National Aeronautics and Space Administration

NASA

GODDARD'S

COLLABORATIVE CODE

tech transfer

How core Flight System Helps Missions to Flourish

VOLUME 17 | NUMBER 4 | FALL 2019

CONTENT

ABOUT THE COVER

The core Flight System is a NASA flight software architecture created to shorten the amount of time spent on flight software development. The lines of code pictured in this illustration came from one of the software's most fundamental actions.

Illustration by: Danielle Battle
Photo Credit: ESA/Hubble, NASA

OFFICE OF THE CHIEF

This summer marked the 50th anniversary of the Apollo 11 mission. It was a great opportunity for the Strategic Partnerships Office at NASA's Goddard Space Flight Center to celebrate all the incredible spinoff technologies that came from the Apollo missions. As a recent story in NPR pointed out, technologies as diverse as freeze dried foods and integrated circuits entered the market thanks to the Apollo program.

Now, NASA is gearing up to launch the next phase of human exploration with the Artemis program. This ambitious and bold venture aims to send the first woman and the next man to the Moon by 2024, ushering in a new generation of lunar discovery. From there, NASA plans to send humans to Mars, using the Moon as a testing ground for new tools, instruments, and equipment.

To achieve these challenging goals, NASA will work with partners in the American space industry to provide mission-enabling solutions through commercial innovation. NASA, in turn, is sharing capabilities from its 60-year legacy of spaceflight. One example includes the core Flight System, a reusable flight software framework developed here at NASA's Goddard Space Flight Center and now used throughout the world. You can read more about the core Flight System in this issue.

Also in this issue, you will find an article on the Molecular Adsorber Coating, a technology being used for several Goddard missions and featured in a partnership between NASA and the Smithsonian Institution. Meet the new deputy chief of the Strategic Partnerships Office and read about our collaboration with the Women's National Basketball Players Association.

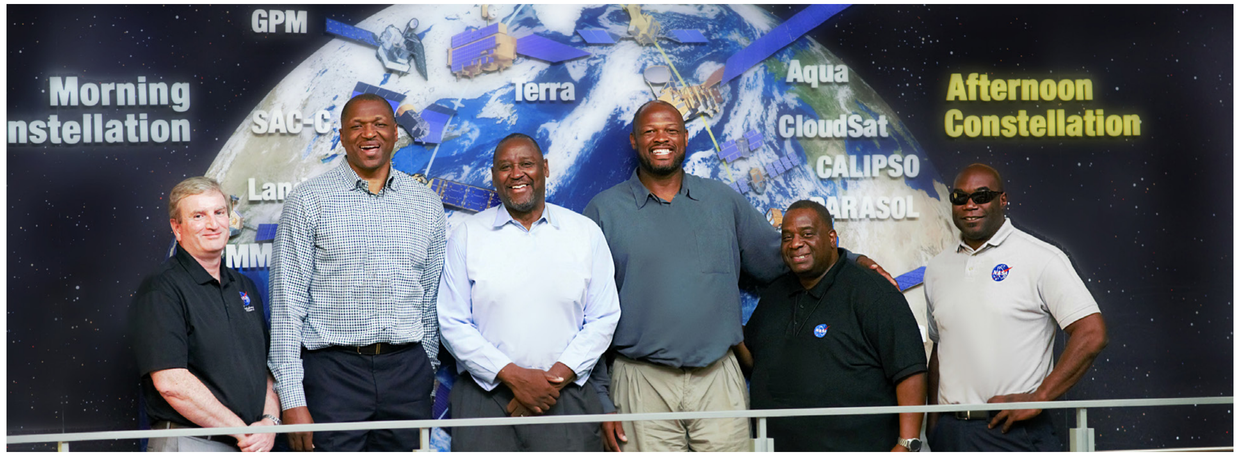
As we move towards an increasingly connected future, it's exciting to think about the essential role technology transfer and partnerships will play in traveling to the Moon and beyond.

Darryl Mitchell

Darryl R. Mitchell, Chief

Strategic Partnerships Office
NASA's Goddard Space Flight Center

NEWS



NOS³ WINS RUNNER UP

Goddard's candidate for NASA's internal Software of the Year competition scored "Runner Up" status in July. The NASA Operational Simulator for Small Satellites (NOS³) emulates flight hardware, allowing a software-only test environment early in a mission's development and testing phases. Developers don't have to wait for physical hardware to be in place and can perform coding, instrument integration, and software testing while hardware is being acquired.

At the tail-end of 2018, a small satellite called Simulation to Flight 1 (STF-1) successfully demonstrated the use of NOS³ in space and continues to carry out its mission. NOS³ will support future Goddard CubeSat missions, including GTOSat, petitSat, and BurstCube. The Goddard SmallSat community has praised the software's effectiveness in reducing programmatic and technical risk, which boosts the likelihood of mission success. NOS³ is a valuable asset at Goddard and outside of NASA as well, with users including the National Science Foundation Center for Space, High Performance, and Resilience Computing, the Air Force Institute of Technology, and the MIT Lincoln Laboratory.

GODDARD TECH 12

The Goddard Tech Transfer Office has created a series to highlight the technologies and innovators connected to Goddard's biggest technology transfer success stories. Called the "Goddard Tech 12," each edition describes a different NASA technology and tells their story from concept to commercialization.

Learn how innovations in mirror polishing for the James Webb Space Telescope helped improve the accuracy of LASIK eye surgery, or how a kite-like innovation called an AeroPod is helping students learn about science and technology.

See the full series at https://partnerships.gsfc.nasa.gov/category/goddard-tech-12.

COMMERCIALIZATION TRAINING CAMP

Over the summer, current and retired professional athletes from the NFL and NBA visited Goddard Space Flight Center to take part in the NASA Commercialization Training Camp, a three-day workshop that introduced NASA's technology portfolio, explained the technology transfer process, and provided points of contact for those interested in using NASA technology to develop a commercial product. The training camp was made possible through Space Act Agreements with the NFL Players Association and the National Basketball Retired Players Association.

Throughout the three days, athletes explored facilities and laboratories at Goddard, learning more about technology development at NASA and Goddard's role as one of NASA's 10 field centers. Attendees were given a list of NASA technologies to research and consider for licensing.

For more on these partnerships and future workshops, check out https://partnerships.gsfc.nasa.gov/news-events/news.

coreVALUE

Goddard flight software helps missions to flourish

There's water on the Moon, and soon, a tiny spacecraft named Lunar IceCube will fly thousands of miles to study it. With NASA's Artemis program planning to land the first woman and next man on the Moon by 2024, Lunar IceCube is a precursor mission, scoping out key resources on the Moon that future astronauts will need.

Though Lunar IceCube is a NASA cube satellite, or CubeSat for short, it's being built at Morehead State University in Kentucky. Initially, the mission team struggled to find flight software that would suit their needs, but a small workshop at the annual Small Satellite Conference in Utah changed Lunar IceCube's course.

"For interplanetary CubeSat missions, some things just don't scale down to CubeSat size," explains Benjamin Malphrus, a Morehead State University professor who is the lead for Lunar IceCube. "We realized that the flight software solution we had planned to use wasn't going to be adequate, and we needed something with the same level of complexity as a larger mission."

That year at the SmallSat Conference, computer engineers David McComas and Jonathan Wilmot from NASA's Goddard Space Flight Center happened to be hosting a workshop on Goddard's core Flight System, a reusable flight software framework created to shorten the amount of time spent on flight software development. Curious to learn more, Malphrus attended the presentation.

"I was completely blown away," Malphrus says. "It was a perfect fit for a small, low-budget mission that really needed sophisticated software but didn't have a big team to develop it."

The core Flight System (cFS) has spent the past decade spreading to other NASA centers and even organizations outside of NASA. Because the cFS is open source, universities and private companies can easily download the code for their own use.

When Lunar IceCube flies to the Moon, it will run using the cFS, joining a long list of spaceflight missions powered by Goddard's collaborative code. As the Artemis program unfolds, the cFS may play an important role in those missions, as well.

THE QUEST FOR BETTER FLIGHT SOFTWARE

Software engineers use words borrowed from architecture and construction to describe the abstract process of coding software programs. Just as an architect might design and build the framework of a house before adding insulation and drywall, software engineers construct layers of code that can build on each other. When software developers refer to "architecture," they're talking about the fundamental structure of the code they write to control NASA's satellites.

Due to the unique requirements of flying a computer in space, Goddard software developers need specialized code, often referred to as flight software, to run onboard a spacecraft. In other words, NASA can't take the software you run on your PC, make a few tweaks, and send it to space. For one thing, personal computers aren't radiation-hardened – subatomic particles outside of low Earth orbit would quickly stop an off-the-shelf laptop from working properly. To account for hardware faults, flight code is designed to be more reliable and fault-tolerant. If a spacecraft is flying to Mars, it won't encounter any local repair shops along the way (yet).

Furthermore, flight software needs to run in real time, and it often has to accommodate distinctive features of individual missions and instruments. A spectrometer designed to study light from stars millions of light years away will run software that differs greatly from software created for a smartphone camera. Because of these unique requirements, any software developed for space needs to be customizable. In the early 1990s, missions at Goddard tended to adopt the "clone and own" approach to flight software development. Mission teams took code from a previous mission and custom-built their own version, getting rid of the pieces they didn't want and building new pieces that suited the needs of the new mission.

While this resulted in made-to-order flight software for each new mission, the approach lacked efficiency. Even if Goddard developers were able to reuse 30 percent of a previous mission's flight software, their total costs didn't go down, as might be expected. During a reorganization, Goddard's flight software engineers began discussing how to resolve this problem.

In their discussions, they realized that new missions were reusing code but not benefitting from the "artifacts" of previous missions. Artifacts are created during the development process and include things such as requirements, design documents, tests, and code reviews. By reusing them as well as code, Goddard could finally reap budget and schedule benefits when building on code from previous missions.

"With each mission, the hardware and operating systems kept changing, so we also needed an architecture that was portable across platforms," adds McComas, who is the program manager for the cFS.

Rather than continuing down the "clone and own" path, the creators of the cFS envisioned a common software architecture. The software package would include 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. This includes an operating system abstraction layer that enables the cFS to port from operating system to operating system with practically no modifications, a platform abstraction layer that makes it easy to port the cFS to new flight computers, and the core Flight Executive (cFE) layer that includes all of the common services NASA missions need to succeed.

"The advantage of the cFS is that we could isolate all the components that don't change," says Alan Cudmore, a computer engineer at Goddard and one of the original developers of the cFS. "We combined some of the best features of the software architectures from past missions."

In the mid-2000s, then-Flight Software Systems Branch Head Elaine Shell instructed Goddard computer engineer Jonathan Wilmot to look at flight software architectures from previous missions and identify which parts could be used to build this new software suite. From this process, the team devised the three-layered flight software framework, with the third layer providing individualized mission applications, much like apps on a smartphone.

"With this 'plug and play' type of architecture, I can write an application, upload it, and have it join the system with minimal effort," says Wilmot, the cFS lead architect.

THE JOURNEY OF THE CFS

The cFS has come a long way since its infancy, Wilmot says. "If it's a Goddard mission, it's going to use cFS, because nobody can justify starting from scratch," he explains. "It really reduces costs."

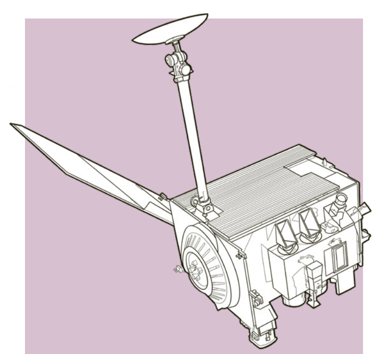
The cFS will play a role in some of Goddard's biggest upcoming missions, including satellite servicing robot Restore-L and space telescope WFIRST. But the path to adoption wasn't straightforward – it took a few big success stories to resonate with the Goddard community. The first in this lineup of successes came in 2009, when NASA's Johnson Space Center in Houston, Texas called to ask about using the cFS for a new flight project.

Johnson was embarking on a project called Morpheus, a futuristic-looking prototype planetary lander that could serve as a testbed for advanced spacecraft technologies. Tethered to the ground for safety, Morpheus would practice vertical takeoffs on a pad at Johnson Space Center and mature technologies to achieve vertical landing on other planets.

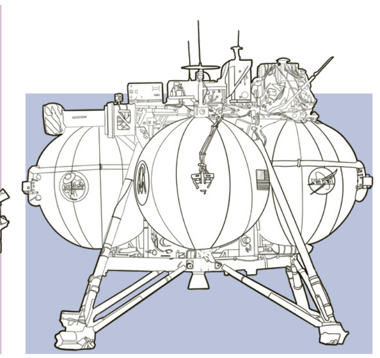
cFS MILESTONES

2000 A reorganization at Goddard brings together software engineers, who envision a reusable flight software architecture.

2003-2005 A Goddard team builds the flight software framework that becomes the cFS.



2009 The Lunar Reconnaissance Orbiter launches, certifying the cFE for flight.



2010 Johnson Space Center successfully flies the Morpheus lander using the cFS.

With a relatively short timeframe to accomplish this task, Johnson asked Goddard about its new flight software framework. Goddard was happy to help, and Johnson's Morpheus project ramped up quickly. In only 14 months, the team conceptualized, built, and successfully flew a vertical lander, and they used the cFS to do it, writing their own apps on top of the existing software architecture.

"It would have taken much longer for them to design something from scratch," Wilmot says. "The Morpheus project is a really powerful argument for using the cFS to rapidly build up a vehicle or system."

Meanwhile, at Goddard, the Lunar Reconnaissance Orbiter (LRO) was preparing for launch. LRO's team helped develop the middle layer of cFS, and after the mission launched in 2009, it certified the cFE and some cFS applications for flight, paving the way for future use.

Next came the Global Precipitation Measurement (GPM) mission – McComas served as GPM's flight software development lead. The rain-detecting weather satellite made it to Earth orbit in 2014, using the full cFS software suite with an initial set of applications in space for the first time.

The cFS reached its next milestone when it became open source. Goddard already had released the cFE in 2011, and four years later, several NASA centers had joined Goddard and Johnson in using the software and helping manage its development, including Ames Research Center in Mountain View, California, and Glenn Research Center in Cleveland, Ohio. With the full release in 2015, the cFS was available to anyone in the world.

OPEN SOURCE ADVANTAGE

Until relatively recently, not many organizations outside of government space agencies had the ability to build a spacecraft and fly it.

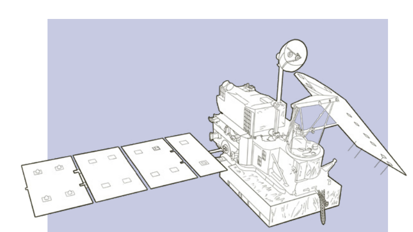
"Ten years ago, a university couldn't have even dreamed of going to space," McComas says. "Space accessibility has increased enormously in the past three years alone."

When Benjamin Malphrus decided to use the cFS for Lunar IceCube, his team could access the software because of its open source status. With the cFS freely available on open source repository GitHub, Malphrus says, it opened new doors for the mission.

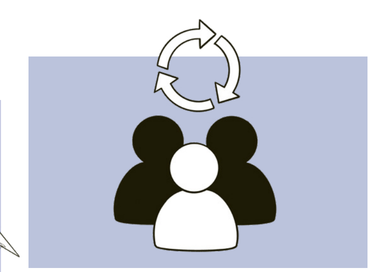
"Creating flight software for these complex, limited-resource missions is just an incredibly daunting task," Malphrus says. "I'd say it's one of the most important enabling tools for our lunar mission. If we had to go out and pay for development or licensing fees, it would have been cost prohibitive."

As it turns out, Lunar IceCube will provide a service back to Goddard. The CubeSat mission plans to demonstrate the use of a new technology called Delay/Disruption Tolerant Networking, or DTN. This protocol suite will make data transfer more reliable when spacecraft send data back to Earth from thousands of miles away. DTN automatically forwards data packets when possible and stores them for future transmission if there is a link disruption.

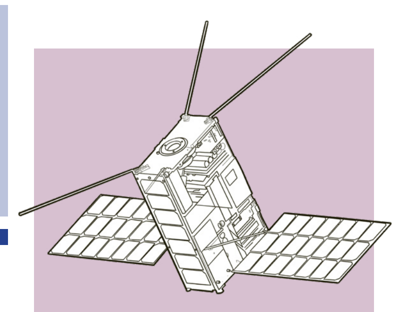
An upcoming Goddard satellite called the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission will use DTN to relay data to ground stations on Earth.



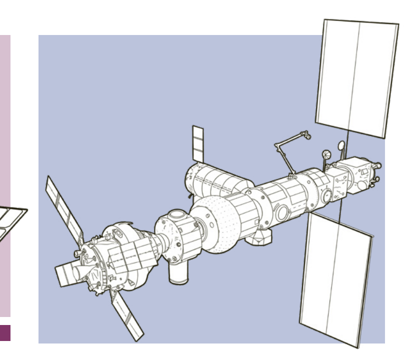
2014 The Global Precipitation Measurement mission flies with the full cFS software suite.



2015 The cFS becomes open source and available for broad use.



2019 The Lunar IceCube mission, supported by the cFS, prepares for flight.



TO THE MOON As the Artemis program unfolds, the cFS may play an important role in missions to the Moon.

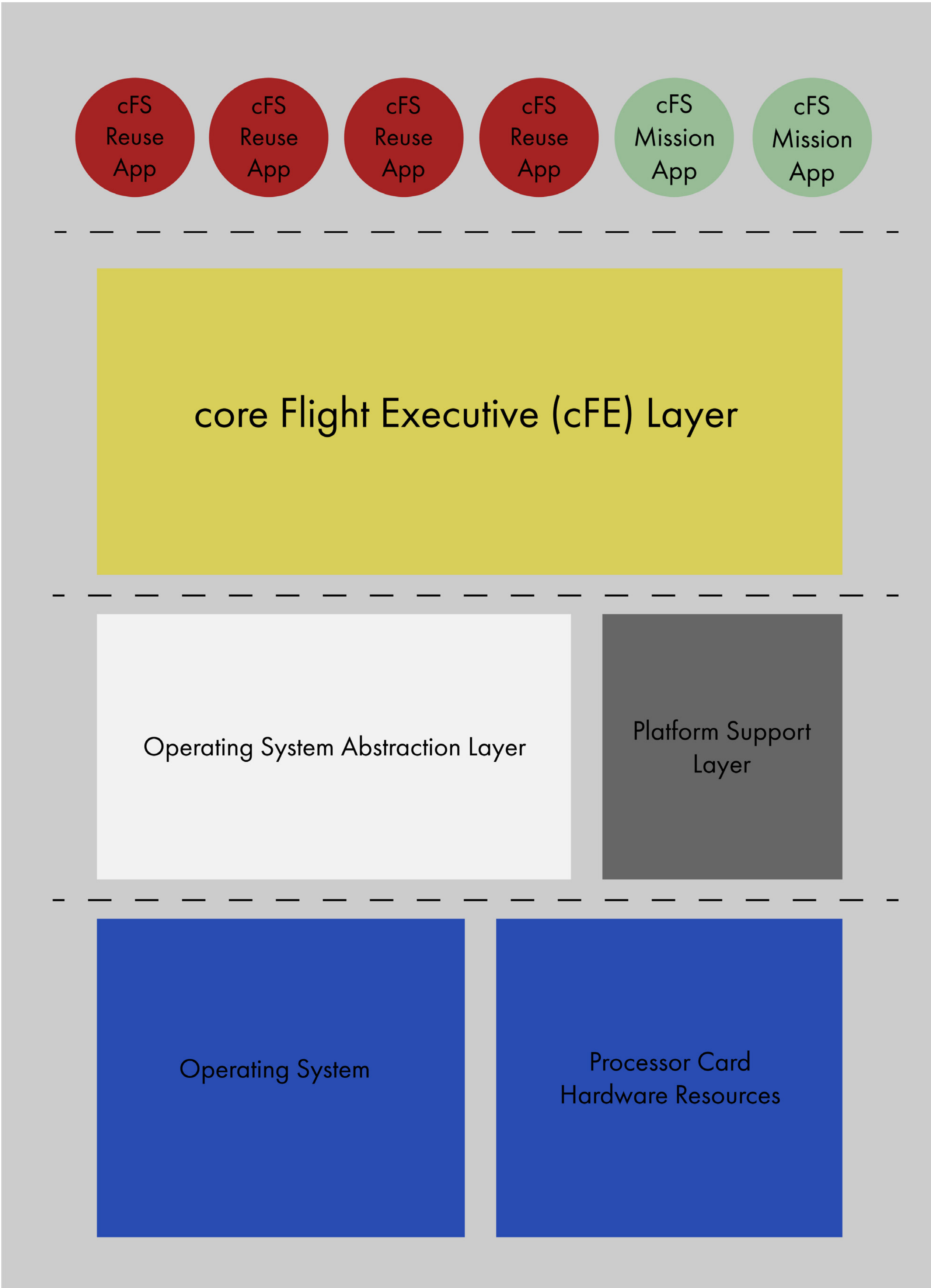


Photo: The core Flight System consists of various layers, demonstrated in this illustration.

Because PACE is using the cFS, a team at Goddard is writing a new DTN app for the mission. Here's where Lunar IceCube swoops in to assist the PACE mission – because the CubeSat uses the cFS, it can test the DTN app in space before PACE is scheduled to launch in 2022, squeaking in a technology demonstration and boosting the app's confidence level. "This wasn't planned at all, but because the app can be used on both missions, it's turned into a neat example of collaboration in technology development," McComas says.

A COMMON FRAMEWORK

McComas sees the space industry trending toward collaboration, commercialization, and accessibility.

"With open source, we have a lot to offer in service of those trends," he adds.

Once the cFS became open source in 2015, it spread outside NASA and threaded its way into diverse nooks and crannies of the space realm. If you search "core Flight System" on a jobs board website, job descriptions pop up that include the cFS in a list of desired skills. Several universities have expressed interest in adding the cFS to their curriculum. Johns Hopkins University's Applied Physics Lab in Laurel, Maryland used the cFE in their work on the Van Allen Probes and later on the Parker Solar Probe, which launched in 2018.

At Goddard, the cFS has captured the attention of the small satellite community. Alan Cudmore worked on Dellingr, a Goddard CubeSat that took flight in 2017, and he says that he used cFE with minimal changes for that mission. When Dellingr experienced a hardware failure after launch, engineers used the cFS to upload new software in orbit, which fixed the issue and allowed the mission to continue.

"A lot of CubeSats don't have that capability, and it gave us a big advantage," Cudmore says.
Dellingr's success paved the way for four upcoming CubeSat missions at Goddard, all of which will use software based on the cFS. Cudmore envisions a future library of CubeSat applications already built and ready to plug into missions. Each year, Goddard participates in the SmallSat Conference in Utah to extoll the virtues of the cFS to companies in attendance.
Finally, as the space arena grows ever more interconnected, the cFS has a story to tell in NASA's future return to the Moon. In 2014, a NASA program called Lunar CATALYST competitively selected three companies to advance the development of robotic lunar landers with the ultimate goal of delivering payloads to the Moon's surface. All three companies decided to use the cFS for their missions.

McComas, Wilmot, and colleague Susanne Strege provided training to each of the companies, helping to bolster adoption and spread the reach of the cFS even further. With the Artemis program's goal launch date of 2024 approaching, the cFS is woven into the fabric of NASA's plans to venture from the Moon to Mars. The Lunar Gateway, a key space station in NASA's Moon to Mars plan, includes the cFS in its mission requirements.

With the cFS potentially in use across the Artemis program, systems and spacecraft become inherently compatible. Developers can work together and share applications vehicles and spacecraft with significantly lower costs for the program. Software applications become portable across the systems, even at run-time, leading to improvements in fault tolerance, safety, and sustainability.

"The cFS framework provides a much-needed, open-source, app-store-like software model, which enables collaboration," McComas says. "The whole world has changed and become more collaborative, and it's absolutely where we need to be."

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

Author's note: The little "c" in core Flight System and core Flight Executive is written that way on purpose. According to the cFS' developers, the little "c" denotes the flight software's simplicity and compact implementation.

Q&A WITH DEPUTY CHIEF

KERRY LEONARD

Since arriving at NASA's Goddard Space Flight Center in 2018 as a technology manager, Kerry Leonard has immersed herself in the world of NASA technologies. As it turns out, Leonard's NASA aspirations started early – when she was only 18 months old, she visited NASA's Kennedy Space Center in Florida.

"I remember being so excited to visit KSC because I couldn't wait to see a launch in person. I thought they launched rockets at Cape Canaveral every day, just like they have parades every day at Disney World," she laughs, describing how she was dazzled by the model rockets and astronaut suits at the visitor center.

Leonard took a circuitous route to NASA – she earned her undergraduate degree in chemical engineering but pursued a career in intellectual property law, picking up her law and MBA degrees along the way. As the new deputy chief of the Strategic Partnerships Office at Goddard, Leonard will help direct technology transfer and partnerships for the center, undertaking NASA's mission to transfer new technologies to the private sector for public benefit. Tech Transfer magazine caught up with Leonard in her office at Goddard to discuss her new role.

WHAT WERE YOU DOING PRIOR TO BECOMING DEPUTY CHIEF OF THE STRATEGIC PARTNERSHIPS OFFICE?

In 2018, I joined Goddard as a technology manager with SPO. Previously, I had been a technology transfer specialist at the Department of Veteran's Affairs (VA) and worked with VA researchers to transfer their inventions to the public. Prior to that, I was working in private practice as a patent attorney. I started off my career as a patent examiner at the United States Patent and Trademark Office. I've appreciated spending time in all these different roles because it's given me perspective on the different aspects of the technology transfer process.

WHY DID YOU CHOOSE TO WORK IN TECHNOLOGY TRANSFER?

Technology transfer allows me to utilize all of my training and approach technology in a holistic way. With technology transfer, I get to combine my technical background with my legal experience and add a bit of the business focus, as well. And while I liked working in patent prosecution, I really enjoy the challenge of taking all these moving parts and creating something bigger and greater out of them. It's fascinating to see how NASA technologies can make a difference by influencing companies and changing industries.

WHAT ROLE DOES TECHNOLOGY TRANSFER PLAY IN FULFILLING NASA'S MISSION?

From day one, technology transfer has been a part of NASA's mission. The National Aeronautics and Space Act that created NASA in 1958 specifically says that NASA should "provide for the widest practicable and appropriate dissemination of information." So in a way, we've always been leading other federal agencies in this field. At NASA, we do technology transfer not only to comply with the law, but also because it's part of our mission to make our developments available for the benefit of others. Bringing NASA technology back down to Earth is a good return on taxpayer dollars because it's not just for the good of the U.S. economy – it's for the benefit of all mankind.

WHAT RESPONSIBILITIES WILL YOU HAVE AS DEPUTY CHIEF?

I'm working with SPO Chief Darryl Mitchell to oversee SPO's core functions and develop ways to hone our approach to technology transfer and agency partnerships. Our office handles licensing technologies and establishing partnerships for Goddard, and my role will involve figuring out the best ways to establish these collaborations that are vital to both NASA and the organizations that work with us. I'm especially excited about doing more in-reach activities on center so that I can meet more of the people who work here, learn more about what they're working on, and find out how SPO can add value to their projects.

HOW IS GODDARD'S TECHNOLOGY PORTFOLIO UNIQUE COMPARED TO OTHER NASA CENTERS?

Goddard possesses a huge breadth of technologies. There is such a diversity of research being done, and the applications are so varied that it's both a challenge and an opportunity to work with the Goddard portfolio. As NASA's largest science-focused center, Goddard has a lot to offer in terms of what we can share with industry, especially with respect to research and development partnerships. We're thinking not just in terms of patent licensing, but also what we can do to collaborate. With our science and research focus, we mesh easily with other research partners. We consider our capabilities and people as part of the portfolio we have to offer.

DO YOU HAVE A FAVORITE GODDARD SPINOFF TECHNOLOGY?

It's impossible to pick just one. But given my background in the medical device industry, I have a soft spot for when our NASA technologies find a terrestrial use in healthcare applications. You have technologies like our Modulated X-Ray Source (MXS) that can improve medical imaging. The Ingestible Thermometer Pill can be used to monitor people and help prevent injuries. There was even the LORAD Stereo Guide that improved breast biopsy techniques. In NASA's Technology Transfer program, we are always striving to bring new technologies "down to Earth" and show how investment in federal R&D can touch our lives. And I think that the healthcare spinoffs that literally touch our lives show the value of what we're trying to do here. Technology transfer can, and does, save lives and we truly are doing this for the benefit of mankind.

WHAT IS YOUR FAVORITE PART OF WORKING AT GODDARD?

Since childhood, it's been a dream of mine to work at NASA. It's truly an honor to work here and be a part of this community. I enjoy working with our researchers and learning about their projects. They are pushing the limits of science and engineering and venturing into the unknown, sometimes literally. It's an incredible responsibility to figure out ways to bring that talent and ingenuity to other applications that can also enhance our lives here on Earth. What's most exciting to me is that there's so much potential in Goddard's people and technologies, and I greatly look forward to helping further NASA's mission in partnership with them.

To explore technology licensing opportunities with SPO, contact Kerry Leonard at kerry.w.leonard@nasa.gov.

QUIZ

WHICH GODDARD SPINOFF ARE YOU?

Q1

On a trip to the grocery store, what is your impulse buy?

A. Cough drops
B. A celebrity gossip magazine
C. A model car kit
D. Treats for your pet

Q2

What is your favorite color?

A. Green, like the color of a tiny circuit board
B. Blue, like the ocean
C. Gray, like an old computer
D. White, like an endangered polar bear

Q3

You're at a party — what are you doing?

A. Finding a quiet corner to hide — you feel out of place in this giant world
B. Bouncing from group to group, gathering information
C. Studying the table piled with snacks, figuring out if it is stable enough
D. Sitting in a chair with a cat in your lap

Q4

What kind of dog do you like best?

A. A Chihuahua — something small and transportable
B. A Saint Bernard — something that can search and rescue
C. A robot dog — something analytical and programmable
D. Any dog — I love all animals

Q5

Your friend is moving. How do you help?

A. You keep a close eye on everyone while they're loading boxes and make sure they don't get overheated
B. You search every packed box for the important piece of paperwork that your friend thought she didn't need
C. You measure the dimensions of every room in her new house and create a report with the optimal configuration of her furniture
D. You set up a room with familiar beds and toys for her dog

Q6

What season makes you happiest?

A. Winter — it's the least likely time for heat exhaustion
B. Fall —the summer is winding down and people aren't getting lost all the time
C. Spring — the weather is nice so I can get out and build things
D. Summer — I can go snorkeling

Q7

What character would you be in a medieval fantasy world?

A. Healer
B. Knight
C. Stonemason
D. Falconer

Q8

What's your favorite food?

A. Watermelons, because they're hydrating
B. Truffles, because they're hard to find
C. Gingerbread, because you can use it to build a house
D. Veggie burgers, because I'm vegan

Q9

What game did you enjoy most as a kid?

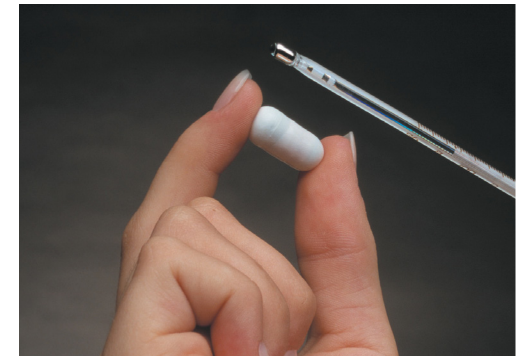
A. Football
B. Hide and seek
C. Fort building
D. Horse

Q10

You're on a camping trip — where can you be found?

A. Checking the first aid kit to make sure there isn't anything missing
B. Looking for logs to burn in the campfire
C. Putting together the tent
D. Taking pictures of wildlife

IF YOU ANSWERED...



MOSTLY A'S: *Ingestible Thermometer Pill*

Monitors football players for heat exhaustion

Sure, you're meek and unassuming, but on the inside, you're packed with an impressive amount of high-powered sensing abilities. Equipped with the ability to see a person's inner workings, you cut right through fake niceties and go straight to the core of the issue. Incredibly adept at reading and interpreting your environment, you're devoted to helping people from the inside out.

MOSTLY B'S: *Search and Rescue Satellite Aided Tracking (SARSAT)*

Emergency satellite beacon system used to save thousands of lives

You have a wide network of contacts, and you know how to use it. Ever the social butterfly, you're constantly reaching out to everyone you know, working your connections from the ground up to find solutions for people who need help. You're constantly listening for signals of distress, and when you hear one, you jump into action, quickly locating the source of the problem and working your hardest to resolve it.

MOSTLY C'S: *NASA Structural Analysis Computer Software (NASTRAN)*

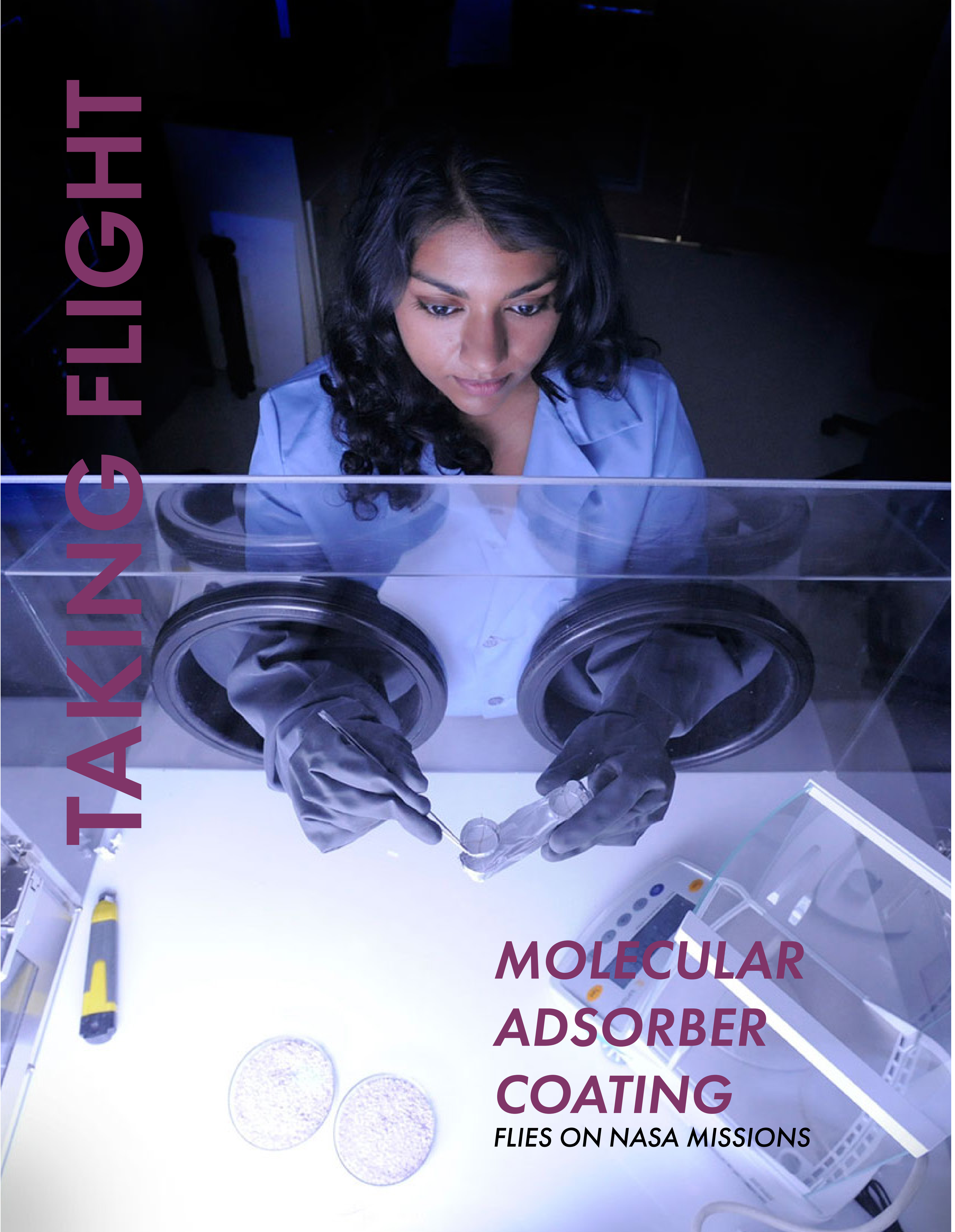
Design software that minimizes trial and error to build safer, light structures

You were the kid who spent hours in computer lab playing the game where you get to build roller coasters. With keen analytical skills and an eye for geometry, you have the vision and resolve to build a product that will stand the test of time. You also know how to design structures safely by quickly and efficiently ruling out options, which explains your vast popularity. You're a classic, and everyone knows it.

MOSTLY D'S: *Groth Algorithm*

Hubble algorithm adapted to assist in endangered species conservation efforts

If you see a stray dog running loose on the road, you'll stop everything to make sure it's safe. You have a big heart for animals of all kinds, and with your attention to detail, you can see patterns and make connections that other people don't notice. With your focus on helping wildlife and fixing broken ecosystems, you can make the world a better place.



MOLECULAR ADSORBER COATING

FLIES ON NASA MISSIONS

Photo Credit: NASA/Pat Izzo

Every day, we're surrounded by billions of tiny, unseen objects. Molecules of all kinds float like invisible motes of dust, impossible to detect with the naked eye but sometimes discernable through smell.

"Think about when you buy a home — you may have new furniture, such as sofas, mattresses, or memory foam pillows, and freshly painted rooms," says Nithin Abraham, a thermal coatings engineer at NASA's Goddard Space Flight Center. "These common household items often have a new smell associated with them, and it's a result of volatile organic compounds being released into the air."

As part of her job, Abraham has to think on the tiniest of scales. At NASA, she works on coatings technology research efforts. Specifically, she tries to address molecular contamination, finding ways to keep molecules from interfering with delicate instruments bound for space. Even the smallest deposition of chemical species on a sensitive telescope mirror can keep it from working properly.

Abraham is the subject matter expert on the Molecular Adsorber Coating (MAC), a NASA technology with broad applications for the aerospace industry. For nine years, Abraham has studied MAC and evaluated its use in protecting spacecraft and instruments from contamination via potentially harmful molecules.

MAC is flying in space aboard the Ionospheric Connection Explorer (ICON) mission, a space weather satellite launched on Oct. 10. MAC is also flying on the International Space Station on-board a NASA lidar mission called the Global Ecosystem Dynamics Investigation (GEDI), which launched last December. As a technology developed for space, MAC could make a valuable addition to the aerospace industry. An ongoing partnership with the Smithsonian Institution shows how MAC might have applications in other industries, as well.

LIGHTER, FASTER, SIMPLER

Abraham started working with MAC during her first year at Goddard in 2010, when she was tasked with converting an old technology into a lighter, more efficient system.

"The old technology was called the adsorber puck system – they flew it on Goddard missions, but there were some disadvantages to using it," she says.

Just like new household items can release or "offgas" molecules into the air, other materials can "outgas" in vacuum. Outgassing can occur from items that often are used within the spacecraft itself, such as epoxies, tapes, and lubricants. In the past, Goddard had used adsorber pucks made of a material called cordierite. These honeycomb patterned materials were layered with a zeolite slurry to "adsorb" or hold molecules within the surface area of the puck. Zeolite is a mineral with open pores or cavities that can capture molecules passively.

This mitigated contaminants from settling on the surfaces of sensitive instruments, where they could interfere with performance. Both the Hubble Space Telescope mission and the Tropical Rainfall Measurement Mission successfully incorporated adsorber pucks.

Photo: Innovator Nithin Abraham won the James Kerley Award for excellence in technology transfer in 2018.

Photo Credit: NASA/Chris Gunn

While the pucks did the job, they were heavy and bulky, and engineers had concerns associated with its durability. In space flight, where engineers carefully calculate mass to the milligram, extra weight can create problems or prevent a mission from adding hardware. Integration of the puck system was also fairly complex, requiring additional hardware for installation, which added time to the project schedule.

Similar to the adsorber pucks, MAC contains zeolite. With its large surface-area-to-mass ratio, zeolite works incredibly well at efficiently trapping molecular contaminants.

While the adsorber pucks are heavy objects that require installation, engineers can spray MAC directly on to a surface, such as the interior of the spacecraft itself or on panels that can be easily installed within instrument cavities and vacuum chambers. It forms a thin, lightweight coating and displays adsorbing capabilities similar to the pucks.

"Our testing has successfully shown that MAC adsorbs a wide range of molecular contaminants, such as hydrocarbons, plasticizers and silicones, in relevant space environments," Abraham says. "The coating's adsorptive properties are impressive and can be tailored for optimal performance per the application."

MAC IN SPACE

So far, MAC has demonstrated its effectiveness a number of times, but Abraham points to three examples in particular.

The ICON mission, which launched this year, incorporated small discs spray-coated with MAC and placed inside the instrument to adsorb contaminants and protect the far ultraviolet instrument from outgassed molecules during its mission lifetime.

"The instrument needs to meet its molecular contamination requirements – if they exceed a specific threshold, it can start to degrade the instrument's performance," Abraham explains. "The project has implemented MAC discs to mitigate the risks associated with on-orbit material outgassing within the highly sensitive instrument cavity."

For the James Webb Space Telescope (JWST) mission, currently scheduled to launch in 2021, engineers used MAC during testing of the optical ground support equipment, thermal pathfinder model, and optical components in a vacuum chamber at NASA's Johnson Space Center in Houston, Texas. NASA uses vacuum chambers to mimic the environment of space and test spacecraft before they launch.

Johnson has a vacuum chamber test facility called Chamber A, and as part of preparing JWST for space flight, engineers performed tests of the telescope's components in vacuum. Engineers placed custom fabricated MAC samples within the test chamber, and the coating worked to entrap outgassed compounds, such as hydrocarbons and silicone-based pump oil. Testing carried on successfully, and JWST's delicate components were not impacted by molecular contamination.

NASA also used MAC for the Global-scale Observations of the Limb and Disk (GOLD) mission, which launched in early 2018. NASA partnered with the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado-Boulder to develop and test the instrumentation for GOLD. The instrument completed vacuum environmental testing in Airbus, France. The project implemented the use of MAC as a mitigation technique to protect the instrument components from outgassed species during testing.

Abraham says that after she received the samples that were used during the test, her team analyzed them to determine the chemical species that were collected during its exposure in the vacuum chamber.

"Vacuum chambers are a great application for MAC because it will help capture those possibly harmful contaminants when testing spaceflight hardware," Abraham says.

MAC IN THE FUTURE

Through a Space Act Agreement between NASA and the Smithsonian Institution's National Museum of Natural History, Abraham and a team of researchers are testing MAC's versatility outside the aerospace industry, as well. Museum conservators wanted to know if MAC, with its ability to adsorb potentially harmful chemicals, could collect mercury vapor and other off-gassed species from some of the museum's specimens.

"They want to protect their artifacts, just like we want to protect our instruments and satellites," Abraham observes. "Contamination is an issue that reaches beyond space applications."

Two years into the collaboration, the study has yielded some interesting results, and as the partnership continues, Abraham and her fellow researchers will be able to determine if MAC is a good fit for artifact conservation.

"The preliminary data seems promising," she says. Looking forward, Abraham says she's open to exploring other partnerships and applications for MAC. "I've been working on MAC for a long time, but it's still exciting to me because I'm constantly learning new things about it," she adds.

I'VE BEEN WORKING ON **MAC** *FOR A LONG TIME, BUT IT'S* **STILL EXCITING** *TO ME BECAUSE I'M CONSTANTLY LEARNING* **NEW THINGS** *ABOUT IT.*
—NITHIN ABRAHAM

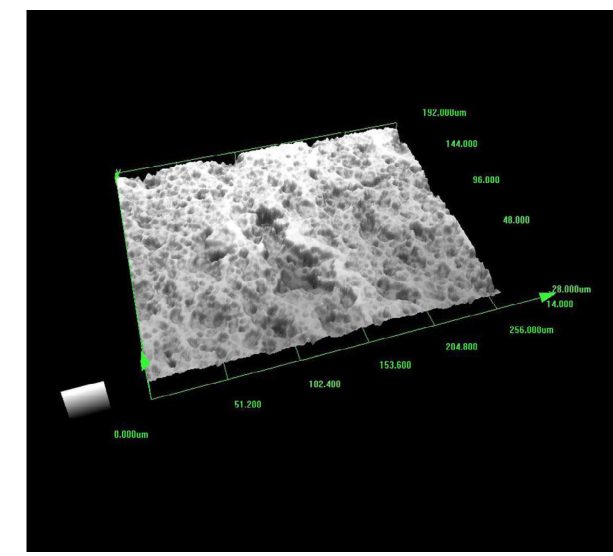


Photo: MAC's microscopic nanotexture enables it to trap molecular contaminants.

Photo Credit: NASA/Chris Gunn

NEW FRONTIERS

Goddard X-ray technology opens new frontiers in space and here on Earth

Time and time again, the path of basic research takes surprising twists and turns.

"Why does NASA spend money on technologies to look at black holes when there are so many things on Earth we need to fix?" asked Keith Gendreau, an astrophysicist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "It turns out that the work we do here impacts people in tangible ways."

A tiny technology Gendreau developed to study black holes now has potential as part of a life-saving medical device, thanks to this process of curiosity and discovery. The Miniaturized High-Speed Modulated X-ray Source (MXS) has a diverse array of possible applications stretching far beyond the realm of astrophysics.

Each year, the NASA Inventions and Contributions Board recognizes a technology that has contributed significantly to NASA programs. The board chose MXS as NASA's 2019 Government Invention of the Year, the first time Goddard has received this recognition since 2002. With its multifaceted uses in medical imaging, materials science, space communication and more, MXS serves as a reminder that NASA's exploration of space can result in tangible benefits for people on Earth.

FROM BLACK HOLES TO CT SCANNERS

MXS was created to help us peer into the universe with sharp X-ray eyes. In his role as an astrophysicist, Gendreau envisioned a highly advanced imager that could capture pictures of a black hole's event horizon. The design of this telescope required an X-ray beacon, so Gendreau developed an X-ray source that could vary the intensity of its output rapidly, brightening and dimming at pre-determined intervals.

"When you go after challenging goals, the technologies required to achieve those goals are even more challenging," Gendreau said. "This often means that you open more doors than you originally intended."

Already, MXS has opened multiple doors. The technology played an important role in testing of NASA's Neutron star Interior Composition Explorer (NICER)/Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) mission, an external payload on the International Space Station. Before NICER's launch in 2017, MXS calibrated the mission's X-ray detectors, ensuring they could make accurate observations of black holes and other X-ray emitting celestial objects. MXS provided both an energy reference and a timing reference, offering unmatched nanosecond-level precision.

"Because the mission's goals are to capture and understand the fast flickers, flashes and pulses in X-rays that are emitted by black holes, neutron stars and other

Photo Credit: NASA/Taylor Mickal

Photo: Keith Gendreau developed MXS to study black holes.

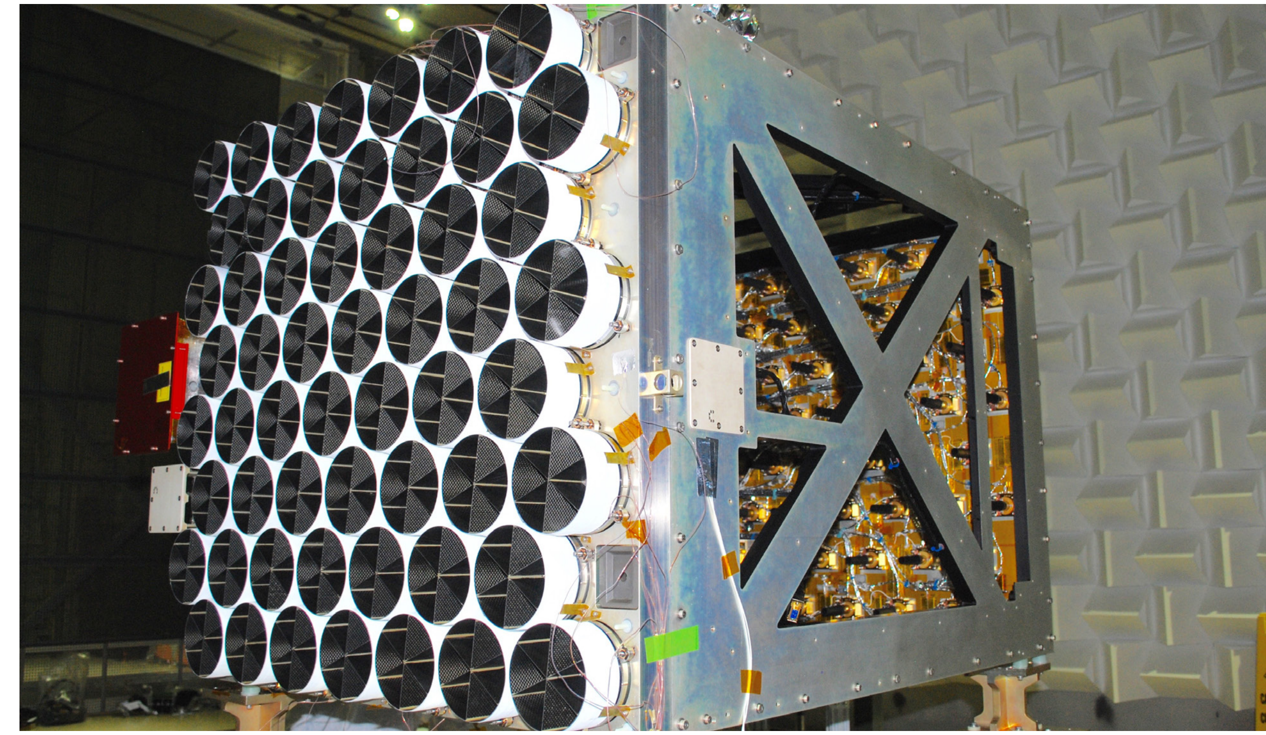


Photo Credit: NASA/Keith Gendreau

Photo: A view of the NICER X-ray Timing Instrument without its protective blanketing shows a colleciton of 56 close-packed sunshades.

energetic objects in the universe, having MXS to simulate those behaviors during ground testing was invaluable," said Zaven Arzoumanian, a Goddard astrophysicist and co-inventor of MXS.

Gendreau and Arzoumanian, along with Goddard co-inventors Steven Kenyon and Nick Salvatore Spartana, knew this application was just one of many for the versatile invention.

"Sometimes, basic research can touch people's lives in ways that you don't immediately know or can't predict," Gendreau says.

For example, the NASA researchers and partners at Massachusetts General Hospital and the Massachusetts Institute of Technology (MIT) have demonstrated an innovative computed tomography (CT) scanner for medical imaging with MXS. CT systems generate 3D images of internal organs by using X-rays to scan the body in cross sections. Computer software stitches the cross sections together to create a highly detailed image, used by medical professionals to screen for tumors, analyze bone fractures, search for blood clots in lungs or examine brain injuries.

A MIT-led 2018 paper in the journal Scientific Reports describes the novel technology — a portable, no-moving-parts imaging system that offers fine-tuning of the radiation dose received by a patient — and laboratory testing, which generated a detailed 3D image of a pig lung at a quality competitive with current CT scanners. The increased mobility and lower dose of radiation offered by an MXS-based device could result in better and safer access to medical care in rural areas and low-income countries. For future space travel, astronauts could bring a portable CT scanner for medical care on long-distance journeys, such as to Mars.

Under NASA's Space Act Agreement with Massachusetts General Hospital, researchers continue to study the innovation for practical use.

WIDER REACH WITH TECHNOLOGY TRANSFER

Massachusetts General Hospital isn't the only organization interested in MXS. Through technology transfer, companies can license MXS from NASA and apply the invention toward a commercial product. With applications in many industries, MXS is full of potential in the private sector.

The device possesses two advantages over prior state-of-the-art X-ray sources. First, it is small and lightweight — about the same size as a deck of cards. Second, MXS is less fragile than traditional X-ray sources and requires less maintenance. The improvements in size, weight, and robustness increase the technology's flexibility and portability, creating opportunities for new applications not previously possible. While several companies are considering MXS for licensing agreements, chemists at Washington State University have incorporated MXS into an ion mobility spectrometer, which can detect chemical agents, including potentially dangerous substances, in the air. Gendreau said it could increase the sensitivity of the device, and since MXS produces X-rays electronically instead of radioactively, it is subject to fewer regulations.

Abundant applications of MXS continue to unfurl in other areas, such as deep space communications. Known as XCOM, this new form of sending information could achieve better power efficiency than radio or laser systems in the vacuum of space, since X-rays have shorter wavelengths. With its roots as a technology for black hole imaging, MXS has blossomed into a practical innovation with many divergent applications. Its tendrils extend to unforeseen areas of purpose, growing ever more versatile as time passes.

"I'm sure there are other functions for MXS that we don't know about yet, waiting to be discovered," Gendreau said.

For more information about NASA's Technology Transfer program, visit: https://technology.nasa.gov/

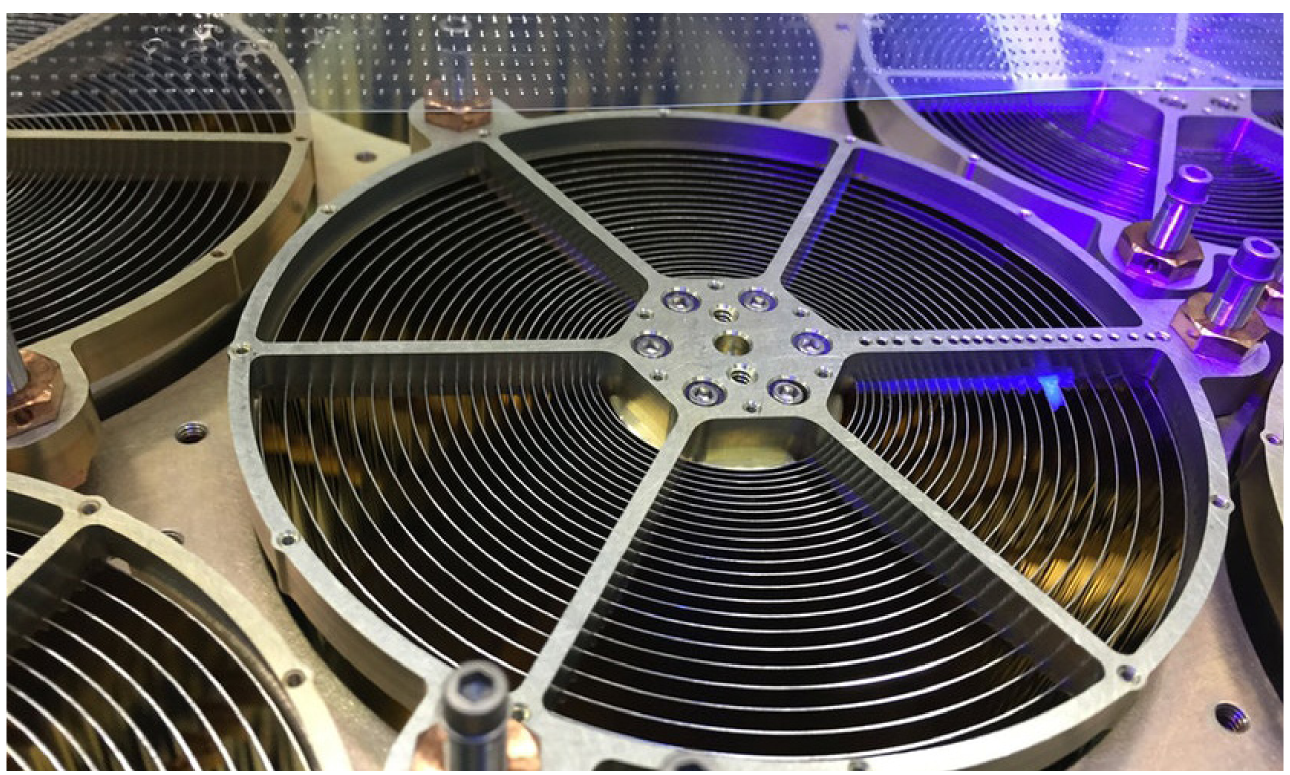


Photo Credit: NASA/Keith Gendreau

Photo: NICER's X-ray concentrator optics are inspected under a black light for dust and object debris that could impair functionality once in space.

PARTNERSHIPS

Partnership will share technology transfer opportunities with professional athletes

NASA & WNBPA TEAM UP FOR TECH TRANSFER

On the heels of the first-ever all-women spacewalk, NASA and the Women's National Basketball Players Association (WNBPA) announced a partnership to provide professional basketball players with opportunities to explore the agency's technology licensing and its various applications.

"Many athletes have pursued successful careers as entrepreneurs after retiring from their athletic pursuits," said Dennis Small, a senior technology manager at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "Through our Space Act Agreement with the WNBPA, we're looking to forge connections with future business owners and share NASA technologies with interested members to generate license agreements and the creation of startups that feature NASA technology."

Founded in 1998, the WNBPA is the labor union for the basketball players of the WNBA. According to the WNBPA's website, the organization's core principles involve engaging members in "activities that will advance and safeguard the economic security and general social welfare of WNBA players both during and after their playing careers."

In collaboration with the WNBPA, NASA will organize a technology workshop for WNBPA members to learn more about existing patented NASA technologies and how those technologies can be transferred to the private sector through licensing agreements. NASA will invite guest speakers to address the foundational skills needed to start a business.

"Over the last few years, the union has worked hard to build relationships with a variety of businesses and organizations that support the interests and career aspirations of WNBA players after basketball," said Terri Jackson, executive director of the WNBPA. "This partnership with NASA allows our members to explore technology discoveries that started with space but could have applications in business."

The WNBPA joins the NFL Players Association, the National Basketball Retired Players Association and the National Basketball Players Association as the fourth professional players association to form a partnership with NASA in the past year.

Jackson said the WNBPA consists of players who are "highly educated and always looking for opportunities to stretch themselves and pursue professional development as working women." Jackson said this partnership with NASA is a positive example of how "we all win when we invest time and energy into girls and women."

Photo: NASA's partnership with the WNBPA will create opportunities for members to explore technology licensing. The WNBPA Executive Committee includes (from left to right) Layshia Clarendon, Elena Delle Donne, Carolyn Swords, and Chiney Ogwumike.

Photo Credit: WNBPA/Isaac Theatus/Redhous Visuals

TECH DISCLOSURES

CARBON NANOTUBE CATALYST ENHANCER
John Hagopian

SPACECUBE VERSION 3.0 MINI PROCESSOR CARD
Alessandro Geist, Cody Brewer, Robin Ripley, Christopher Wilson, Nicholas Franconi, Gary Crum, David Patrick, Thomas Flatley

COMMUNITY OBSERVATION PLANNING SOFTWARE FOR THE TRANSITING EXPOLANET SURVEY SATELLITE (TESS)
Tess Jaffe, Koji Mukai

PORTABLE DISTRIBUTED SCRIPTS (PODS)
Jules Kouatchou

ABSOLUTE CARBON NANOTUBE MICROBOLOMETER
David Harber, Cameron Straatsma, Joel Rutkowski, Chris Young, Nathan Tomlin, Michelle Stephens

NAFTU CONFIGURATION LOADER
Nathan Riolo

PRECISION THERMO-CONDUCTIVE BONDING OF LASER RODS WITH MECHANICAL ISOLATION
Barry Coyle

GLOBE OBSERVER APP FOR IOS AND ANDROID
Cornell Lewis, Joe Wieclawek

A CONFORMAL STRUCTURAL FOAM
Vincent Bly

LIQUID DEPOSITION INTERFACE TO A LASER DESORPTION/IONIZATION MASS SPECTROMETER
Stephanie Getty, Adrian Southard, Andrej Grubisic, Manuel Balvin, Jerome Ferrance, Xiang Li, William Brinckerhoff, Jamie Cook

PROXY CORE FLIGHT SYSTEM APPLICATION AND CLIENT FOR EXTERNAL PROCESS
James Marshall, Alan Gibson, Nathan Riolo

SPACE WEATHER APP (IOS) VERSION 2
Richard Mullinix

TRACEABILITY MATRIX GENERATOR
Nathan Riolo, Richard Mullinix

CATADIOPTRIC TELESCOPE DESIGN
Luis Ramos-Izquierdo

CLOSED-LOOP MICROBOLOMETER READOUT WITH A SINGLE COMMON THERMISTOR-HEATER ELEMENT
David Harber, Cameron Straatsma, Joel Rutkowski

ACTUATION FORCE STUDY OF NEXT GENERATION MICRO SHUTTER ARRAY FOR MORE RELIABLE ACTUATION
Kyowon Kim, Alexander Kutyrev, Mary Li, Matthew Greenhouse

APPLICATION OF BORON ALUMINUM OXIDE COMPOSITE DEPOSITED BY ATOMIC LAYER DEPOSITION (ALD) ON GRAPHENE FOAM FOR LIGHT WEIGHT RADIATION SHIELDING
Vivek Dwivedi

OPERATING SYSTEM ABSTRACTION LAYER
Alan Cudmore, Joseph Hickey, Steve Duran, Tam Ngo, Nicholas Yanchik, Allen Brown, Russell McCluney

INFLATABLE ANTENNA FOR MANNED CAPSULES
David Watson

NOVEL METHOD FOR THE SIMULTANEOUS GAS CHROMATOGRAPHIC ENANTIOMERIC AND ISOTOPIC ANALYSES OF MONOCARBOXYLIC ACIDS
Jason Dworkin, Jose Aponte, Jamie Cook, Hannah Woodward, Neyda Abreu

BOOM RETRACTION MECHANISM AS PART OF SAMPLE ACQUISITION SYSTEM
Walter Smith

DELAY/DISRUPTION TOLERANT NETWORKING (DTN) BUNDLE PROTOCOL NODE FOR GROUND (BPNGND)
Susanne Strege, Dylan Baker, Syeda Kazmi, Gregory Greer, Mark Richardson, Mark Neuberger

ADVANCED NET FLUX RADIOMETER
Shahid Aslam, Gerard Quilligan, Nicolas Gorius, Dat Tran

FEMTOSECOND LASER WELDING OF DIAMOND, CALCIUM FLUORIDE, AND OTHER TRANSPARENT CRYSTALLINE MATERIALS TO METALS
Robert Lafon, Steven Li, Frankie Micalizzi

COMPACT NON-DISPERSIVE INFRARED GAS ANALYZER (NDIRGA)
Shahid Aslam, Daniel Glavin, Gerard Quilligan, Nicolas Gorius, Perry Gerakines, John Kolasinski, Dat Tran, Todd Purser

USING MINIATURE LASER RETROREFLECTOR ARRAYS ON LUNAR LANDERS TO MEASURE TRANSIENT WATER ICE DEPOSITION ON THE MOON
Daniel Cremons, Xiaoli Sun, Paul Lucey

METHANE ALERTSTATION
Gerard Quilligan, Nicolas Gorius, Shahid Aslam, Conor Nixon

CARBON NANOTUBE POLYMER COMPOSITE MIRRORS FOR CUBESAT TELESCOPES
Shahid Aslam, Nicolas Gorius, Tilak Hewagama, Peter Chen, Theodor Kostiuk, John Kolasinski

S/W RESOLVER TO DIGITAL CONVERTER
Brian Tibbets, Charles Kupelian, Ernest Bowden

COOPERATIVE ROTARY ACTUATOR FOR ROBOTICALLY OPERATED DOORS OR COVERS
Hans Raven, Kate McGinnis, Elliott Martin

CONTAINER FLIGHT SOFTWARE
Alan Cudmore, Krystine Carrington

OPTICAL DEVICES WITH TRANSVERSE COUPLED CAVITY
Hamed Dalir, Ray Chen

OPTIMIZATION OF FEMTOSECOND LASER-MATTER INTERACTION VIA ADVANCED MODELLING
Jie Qiao, Christophe Dorrer

TECH DISCLOSURES *cont'd*

TRADE-SPACE ANALYSIS TOOL FOR DESIGNING CONSTELLATIONS (TAT-C) VERSION 2.0
Carlos Dutan, Jacqueline Le Moigne-Stewart, Jonathan Verville, Philip Dabney, Matthew Holland, Steven Hughes, Afreen Siddiqi, Sreeja Nag, Paul Grogan, Daniel Selva, Vinay Ravindra, Gabriel Apaza, Joseph Gurganus, Michael Stark, Eric Magliarditi, Lindsay Portelli, Matt Sabatini, Hitomi Nozomi, Prachi Dutta, Pau Garcia Buzzi

HIGH VOLTAGE, HIGH SLEW RATE PULSE DRIVER ELECTRONICS FOR CAPACITIVE ELECTRO-OPTIC DEVICES
Emanuel Hernandez, Donald Coyle

SOFTWARE BUS NETWORK CLIENT FOR EXTERNAL PROCESS
Alan Gibson, James Marshall, Nathan Riolo

CFS BENCHMARK SUITE
Nathan Riolo, James Marshall, Alan Gibson

SI-BASED LAB-ON-A-CHIP INTEGRATED PHOTONIC SPECTROMETER
Gary Tompa, Arul Arjunan

SUBWAVELENGTH GRATING METAMATERIAL WAVEGUIDE RING RESONATOR FOR ULTRA-SENSITIVE LABEL-FREE BIOSENSING
Ray Chen

MICROCHANNEL PLATE-BASED FARADAY CUP
Daniel Gershman, Levon Avanov, Corey Tucker

GODDARD ENHANCED ON-BOARD NAVIGATION SYSTEM (GEONS) VERSION 3.0
Luke Winternitz, Samuel Price, Anne Long, James Carpenter, Cheryl Gramling, Jennifer Donaldson, Cinnamon Wright, William Bamford, Joel Getchius, Chris D'Souza, David Gaylor

RHBD CMOS CRYSTAL OSCILLATOR FOR READOUT TELEMETRY
Gerard Quilligan, Terry Hurford

REQUIREMENTS DOCUMENT GENERATOR
Nathan Riolo, Erik Magnuson

INTEGRATED NETWORK OF VEHICLES
Eleanya Onuma

MODIFICATION OF "GREEN" TANNIN BASED FOAMS UTILIZING 10B-AL-N ATOMIC LAYER DEPOSITION FOR RADIATION PROTECTION
Vivek Dwivedi

NOVEL METHOD FOR THE GAS CHROMATOGRAPHIC ANALYSES OF ALIPHATIC ALDEHYDES AND KETONES
Jose Aponte, Jamie Cook, Jason Dworkin

ANTENNA ARRAYING CAPABLE OF HANDLING VERY HIGH DATA RATES IN REAL TIME
Howard Garon

PANDURATA: A MONTE CARLO CODE FOR RADIATION TRANSPORT AROUND BLACK HOLES
Jeremy Schnittman

RADIATION HARD AUTONOMOUS DIGITAL READOUT (RHADR)
Gerard Quilligan, Shahid Aslam, Terry Hurford

DECISION SUPPORT PLATFORM FOR CROPLAND MANAGEMENT AND FORECASTING – YEAR 2
Jeffrey Orrey, Bernie Johnston, Andrew Catellier, Matthew Kotalik, Nicholas Dana

SPACECUBE 3.0 MINI EVALUATION BOARD
Cody Brewer, Alessandro Geist, Nicholas Franconi, Christopher Wilson, Yvonne Kamdem Manewa, Robin Ripley

SPACECUBE 3.0 RADHARD MONITOR
Travis Wise, Alessandro Geist

SPACECUBE 3.0 FMC+ MEZZANINE TEST CARD
Cody Brewer, Alessandro Geist, Nicholas Franconi, Christopher Wilson, Yvonne Kamdem Manewa, Robin Ripley

SPACECUBE 3.0 MINI ASTM BOARD
Alessandro Geist, Cody Brewer, Yvonne Kamdem Manewa

NAVCUBE 2.0 DUAL FREQUENCY GPS L1/L2C LUNAR RECEIVER
Munther Hassouneh, Luke Winternitz, Samuel Price, Luke Thomas, Yan Lu Chen, Jason Mitchell

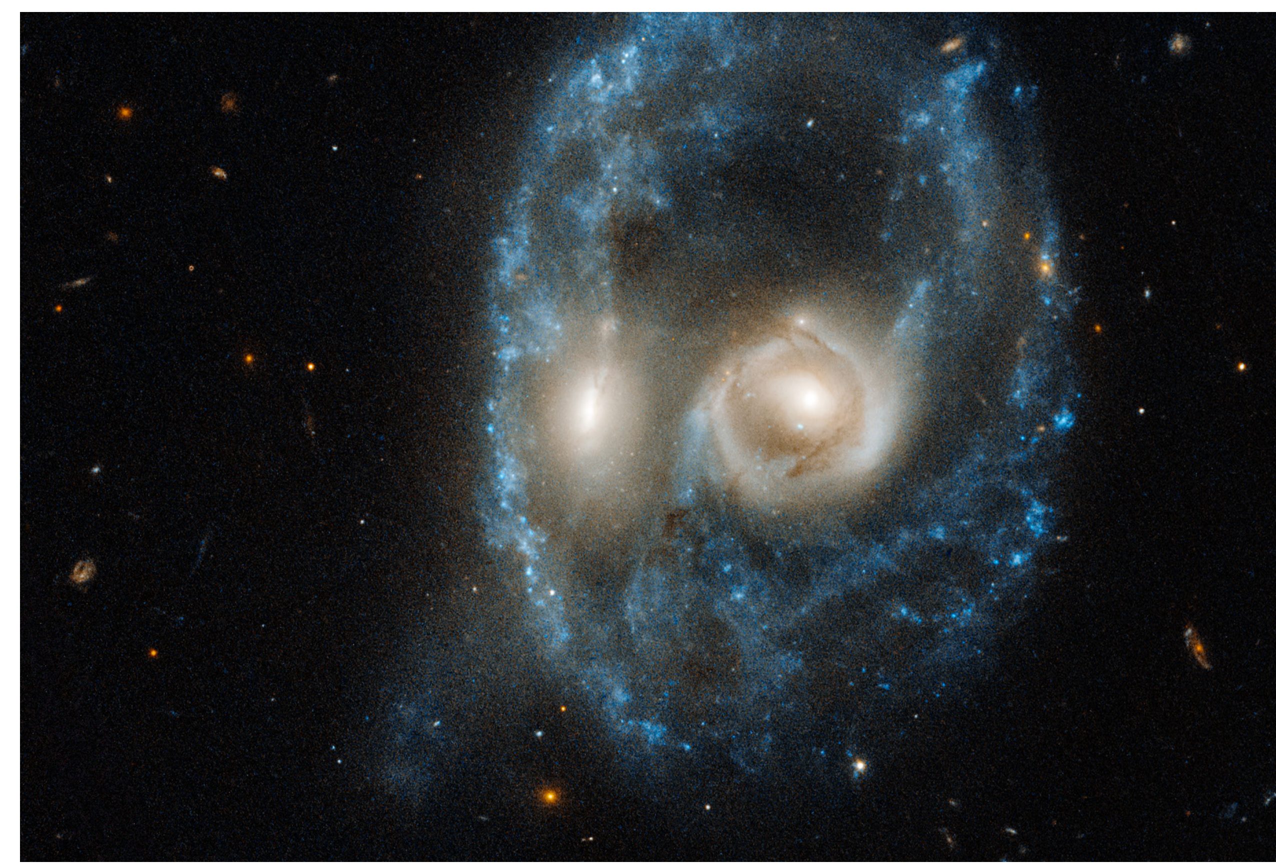


Photo Credit: NASA/Space Telescope Science Institute

Photo: Two galaxies collide in this Hubble image released on Oct. 28, 2019.

LICENSING ACTIVITIES

NASA COMMERCIALIZATION TRAINING CAMP June 24-26, 2019

Goddard's Technology Transfer Office (TTO) hosted the NASA Commercialization Training Camp, a three-day introduction to NASA technology transfer and commercialization. Through partnerships with the National Football League Players Association and the National Basketball Retired Players Association, Goddard TTO helped coordinate this agency-wide effort to connect current and retired professional athletes with information and people who can help them evaluate, license, and commercialize NASA technologies. Speakers for the inaugural workshop included members of the NASA technology transfer team, in addition to Dave Naves, a NASA contractor and NBRPA board member; Darryl Gaines, a NASA civil servant and retired NFL player; Ben Solomon, founder and managing partner of research and development spinoff accelerator FedTech; Jim Liew, an assistant professor of finance at Johns Hopkins Carey Business School; and Femi Ayanbadejo, an entrepreneur, licensee of NASA technology, and former NFL player.

GODDARD SCIENCE JAMBOREE July 11, 2019

Goddard TTO participated in Goddard's Annual Science Jamboree in July. Hosted by the Goddard Sciences and Exploration Directorate, the Science Jamboree provides a venue for Goddard scientists to share information and updates on their work in an informal setting.

Photo Above: Attendees of the NASA Commercialization Training Camp gathered in June. Below: Goddard TTO spoke with innovators at the annual Goddard Science Jamboree.

MINISTRY OF SUPPLY APOLLO CELEBRATION July 18, 2019

Representatives with Goddard TTO traveled to Boston and Washington, DC to partake in an Apollo 11 celebration hosted by Ministry of Supply, a NASA spinoff company that produces clothing with NASA technology. The representatives gave speeches that reflected on NASA spinoffs resulting from the Apollo 11 program, as well as looked forward to "spinoffs of the future" that will come from the Artemis mission.

NBPA MEETING July 24, 2019

NBA athletes with the National Basketball Players Association (NBPA) visited Goddard Space Flight Center on July 24 to learn about technology transfer and commercialization opportunities with NASA. The one-day meeting provided athletes and their business managers with an overview of licensing opportunities and procedures at NASA. Attendees heard from a successful licensee of NASA technology as well as a Goddard innovator with experience in technology transfer.

SMALL SATELLITE CONFERENCE August 3-8, 2019

Goddard TTO representatives participated in the 33rd Annual Small Satellite Conference in Logan, Utah. Representatives spoke with attendees of the conference at a booth and provided information on licensable Goddard technologies related to small satellites. They networked with members of the small satellite community and answered questions about how working with Goddard could benefit them. Additionally, two technology managers gave presentations to attendees about doing business with Goddard and about a patented SmallSat technology available for licensing.

Photo Credit: Brian Hammonds

NATIONAL CONFERENCE OF STATE LEGISLATURES August 5-8, 2019

Representatives with Goddard TTO participated in the National Conference of State Legislatures (NCSL) Legislative Summit in Nashville, Tennessee. NCSL supports the interests of state legislators by providing them with information and resources to solve problems in their states. The representatives shared information about Goddard technology transfer opportunities and celebrated Goddard's 60th anniversary with a video.

OPTICS WEBINAR September 18, 2019

Goddard TTO worked with Tech Briefs to host an optics webinar featuring Goddard innovator Mark Stephen, who spoke about advances in photonics for space and commercial applications. Specifically, he highlighted NASA's work with photonic integrated circuits, which enable critical improvements to microprocessors, communication buses, science instrument optical systems, and other technologies. The webinar is available at Tech Briefs' website until September 2020.

Photo: NASA spinoff company Ministry of Supply celebrated the Apollo II anniversary in July.

GODDARD TECH TRANSFER MAGAZINE

Goddard Tech Transfer Magazine shares stories about technology transfer at NASA and the innovative people who make it all possible. The magazine is published quarterly by the Strategic Partnerships Office at NASA's Goddard Space Flight Center.

Also available online at: https://partnerships.gsfc.nasa.gov

Send suggestions to Amy Klarup, magazine editor: amy.k.klarup@nasa.gov