National Aeronautics and Space Administration

TECH TRANSFER MAGAZINE IS NOW

THE SPARK

TECH TRANSFER, PARTNERSHIPS, AND SBIR/STTR AT GODDARD

CRUNCHING DATA *IN THE CARIBBEAN*

Goddard Tool Connects Businesses with Earth Science Data

VOLUME 18 | NUMBER 1 | WINTER 2020

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ABOUT THE COVER

In the Caribbean Islands, where millions of tourists visit each year, climate change represents a potential upheaval of business as usual. Two entrepreneurs are leveraging Goddard technologies in an effort to better understand the Caribbean's complex climate rhythms.

Photo Credit: National Park Service

OFFICE OF THE CHIEF

Massive sheets of ice expand and contract in "48 Years of Alaska's Glaciers," a video released by NASA's Goddard Space Flight Center at the end of 2019. Since the 1970s, NASA has kept a close eye on Earth and its ever-shifting landscape, and though human beings are notoriously bad at noticing small, incremental change, NASA's satellite footage clearly shows the dynamic shifts Alaska's glaciers have taken over the course of nearly five decades.

Many stories such as this one lie hidden in NASA's petabytes of satellite data – you just have to know where to look. A team at Goddard, led by computer scientist John Schnase, has developed a patented technology to improve access to NASA's vast collection of Earth science data and serve as a tool in answering both climate- and business-related questions.

We're also announcing a new name and look for our publication as we enter the 2020s. Tech Transfer magazine has existed in some form for more than a decade, and we will continue to share the latest stories of technology transfer and partnerships here at NASA's Goddard Space Flight Center. However, moving forward, we have renamed this publication *The Spark*. After all, every successful spinoff technology begins with the spark of creativity and innovation. We celebrate that process here, and we hope you do, too.

In this issue of *The Spark*, we explore the power of big data and explain how the climate is connected to nearly everything – including the commercial world. We talk to Goddard inventor Negar Ehsan, whose remote sensing technology is patented and available for licensing. We also catch up with technology manager and patent-holder Manohar Deshpande about his experience working as an inventor as well as a technology transfer professional.

Though valuable business insights come from studying human behavior, what can we learn by turning our careful attention to Earth and its climate? Join us in the following pages as we unravel that question and more.

Darryl R. Mitchell, Chief

Strategic Partnerships Office
NASA's Goddard Space Flight Center

NEWS

Photo Credit: NASA/The Invisible Network Team

GODDARD'S TECHNOLOGY TRANSFER STORIES IN NASA PODCAST

A NASA podcast called "The Invisible Network," tells NASA stories that take place behind-the-scenes. Episode 5 features an interview with Goddard innovator Tom Williams, who in the 1970s developed a technology to freeze bone marrow based on technology used in Goddard's thermal vacuum chambers.

"Most people don't know that NASA's work isn't just aerospace and satellites," Williams says in an interview with podcast host Danny Baird. "The work we do ends up helping people that have little to do with the space program and little interest in it."

In Episode 10, Baird takes on the topic of the Cospas-Sarsat program, an "international effort to provide first-responders with satellite-aided search and rescue data." Using NASA satellites and beacons and ground station components created by Goddard contractors, the rescue network took shape in the 1980s and has saved thousands of lives since.

Check out these episodes and more here: *https://www.nasa.gov/content/goddard/the-invisible-network-podcast*.

SPO 2019 ACCOMPLISHMENTS REPORT

The Strategic Partnerships Office's annual report is available for download! The report highlights the office's technology transfer and partnerships activities from throughout the year, including the inaugural NASA Commercialization Training Camp for professional athletes, an overview of the Modulated X-ray Source, which won NASA's Government Invention of the Year Award, and other technology stories from 2019. You can read it here: *https://partnerships.gsfc.nasa.gov/wp-content/uploads/Accomplishments_Report2019.pdf*.

MERRA/AS

Goddard technology occupies the intersection of science and business

EARTH INSIGHTS

Businesses have leveraged the power of big data for years to gain more information about their customers. Look no further than online retailers, who analyze their customers' purchases and browsing history to generate targeted advertisements. As companies collect vast amounts of data about the people who buy their products, analysts learn more about customer characteristics and behavior, painting detailed portraits that can inform business decisions.

For scientists at NASA, this boom in data storage and processing capabilities has unleashed a new way to answer questions about the physical world that previously went unanswered.
"If you take a look at the legislation that brought NASA into existence, there's no mention of human spaceflight in the original document," says John Schnase, a computer scientist emeritus at NASA's Goddard Space Flight Center. "However, there is language about using space as a platform for the scientific measurements and observations that allow us to look back on Earth and understand our planet."

NASA has accumulated more than 40 years' worth of detailed information about Earth, and just as companies use data to understand their customers, NASA uses data to figure out the complex rhythms of the world. It's no small feat – NASA has approximately 100 petabytes of data in its possession. For context, a system with one petabyte of data storage could hold more than 250,000 movies. It would take about 57 years to play them all back-to-back. It's a little much, even for the most dedicated binge-watcher.

Schnase and other computer scientists at Goddard are developing tools to improve access to NASA's Earth science data for climate scientists and other groups who pull kernels of interest from the mountainous towers of information. Recently, they have focused on one of NASA's more interesting but less-well-known datasets: The Modern-Era Retrospective Analysis for Research and Applications (MERRA).

At about a petabyte in size, the MERRA dataset is massive. It contains a global, hour-by-hour simulation of Earth's weather over the past 40 years and contains hundreds of descriptive variables such as wind direction and speed, temperature, humidity, precipitation, sunlight, and cloud cover. MERRA is produced by the Goddard Earth Observing System, Version 5 (GEOS-5) numerical modeling framework, a computer program which uses the decades of information NASA has accumulated to create this remarkably rich record of Earth's climate.

To the average person, MERRA represents a crushing cascade of numbers, but a patented technology called MERRA Analytic Services (MERRA/AS) seeks to improve access and unleash treasure troves of Earth insights for scientists and CEOs alike. Just last year, a new network of entrepreneurs and student innovators has licensed the technology to explore its application in the Caribbean tourism industry.
"Climate touches so many things in life, and any dataset that describes the complexities of climate over long periods of time inevitably is going to be very large," Schnase says. "Unless you have tools that allow you to pick out the parts of that data you want and do it quickly, it is useless data. And that's the problem we're seeking to address."

TAKING EARTH'S PULSE

Like a doctor taking a patient's vital signs, NASA collects detailed information about Earth and has done so for decades. Instead of a stethoscope or a thermometer, NASA uses sensors of all kinds, sometimes attached to satellites in space or affixed to balloons floating in the sky. These instruments measure the pulse of Earth and all its intricacies, from rainfall in Mongolia to ice height in Antarctica.

By analyzing this data, scientists can better understand the fluctuations of Earth and gain awareness of emergent patterns. Imagine having 40 years' worth of detailed medical records about yourself and how useful that might be when trying to understand your body's rhythms and reactions. Essentially, that's what NASA and other science organizations around the world are doing for our planet.
The volume of data collected through the years is overwhelming in its enormity. This tidal wave of information requires entire teams of people to

manage, organize, and store. Each day, new vital signs from Goddard's satellites come pouring in, tracking temperatures in Tunisia and wind speeds in Wales. And it doesn't stop there. That tidal wave of information is often used to create even larger, specialized datasets such as MERRA's historical simulation of Earth's climate.

MERRA/AS helps address NASA's unique big data challenge by harnessing the power of the MERRA dataset. Scientists gain the ability to answer new scientific questions quickly and efficiently, which hasn't always been the case.

In 2013, scientist Jiangfeng Wei with the Center for Ocean-Land-Atmosphere Studies in Calverton, Maryland used MERRA to examine the relationship between crop irrigation and rainfall. To estimate the contribution of irrigation to precipitation amounts, Wei went back in time and analyzed decades of climate data from agricultural areas around the world. Wei found the answers he was looking for – heavy irrigation in certain areas does affect precipitation – but it took him weeks to track down the numbers he needed and process the information on his personal workstation.

"If he ran that same experiment now using MERRA/AS, he could get the results in just a few minutes," Schnase says. "With MERRA/AS, you don't need the power of 10,000 processors on your desktop to wrangle the data. You just need MERRA/AS running in the cloud."

"THE THING WITH FEATHERS"

Think of MERRA/AS as a deluxe spreadsheet, Schnase says. Instead of a monthly budget, you're working with a petabyte of numbers that describe the Earth system. MERRA/AS helps to narrow the scope of a search to the basic pieces you need to answer a question. Instead of sifting through unimaginably vast volumes of data, a user can perform simple operations that create the needed subsets of information.

"Getting all of MERRA's variables onto a local machine is not realistic, and it just doesn't make sense to do it that way," says Mark Carroll, a data scientist in Goddard's Computational and Information Sciences and Technology Office (CISTO). "When you don't have to go through the trouble of downloading all that data, it cuts down a third of the effort for scientists like me. Now you can process more things, answer the question you're asking, or write a paper and get that information to other people."

To illustrate the power of the concept, Schnase tells the story of the Cassin's sparrow, a bird species that lives in the Southwestern United States. Before becoming a computer scientist at Goddard, Schnase studied biology and did his master's thesis on the Cassin's sparrow. Since then, he says, the species has served as his guide, always flittering in the back of his mind.

The Cassin's sparrow is a brown-plumaged forager, possessing unassuming looks that mask its glitzy mating ritual, according to the Audubon Society. To attract female sparrows, male Cassin's sparrows participate in an elaborate behavior known as "skylarking."

First, the bird flies straight upward, furiously beating his wings in a blaze of avian energy. Once properly aloft, sometimes as high as 50 feet, he spreads his wings wide and drifts downward with the grace of a ballet dancer, all the while chirping an elaborate melody. In addition to their aerial wooing skills, Cassin's sparrows are creatures of mystery – they travel in large groups and have difficult-to-observe migration patterns, disappearing from one location then popping up in another area years later, according to Cornell University.

So, what does a technology like MERRA/AS have to do with this spirited little bird? Schnase has a few ideas. Legions of avian aficionados, known collectively as "birders," make a hobby of wild bird observations. These citizen scientists' records form a useful body of data that, when layered atop MERRA and NASA's growing suite of analytic technologies, can reveal where certain species prefer to live, also called a "bioclimatic niche."

"With the Cassin's sparrow as an example, there have been thousands of observations over the past 30 years," Schnase explains. These observations, he says, map to points in time and space within the MERRA dataset. Birds exist everywhere on Earth and tend to be very sensitive to environmental change, particularly desert-adapted birds like Cassin's sparrow. Fluctuations in their appearance or disappearance provide useful clues to climate researchers studying these phenomena.

Armed with information, conservationists can find a species' historical range and predict how it might change in the future. Ever the hardworking hound dog, MERRA/AS sniffs out trends hidden deep in thick data forests that help us monitor the health of our planet.

CLIMATE CLUES

Now, Schnase says, take that basic concept and apply it to business. Stock traders might use climate data to inform the buying and selling of agricultural commodities. State governments or humanitarian aid organizations could find associations in the climate data between natural disasters such as droughts and availability of resources. MERRA is a window to the past, and paired with a climate model that simulates the future, it can reveal surprising findings.

A road construction company, Schnase points out, could make financially savvy decisions if they knew which areas of the country were most likely to experience increasingly rough winters. Harsh salt and chemical deicers degrade road quality, requiring different road-building strategies for diverse environments. A wind energy company might want to know where to place their turbines and could use MERRA/AS to identify locations with ideal wind speed conditions.

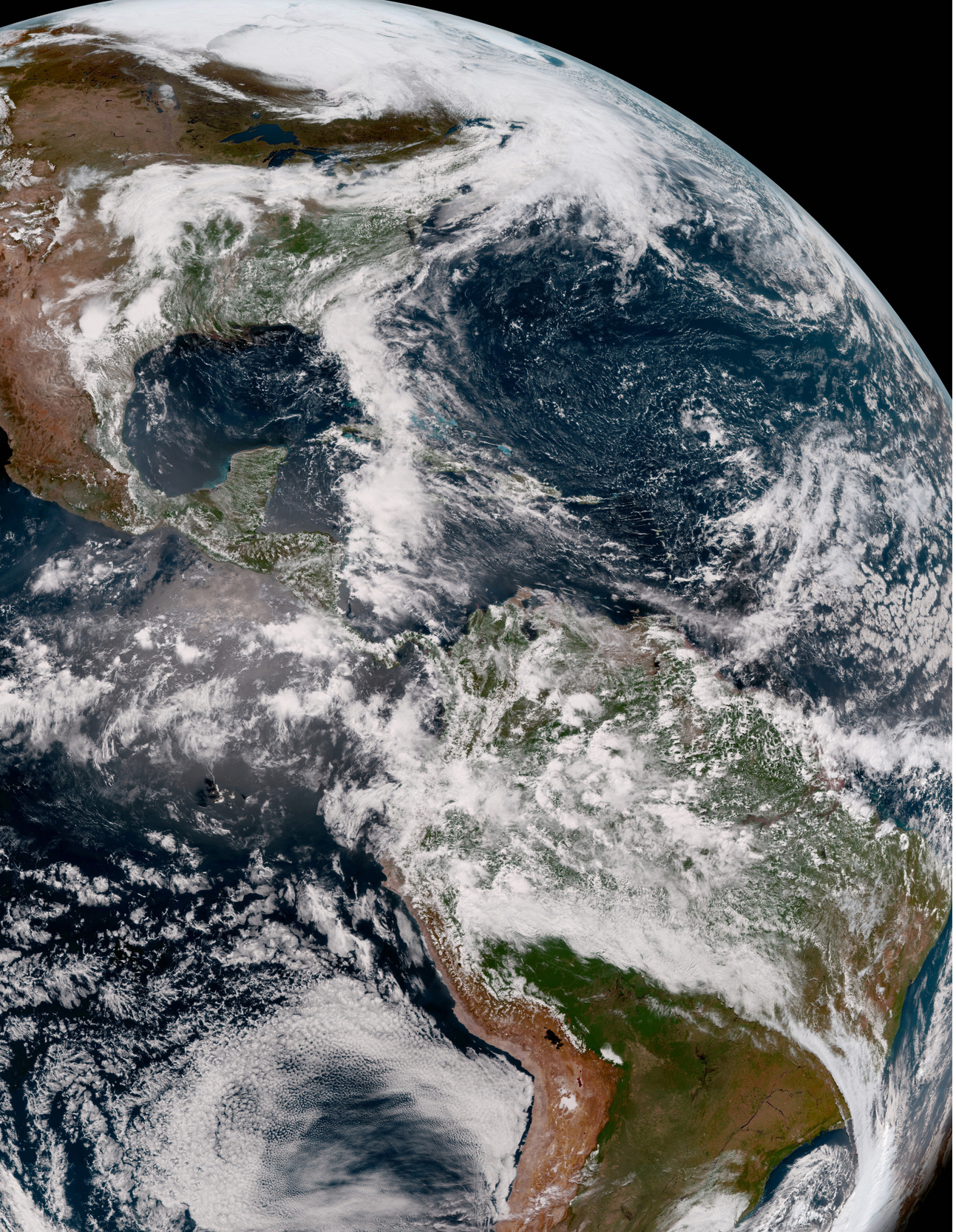
"In almost every market segment, there's some aspect of the business that ties to climate," Schnase says.

Initially, Schnase saw MERRA/AS as an opportunity to help climate scientists like Wei and Carroll reduce their processing time and free them to tackle their research questions. He realized the same insights that help researchers understand natural phenomena could prove useful to other sectors.

The list of potential uses is limited only by the mental effort it takes to imagine them. Smart clothing manufacturers with temperature-adjusting apparel might want to know average temperature projections in New York City. City planners need to factor sea level rise into their calculations. The tourism industry could benefit from knowing past and future trends in weather patterns.

"People have been talking about big data for at least a decade, but it's really only come to fruition in the past few years," Carroll says.

Three breakthroughs have made this progress possible – better hardware to store the data, better computers to process the data, and better software to interrogate the data.



"You need all three," Carroll says, and he expects the convergence of these capabilities will lead to even more discoveries in the coming years.

"Climate touches almost everything in life," Schnase adds. "The examples just go on and on about how people are beginning to use climate data to fine tune and create new opportunities for their business." What's more, CEOs are increasingly called upon to factor climate change risk into their corporate decision-making. As a result, datasets like MERRA and tools like MERRA/AS are becoming more important.

COMMERCE AND THE CARIBBEAN

In the Caribbean Islands, where millions of tourists visit each year, climate change represents a potential upheaval of business as usual. The more industries in the Caribbean know about climate history and predictions, the better prepared they will be in an increasingly unstable environment. After a flurry of massive, record-breaking hurricanes hit the Caribbean and surrounding areas in 2017, residents have a growing concern for their economy in the face of unprecedented damage and loss.

"Tourism in the Caribbean is a multibillion dollar industry," says Oliver Jones, who has a doctorate in organizational leadership and is a professor in Hampton University's School of Business, based in Hampton, Virginia. "When you focus on tourism, you're also talking about climate health, economic health, and the workers who support the system."

Jones is working with M. von Nkosi, who is an architect, Hampton University alumnus and founder of the New Orleans-based Institute for Local Innovations (ILI), to leverage Goddard technologies in an effort to better understand the Caribbean's complex climate rhythms. After licensing MERRA/AS and another Goddard technology in the spring of 2019, ILI and Jones have formed the ILI Global Delivery System, a multifaceted team that will use data analysis to tackle climate issues impacting public health, disaster response, emergency services, and other areas.

Jones, who is originally from the Caribbean, and Nkosi envision a collaborative effort connecting the worlds of science, technology, economics, and business in pursuit of Earth insights. The ILI Global Delivery System will work with students through ILI's TIME Challenge who attend Historically Black Colleges and Universities (HBCUs) and other Minority Serving Institutions (MSIs) to infuse diversity and new perspectives into the venture.

While the concept is in its early stages, more than 120 students from around 15 HBCUs and MSIs have signed up for the ILI TIME Challenge. Some of these students will participate in building a network of collaborators focused on delivering data to communities impacted by climate change. Already, the team has made connections with Caribbean tourism companies. Because climate is entangled with practically every aspect in life, von Nkosi says, everyone has a connection to it. "In the next 50 years, climate change will transform and disrupt all the systems that support us," Nkosi adds. "By starting in the Caribbean, we can begin to understand the impacts to come."

Photo Credit: Name of Photographer/Organization

Q&A W/TECH MANAGER

Photo Credit: NASA/Samantha Kilgore

NASA has its fair share of scientists and engineers, but other skills are also useful in keeping the space agency running. The staff of Goddard's Strategic Partnerships Office have a surprising range of backgrounds that inform their work at NASA – from law degrees to marketing and scientific research, these diverse professionals approach technology transfer from a variety of angles. With three patents to his name, Manohar Deshpande views technology transfer from the perspective of an inventor as well as that of a technology manager. "It definitely helps to have been in the same boat as other inventors here at Goddard," Deshpande says. Deshpande has spent most of his life as a researcher but made the switch to technology transfer two years ago. Here, he shares his experiences and viewpoints on working as both a technology manager and an engineer at Goddard.

HOW DID YOU END UP WORKING IN TECHNOLOGY TRANSFER AT GODDARD?

I come from a very small village in India, where the community was focused on farming and agriculture. People typically completed their educations by 10th grade. I did very well in mathematics, so the teacher encouraged me to go to college in engineering. I attended the Indian Institute of Technologies and eventually completed my education with a Ph.D. in engineering. In the 1980s, I applied for post-doctoral position at NASA's Langley Research Center, and after two years in the U.S., I went back to India. I returned to NASA after a time and eventually gained U.S. citizenship. In 2005, I transferred to Goddard and worked as an engineer here until two years ago, when I took a detail position with Goddard's Strategic Partnerships Office.

WHAT PROJECTS YOU HAVE WORKED ON THROUGHOUT YOUR CAREER?

Most of my work is on radiometers, antennas, and micro-components. These are the pieces of spacecraft that enable communications and data transmission, so they're very important parts of NASA missions. When I was at Langley, I worked on antennas for aircraft communication. We were put on an important project at Langley – in the 1990s, there was an accident with a flight from New York to Paris. The airplane crashed, and investigators suspected it was due to electromagnetic interference. I was part of a team tasked to determine if interference caused this accident. Ultimately, we found that electromagnetic interference was very unlikely to be the cause of the crash. At Goddard, I've always worked on many different projects. I've submitted many proposals for hardware, some of which received funding. One that stands out in my mind was a request to refine and miniaturize a technology that could precisely measure how much fuel is in the fuel tanks of a spacecraft. If you can take an accurate reading of the fuel, you don't need to bring 20 percent extra, which would reduce the weight and expenses.
The project was called electrical capacitance tomography, and we wanted to test it, so I applied to fly the experiment on Johnson Space Center's zero gravity plane. We flew for about two hours – I was almost 50 years old at the time, and I knew I had to do it, because the opportunity to fly in that plane doesn't come along every day!

MANOHAR DESHPANDE

WHAT PATENTS DO YOU HAVE?

I have three patents, and two of them are the result of funding through Goddard's Internal Research and Development (IRAD) program. Two companies have expressed their interest in one of the patents, and a different company is interested in using another patent for CubeSats. Just before coming to the Strategic Partnerships Office on detail, I submitted an idea to NASA Headquarters that involved designing an embedded antenna in a CubeSat. I designed and fabricated it, and it worked well, so I submitted a New Technology Report (NTR) for it. Around the same time, I began my detail in technology transfer, and so I saw the process from both sides for the first time. It really changed my perspective on submitting NTRs.

WHAT KINDS OF TECHNOLOGIES DO YOU EVALUATE IN YOUR ROLE OF TECHNOLOGY MANAGER?

I'm mostly evaluating hardware to see if it has commercial potential outside of NASA. This includes many different kinds of instruments, such as detectors or plasma spectrometers. In the past, I've managed the Instrument Systems and Technology Division as well as the Mission Engineering and Systems Analysis Division. Currently, I'm working with the Electrical Engineering Division.

HOW DOES TECHNOLOGY TRANSFER HELP NASA FULFILL ITS MISSION AS AN AGENCY?

When NASA develops a technology, it's typically intended for a specific project or mission. Because of technology transfer, new technologies don't just collect dust in some forgotten storage room once a mission is complete. With a little modification, NASA technologies often prove useful for commercial applications. NASA's Technology Transfer Program plays an important role here, because maybe the inventor doesn't have time to transfer the technology, but technology transfer managers make that connection between NASA and the outside world.

WHAT DO YOU LIKE AND WHAT DO YOU FIND CHALLENGING ABOUT WORKING IN TECHNOLOGY TRANSFER?

Coordinating all the moving pieces can be challenging. The first step is trying to get the potential partner to meet with the inventor, and it can take some time to get them on the same page. Another challenge is when a company sees a technology and contacts us to learn more about it, but then it turns out to be a poor fit or they lose interest. It's always worth it, though, because you have to turn over every stone sometimes to find what you're looking for. We don't know in the beginning which leads will turn into successful partnerships. I really like being able to connect with people outside of NASA and continue my own work in technology development. Sometimes talking with people about their work can lead to new ideas of my own. When you work with technology, it's so important to keep your mind open – inspiration can come from anywhere.

Photo Credit: NASA/Samantha Kilgore

Photo Above: Manohar Deshpande shakes hands with Goddard's Center Director Dennis Andrucyk at the 25th New Technology Reporting Program on Feb. 27, 2020.

INNOVATOR PROFILE

Photo Credit: NASA/Samantha Kilgore

MAKING SOME NOISE

Goddard engineer invents patented technology for remote sensing

Engineer Negar Ehsan says she never planned to have her name on a patent, but when you're working at NASA's Goddard Space Flight Center, it can be a perk of the job. Ehsan works in the Microwave Instrument Technology Branch at Goddard, where she develops technologies that help Earth-facing satellites collect information about our planet.

As an electrical engineer, Ehsan has devoted her career to harnessing the microwave range of the electromagnetic spectrum, designing instruments for NASA's satellites that orbit Earth. With an interest in math and science starting when she was a child, Ehsan says she chose to major in electrical engineering because she enjoyed physics and math.

"I knew electrical engineering had more math than other engineering disciplines," Ehsan explains.

Even though she chose a math-heavy major, she found inspiration in a high school literature teacher, whose rigorous style of teaching left an impression on her.

"She was detail-oriented and posed very difficult questions," Ehsan says. "She basically taught me how to study."

Ehsan moved from Iran to the United States to attend college at the University of Colorado at Boulder. She enjoyed her studies, but it wasn't until she took a class on electromagnetic fields that knew she had made the right choice of major. She says the mathematics and physics behind these fields fascinated her, helping her to visualize the invisible electromagnetic domain.

After completing her Ph.D. with CU Boulder Professor Zoya Popovic as her advisor and mentor, Ehsan accepted a position at Goddard, where she has worked since 2010. In her work as an electrical engineer, Ehsan exercises her penchant for analytical thinking, tackling challenges, and coming up with solutions.

"I get to problem-solve all the time as a microwave designer," Ehsan says.

She has worked on several NASA missions, including a CubeSat called IceCube and a larger mission called Soil Moisture Active Passive (SMAP). Designed to measure moisture levels in Earth's soil, SMAP uses a radiometer to measure faint amounts of blackbody radiation emitted from soil. The highly sensitive radiometer informs NASA researchers back on Earth about soil conditions, which has a bearing on agriculture, drought and flood forecasting, and more.

For the SMAP mission, Ehsan designed the satellite's L-band radiometer's internal calibration circuitry. Engineers calibrate instruments to make sure their measurements are accurate – for example, if you were trying

Photo Credit: NASA/Samantha Kilgore

NEGAR EHSAN

to calibrate a scale, you would weigh something with an already established weight. If the scale gives a different measurement, you know it's wrong and needs adjustment.

For a radiometer, one type of calibration involves exposing the instrument to a module known as a noise source that simulates microwave radiation. Ehsan built a custom noise source for the SMAP radiometer, since a commercial-off-the-shelf version was not available.

Once the SMAP mission launched, "we were doing a lot of millimeter and sub-millimeter work," Ehsan says, referring to the high-frequency wavelengths she and her team were using in their instruments. Ehsan found that in the millimeter to sub-millimeter range, noise sources weren't easy to find commercially, and her colleague Jeffrey Piepmeier proposed that they create their own noise source designed specifically for millimeter to sub-millimeter wavelengths.

"Right off the bat, we knew this wasn't something that had been done before," Ehsan says.
In 2018, Ehsan and her fellow inventors Jeffrey Piepmeier and Edward Wollack received a patent for their invention, a "Robust Waveguide Millimeter Wave Noise Source" that can generate noise power at millimeter-wave frequencies.

With Ehsan's first patent under her belt, she's continuing to work on noise sources, this time for planetary missions using instruments in the 500-600 GHz range. These tiny noise sources can be integrated into the internal system of a radiometer, resulting in lower size, weight, and power strains on the spacecraft.
As she continues her design work, more patents might be in her future. But the primary motivation for Ehsan, she says, is solving Goddard's technology challenges and helping send new satellites into space.
"Problem-solving can be stressful, but it's so rewarding when you discover the answer. It's like an adrenaline rush," she adds.

To learn more about licensing Ehsan's technology, visit https://technology.nasa.gov/patent/GSC-TOPS-175.

OPTICS SOLUTIONS

Goddard engineers develop receiver for spectroscopy and altimetry

Scientists at NASA's Goddard Space Flight Center use radar and lidar to track everything from weather events in the Midwestern United States to ice heights in Antarctica. Satellites in low Earth orbit (LEO) send radio waves or beams of photons down to Earth, which bounce off the ground and return to the satellite.

Compared to radar, lidar poses a particular challenge to engineers – when photons hit clouds, some bounce back and fail to make it to the ground. When some photons hit clouds and others hit the ground, it's difficult to distinguish between them. This limits the rate of laser pulses sent from the satellite, which in turn impacts resolution quality.

A new Goddard technology called the Recirculating Advanced Coupled-cavity Etalon Receiver (RACER) addresses this problem, and it's available to the public for licensing, with applications for companies interested in mapping land heights and measuring greenhouse gas emissions in the atmosphere.

RACER divides wavelengths into separate channels, which means the signals can be differentiated from each other. According to Mark Stephen, a laser and electro-optics engineer at Goddard, RACER increases spectral resolution while providing signal differentiation.

"In any of these systems, every photon is precious," Stephen says. "With spectroscopy or Doppler measurements, when you're trying to bounce photons off the air, then you really want to preserve the photons you get."

RACER takes in photons and then recirculates them, increasing the probability they will be measured and boosting the accuracy of the measurement, ultimately improving the performance of the entire lidar system.

Stephen says some companies use passive techniques to achieve these results, harnessing photons from the Sun to accomplish their measurements and avoiding the need to leverage lidar from space.

"The main advantage is that you don't need as much power because you don't need to fire up a laser that makes it all the way to the ground and back," Stephen says.

Companies might use this cost-effective method if they wanted to monitor CO_2 in the atmosphere as part of a government cap-and-trade system to curb carbon emissions. The downside to this approach is that it's more error-prone – cloud patterns and time of day can interfere with the sunlight that provides the photons needed to take measurements. No measurements are possible at night.

While both approaches have their drawbacks, Stephen says that technologies such as RACER, which provide their own light source, tend to have greater accuracy and generate more reliable data.

Currently, Stephen says, the biggest commercial use for lidar is autonomous vehicles. Self-driving cars send laser pulses ahead of them and navigate based on the photons that reflect back to detectors on the vehicle. Though RACER's applications are mainly limited to spectroscopy and altimetry, Stephen and his team at Goddard continue to work on new technologies that push the field of optics forward.

This includes integrated photonics, a new field that leverages knowledge gained from integrated circuits to create "photonics on a chip" and transmit light.

"Instead of moving electrons around on a chip, you're moving photons around on a chip," Stephen explains. "Potentially you can perform a number of optical techniques all on one chip." Stephen says it's an exciting time to work in optics, and he has worked with NASA's Small Business Innovation Research Program and Small Business Technology Transfer Program to advance integrated photonics.

"These technologies are especially exciting for NASA, where we're trying to shrink things down," Stephen adds. "Integrated photonic circuits can be orders of magnitude smaller and lighter, and they use significantly less power."

To license RACER or explore Goddard's other optics and photonics technologies, please call 301-286-5810 or email techtransfer@gsfc.nasa.gov.

TECH DISCLOSURES

REQUIREMENTS DOCUMENT GENERATOR
Nathan Riolo, Erik Magnuson

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

A METHOD FOR OBTAINING A HERMETICALLY SEALED JOINT WITH THE USE OF A REACTIVE MULTI-LAYER FOIL AS THE HEAT SOURCE IN A BRAZING OR SOLDERING OPERATION FOR IN-SPACE ROBOTIC ASSEMBLY PROCESSES
Nathan Smith

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

ULTRA-FAST LASER DIRECT WRITE METHOD FOR EMBEDDED CONDUCTIVE TRACE FABRICATION IN PRINTED HYBRID ELECTRONIC SUBSTRATES
Eleanya Onuma, Beth Paquette

IMPLEMENTATION OF A PACKET INTERFACE FOR THE GSFC UART CORE
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RADIATION HARD AUTONOMOUS DIGITAL READOUT
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AN API FOR GENERATING VERY HIGH-RESOLUTION COMMERCIAL VALIDATION PRODUCTS
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Cody Brewer, Alessandro Geist, Nicholas Franconi, Christopher Wilson, Yvonne Kamdem Manewa, Robin Ripley

SPACECUBE V. 3.0 FMC+ MEZZANINE TEST CARD
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TWIN COUPLED MODE PHASE-SENSITIVE AMPLIFIER WITHOUT OPTICAL PHASE-LOCKED LOOP AND INJECTION-LOCKED PUMP LASER
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THE COMPLEX FIELD THEORY, A NEW PERSPECTIVE FOR GRAVITY, ETHER, DARK ENERGY, AND THE UNIVERSE
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NAVCUBE V. 2.0 DUAL FREQUENCY GPS L1/L2C LUNAR RECEIVER
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CONTAINER FLIGHT SOFTWARE
Alan Cudmore, Krystine Carrington

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SPIN-ON-TOPAS MICROWAVE COUPLERS
Elissa Williams, Kevin Denis, Negar Ehsan, Chase Kielbasa, Edward Wollack

Photo Credit: NASA/The Hubble Heritage Team

MARKETING ACTIVITIES

NOVA LABS PRESENTATION Oct. 9, 2019

Goddard's Strategic Partnerships Office (SPO) gave a presentation in Reston, Virginia, at NOVA Labs, the largest makerspace in the Washington, DC, Maryland, and Virginia area. The presentation focused on technology transfer and partnership opportunities with NASA. Goddard's SPO shared with an audience of small business owners how to get in touch and explore NASA technologies that might play a role in their business ideas.

INTERNATIONAL ASTRONAUTICAL CONGRESS

Oct. 21-25, 2019

Goddard SPO traveled to Washington, DC to participate in the International Astronautical Congress (IAC), a global event that attracts thousands of people invested in the space sector. A staff member with Goddard SPO chaired a technical panel session about how space research and development has benefited society. The representative also networked with attendees and shared information on NASA technology transfer and invention licensing.

FEDERAL LABS CONSORTIUM MID-ATLANTIC REGIONAL MEETING Nov. 5-6, 2019

In Rockville, Maryland, Goddard's SPO attended the 2019 Federal Labs Consortium (FLC) Mid-Atlantic Regional Meeting at The Universities at Shady Grove. The meeting brings together local industry members and technology transfer professionals from federal laboratories in the Mid-Atlantic region to discuss topics of mutual interest and share ideas, updates, and best practices. Goddard's SPO representatives attended several panels and talks, including a presentation on artificial intelligence (AI) and challenges related to patenting AI technologies.

Photo Credit: NASA/Marcus Payne

SPACECOM Nov. 20-21, 2019

Goddard's SPO traveled to SpaceCom in Houston, Texas in November. SpaceCom is a commercial space conference and exposition that brings together legislative officials, international space agencies, engineers and scientists in the aerospace field, and many other related industries. Goddard's SPO had a booth at the event and informed attendees of NASA technology licensing opportunities available to industry.

ACQUISITION-X Dec. 5, 2019

In Falls Church, Virginia, a Goddard's SPO representative gave a presentation at Acquisition-X, a professional development symposium of thought leaders and practitioners in federal acquisition interested in accelerating science and technology innovation. The presentation highlighted how the NASA Technology Transfer Program can work in tandem with Space Act Agreements – companies can license early-stage technologies and then work with NASA through Space Act Agreements to further advance technologies.

THE SPARK

Goddard's *The Spark* 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*.