantalized by the science we have done on the International Space Station," said Melroy in conclusion. "So, we need to practice the [Moon to Mars] blueprint with our activities on the Moon and then we need to demonstrate it on Mars. I hope that in another decade, you will have another administrator standing in front of you talking about – based on the interesting science that you guys [at Goddard] are working on – what is the next destination after Mars. The [Moon to Mars] blueprint for how we sustain human presence in explorations should resonate as the set of objectives that we have to achieve. It will be different for every [planetary] destination, but the foundational principles will be the same."

THE STRATEGIC PARTNERSHIPS (SPO) OFFICE PRESENTS

INNOVATOR HOUR

Have questions about protecting your innovation?
Want to learn more about how to submit New Technology Reports?
Have general questions about technology transfer and partnerships?
Sign up for a one-on-one 20-minute timeslot with a SPO representative.
Meetings will be held virtually via Microsoft Teams.

NEXT SESSION: **TUESDAY, FEBRUARY 14, 2023**
1:00-2:00 P.M.

Available Timeslots
1:00-1:20 P.M.
1:20-1:40 P.M.
1:40-2:00 P.M.

How to Sign Up

To register for the upcoming session and secure your timeslot, complete the registration form.

Inventors of the Month

Safe Landing on the Moon

When Apollo 11 touched down on the Moon on July 20, 1969, it was one of the biggest milestones in human history. Today, we take it for granted that a lunar landing on the Moon is possible. But at the time, nobody had ever done anything even remotely lke it. NASA's recent announcement of a return to the Moon (see page 2) brings into focus a pertinent question: How does NASA successfully land a lunar module safely on the Moon?

Children's fairytales tell us the Moon is made of green cheese, but actually the surface is covered with dead volcanoes, impact craters, and lava flows. Apollo astronauts who visited the Moon have relayed that the crust is a rocky surface covered with regolith, defined as a region of loose unconsolidated rock and dust that sits atop a layer of bedrock. Astronauts have described it as walking on "fine broken glass," which can be hazardous.

As prescribed by NASA's Moon to Mars strategy, a manned Moon landing with a lunar module will involve a series of five stages. The first is the initial entry to the Moon followed by a powered decent to the Moon surface and an approach in which the lunar module will maneuver to a pre-determined landing site. In the fourth stage, the lunar module will divert to accurately identify the site location before finally completing a precise touchdown on a safe landing location.

To ensure safety, NASA will rely on advanced navigation lidar – or light remote sensing – to carefully guide the spacecraft as it descends down to the surface. NASA also will employ high-resolution

Jeffrey Chen -1550nm CASALS lidar rooftop demonstration, Photo Credit: NASA

3D imaging through advanced swath-mapping lidar technology to provide highly accurate global elevation data of the proposed landing site.

"That is very challenging," said Jan-Peter Muller, professor at University College London, who in 2020 was commissioned by NASA's Jet Propulsion Laboratory to create a 3D model and image of Aristarchus, a crater on the Moon that was originally selected as the landing site of the cancelled Apollo 18 mission. "NASA needs better quality maps, models, and imagery of the Moon surface to minimize the risks and maximize the safety of astronauts."

A team of Goddard engineers and research scientists are working to solve to that problem. Dr. Guangning Yang, Dr. Jeffery Chen, Dr. Mark Stephen, and Dr. Hui Li are now developing the Concurrent Artificially-intelligent Spectrometry and Adaptive Lidar System (CASALS). This technology uses multiple wavelengths, advanced lidar, and laser technology to rapidly and accurately map a landing site on the Moon or planetary surface the size of 100 meters by 100 meters.

"The new technology [CASALS] will provide more measurements, use less power, is smaller, and more efficient than any of the existing [lidar] technology," said Chen. "But to accomplish this we needed to create a breakthrough technology. [Existing lidar] technology scans a beam mechanically, but that is unreliable and also too slow. We developed a smart laser system that can scan one single beam very fast [over a given area]. By [fine] tuning the laser wavelength and using something called 'optical grating,' we can change the angle of the laser beam to allow us to scan the beam faster and wider [over a given area]."

Chen said another advantage of CASALS over present lidar scanning technology is that it can both measure and calculate distance as the lunar module is descending, as well as map the desired landing area on the Moon. In addition, CASALS can begin taking mapping measurements of the lunar surface from a distance of two kilometers (or 1.2 miles) from the surface. Present technology can only map the landing site from about one half a kilometer away.

"The key to the CASALS technology is to make it super-efficient because a satellite has only so much available power," noted Chen. "The Moon landing lidar is power hungry. Our lidar uses only about 80 watts and therefore is more efficient."

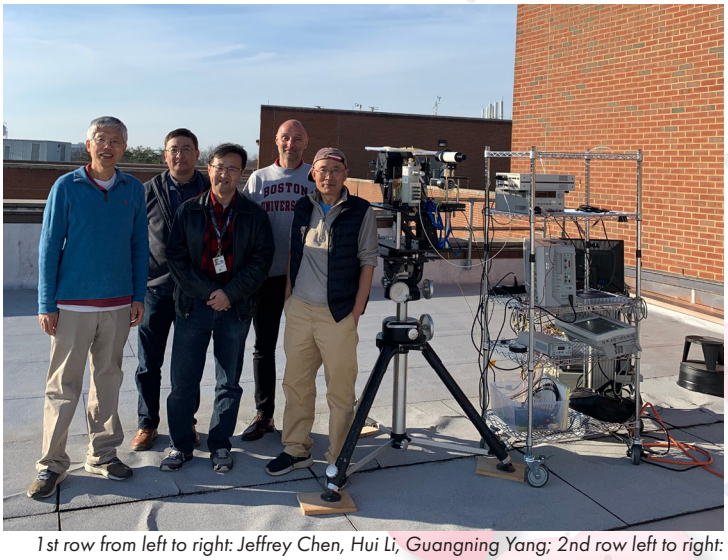
Work to date has focused on maturing the lidar components and demonstrating the performance required for space. The CASALS lidar has already been demonstrated in various rooftop tests at Goddard.

Originally supported by NASA's Radical Innovative Initiative (RI2) Internal Research and Development (IRAD) program and is presently supported by an Instrument Incubator Program (IIP-19) and several IRAD projects, CASALS currently has three patent applications with the U.S. Patent and Trademark Office. The technology is presently in a Technology Readiness Level 5 or 6 (component validation and protype demonstration in a relevant environment). The goal, Chen said, is to have CASALS developed and ready for Artimus III, the first crewed Moon landing targeted for 2025.

"NASA [leadership] is very excited about the CASALS technology, and we have gotten a lot of support from them," said Chen. "To have it ready for the Moon landing, we are working on having an airborne demonstration over the next year."

CASALS was originally designed and received funding from three other NASA projects before being targeted for the Moon landing mission. Engineers first designed CASALS for Earth Science mapping applications such as ICE-Sat-2, NASA's satellite mission for measuring ice sheet elevation and ice thickness. It also was designed to map the lunar surface of the Moon on NASA's Lunar Orbiter Laser Altimeter (LOLA). LOLA's mission was to survey the lunar landscape from an orbiting spacecraft. In addition, it was also going to be used for asteroid mapping. Now, the CASALS technology is extended for Moon landing.

"Up to now, our architecture [for the Moon to Mars mission] has focused on initial human landing capabilities of putting two humans on the surface of the Moon, and eventually expanding that to four, for extensive periods of time," said Cathy Koerner, NASA's deputy associate administrator for the Exploration Systems Development Mission Directorate. "That is going to require us to infuse new technologies [like CASALS] and develop infrastructure that will eventually help us to establish more capabilities on the lunar surface."



1st row from left to right: Jeffrey Chen, Hui Li, Guangning Yang; 2nd row left to right: Wei Lu and Zoran Kahric, Photo Credit: NASA

Finding Water on the Moon

For centuries, astronomers have debated whether water exists on the Moon. As far back as 1645, Dutch astronomer Michael van Langren published the first-known map of the Moon referring to the dark spots as "maria," the Latin word for seas. This put in writing the beginning of a widely held view that there were oceans on the lunar surface. Today astronomers know that these dark spots are not oceans but the remains of volcanic eruptions.

In 2020, NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) confirmed, for the first time, that water could exist on the sunlit surface of the Moon. This discovery indicates that water may be distributed across the lunar surface, not just in the colder, shadowed places on the dark side. SOFIA is a modified Boeing 747SP aircraft that is used by NASA as an infrared observatory to explore the birth of new stars, planetary nebulas and supernova remnants, the atmospheres of objects in the Solar System, and most recently, the existence of water on the Moon.

Previous observations of the Moon's surface detected some form of hydration but were unable to distinguish between water and its close chemical relative, hydroxyl (OH). SOFIA detected water molecules (H_2O) in the Clavius Crater, one of the largest craters visible from Earth, located in the Moon's southern hemisphere. Data from this location indicated amounts of water – roughly equivalent to a 12-ounce bottle of water – are trapped in a cubic meter of soil spread across the lunar surface.

"We had indications that H_2O – the familiar water we know – might be present on the sunlit side of the Moon," said Paul Hertz, director of the Astrophysics Division in NASA's Science Mission Directorate. "Now we know it is there. This discovery challenges our understanding of the lunar surface and raises intriguing questions about resources relevant for deep space exploration."

The discovery and presence of large quantities of water on the Moon could prove to be a significant factor in the human habitation phase of NASA's Artemis mission (see page 2) to build a permanent base on the Moon as a stepping-stone to deeper human exploration of Mars and the solar system. The presence of large quantities of water in either liquid, ice, or vapor form in the Moon subsurface would help to offset the prohibitively expensive cost of transporting drinking water to sustain human life and plant propagation.

Dr. Berhanu Bulcha shows off his terahertz laser technology in his lab at Goddard NASA's Goddard., Photo Credits: NASA/Michael Giunto

However, large amounts of water cannot be found in the exosphere of the Moon, you have to find it in the subsurface. Presently, most existing broadband spectrometer technologies cannot distinguish H_2O from OH. The question remains, without extensive costly excavation to dig into the lunar surface, how can NASA find this water on the Moon? How do we know where to dig?

Dr. Berhanu Bulcha, a research engineer at Goddard, be-

lieves he and his team have the answer. Initially funded by an Internal Research and Development (IRAD), in collaboration with Longwave Photonics through NASA's Small Business Innovation Research (SBIR) program, Bulcha and his team are developing the Terahertz Heterodyne Spectrometer for In Situ Resource Utilization (THSiRU). THSiRU – a scientific instrumentation used to separate and measure spectral or hidden components of a physical object – to detect the presence of H_2O, OH, and/or HDO (semi heavy water) trapped under the lunar surface of the Moon.

"Molecules like water have their own signature, which provides a unique way of identifying composition and that is what we are doing [with THSiRU], looking for those water signatures," explained Bulcha. "[THSiRU] relies on a heterodyning technique, where a high-powered terahertz [THz] laser source is used to convert the frequency spectrum of the signature and digitizing for reading."

Simply finding water on the Moon is just the first objective. You next need to make sure the water is non-toxic or drinkable. "What our instrument does," said Bulcha, "it can be modified easily to allow us to use this same technique to identify the drinkability of the water or tell if the water is contaminated and contains some bad chemicals."

Bulcha and his team are developing the THSiRU as a small, lightweight, energy efficient, hand-held device – the size of loaf of bread – which astronauts can take with them as they explore and conduct science missions on the surface of the Moon. To use THSiRU, they simply point it toward an area on the surface of the Moon. The device then captures data that can be automatically transmitted to scientists, who then analyze the information to discover the existence of water – either vapor, liquid, or ice – in the subsurface.

"Our goal is when the astronauts go to the Moon, they will take this instrument with them," said Bulcha. "We're doing testing on the prototype in the lab right now, which is leading us to a [Technology Readiness Level] 5 and 6 [component validation in a relevant environment and prototype demonstration] in the near future. I am optimistic this will be finished and ready for astronauts landing on the Moon in two years."

As NASA's plans to return to the Moon, an essential part of the Artemis mission, senior leadership has outlined – through the Moon to Mars mission – how highly critical it is for the agency to develop and demonstrate technologies and operations to live and work on other planetary surfaces for extended periods. Having access to water is essential for meeting this goal.

"Water is a valuable resource, for both scientific purposes and for use by our explorers," said Jacob Bleacher, chief exploration scientist for NASA's Human Exploration and Operations Mission Directorate. "If we can use resources on the Moon, then we can carry less water and more equipment to help enable new scientific discoveries."

PATENT of the MONTH

A key component of the THSiRU is an advanced bandpass filter (BPF), or device that passes frequencies within a certain range or rejects attenuate frequencies outside of that range. Dr. Berhanu Bulcha received a patent for this BPF called the "Bandpass Filter Using Triangular Patch Resonators" with the U.S. Patent and Trademark Office this past summer. Bulcha says this filter will make the THSiRU more "sensitive" to discovering water on the Moon by rejecting unwanted signals.

According to the patent, the object of the invention is to provide a compact and low-cost, scalable BPF for use in a single side-band receiver system – such as the THSiRU – whose frequency can be fine-tuned to reject an unwanted image signal. This patented technology is available for licensure through Goddard's Strategic Partnership Office.

"In addition to finding water on the Moon, the technology in this [BPF] patent has several other potential commercial applications such as in the area of frequency-selective receivers, spectrometers, and radar technologies for astronomy, military, and communication applications," said Bulcha, who received a patent plaque from SPO at the 2022 I.D.E.A award ceremony in December [see the January issue of the Innovation Catalyst]. "This compact filter has a great frequency rejection outside the band that is highly needed in high-powered communication systems such as 5G and 6G."

Getting to Know You

Meet the Staff in Goddard's Strategic Partnerships Office

***Viva Miller,* Senior Technology Manager**

At Goddard, Miller fuses her interests in technology, law, and business with her love for space. As senior technology manager, she is responsible for Goddard partnerships and software release.

Bio

Miller's path to NASA started in high school, when she accepted a summer apprenticeship at NASA's Langley Research Center in Hampton, Virginia. With interests in math, engineering, and analytical writing, Miller pursued an assortment of academic credentials in each area. Miller possesses a bachelor's degree in applied mathematics with a focus on Computer Science from William and Mary, a master's degree in engineering management from Duke University, and a law degree from Rutgers University. After working at the U.S. Patent and Trademark Office as a primary patent examiner in software development for almost 10 years, Miller took a detail position with Goddard's Strategic Partnerships Office in 2018 and officially joined NASA in 2020 as a senior technology manager.

What is One Thing About Licensure and Partnerships Everyone Should Know?

With Goddard technology, businesses and potential licensees have the advantage of working with technologies that have been tested through and through. When you work with Goddard, you know you're working with a good product. We have talented engineers and scientists who will communicate with private industry, and you can trust that they want to help. People who are working for a government agency are doing this because they believe in the cause. We have people who are very invested in technology development here, and that's a great reason to work with us.

For questions about Goddard partnership topics, you can contact Viva Miller via email: viva.l.miller@nasa.gov.
Or by phone: 301/286-5169

Next month, read about another SPO staff member.