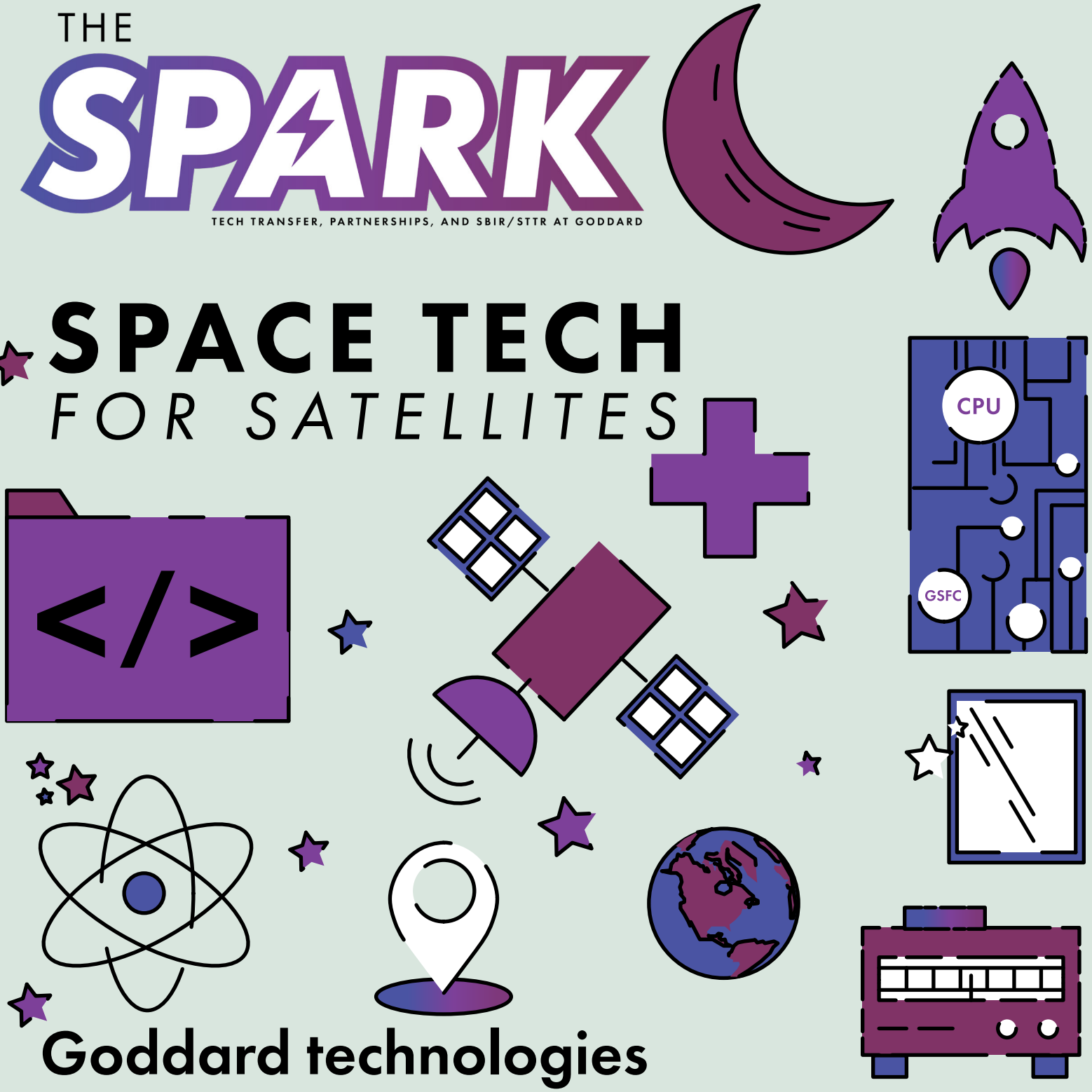
National Aeronautics and Space Administration

THE SPARK

TECH TRANSFER, PARTNERSHIPS, AND SBIR/STTR AT GODDARD

SPACE TECH *FOR SATELLITES*



Goddard technologies provide navigation, image stabilization, and more

VOLUME 18 | NUMBER 4 | FALL 2020

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ABOUT THE COVER

NASA's Goddard Space Flight Center has an extensive portfolio of patented space technologies available for licensing. Goddard's technologies for space can adapt from satellite missions to drones or airplanes, making them transferrable to multiple industries. These icons represent a variety of Goddard innovations for space, which you can find highlighted in this issue.

Illustration by: NASA/Danielle Battle

OFFICE OF THE CHIEF

As a government agency, NASA uses license agreements to fuel the process of technology transfer, putting federal innovations in the hands of the private sector, where they can spin off and grow into commercial products. At Goddard's Strategic Partnerships Office, we're proud of the license agreements we've negotiated in the past year, and I'd like to share a few examples with you that demonstrate the value and humanitarian benefits of technology transfer.

We recently licensed the Goddard-developed Compact Thermal Imager (CTI) to a Georgia-based company called Cybercorps LLC. By measuring surface temperature, CTI can provide high-resolution information about crop health and soil conditions. Cybercorps plans to fly CTI on a CubeSat and offer a subscription service for real-time agricultural data. Those who subscribe to the service – farmers, resource managers, first responders, or other interested user groups – will gain valuable insights to inform their strategies in response to weather conditions such as flooding.

Another great example involves a search and rescue receiver we licensed to a Maryland-based company called Concentric Real Time LLC. NASA's Search and Rescue Office is based at Goddard, where this technology was developed. The search and rescue receiver provides more accurate location data than older systems. NASA develops these technologies for Cospas-Sarsat, an international cooperative search and rescue program that has helped locate more than 46,000 people. Through license agreements, we're expanding the technology's impact even further.

This issue of The Spark magazine includes these licensing success stories, as well as stories about technologies yet to be licensed. You can also find a Q&A with one of our new senior technology managers, Viva Miller, and a spotlight on an innovative Goddard computer engineer, Elizabeth Timmons. As you read this issue, I hope you're inspired to consider the positive impacts of NASA technology in the world around you.

Darryl Mitchell

Darryl R. Mitchell, Chief

Strategic Partnerships Office
NASA's Goddard Space Flight Center

MAKING A SPLASH

GODDARD'S TECHNOLOGIES SCORED AWARDS IN 2020

When Goddard-related technologies receive the recognition they deserve, it's an occasion worth celebrating. This year was an especially prolific year for Goddard technology, with awards from NASA's Inventions and Contributions Board, the Federal Labs Consortium, and the Space Technology Hall of Fame. Here, SPO features some highlights from this year's collection of award-winning technologies.

NASA SOFTWARE OF THE YEAR 2020

Flight software is the specialized code that runs onboard a spacecraft. With core Flight System (cFS), software developers at Goddard created a software package that included the core pieces of code that every mission needs, as well as the artifacts that accompanied it, featuring a "layered" approach that would allow for the addition of mission-specific code built on top of validated and existing code. For its incredible impact at Goddard, across NASA, and beyond, cFS won NASA's Software of the Year 2020 award.

The cFS structure includes an operating system abstraction layer that enables cFS to port from operating system to operating system with practically no modifications, a platform abstraction layer that makes it easy to port cFS to new flight computers, and the core Flight Executive layer that includes all of the common services NASA missions need to succeed.

This layered flight software framework also includes individualized mission applications, much like apps on a smartphone. cFS became fully open source in 2015, and many NASA missions have used cFS, including the CubeSat Dellingr and the larger Global Precipitation Measurement (GPM) mission.

cFS has a number of advantages that make it a great fit for small satellite missions, as well as larger endeavors such as the Artemis program. It has a robust flight heritage, and its open source nature makes it readily available.

To view and download cFS, please visit: https://cfs.gsfc.nasa.gov

SPACE TECHNOLOGY HALL OF FAME 2020

Now more than ever, we rely on technology to keep us connected when we can't see each other in person. With today's video conferencing systems, members of the NASA community can communicate with each other in a matter of seconds, no matter how many miles of distance separate them. These advances wouldn't be possible without earlier innovations that paved the way, such as the Audio Conference Bridge Technology, invented through a contract at NASA's Goddard Space Flight Center. This pivotal communication system joined the Space Technology Hall of Fame in 2020.

In the 1950s, NASA used a complex system with dozens of technicians working around the clock, manually plugging and unplugging cables to enable groups on the ground to connect with each other and astronauts in space. The agency envisioned a simpler, more efficient system, and in the 1980s, NASA hired a company to make instant and automatic voice connections possible. After contracting with Goddard to build out the system and develop the conference bridge, the company took that concept and commercialized it.

Today, the Compunetix conference bridge can be found behind the scenes enabling numerous call-in meeting lines, and even some web-based video conference calls rely on a Compunetix switch to connect audio. The technology improved NASA's communications while helping teams all across the world work more effectively together, regardless of location.

See the full Space Tech Hall of Fame here: https://www.spacefoundation.org/what-we-do/space-technology-hall-of-fame-2/inducted-technologies/

AWARD-WINNING TECH

NASA COMMERCIAL INVENTION OF THE YEAR 2020 RUNNER UP

Thermal Management Technologies (TMT), a company based in North Logan, Utah, licensed the Diminutive Assembly for Nanosatellite deploYables (DANY) in 2018, and in 2019, TMT completed its first sale. This year, DANY won the recognition of runner-up in NASA's Commercial Invention of the Year award.

DANY – created by Goddard inventors Luis Santos, Scott Hesh, and John Hudeck – provides a reliable mechanism to secure deployable elements of a small satellite, safely stowing them until receiving a signal to burn through a plastic restraining link and release them for use in space. Deployable elements on a small satellite can include solar arrays, sun shades, radiators, or antennas. The entire assembly is about the size of a credit card, making it ideal for small satellites that have significant space constraints.

TMT used DANY as the core of its "Gecko Release Mechanism," named after the device's gecko-like size and ability to grip tightly onto a spacecraft. The TMT team modified NASA's original design to enable the production of multiple units, and after several months of adjustments, TMT now has a marketable product for sale.

Learn more about DANY here: https://technology.nasa.gov/patent/GSC-TOPS-36

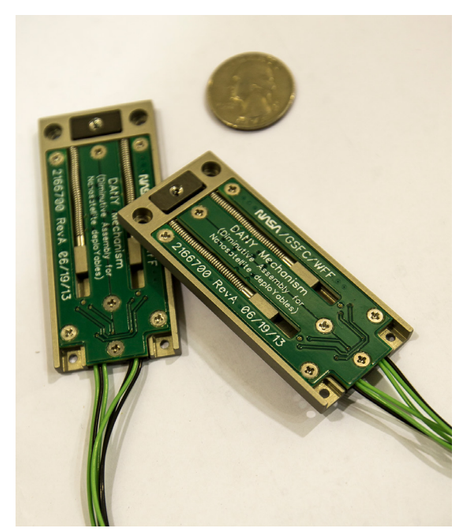


PHOTO: DANY was invented for use on the Dellingr mission, which launched in 2017. Credit: NASA

FEDERAL LABS CONSORTIUM MID-ATLANTIC REGIONAL AWARD 2020

NASA innovator Geoff Bland received recognition from the Federal Labs Consortium (FLC) for his work in education. The Educational Institution and Federal Laboratory Partnership Award "recognizes the efforts of federal science and technology employees and educational institutions in the region who have collaboratively accomplished outstanding work in the process of transferring a technology," according to the FLC Mid-Atlantic Region's website.

Bland, co-inventor of the Aeropod, has spent years working with SPO Tech Manager Eric McGill to connect his technology with educational institutions through license agreements. Aeropods make ideal education tools because they open the door to remote sensing with the relative accessibility of kite-flying. The lightweight, inexpensive structure stabilizes science instruments and easily attaches to kites, making data-collecting operations low-cost and easier to execute.

Bland founded the Advancing Earth Research Observations with Kites and Atmospheric/Terrestrial Sensors (AEROKATS) program, which is now rolled into the AEROKATS and ROVER Education Network (AREN) with Principal Investigator Andy Henry of the Wayne County Regional Educational Service Agency. The AREN team has conducted dozens of trainings with groups of teachers to explain the technology and show them how to gather data safely. Goddard has granted nine licenses for Aeropods to educational institutions, and since the licenses are non-exclusive and educational, the technology is available for others to license.

Learn more about Aeropods here: https://technology.nasa.gov/patent/GSC-TOPS-10

PHOTO: Aeropods utilize kites to collect remote sensing data. Credit: NASA/Geoff Bland

RECENT LICENSES

GODDARD TECHNOLOGY TO REVEAL CROP HEALTH INSIGHTS FOR AGRICULTURE INDUSTRY

A Georgia-based company called Cybercorps LLC plans to offer real-time agricultural data for farmers, resource managers, first responders, and other interested user groups with the help of a patented NASA technology. Cybercorps has signed a license agreement with NASA for the Compact Thermal Imager (CTI), a technology developed at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

The technology, conceived at Goddard by CTI Principal Investigator Murzy Jhabvala, is small enough to fit on a cube satellite, or CubeSat, a type of miniaturized satellite whose size is measured in units of 10 square centimeters that plays a growing role at NASA for science missions and technology demonstrations. Though tiny in size, CTI can provide high-resolution information about crop health and soil conditions by measuring surface temperature. After collecting more than 15 million images of Earth during a successful demonstration on the International Space Station in 2019, the instrument is now ready for commercial use.

"Technologies like CTI were developed for research purposes, but they often have additional applications outside of pure science," said Eric McGill, a senior technology manager with the Strategic Partnerships Office at Goddard. "In this case, infrared imaging can play an important role in monitoring crop health and helping members of the agricultural community yield better harvests."

The CubeSat that will carry CTI will capture thermal images while pointed at Earth's surface. Farmers and other interested customers can subscribe to Cybercorps' service to access the thermal imaging data, which can be used to evaluate the health of agricultural and aquatic ecosystems. In combination with more traditional techniques, this bundle of information could help farmers optimize fertilizer treatments and watering schedules.

"This instrument is very versatile," said Compton Tucker, a senior Earth scientist at Goddard and co-investigator for CTI. "As a new technology, it has tremendous usage potential in biomass burning and crop surface temperature."

In addition to CTI's agricultural applications, Tucker said the technology can help detect wildfire activity by distinguishing between high combustion areas and less hot, smoldering sections of land. For firefighters on the ground, this data could guide them to actively burning areas. CTI provides precise spatial resolution of around 262 feet (80 meters) per pixel, improving on older instruments that provided less detailed resolution at 3,280 feet (1 kilometer) per pixel.

Cybercorps will take advantage of CTI's ability to measure surface temperature. Plants need sufficient water to complete photosynthesis, and surface temperature provides a key data point in determining how much irrigation is needed to prevent crop death.

"Our company's core components are research, education, and commercialization, so the space camera subscription project spans all three of our objectives," said Kevin Howard, chairman and founder of Cybercorps.

In addition to commercializing its service, Cybercorps wil include students in the development of this project. The company participated in the NASA International Space Apps Challenge in early October.

"This is our first license agreement with NASA, and we're really excited about the opportunity to collaborate with Goddard on this," Howard said.

CTI was installed on the space station in 2019 as part of the Robotic Refueling Mission 3, with the goal of qualifying Strained Layer Superlattice (SLS), an advanced detector technology. SLS is an improved version of the detector technology that is part of the thermal infrared sensor on Landsat 8 and the upcoming Landsat 9. CTI instrument development was supported and funded by NASA's Earth Science Technology Office (ESTO) under the Sustainable Land Imaging Technology Program.

SUCCESS STORIES

MARYLAND COMPANY LICENSES NASA'S NEW SEARCH AND RESCUE TECHNOLOGY

Technologies developed at NASA have helped locate more than 46,000 people through Cospas-Sarsat, an international cooperative system for search and rescue. Furthering the impact of the program, the Strategic Partnerships Office at NASA's Goddard Space Flight Center in Greenbelt, Maryland, has licensed a second-generation search-and-rescue technology to a company named Concentric Real Time LLC, based in Ellicott City, Maryland.

"NASA's search and rescue technologies have saved the lives of thousands of people," says Eric McGill, a senior technology manager with Goddard's Strategic Partnerships Office. "By licensing this receiver technology, we're expanding the reach of NASA's lifesaving innovations."

NASA's Search and Rescue (SAR) Office, based at Goddard, generates search and rescue technologies for the Cospas-Sarsat community, which uses satellites to provide location data to authorities searching for people who are lost or otherwise in need of rescue. Individuals can carry personal locator beacons; ships, pleasure craft, and aircraft can store beacons on board in case of emergency, which Cospas-Sarsat uses to determine their position.

The new receiver improves on the previous generation of technologies, providing more accurate location data than older systems. Reese Bovard, the president of Concentric Real Time, built the new receiver that his company is licensing. Currently a contractor for NASA's SAR Office, Bovard has worked at Goddard for 13 years as an engineer. The receiver he developed pairs with a new, higher-resolution signal that produces highly accurate location results.

Bovard says the receiver technology is an important building block for the new search-and-rescue system that NASA's SAR Office has developed. Though civil search and rescue is the office's primary mission, the group's technologies have also been adapted for astronauts as part of their survival gear upon return.

"With search and rescue, there's a direct humanitarian benefit that comes from this work," Bovard says.

PHOTO: NASA developed search and rescue technology that has saved more than 40,000 lives around the world since 1982. Credit: U.S. Coast Guard

Q&A W/TECH MANAGER

VIVA MILLER

At NASA, Viva Miller fuses her interests in technology, law, and business with her love for space.

"The great thing about space is the unknown," Miller says. "As much as there is comfort in familiarity, I think the unknown just brings out that excitement in me. We don't know what else is out there. NASA is always going to be that agency that people get excited about and want to win, because there's so much you can do with space."

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, with a bachelor's degree in applied mathematics 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 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. The Spark magazine checked in with Miller to see what she's tackled in her first month on the job.

WHAT CAREERS DID YOU CONSIDER WHEN YOU WERE GROWING UP?

I was looking at things related to engineering. I always liked the sciences and math in particular, so I knew I wanted to do something in that realm. While I was in high school, I had this affinity for writing and analysis. I wasn't a huge fan of English class until I had a really good teacher in high school who opened my eyes to writing and allowed me to explore that avenue. Law school opened up a way to pursue my love of analytical writing.

WHY DID YOU CHOOSE TO WORK AT NASA IN TECHNOLOGY TRANSFER?

With my academic background in applied mathematics, law, and engineering management, I wanted to do all three, which is why I'm here – this job really allows me to explore the business aspect of law combined with technology. I've always had the mentality that when you have a vast academic background, there are many paths you can explore, even though you may want to focus on one path at a particular time. I knew with my three degrees, I'd be able to do something like tech transfer.

NASA and the Strategic Partnerships Office in particular provide the perfect combination of all three subject areas I've always loved. From the science and math perspective, I get to explore different technologies and gain a better understanding of them. From the law perspective, I'm able to participate in agreements and the licensing side of things. And then there's a business angle that covers all aspects of tech transfer, because I'm considering the technology's value in the marketplace in terms of commercialization.

PHOTO: NASA/Samantha Kilgore

WHAT DO YOU ENJOY MOST ABOUT WORKING WITH GODDARD'S TECHNOLOGIES?

I think what really excites me about Goddard is the vast array of software in our portfolio. That's up my alley, because at the patent office, those were the types of technologies I examined. I explored all aspects related to software development, debugging, and upgrading. At NASA, there's such a vast array of things we can do with software. When I was on detail here last year, I got to work with technologies related to satellite servicing at Goddard, and I was very intrigued by that, as well.

WHAT IS IT LIKE TO WORK WITH SOFTWARE?

Software is nebulous and abstract. It's not tangible in the sense that physically, you can't put your finger on it. What really excites me about software is that it's constantly evolving. You can make minute changes that alter it dramatically, and that's a beautiful thing about software. Hardware can be incredibly expensive, but oftentimes with software, you can do the same things without the expense. Another interesting aspect of software is that there can be so many different ways you can use a specific software program, and it can apply to a variety of technologies. When you're talking about commercialization and other uses for technology, software is one of those areas where you're going to have a range of uses. And that's what makes software such a flexible platform.

WHY DOES THE SOFTWARE RELEASE PROCESS MATTER?

One of the biggest justifications for software release is to protect your rights as an inventor as well as NASA's rights. That's a huge reason for it. As an inventor, your software is just as important as a robot arm or any other piece of hardware. It's the same thing because comes from your mind as intellectual property, and it's still worth protection. That's why we go through the process of software release. And in order for your software to reach its full potential, it has to meet legal requirements and standards. This is to help protect the agency as well as you, the inventor.

HOW CAN BUSINESSES BEST TAKE ADVANTAGE OF GODDARD'S TECHNOLOGY OFFERINGS?

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 us, you know you're working with a good product. We have talented engineers and scientists who will communicate with you, 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 software or other technology transfer topics, you can contact Viva Miller via email: viva.l.miller@nasa.gov.

> "WHAT REALLY EXCITES ME ABOUT *SOFTWARE* IS THAT IT'S CONSTANTLY EVOLVING."

GPS IN SPACE

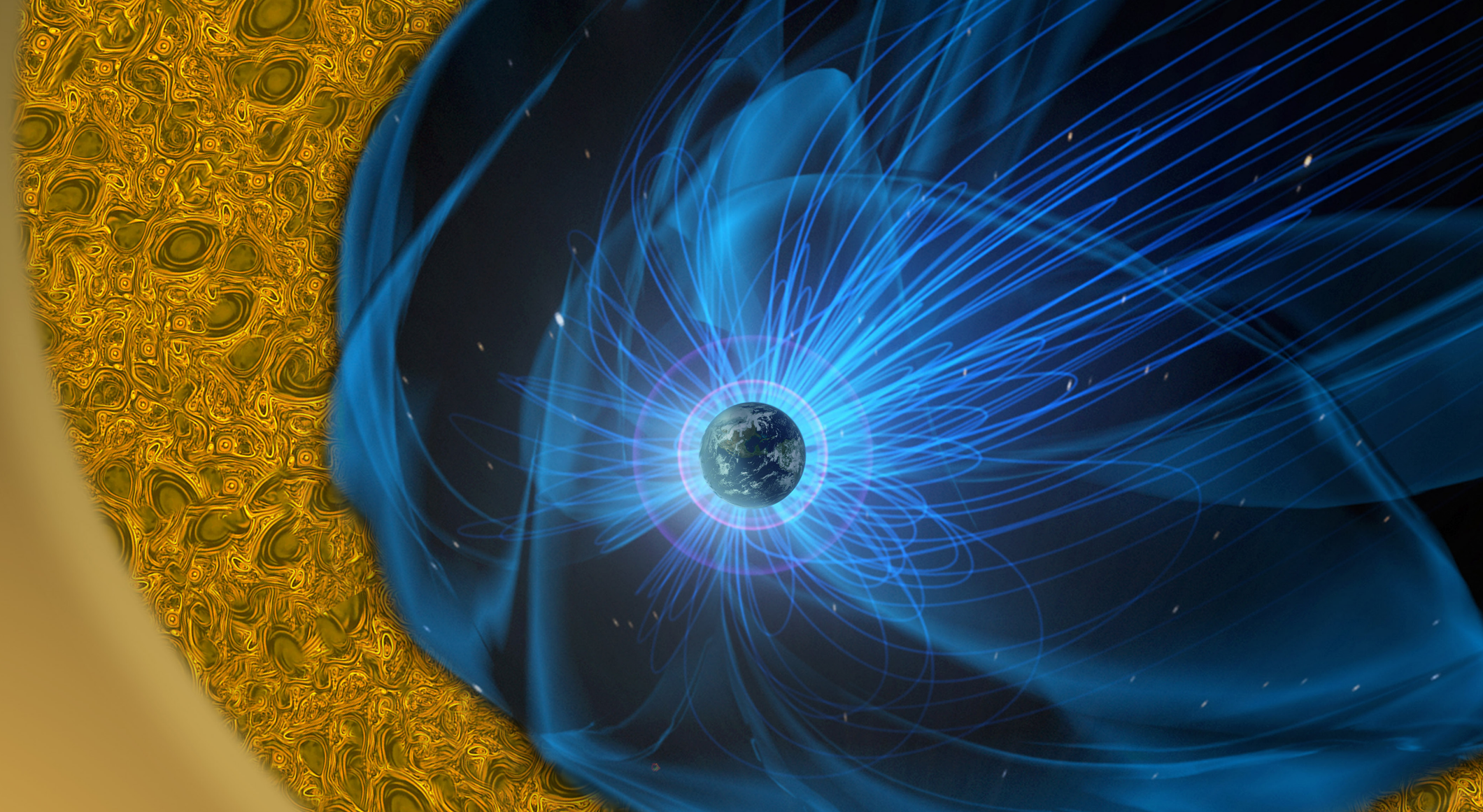


PHOTO: The GPS receiver was developed for the Magnetospheric Multiscale mission, which studies the region surrounding Earth known as the magnetosphere. Credit: NASA/Mary Pat Hrybyk-Keith

GODDARD TECHNOLOGY BRINGS GPS NAVIGATION TO HIGH-ALTITUDE MISSIONS

When NASA astronauts first flew to the Moon in 1969, GPS didn't exist. Through the Artemis program, NASA will return to the Moon in the coming decade, and GPS could serve as a valuable navigation tool for those missions. Engineers at NASA's Goddard Space Flight Center have developed a GPS receiver that can pick up GPS signals from Earth-orbiting satellites while more than 100,000 miles away, and the team is developing a next-generation technology that could make GPS navigation from the Moon possible.

Launched in 2015, NASA's Magnetospheric Multiscale (MMS) mission landed in the Guinness Book of World Records by using GPS from an altitude of 116,300 miles, or halfway to the Moon. This impressive, record-breaking feat owes its success in part to the Navigator GPS receiver, a technology developed with high-altitude missions in mind.

With the MMS mission, Goddard engineers successfully demonstrated the GPS receiver's ability to navigate using GPS signals from farther distances than ever before. The MMS mission consists of four spacecraft that use GPS measurements to fly in formation and maintain orbit.

The MMS spacecraft also use GPS when collecting science data to track timing for measurements. By adopting a highly elliptical orbit through Earth's magnetosphere and flying in tight formation, the four MMS spacecraft have gathered unique observations of this region surrounding Earth.

The MMS mission aims to help NASA scientists better understand a physical process called magnetic reconnection, a phenomenon related to space weather in Earth's magnetosphere. Magnetic reconnection influences events such as geomagnetic storms that can cause electrical outages and pose a threat to power grids, making it all the more important to study.

"GPS navigation was very important for the MMS mission's objectives," says Luke Winternitz, a Goddard engineer and the architect of the MMS GPS receiver. "However, prior to the MMS launch, operational use of GPS was unproven in very high-altitude orbits like those of MMS."

For many years, satellites in low-Earth orbit (LEO) have used GPS – or more broadly Global Navigation Satellite Systems (GNSS) – because it provides highly accurate navigation that costs less than ground tracking. Navigation systems help spacecraft maintain their orbit and provide location and timing information for science data.

"Many LEO satellites take advantage of GPS," says Goddard engineer Munther Hassouneh, who serves as the lead for ongoing Navigator GPS receiver development. "With this technology, we wanted to also enable the use of GPS for high altitude missions, including geostationary orbits, highly elliptic orbits like MMS, and even for lunar space."

Presently, the use of GPS/GNSS for navigation in high-altitude orbits, especially geostationary orbit (GEO), is growing more common. Commercial receivers are now flying on multiple GEO missions, including the latest generation of GOES weather satellites.

The Navigator GPS receiver helped the MMS mission utilize GPS while flying in a high-altitude orbit, well above the GPS constellation, and it can do the same for other missions that plan to fly beyond LEO. The GPS receiver takes advantage of secondary antenna signals called "side lobes" emitted from each GPS satellite. The main antenna signal points down towards Earth, but the side lobes emanate outward into space. Spacecraft operating above the GPS satellite constellation can utilize those signals in addition to the GPS main lobes.

"We designed the GPS receiver so that it has sensitivity to acquire and track those side lobe signals," Winternitz explains. "They're much weaker but can provide more availability."

Based on recent simulations conducted by the Navigator team, the technology, when equipped with the appropriate antenna, could enable GPS/GNSS navigation for lunar purposes. This opens up possibilities for use in planned and upcoming Moon missions.

While the version of the Navigator GPS receiver used by the MMS mission is patented and currently available for licensing, the development team is working on a next-generation receiver called NavCube that will conform to smaller platforms, making it ideal for SmallSat and CubeSat buses as well as larger spacecraft.

As NASA and industry eye the Moon for further exploration, mission-enabling technologies like the Navigator/NavCube GPS receiver will grow increasingly important in making those plans a reality.

For those interested in licensing this technology, please contact the Strategic Partnerships Office by emailing techtransfer@gsfc.nasa.gov or searching for "Navigator GPS Receiver" at https://technology.nasa.gov.

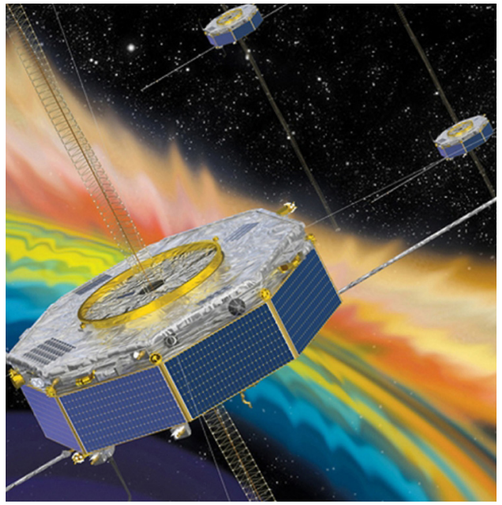


PHOTO: The MMS mission consists of four identically instrumented spacecraft. Credit: NASA

SEEKING TO STABILIZE

IMAGE BLUR CAN BE SIGNIFICANTLY REDUCED WITH PATENTED GODDARD TECHNOLOGY

While "tip, tilt, jitter, and roll" might sounds like dance moves, they're actually words used to describe a spacecraft experiencing movement of some kind. Satellites can get jostled around in space, and when they do, their motions can interfere with the ability of onboard instruments to collect data. In the case of a satellite carrying a spectrometer, one unexpected move can destabilize the instrument and compromise the integrity of spectrometer image data. Some blur can be corrected through ground processing, but other times the data can't be recovered.

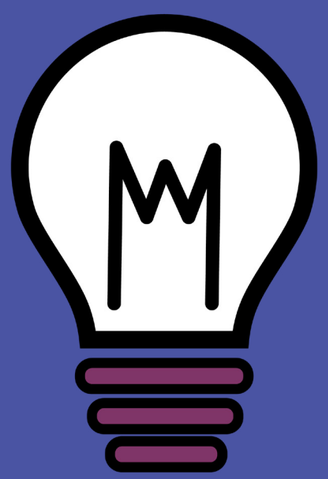
A technology developed at NASA's Goddard Space Flight Center addresses this problem by correcting for misalignments caused by jitter in real time, using a fast-steering mirror to compensate for an instrument's displacement. Called the "Optical Active Pointing Control System," this technology is patented and available for licensing.

The control system was developed for the Geostationary Coastal and Air Pollution Events (GEO-CAPE) mission. GEO-CAPE Principal Investigator Antonia Mannino proposed one of its instruments, the GEO-CAPE Coastal Ecosystem Dynamics Imager (COEDI) instrument. The COEDI control system was developed by Goddard inventors Catherine Marx, Irving Linares, Peter Shu, and James Smith for the proposed Earth science mission that would have observed oil spills, river pollution, hypoxic zones, and other environmental phenomena from geosynchronous orbit. While the mission did not progress beyond proposal phase, the technology has potential uses beyond its mission of origin, and it received a patent in 2018.

A LOOK AT THE TECHNOLOGY

BENEFITS

+ Eliminates the need for dedicated pointing monitor circuitry greatly reducing focal plane cost complexity
+ Improved image quality due to reduced tip and tilt
+ Operates in both the visible and IR spectral regions
+ Can be adapted to different optical systems and platforms (space, aerial, ground)
+ Does not require any special manufacturing processes or materials
+ Can be modified to enable optical axis roll motion detection



APPLICATIONS

+ Intelligence, Surveillance, and Reconnaissance (ISR)
+ Satellite Imaging
+ Remote Sensing

With applications for camera and spectrometer stabilization in airplanes, drones, and satellites, the control system provides a unique system architecture that detects motion to maximize scientific image quality. The fast-steering mirror plays a crucial role in the technology's function by re-centering the image when a movement is detected and compensating for the displacement of the detector. During a technology demonstration, the system could nominally perform corrections up to 1,000 times a second.

A wide variety of events can cause a satellite to experience motion while in orbit, says Irving Linares, a Goddard engineer and co-inventor of the technology.

"Let's say you're in low-Earth orbit (LEO), and when you transition from the Sun to the shade behind Earth, that creates a temperature difference in the hardware," Linares explains. "Because you have a sudden temperature change, the spacecraft experiences jitter, and that affects stability."

Other types of movements can be caused by satellite components. For example, when a satellite moves its solar panels to point in the direction of the Sun and maximize energy, it can affect the instrument onboard. Thrusters and reaction wheels that adjust the attitude of the spacecraft can create instrument destabilization when put into action. Additional causes include the spacecraft's center of gravity changing due to aging and solar winds shifting the position of the spacecraft.

"For every action, there is a reaction," Linares points out.

The words "tip, tilt, jitter, and roll" refer to specific kinds of motion. "Tip" means side to side, while "tilt" describes up-and-down movement. "Jitter" encompasses both tip and tilt, while "roll" alludes to motion along the x-axis of the satellite.

Linares says there are several advantages to fixing image quality in space rather than waiting to process the image after the data is sent back to Earth. First, it saves time and effort. Instead of needing to process and restore the data after collection, scientists receive a fully usable image.

Second, some kinds of jitter cause blur that cannot be corrected on the ground.

"If you know what type of blur it is – such as vertical or even diagonal – you can remove the blur, but when it's a mix of things, then you're out of luck," Linares says.

Image stabilization is even more important for high-altitude missions flying thousands of miles above Earth. In geosynchronous orbit, at an altitude of about 23,000 miles, unwanted movement could knock an instrument's focus completely off its target with no way to recover the missing data.

"If your pixel size is 1 square meter and your spacecraft moves 2 meters, you might not get the data you're looking for," Linares says.

Though the control system was developed for a proposed satellite mission, the technology also has applications closer to the ground aboard airplanes and drones that require image stabilization. In 2018, Linares helped explore commercialization opportunities by participating in a program called FedTech, which collaborates with government laboratories to connect entrepreneurs with promising technologies. By participating in these programs, Goddard innovators help to find licensees who can further the impact of NASA technologies in the private sector.

FOR THOSE INTERESTED IN PURSUING A LICENSE FOR THIS TECHNOLOGY,

PLEASE EMAIL :
techtransfer@gsfc.nasa.gov

OR

SEARCH FOR "ACTIVE POINTING MONITOR FOR A 2-AXIS OPTICAL CONTROL SYSTEM" AT
https://technology.nasa.gov.

INNOVATOR PROFILE

ELIZABETH TIMMONS

Though more than 200 individuals from all over the world have visited the International Space Station in person, many hundreds of people on the ground also have a special connection to the ISS. For Elizabeth Timmons, a computer engineer at NASA's Goddard Space Flight Center, the ISS featured prominently in her first seven years with NASA.

"For one of my first missions, I wrote software that sent images down from a camera on an ISS payload," Timmons says. "It's just a really cool, unbelievable feeling to see those images come back."

In her multiple roles at Goddard, Timmons innovates every day and comes up with creative software solutions to launch NASA missions and keep them running smoothly.

FLIGHT SOFTWARE FOCUS

Computer engineers like Timmons carefully construct software programs that make spaceflight possible. Timmons' job involves planning with colleagues, talking to stakeholders, designing system architectures, writing code, and working with systems engineers to figure out operational needs. As an associate branch head for Goddard's Flight Software Systems Branch and the lead for Goddard core Flight System applications, Timmons splits her time between management and technical responsibilities.

"In both roles, I get to see how flight software is developed for the missions we support and contribute to writing that software in the most efficient way that meets cost and schedule as well as mission goals," Timmons explains.

Timmons didn't grow up dreaming of a career in computer engineering. Though she took a computer science course in high school and majored in computer science at Virginia Tech, an internship at Goddard opened her eyes to the practical applications of the field.

"It was the first time I could see how computer science directly tied to and positively impacted a NASA science mission," she says.

Early on, Timmons worked on software for a variety of ISS payloads, including Space Test Program Houston 5 (STP-H5) and the Robotic Refueling Mission 3 (RRM-3). She says that working on those missions taught her the ins and outs of flight software. Over a five-year span, she could see the entire life cycle of a mission, from development to operations onboard the ISS.

LAYERS AND APPLICATIONS

In addition to her management work, Timmons now keeps busy as the lead for Goddard-developed applications associated with core Flight System (cFS), a reusable flight software framework created at Goddard to shorten the amount of time spent on flight software development. This means she works with projects at Goddard and across NASA to meet the needs of the missions and their teams.

"It's been very interesting to transition from someone who used cFS on a project to someone who works on cFS itself," Timmons says. "So many missions use cFS, so it's a fun software engineering challenge to balance the needs of all these different groups."

PHOTO: Courtesy of Elizabeth Timmons

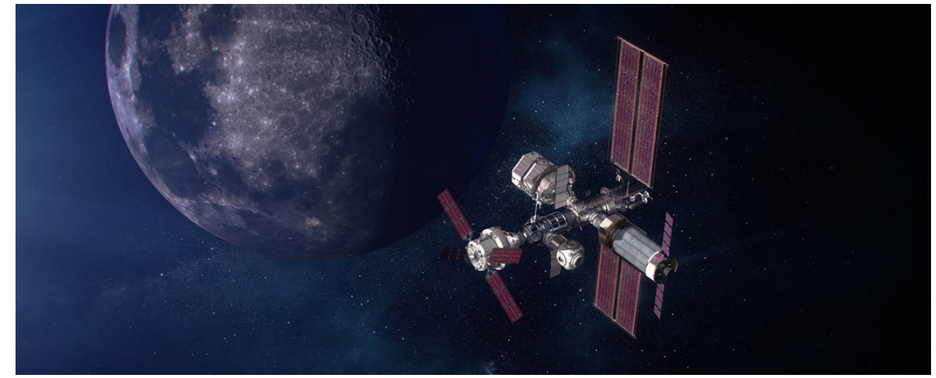


PHOTO: Elizabeth Timmons is working with a team at Johnson to validate cFS for the Lunar Gateway, pictured here. Credit: NASA Johnson

The software package known as cFS changed the way developers approached flight software at Goddard. By offering a layered approach, cFS allows for the addition of mission-specific code built on top of validated and existing code. In doing so, cFS combines some of the best features of software architectures from past missions while also providing individualization in the form of mission applications, much like apps on a smartphone.

With this option to customize, software developers can create new apps that cater to the needs of their unique missions. There's also a collection of generic applications used across missions which Timmons manages.

Once cFS became open source in 2015, it spread outside NASA and threaded its way into diverse nooks and crannies in the space realm, making it difficult to estimate just how widespread it has become. Within NASA, Timmons says that five main projects in Goddard's Flight Software Systems Branch use cFS, and she estimates that 40 NASA projects have used it in the past 20 years.

IMPACT AT NASA AND BEYOND

Currently, Timmons is working with NASA's Johnson Space Center in Houston, Texas to certify cFS for the Lunar Gateway, a key piece of the Artemis program that will serve as an outpost and support system when NASA returns to the Moon. This comprehensive process involves code reviews for both the cFS framework and the apps, ensuring the highest quality possible for the project.

Though cFS started at Goddard, its impact has spread to academia and industry, as well.
"I'd say cFS is a really great example of Goddard software helping the private sector because it's open source," Timmons says. "We know of small companies that have sprung up using cFS, and there are entire product lines built around it."

The flight software framework has even appeared in university courses, giving the next generation of computer engineers a strong foundation in the world of space software. Timmons says it's gratifying to see cFS play a role in lowering the barrier to entry for students interested in flight software.

"When you're starting from scratch with space software, it can be really hard, but if you have a starting point you trust, it's an advantage to everyone," Timmons adds.

To aspiring computer engineers, Timmons says that she's learned something from everyone she's worked with, including her parents, who are both computer engineers themselves. One of the biggest lessons she can share, she says, is remembering that it's OK not to know everything. Computer engineers at Goddard constantly tackle new and challenging problems, from payloads on the ISS to flight software frameworks that span multiple missions. The only way forward is to jump in the fray and give it a whirl.

"At NASA, you can't be afraid to try something you've never done before, because everything we do here is new," she adds.

PATENTS FOR 2020

SPACE-BASED SODIUM LIDAR INSTRUMENT AND METHOD OF OPERATION
Anthony W. Yu, Michael A. Krainak, Diego Janches, Sarah L. Jones, Branimir Blagojevic
PATENT NUMBER: 10,429,243

METHOD OF MANUFACTURING LARGE AREA GRAPHENE AND GRAPHENE-BASED PHOTONICS DEVICES
Mahmooda Sultana, Mary J. Li, Anthony W. Yu
PATENT NUMBER: 10,450,650

NIOBIUM TITANIUM NITRIDE THIN FILM COATINGS FOR FAR-INFRARED ABSORPTION AND FILTERING
Ari D. Brown, Edward J. Wollack, Kevin H. Miller
PATENT NUMBER: 10,458,853

MICRO SCALE ELECTRO HYDRODYNAMIC (EHD) MODULAR CARTRIDGE PUMP
Matthew T. Showalter, Jeffrey R. Didion, Mario S. Martins, Franklin L. Robinson
PATENT NUMBER: 10,461,621

HIGH RESOLUTION ADDITIVE MANUFACTURING METHOD WITH REAL MATERIALS
Vincent T. Bly
PATENT NUMBER: 10,465,281

MOLYBDENUM NITRIDE ABSORBER COATING FOR A DETECTOR
Ari D. Brown, Kevin H. Miller, Edward J. Wollack
PATENT NUMBER: 10,466,108

KA-BAND HIGH-GAIN EARTH COVER ANTENNA
Victor J. Marrero-Fontanez, Cornelis F. DuToit
PATENT NUMBER: 10,476,141

WAVEGUIDE MOUNT FOR MICROSTRIP CIRCUIT AND MATERIAL CHARACTERIZATION
Kongpop U-Yen, Edward J. Wollack, Ari D. Brown
PATENT NUMBER: 10,483,610

DETECTOR CONTROL AND DATA ACQUISITION WITH CUSTOM APPLICATION SPECIFIC INTEGRATED CIRCUIT (ASIC)
Brian S. Smith, Markus Loose, Atul Joshi, Greg T. Alkire, Daniel P. Kelly, Edward S. Cheng
PATENT NUMBER: 10,502,622

SPATIALLY DISTRIBUTED GAIN ELEMENT SELF-PHASE-LOCKED, LASER APPARATUS AND METHOD
Mark A. Stephen
PATENT NUMBER: 10,516,246

POLARIZATION MAINTAINING, LARGE MODE AREA (PMVLMA) ERBIUM-DOPED OPTICAL FIBER AND AMPLIFIER
Mark A. Stephen, Anthony W. Yu, Jeffrey W. Nicholson
PATENT NUMBER: 10,530,114

HIGH EFFICIENCY S-BAND AMPLIFIER
Steven N. Bundick, Wei-Chung Huang
PATENT NUMBER: 10,560,063

SLOT SYNTHESIS FOR HIGH CARDINALITY PULSE POSITION MODULATION
Scott A. Merritt
PATENT NUMBER: 10,573,344

DISTRIBUTED HASH OBJECT ARCHIVE SYSTEM
Navid Golpayegani, Curt A. Tilmes, Damon N. Earp, Jihad S. Ashkar
PATENT NUMBER: 10,579,586

MAGNETIC SHAPE MEMORY ALLOY ACTUATOR
Umeshkumar D. Patel
PATENT NUMBER: 10,581,345

CAPSULATION SATELLITE SYSTEM
Irving Joseph Burt
PATENT NUMBER: 10,604,280

COOPERATIVE SERVICE VALVE FOR SATELLITE MEDIA TRANSFER
Hans Raven, Matthew Ashmore, Erich Schulze
PATENT NUMBER: 10,604,281

MICROCONTROLLER CONTROLLED ALTIMETER
Scott V. Hesh, Taylor A. Green, Joshua T. Yacobucci
PATENT NUMBER: 10,648,806

SOLID STATE ANALOG ALTIMETER SWITCH
Scott V. Hesh
PATENT NUMBER: 10,648,807

SPACEBORNE SYNTHETIC APERTURE RADAR SYSTEM AND METHOD
Rafael F. Rincon, Kenneth J. Ranson, Agueh Fatoyinbo, Temilola E. Fatoyinbo Agueh, Lynn M. Carter
PATENT NUMBER: 10,649,081

RADIATION HARDENED INPUT/OUTPUT EXPANDER WITH I.SUP.2C AND SPI SERIAL INTERFACES
George Suarez, Jeffrey J. Dumonthier
PATENT NUMBER: 10,649,949

GODDARD TECHNOLOGIES

COMPACT WIDE BANDWIDTH PASSIVE PHASE SHIFTER FOR RADIO FREQUENCY AND MICROWAVE APPLICATIONS
Wei-Chung Huang
PATENT NUMBER: 10,651,815

CAVITY ENHANCED ABSORPTION SPECTROSCOPY (CEAS) FOR OZONE DETECTION
Steven A. Bailey, Thomas Hanisco
PATENT NUMBER: 10,656,131

MINIATURIZED ASTROMETRIC ALIGNMENT SENSOR FOR DISTRIBUTED AND NON-DISTRIBUTED GUIDANCE, NAVIGATION, AND CONTROL SYSTEMS
Sabrina N. Thompson, Sean R. Semper, Philip C. Calhoun, Neerav Shah
PATENT NUMBER: 10,657,371

EARTH COVERAGE ANTENNA SYSTEM FOR KA-BAND COMMUNICATION
Victor J. Marrero-Fontanez, Cornelis F. Du Toit
PATENT NUMBER: 10,658,756

ULTRA-BROADBAND MICROWAVE RADIOMETER OPTIMIZED FOR MICROSATELLITE APPLICATIONS
Joseph Knuble, Jeffrey Piepmeier, Kevin Horgan, Jared Lucey
PATENT NUMBER: 10,659,094

TWO-DIMENSIONAL PHONONIC METAMATERIAL FILTER STRUCTURE FOR ULTRA-LOW-BACKGROUND DETECTORS
Edward J. Wollack, David T. Chuss, Kevin L. Denis, Samuel H. Moseley, Karwan Rostem
PATENT NUMBER: 10,663,350

DUAL DYNAMIC RANDOM (DDR) ACCESS MEMORY INTERFACE DESIGN FOR AEROSPACE PRINTED CIRCUIT BOARDS
David J. Petrick, Alessandro D. Geist, Thomas P. Flatley
PATENT NUMBER: 10,667,398

SPACECUBE V2.0 FLIGHT CARD MECHANICAL SYSTEM
Milton C. Davis, David J. Petrick
PATENT NUMBER: 10,681,837

APPARATUS AND METHOD OF HYDROXYL DETECTION
Steven A. Bailey, Thomas F. Hanisco
PATENT NUMBER: 10,697,890

ROBOT ELECTRONICS UNIT (REU) MOTOR CONTROL BOARD (MCB)
Ireneusz Orlowski, Pietro A. Sparacino, Seshagiri Nadendla, Roger M. Chiei, David J. Petrick
PATENT NUMBER: 10,715,073

DEPLOYABLE MULTI-SECTION BOOM
Luis H. Santos Soto
PATENT NUMBER: 10,717,548

OXIDIZER NOZZLE TOOL AND QUICK DISCONNECT SYSTEM FOR FUELING
Hans R. Raven, Matthew W. Sammons, Patrick O'Neill
PATENT NUMBER: 10,730,646

SELF-REGULATING CURRENT CIRCUIT APPARATUS AND METHOD
Scott V. Hesh, Michael J. Mahon
PATENT NUMBER: 10,742,115

THERMOPILE BIAS METHOD FOR LOW VOLTAGE INFRARED READOUT INTEGRATED CIRCUITS
Gerard Quilligan, Shahid Aslam, Nicolas Gorius, Daniel Glavin, John Kolasinski, Dat Tran
PATENT NUMBER: 10,746,594

SOFTWARE-DEFINED RADIOMETER
Lynn R. Miles, Damon C. Bradley, Englin Wong, Alicia T. Joseph
PATENT NUMBER: 10,768,213

SPACE WEATHER DATABASE
Chiu P. Wiegand
PATENT NUMBER: 10,769,224

COHERENT OPTICAL TRANSISTOR
Michael A. Krainak
PATENT NUMBER: 10,775,679

FREQUENCY DIVISION MULTIPLEXING SCHEME FOR PHASING SYNTHETIC APERTURE RADARS AND RECEIVERS
Rafael Rincon, Dee-Pong Daniel Lu
PATENT NUMBER: 10,778,355

MODIFICATION OF RADIATOR PIGMENTS USING ATOMIC LAYER DEPOSITION (ALD) OF THERMAL PROTECTIVE FILM MATERIAL
Vivek H. Dwivedi
PATENT NUMBER: 10,781,517

SUPERHYDROPHOBIC AND DUST MITIGATING COATINGS
Sharon A. Straka, Mark M. Hasegawa, Kenneth M. O'Connor, Victoria J. Stotzer
PATENT NUMBER: 10,786,830

BLACK MOLECULAR ADSORBER COATING SYSTEM
Nithin S. Abraham, Mark M. Hasegawa, Sharon A. Straka, John C. Petro
PATENT NUMBER: 10,787,575

THE SPARK

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