SUMMER 2024

40 YEARS OF

TECHNOLOGY TODAY

SOUTHWEST RESEARCH INSTITUTE

High school students (from right) Lucy Xie and Kathy Le learned about a wide range of science, technology, engineering and mathematics (STEM) occupations during the 13-day Young Engineers and Scientists (YES) program that Southwest Research Institute has hosted for more than 30 years. They then spent a year working with their mentor, Lead Scientist Ed Patrick, on projects that included how a golf-ball-shaped, smartphone-controlled educational mini-robot might be used to roll around regolith to release gases from the lunar surface for easier detection. Patrick designed a test setup to demonstrate the robot under vacuum. The project showed the potential for adapting low-cost technology for the Moon or Mars while exciting these students about the out-of-this-world possibilities of a STEM career.

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ON THE COVER

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SwRI supports worldwide Shell Eco-Marathon (SEM) events, where novel student-built vehicles compete with sustainability instead of speed as the goal. The cover depicts the entries in the 2024 SEM Americas event held at the famous Indianapolis Motor Speedway in April.

IMAGE COURTESY SHELL ECO-MARATHON/AJ MAST

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IN THIS ISSUE

Southwest Research Institute's founder is sometimes called "the most interesting man you've never heard of." The son of a wealthy oilman, Tom Slick was passionate about many things — art, architecture, philanthropy — as well as having more esoteric interests such as searching for the Yeti and the Loch Ness monster. But as evidenced by his creation of SwRI and what is now Texas Biomedical Research Institute, he was probably most passionate about science and technology and their ability to solve some of the world's most challenging problems.

Over the last 76 years, SwRI has maintained that zeal, creating technical solutions from deep sea to deep space. As an organization, SwRI concentrates its outreach efforts on boosting science, technology, engineering and mathematics, or STEM, in the community. This takes many forms, including scholarships, science fair prizes, tours, mentoring and many more programs.

This issue of Technology Today features a few of those programs, including its 30 years of hosting the Young Engineers and Scientists program featured on the opposite page.

We also included a feature about utilizing a corps of over 200 citizen scientists to conduct solar science during the recent eclipse. These volunteers from across the country were outfitted with specialized telescopes to collect data. This sort of hands-on experience can change the path of someone's life.

The cover story is about SwRI's decade of support for Shell Eco-Marathons (SEMs), another seminal student STEM experience, allowing high school and college teams to build vehicles where the goal is not speed, but efficiency. SwRI serves as a sponsor, providing SEM teams support to get their vehicles across the finish line and selecting the Technical Innovation Award-winning team.

All this is part of Tom Slick's legacy, fostering a passion for STEM in the next generation. And if you want to learn more about SwRI's founder, tune into a scripted podcast about his life, "Tom Slick: Mystery Hunter," with the title role played by actor Owen Wilson.

Sincerely,

Walter D. Downing, P.E.
Executive Vice President/COO

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What could be the next generation of solar scientists get their first taste of totality from the SwRI-led Citizen Continental-America Telescopic Eclipse (CATE) 2024 site in Attica, Ohio.

Chasing the Great American Eclipse 2024

SwRI conducts experiments by land & air

By Amir Caspi, Ph.D., and
Dan Seaton, Ph.D.

ABOUT THE AUTHORS: Dr. Amir Caspi (right) is an experimental solar astrophysicist specializing in high-energy solar events and the solar corona. He is the principal investigator of the CATE 2024 experiment and observations of the solar corona from aboard NASA's WB-57 aircraft for the recent total solar eclipse. Dr. Dan Seaton is a solar physicist who specializes in observing and modeling the inner and middle solar corona. He serves as the science lead on the two projects above and is the deputy principal investigator of a proposed solar mission observing the middle corona in extreme ultraviolet wavelengths. Caspi and Seaton demonstrated CATE 2024 telescopes during the October 2023 annular eclipse from Loveland Pass in Colorado.

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COURTESY SwRI / CITIZEN CATE 2024 / RITESH PATEL / DAN SEATON

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On April 8, 2024, a total solar eclipse cast its shadow from Eagle Pass, Texas, to Houlton, Maine, likely becoming the country's most viewed celestial event ever.

During the total solar eclipse, the Moon covered the disc of the Sun, creating a few minutes of shade across a 115-mile-wide swath of the United States. This solar eclipse passed over the homes of around 32 million people, including three of the top 10 most populous U.S. cities — San Antonio, Austin and Dallas — as well as Indianapolis, Cleveland and Buffalo. Millions more trekked to the trail of totality, while the Moon blocked at least half of the Sun's face across most of the rest of the country.

It was an exciting day, because the odds of seeing a total solar eclipse if you cannot travel to one are actually quite small. This eclipse traveled from Mexico to Maine, allowing Southwest Research Institute the unique and rare opportunity to conduct two nearly simultaneous projects to study the solar corona, the Sun's outer atmosphere. Teams led by SwRI successfully executed two ground-breaking experiments — by land and air — collecting unique solar data from the total eclipse.

ECLIPSE EXPERIMENTS

The Citizen Continental-America Telescopic Eclipse (CATE) 2024 experiment engaged more than 200 community participants in a broad, approachable and inclusive attempt to make a continuous 60-minute high-resolution movie of this exciting event. A nearly simultaneous investigation used unique equipment installed in NASA's WB-57F research aircraft to chase the eclipse shadow, making observations accessible only from a bird's-eye view.

This high-res processed image of the April 8 eclipse shows the Sun's corona, its outermost atmosphere, in artificial colors that indicate the polarization or orientation of the light. Citizen scientists in Dallas collected these data through the SwRI-led CATE 2024 experiment.

COURTESY NASA/KEEGAN BARBER

Total solar eclipses offer unique opportunities for scientists to study the hot atmosphere above the Sun's visible surface. When the Moon covers the disc of the Sun, complex and dynamic features of the Sun's outer atmosphere are made visible in ways not possible or practical by any other means, opening new windows into the understanding of the solar corona. The faint light from the corona is usually overpowered by the intense brightness of the Sun itself, and some wavelengths of light are blocked by Earth's atmosphere.

The Sun is a ball of hot ionized gas. It has many different layers, but the most visible is the photosphere, or the surface of the Sun, which is about 10,000 F (or 6,000 C). Above that is the Sun's tenuous outer atmosphere, including the outermost layer, the corona, which extends from just above the solar surface all the way to the edge of our solar system.

The corona is millions of degrees, hundreds of times hotter than the visible surface below, a curious paradox that is a longstanding scientific mystery. The corona is also one of the major sources of eruptions that cause geomagnetic storms around Earth. These phenomena damage satellites, cause power grid blackouts and disrupt communication and GPS signals, so it's important to better understand them as the world becomes increasingly dependent on such systems.

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The Skycenter and Observatory hosted a large public event at Tupper Lake, New York. The Site 30 team from P-TECH schools shared information about the CATE 2024 program with visitors as they prepared to image the eclipse.

The Site 24 team set up their CATE 2024 telescope in Cleveland and waited for totality.

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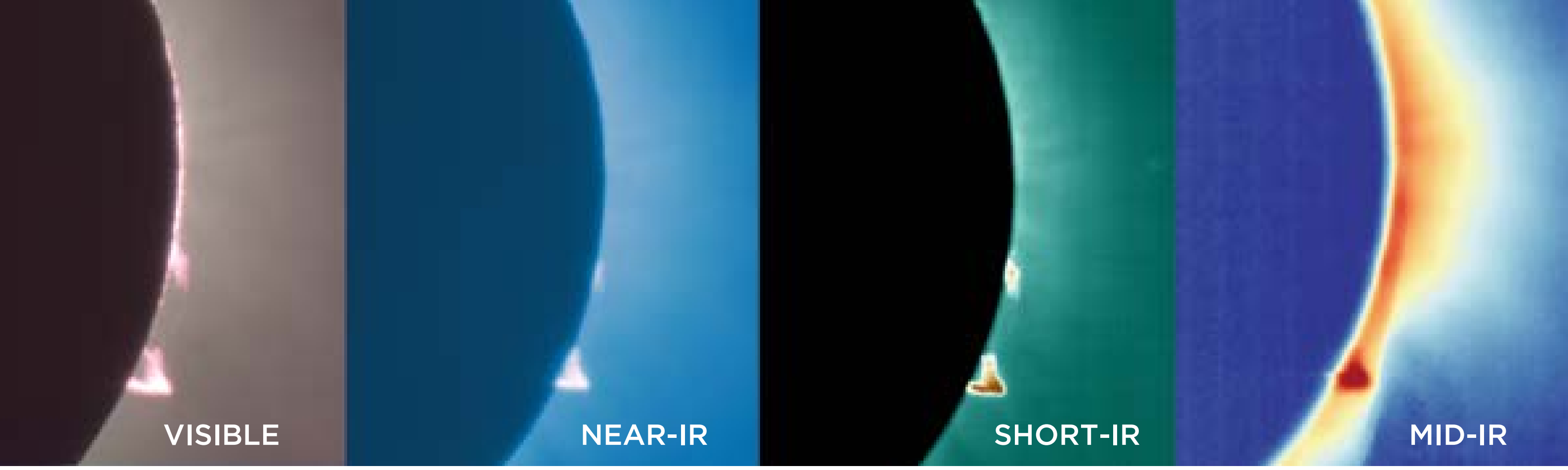
Both experiments address two very important solar physics questions: why the corona gets so hot and where the solar wind originates. This constant stream of high-energy particles emitted by the Sun all the time and spreading out into interplanetary space travels faster than it seemingly should. These experiments are looking for where the solar wind is born and where its energy comes from as it propagates through the solar system.

But CATE 2024 also provided a tremendous transformative experience, connecting communities with scientists to document one of the most awe-inspiring cosmic phenomena humans can encounter. It was the ultimate science, technology, engineering and mathematics, or STEM, outreach event, attracting teams of volunteers who then shared what they were doing with their wider community.

CATE 2024

CATE 2024 deployed a network of 35 teams of community participants, or "citizen scientists," representing local communities along the eclipse path. Hundreds of CATE participants deployed a "bucket brigade" of small telescopes following the eclipse's cross-country path from the Mexican to the Canadian borders.



COURTESY SwRI / NASA / DAN SEATON /MATTHEW WEST

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These preliminary images from a new suite of sensitive, high-speed, visible-light and infrared imagers aboard one of NASA's WB-57 jets show the corona and prominences visible during the April 8 eclipse in four wavelength ranges. Moving forward, SwRI scientists will significantly improve the images through processing and analysis of the rich and complex data.

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From left, Bob Benedict, Theresa Costilow and Carlyn Rocazella celebrate getting their telescope, camera and computer equipment set to film the moments of totality from Site 25, a campground along Lake Erie in Kingsville, Ohio.

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When Hazel Wilkins, the CATE 24 northeast regional trainer, slipped off her eclipse glasses and the solar filter from the telescope, she was overcome with the sight of the total solar eclipse from the shore of Lake Champlain, near the New York-Vermont border.

This experiment and the eclipse offered a bonding experience between scientists and communities along the path as the public donned and doffed eclipse glasses to experience a phenomenon that peoples throughout time have used to study the Sun and its mysteries.

This experiment follows the Citizen CATE 2017 experiment, which imaged the Aug. 21, 2017, event from coast to coast, using more than 60 teams of academics, school children and other volunteers. CATE 2017 was led by Dr. Matt Penn, who was then an astronomer with the National Solar Observatory in Tucson, Arizona. The project collected over 1 terabyte of white light images of the inner solar corona, creating a 90-minute, cross-country movie of the event.

CATE 2024's next-generation scientific objectives required measuring the polarization of light, or the orientation of oscillating light waves, in the corona. Light behaves as a wave, like a string or the battle ropes in Crossfit that wave in a particular direction. Most people understand polarization based on the filters that block out light coming from a certain direction. Polarized sunglasses filter out light from a direction typically associated with glare.

The Citizen CATE 2024 cameras have a polarizing filter — little sunglasses — baked onto every pixel of the sensor, allowing them to measure four different angles of polarization everywhere in the corona, providing much more information than just measuring the brightness of the light.

The 2024 experiments are studying complex motion in the solar corona, at new wavelengths and with new polarization measurements, to help scientists understand why it is so hot.

Each team received a telescope, camera, computer and training to document the eclipse. The equipment is relatively new and only

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National Solar Observatory Astronomer Emeritus David Elmore and his son Chris used a CATE 2024 setup to gather eclipse data from first landfall of the total eclipse at Mazatlan, Mexico.

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Students from the University of Indianapolis, or UINDY, collected CATE 2024 data from a site near Waynesfield, Ohio.

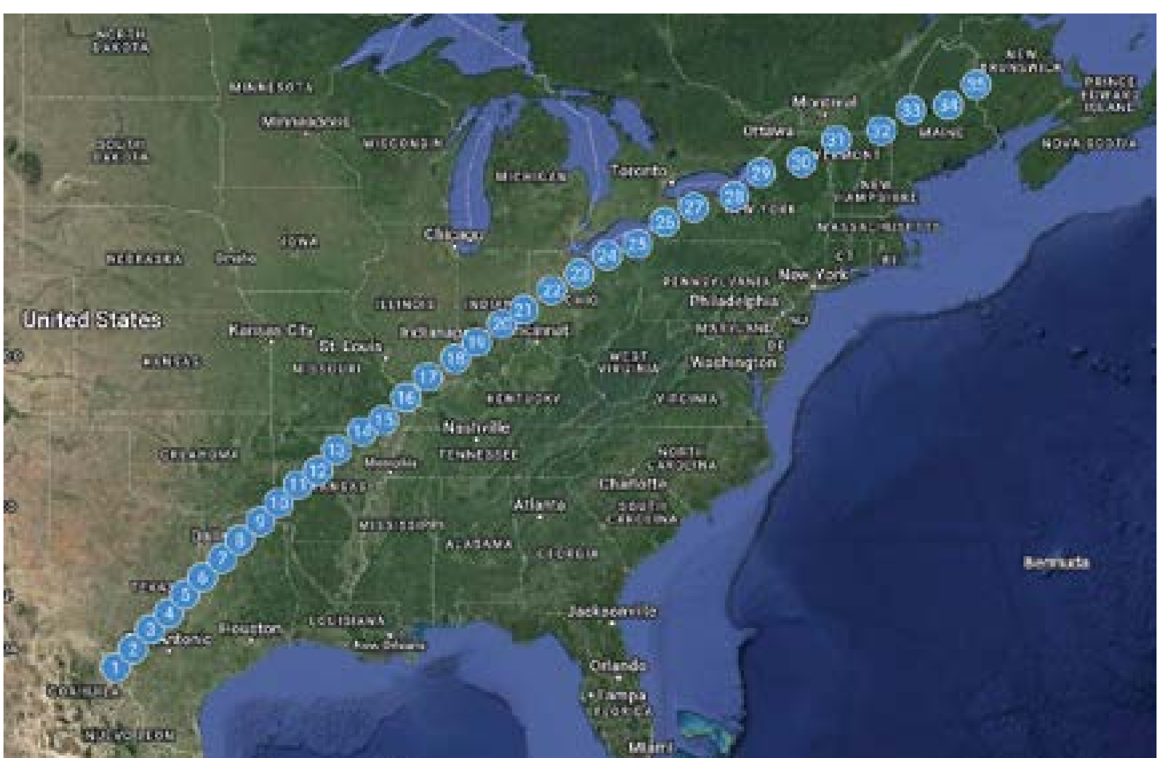
recently affordable, allowing CATE to create this distributed network across the U.S. The team beta tested the experiment taking the equipment and community volunteer leaders to Australia to observe an April 2023 total solar eclipse. They collected excellent data and demonstrated the ability to collect high dynamic range (HDR) images, where short exposures imaged the very bright elements and longer exposures collected dimmer light. The scientists then combined the data into one amazing image. They assigned a color to each of the polarization angles to create a rainbow image of the polarized light as well as the more intense white light solar prominences erupting from the surface of the Sun.

The images from these experiments are not just stunning but scientifically dense with data the scientists are still investigating. However, that is just one facet of the CATE experiment. By donating the equipment and training the citizen scientist volunteers, CATE invested in the communities along the path of totality, including many areas that are historically underrepresented or overburdened in terms of science education. Having the opportunity to engage in a scientific experiment like this provided transformative new experiences.

For instance, SwRI's project manager for CATE 2024, Sarah Kovac, started out on the CATE 2017 experiment as one of the community leaders. That inspired her to go into solar physics, get her graduate degree and then help lead the next-generation experiment with the next generation of citizen scientists. It shows the power of the community to do high-quality science, to observe one of the most amazing cosmic phenomena that can be seen with the naked eye.

Once the experiments were done, these communities kept the telescopes and auxiliary equipment to support future educational opportunities and community events.

COURTESY CITIZEN CATE PROJECT 100085



With 35 teams of local community participants, or "citizen scientists," the Citizen Continental-America Telescopic Eclipse (CATE) 2024 project collected next-generation polarized observations during the 2024 total solar eclipse from Texas to Maine. The network of 35 telescopes may provide 60 continuous minutes of totality images. The CATE 2024 experiment addresses compelling open science questions that require the novel dataset provided by multi-point observations across the entire eclipse path.

A new suite of sensitive, high-speed, visible-light and infrared imagers, built by the SCIFLI team at NASA's Langley Research Center, were installed in the nose cone of one of NASA's highflying WB-57 jets to observe the solar eclipse. SwRI will use the multispectral data to understand the physics behind the hot glow of various solar features.

COURTESY NASA/JAMES BLAIR 100129

AIRBORNE EXPERIMENTS

SwRI also led a 2024 airborne project to observe the corona during the eclipse from 50,000 feet. These high-altitude observations both provide measurements that can't be made from the ground and avoid any weather-related risks. The team deployed a new suite of sensitive, high-speed, visible-light and infrared imagers, built by the SCIFLI team at NASA's Langley Research Center, installed in the nose cone of a WB-57 jet.

This followed a 2017 experiment SwRI led using these unique aircraft, which have a wingspan of 122 feet. The aircraft have comparatively small bodies, allowing them to glide at high altitudes above 90% of the Earth's atmosphere. In 2017, two NASA WB-57F research aircraft successfully tracked the solar eclipse to study the solar corona in the midwave infrared or thermal infrared. The stabilized telescopes used sensitive, high-speed, visible-light and infrared cameras to collect spectacular images, showing clear images of the Sun's outer atmosphere.

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The Site 31 team took a group shot, capturing a particularly awe-inspiring view of the eclipse.

Kemp, Texas, a town of 1,200 less than 50 miles southeast of Dallas, assembled one of a few high school CATE 2024 teams, with seven students and two teachers. Just 90 seconds before totality, co-captain Katy Kiser followed her hunch to make final camera adjustments, as her teachers Billy House (left) and Kyle Rimler let her take the lead. And CATE 2024 Site 7 collected perfectly centered, focused images.

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Just south of the Canadian border in Pittsburg, Vermont, Site 32 enjoyed a full day of eclipse viewing activities. After setting up their CATE 2024 equipment, they used PUNCH pinhole projectors to view the eclipse indirectly as well as PUNCH sunglasses that show the polarized coronal light. A complementary SwRI-led mission, the Polarimeter to UNify the Corona and Heliosphere (PUNCH) mission will launch four suitcase-sized satellites into polar orbit in 2025 to study the solar corona with the goal of understanding the origin of the solar wind.

The experiment discovered that various structures on the Sun glow in essentially equal brightness in this wavelength. However, these structures can differ in temperature by 100 times. For instance, solar prominences are only tens of thousands of degrees, but structures known as active regions are billions of degrees, so the physics of why they glow in infrared is different, but they glow equally bright.

The 2024 experiment flew a new instrument package that uses four cameras equipped with an array of filters, to measure a range of wavelengths to get information across the color spectrum. The flight collected data from ultraviolet to visible light as well as near-infrared, short infrared and four different ranges of mid-infrared light to try and understand the physics of various types of brightly glowing structures.

The SwRI-led airborne team includes scientists from the National Center for Atmospheric Research High Altitude Observatory, NASA Langley Research Center, and Predictive Sciences Inc., with collaborators at the Smithsonian Astrophysical Observatory. The SwRI-led CATE 2024 project, funded by NSF and NASA, includes scientists from the National Center for Atmospheric Research, the National Solar Observatory, the Laboratory for Atmospheric and Space Physics at the University of Colorado, and the Space Science Institute, with collaborators at New Mexico State University and the Livelihoods Knowledge Exchange Network, community leaders at Rice University, Indiana University Bloomington, the University of Maine, and over 200 community participants in 35 communities along the eclipse path.

Questions about this story? Contact Caspi at amir.caspi@swri.org or (303) 546-6351 or Seaton at daniel.seaton@swri.org or (720) 240-0109.

The authors would like to acknowledge the leadership of Sarah Kovac, who played a key role in CATE 2024's success, as well as the assistance of Willow Reed and the Laboratory for Atmospheric and Space Physics. The authors also thank the Citizen CATE 2024 site teams for sharing their photographs.

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In support of the Kemp high school CATE 2024 team, the school district organized a "Solar Bowl" flag football game including drill, cheer and band performances in addition to observing the eclipse.

The EcoVolt team from Instituto Tecnológico y de Estudios Superiores de Monterrey (Tec) was one of 70 teams from across the Americas. Incidentally, SwRI recently entered into a collaborative agreement with Tec to jointly fund research and development initiatives to advance sustainable manufacturing and technology in the United States and Mexico.

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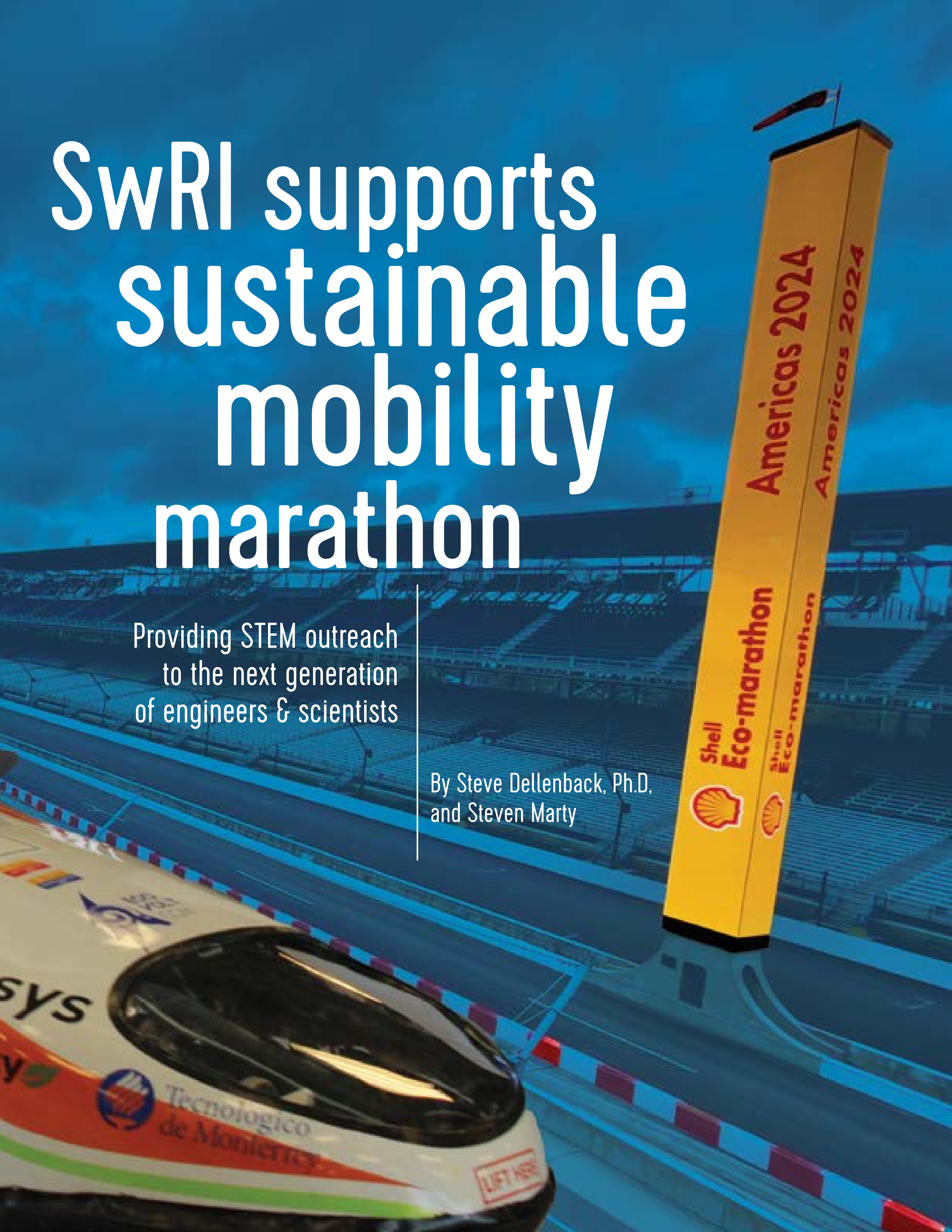
SwRI supports sustainable mobility marathon

Providing STEM outreach to the next generation of engineers & scientists

By Steve Dellenback, Ph.D, and Steven Marty



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Teams queue up at the Indianapolis Motor Speedway track entrance in anticipation of the first day of the Shell Eco-Marathon Americas competition.

As the U.S. and other countries around the world aim for net-zero greenhouse gas (GHG) economies by 2050, decarbonizing the transportation sector will play a critical role in addressing climate change and protecting human health and the environment. Transportation is the largest source of GHG emissions in the U.S., which are 97% carbon dioxide.

The transportation sector needs to eliminate nearly all GHG emissions using a holistic strategy to create a clean, safe, secure, accessible and affordable mobility system with sustainable transportation options for people and goods.[1]

For a little over 10 years, Southwest Research Institute (SwRI) has served as a Shell Eco-Marathon (SEM) sponsor, providing science, technology, engineering and math (STEM) outreach as well as evaluation of the latest efficient and automated driving technologies. These annual engineering competitions challenge hundreds of student teams from around the globe to design, build, test and drive ultra-energy-efficient vehicles. SwRI staff provide technical and engineering support and present one student team with an award recognizing innovation.

SEM shares many of the same sustainability goals and has a similar philanthropic mission as SwRI, which focuses its outreach activities on STEM programs. SEM events provide the next generation of engineers and scientists around the world with the opportunity to collaborate as teams and explore current and future vehicles and energy that will shape a lower carbon future for all.

As one of the largest independent engine, fuel and lubricant research and development organizations in the world, SwRI is well-positioned to provide the SEM teams with the support they need to compete. Plus, using more than 20 years of experience developing automated driving solutions, the Institute is developing techniques to reduce vehicular energy consumption using next-generation connected and automated driving technology.

SwRI staff recently participated in the 2024 SEM Americas, held in April at the Indianapolis Motor Speedway (IMS),

Teams from across North and South America developed urban concept vehicles (typically four-wheeled) and prototype ultra-efficient lightweight vehicles (usually three-wheeled) powered by three engine categories for the SEM Americas competition. These vehicles include internal combustion engines (ICEs) — powered by gasoline, diesel, ethanol or compressed natural gas — as well as hydrogen fuel cells and battery-electric vehicles (BEVs).

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[1] *https://www.epa.gov/greenvehicles/us-national-blueprint-transportation-decarbonization*

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From left, SwRI staff member Logan Elliott and consultant Joe Redfield check Kankakee Valley High School's urban concept internal combustion engine vehicle before an attempted run.

and the 2024 SEM Europe-Africa competition in Nogaro, France, held in May. Thousands of students participate in SEM events each year gaining valuable STEM knowledge and hands-on experience. This year SEM is also featuring regional events for students from the Asia-Pacific and Middle East, Brazil and China, along with an Autonomous Urban Concept Competition that took place concurrently with the Europe and Africa event. SwRI has a presence at nearly every eco-marathon in some way.

> We've seen a lot of first-time competitors and a lot of first-time designs. Seeing the students' excitement when their hard work has paid off, they have passed their tech and safety inspections, and they realize their vehicle will make it to the track. Even if they don't win, just passing and getting out there brings the teams immense joy. Experiencing that alongside the students has been tremendously rewarding.
>
> Jose Starling, senior research engineer in SwRI's Fuels and Lubricants Research Division, who focused on pre-competition inspections

The competition recognizes two different car types — urban concept vehicles, which are typically four-wheeled, and prototype ultra-efficient lightweight vehicles, which are usually three-wheeled. Teams can choose between three engine categories, including internal combustion engines (ICEs) powered by gasoline, diesel, ethanol or compressed natural gas. The other platforms are battery-electric vehicles (BEVs), powered by hydrogen or lithium, and hydrogen fuel cell vehicles. 2024 SEMs will host three big regional events. These "supermileage" events allow experienced teams to push new boundaries, encouraging innovation and novel approaches to achieving energy efficiency.

SEM AMERICAS

On a cold, wet and windy April morning, hundreds of high school and college students from across North and South America bundled up in heavy jackets, scarves and beanies at the famous Indianapolis venue to begin the multiday competition.

In dozens of paddocks just off the track, teams of up to 15 student engineers work rapidly and intently, preparing the ultra-energy-efficient vehicles transported from across the Western Hemisphere. Some of the vehicles resemble a single-rider coupe, while other, more experimental designs evoke submarines or jet cockpits. The teams have painstakingly designed and built their vehicles for the opportunity to complete the 2.5-mile-long track and prove their design is the

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SwRI's Jared Cavaliere (second from left) collaborates with a Shell employee, reviewing the Escudería EcoVolt team's prototype BEV.

most energy-efficient vehicle in Indianapolis this year. Before their car can even make it onto the track, it must pass rigorous technical and safety evaluations conducted by SwRI and Shell.

SwRI staff from the Fuels and Lubricants Research and Intelligent Systems divisions work alongside Shell staff to ensure the proceedings run safely and smoothly. In a row of garages adjacent to the famous IMS track, SwRI and Shell staff members mentor students, testing each vehicle and evaluating everything from electrical and fuel systems to brakes and seat belts. The requirements are so rigorous that teams that have spent months working on their vehicles may falter at the inspections. Many teams have the simple goal of passing the inspection.

For instance, safety feature and vehicle design inspections verified that drivers could exit the vehicles easily and safely and that seatbelts are properly installed. Students would be prompted to complete mock-emergency evacuations of their vehicles within a certain time limit. Interiors were examined for potential hazards.

> It's been hard. During travel, part of our frame cracked, and it's not a spot fix. It's a take-everything-apart-and-fix-that-one-thing problem to put it back together. We were working all the 12 hours we were allowed to be in the paddock and trying to get it ready for the inspection to just pass with two minutes left in the inspection … but we're a strong team with a lot of determination and perseverance.
>
> **Siobhan Scott, team manager from the University of Manitoba, Canada, racing a BEV prototype**

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SwRI's Michael Moneer (left) and Jose Starling (right) conduct an interior safety check of the University of Manitoba's EcoMotion prototype BEV.

In 2024, more than 70 teams including 750 students from five countries participated in the SEM Americas regional event, competing in on-track categories representing different fuel and design philosophies. The goal of the competition is to inspire students to experiment with different energy solutions, challenging them to travel the longest distance using as little energy as possible. Each vehicle and engine category has its own requirements that must be met to attempt a run around the track.

Over the course of each competition day, students pull their vehicles from the paddock to the inspection garages, lining up for evaluation. Then they either move onto the track to attempt a run or haul them back to their paddock for last-minute improvements. Teams have up

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Students from the Alérion supermileage team with Université Laval in Canada haul their prototype BEV to the test track for inspection. Their team placed third in their category with a best attempt of 197.28 mi/kWh.

It's a once-in-a-lifetime experience ... How many kids can say they drove a vehicle around IMS or Sonoma? I don't think we've had any negative feedback. It's very reassuring to the students who've put all their time, blood, sweat and tears into it. It's been an exciting, transformative experience.

David Hass, an advisor for the Kankakee Valley High School team, which placed second overall in their category

to six run attempts with their energy use (mi/kWh) recorded on scoreboard monitors around IMS. Their best completed attempt determines their place in the competition. Countless factors can make or break a run, from the weather to a miscalculated turn to overzealous acceleration. At SEM, efficiency, not speed, is the most important factor in the race.

For the teams, every second, every move, every mechanical function, and every bit of expended energy on the track could be the difference between leaving IMS with a win or not. During runs, students often dress in team uniforms, peering through binoculars from the stands and offering drivers potential efficiency hints via walkie talkie. At times, cars on the track stall out and are towed to their paddocks. Then the work begins anew to troubleshoot and fix the cause of a failed run before trying again. Difficulties can crop up during any stage of the competition, and students are challenged to find solutions.

By the third day of SEM Americas, teams have settled into a groove. Teams can work and race up to 12 hours a day. In the

SwRI's Jose Starling (in white) checks the urban concept BEV designed and built by Team RUDI from Mater Dei High School. Team RUDI placed first in their category reaching an efficiency of 120.38 mi/kWh.

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Six vehicles, designed by high schools in Minnesota and Indiana as well as the University of Ottawa, competed in the SEM Americas urban concept vehicle race on Sunday, April 7.

evening, many teams camp out at IMS. Several teams have been here before and are already planning to come back in 2025, but for others, this is one of the few opportunities that they have as students to get this kind of hands-on STEM experience.

SEM Americas ends with a regional championship race between the top-scoring urban concept vehicles from each energy category. This year, six teams — five high school teams, including Kankakee Valley High School, and one university team, the University of Ottawa, competed in the finals, with the challenge to complete four laps on a set amount of fuel/energy. The combination of starting position and energy usage efficiency determines the winner of the race.

The Gold Warriors Team from Wawasee High School in Syracuse, Ind., and their gasoline internal combustion engine vehicle finished with the gold this year. All but one team completed the four laps to cross the finish line.

SwRI vice presidents Steve Marty, Dr. Steve Dellenback and Tony Magaro participated in the event to share information about SwRI with interested students and select the winning team for the SwRI-sponsored award. Marty and Dellenback interviewed 10 teams, including a team that focused on increasing engine performance and reducing emissions immediately after engine start-up addressing these high transient emissions associated with cold starts.

In the process of selecting the Technical Innovation Award winner, SwRI saw first-hand the students' ingenuity and problem-solving skills at work. Transient-based emissions are extremely relevant for current low-emissions goals with real-world applicability for solving today's problems, and students were applying this for a race/mileage advantage.

SwRI presented the Off-Track Technical Innovation Award to the supermileage entry from Brigham Young University.

> Students in this year's autonomous urban concept competition made significant strides in their cars. For the first time, a team completed all stages of the test track and did so using only cameras and lidar, without any GPS guidance at all. All the teams made it much farther in the course than they had in the previous years, demonstrating sophisticated autonomy and machine learning algorithms. SwRI staff had a great time judging the contest and talking with the students about their hard work.

Dr. David Anthony, a lead engineer in SwRI's Intelligent Systems Division, who took part in vehicle inspections as well as the automated driving competition

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SwRI Vice President Steve Marty (right) presents the Technical Innovation Award to the leaders of the Brigham Young University team.

SEM EUROPE/AFRICA

The SEM Europe / Africa competition was held May 19–24 in Nogaro, France, home of Circuit Paul Armagnac, a motorsport racetrack in southwestern France. Over 300 student teams participated in the vehicle efficiency marathon. The Europe-Africa event also included an autonomous urban concept competition.

In addition to providing technical team support for the high-mileage competition similar to the SEM Americas, SwRI provided technical support and guidance for the automated system competition held prior to the super-high-mileage challenge. Of the six teams that submitted entries, five teams successfully passed their technical inspections and moved onto the track for competition.

The competition consisted of three automation challenges that must be completed without driver intervention. First, vehicles must traverse multiple corners of the F-1 track over a distance of approximately 1 kilometer. Then entries must complete an obstacle course, which requires vehicles to take a circuitous route to complete the challenge. And finally, each vehicle must identify which of the three parking places is vacant and park itself within the lines. After the driving competition, each team made a business presentation and was judged on its technical approach to solving the challenges. SwRI's Intelligent Systems Division provided Shell with input and planning assistance based on almost 20 years of experience in developing automated driving solutions.

Taking part in SEM is just one facet of SwRI's commitment to STEM outreach. The Institute also collaborates with Shell in providing an eco-marathon internship program for junior and senior university engineering students. Interns work alongside SwRI engineers on projects tackling current and future mobility technologies. SwRI also has STEM outreach programs in engineering and robotics that it has supported for more than 30 years.

Challenging the next generation of engineers and scientists — who will tackle the problems where the current generation leaves off — is crucial. For instance, SwRI's automated driving system program was inspired, in part, by new staff members who took part in DARPA's automated driving challenges as students. Inspiring and equipping the next generation is critical to meeting net-zero emissions goals.

For more information about the SwRI and Shell Eco-Marathon Internship, visit: www.swri.org/swri-and-shell-eco-marathon-internship

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A team from Yildiz Technical University (YTU) in Instanbul, Turkey, prepares their automated driving entry for three challenges that must be completed without driver intervention, including track driving, an obstacle course and parking. From right, SwRI's Dan Engstrom, David Anthony, Shell's Melle de Wit and SwRI's Logan Elliott advise the YTU team.

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In the background, from left, SwRI's Dan Engstrom, David Anthony and (right) Logan Elliott worked alongside Shell's Melle de Wit (second from right) to certify that this automated driving concept car was cleared to compete. A team from the Technical University of Munich, one of Germany's leading universities for research and teaching in natural sciences and engineering, developed this novel vehicle.

ABOUT THE AUTHORS:

Steven Marty (right), vice president of SwRI's Fuels and Lubricants Research Division, brings automotive specialists to support the safety and technical evaluations of the student-developed ultra-energy-efficient vehicles participating in the Shell Eco-Marathon. Dr. Steve Dellenback, vice president of the Intelligent Systems Division, brings connected and automated vehicle specialists to lend their expertise to the pre-race inspections as well as the automated driving competition held in France.

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SWRI STEM SUPPORT

Southwest Research Institute focuses its community outreach efforts to support science, technology, engineering and mathematics (STEM) education, particularly for underrepresented populations. SwRI has collaborated with Community of Churches for Social Activism to provide renewable scholarships and internships to students who live in underserved communities. Other STEM support includes tours, judging science fairs, participating in career days, developing STEM curriculum and mentoring students and teachers.

Young Engineers & Scientists (YES)

- 30 years
- 13-day YES program
- 1-year mentoring
- 23 students in 2024

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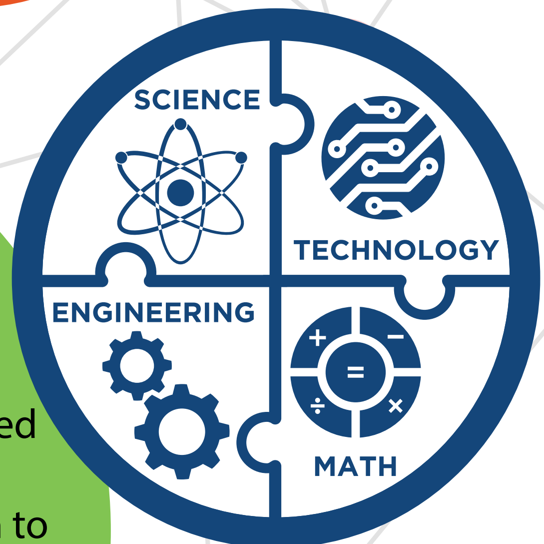

Great American eclipse outreach

- >25 events
- >20 staff involved
- >13,000 eclipse glasses supplied
- 100,000 mission-themed pinhole projectors distributed
- CATE 2024 outreach (see story p. 2)

100102

100125

Student tours/presentations

- High schools
- Undergrads
- Graduate students
- Student engineering societies
- Community organizations

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Internships

- 181 student hires in 2024, including:
  - 38 graduate students
  - 6 NASA MUREP (Minority University Research and Education Project) interns
  - 19 SA WORX interns
  - 10 NASA Europa ICONS (Inspiring Clipper: Opportunities for Next-generation Scientists) interns
- 9 postdoctoral researchers
- Shell Eco-Marathon internship (see story p. 10)

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Robotics competitions

- SA BEST (Boosting Engineering, Science and Technology)
  - >30 years
  - SwRI-chartered
  - ±15 staff/retiree volunteers
  - Board representatives
- FIRST (For Inspiration and Recognition of Science and Technology) Robotics
  - Staff mentors

100116

Mentoring

- Big Brothers, Big Sisters program
- Individual matches
- Supporting girls in STEM
- Teacher mentoring
- NSITE high school

100131

HOT TIMES IN COOL PLACES

A team co-led by SwRI found evidence for hydrothermal or metamorphic activity within the icy dwarf planets Eris and Makemake, located in the Kuiper Belt. Methane detected on their surfaces has the tell-tale signs of warm or even hot geochemistry in their rocky cores. This is markedly different than the signature of methane from a comet, which is what the team was expecting to find.

“We see some interesting signs of hot times in cool places,” said SwRI’s Dr. Christopher Glein, an expert in planetary geochemistry and lead author of a paper about this discovery. “I came into this project thinking that large Kuiper Belt objects (KBOs) should have ancient surfaces populated by materials inherited from the primordial solar nebula, as their cold surfaces can preserve volatiles like methane. Instead, the James Webb Space Telescope (JWST) gave us a surprise! We found evidence pointing to thermal processes producing methane from within Eris and Makemake.”

The Kuiper Belt is a vast donut-shaped region of icy bodies beyond the orbit of Neptune at the edge of the solar system. Eris and Makemake are comparable in size to Pluto and its moon Charon. These bodies likely formed early in the history of our solar system, about 4.5 billion years ago. Far from the heat of our Sun, KBOs were believed to be cold, inert objects — until now.

Newly published work from JWST studies made the first observations of isotopic molecules on the surfaces of Eris and Makemake. These so-called isotopologues are molecules that contain atoms having a different number of neutrons, useful in understanding planetary geology.

The JWST team measured the composition of the dwarf planets’ surfaces, particularly the deuterium (heavy hydrogen, D) to hydrogen (H) ratio in methane. Deuterium is believed to have formed in the Big Bang, and hydrogen is the most abundant nucleus in the universe.

“The moderate D/H ratio we observed with JWST belies the presence of primordial methane on an ancient surface. Primordial methane would have a much higher D/H ratio,” Glein said. “Instead, the D/H ratio points to geochemical origins for methane produced in the deep interior.

“The D/H ratio is like a window. We can use it in a sense to peer into the subsurface,” Glein added. “Our data suggest elevated temperatures in the rocky cores of these worlds and hot cores could also point to potential sources of liquid water beneath their icy surfaces.”

Over the past two decades, scientists have learned that icy worlds can be much more internally evolved than once believed. Evidence for subsurface oceans has been found at several icy moons such as Saturn’s moon Enceladus and Jupiter’s moon Europa. Liquid water is one of the key ingredients in determining potential planetary habitability.

The possibility of water oceans inside Eris and Makemake is something that scientists are going to study in the years ahead. If either of them is habitable, then it would become the most distant world in the solar system that could possibly support life. Finding chemical indicators of internally driven processes takes them a step in this direction.

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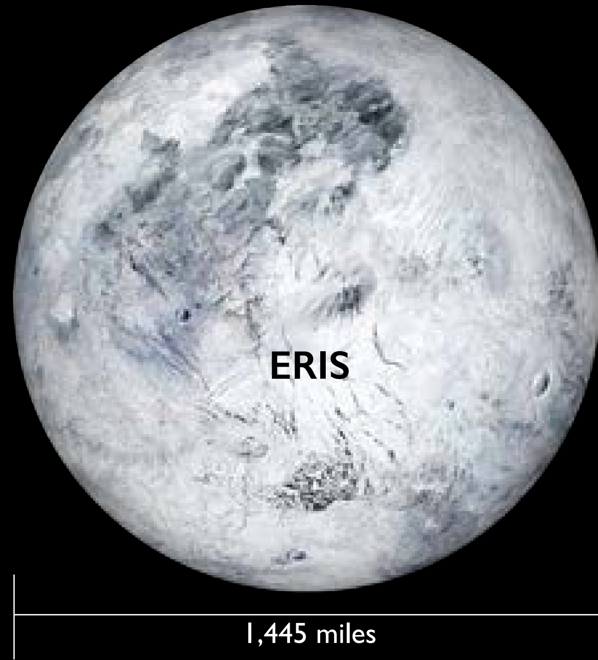

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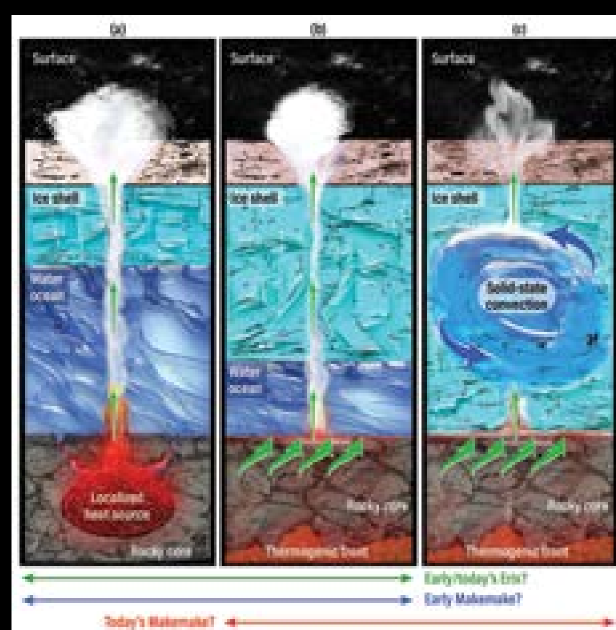


Using data from the James Webb Space Telescope, SwRI modeled the subsurface geothermal processes that could explain how methane ended up on the surfaces of Eris and Makemake, two dwarf planets in the distant Kuiper Belt. The illustration points to three possibilities, including the potential that liquid water exists within these icy bodies at the edge of the solar system, far from the heat of the Sun.

Off-Road Automated Driving Tools Offer Stealth, Agility

IMAGE COURTESY NASA/GODDARD SPACE FLIGHT CENTER-CONCEPTUAL IMAGE LAB

SwRI has developed off-road autonomous driving tools using a vision-based system pairing stereo cameras with novel algorithms, eliminating the need for lidar and active sensors. The system provides stealth for military deployments and compact agility for space and agriculture applications.

"We reflected on the toughest machine vision challenges and then focused on achieving dense, robust modeling for off-road navigation," said Abe Garza, a research engineer in SwRI's Intelligent Systems Division.

Through internal research, SwRI engineers developed a suite of tools known as Vision for Off-Road Autonomy (VORA). The passive system can perceive objects, model environments and simultaneously localize and map while navigating off-road environments.

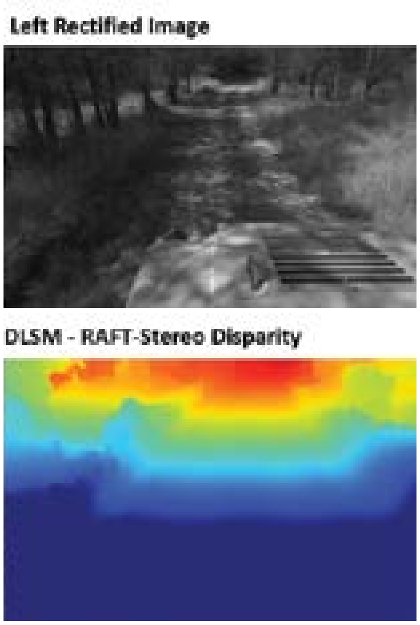
The VORA team envisioned a camera system as a passive sensing alternative to lidar, a light detection and ranging sensor, that emits active lasers to probe objects and calculate depth and distance. Though highly reliable, lidar sensors produce light that can be detected by hostile forces. Radar, which emits radio waves, is also detectable. GPS navigation can be jammed, and signals are often blocked in canyons and mountains.

"For our defense clients, we wanted to develop better passive sensing capabilities but discovered that these new computer vision tools could benefit agriculture and space research," said Assistant Program Manager Meera Towler, who led the project.

In space, autonomous robots are limited by power, payload capacity and intermittent connectivity. Cameras make more sense than power-hungry lidar systems to explore planetary surfaces.

To overcome various challenges, the team developed new software to use stereo camera data for high-precision tasks traditionally accomplished using lidar. These tasks include localization, perception, mapping and world modeling.

"We apply our autonomy research to military and commercial vehicles, agriculture applications and so much more," Towler said.



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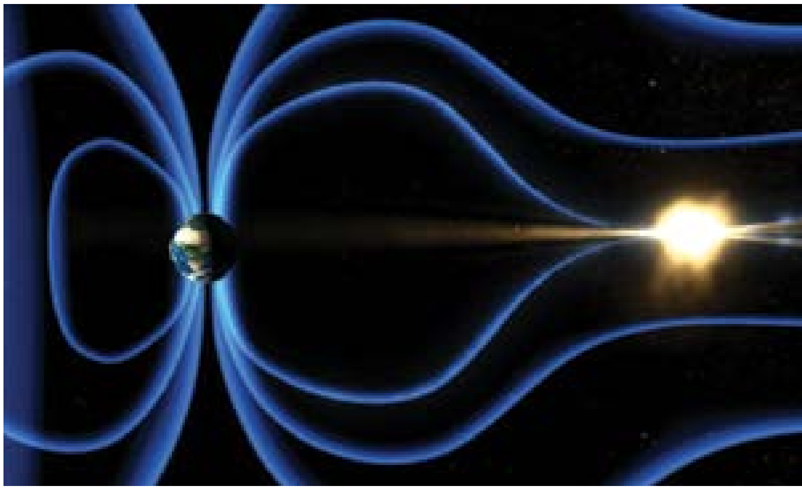
SwRI developed a stealthy vision-based system to perceive objects, model environments and simultaneously localize and map while navigating off-road environments.



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This illustration shows magnetic field lines around the Earth reconnecting in the magnetotail, usually one of the first signs of a substorm.

SwRI STUDIES EARTH'S MAGNETOTAIL

SwRI is investigating an unusual event in the Earth's magnetotail, the elongated portion of the planet's magnetosphere trailing away from the Sun. Using data from the SwRI-led Magnetospheric Multiscale (MMS) mission, SwRI scientists are examining the nature of substorms, fleeting disturbances in the magnetotail that release energy and often cause aurorae.

Since their launch in 2015, NASA's four MMS spacecraft have been surveying the magnetopause, the boundary between the magnetosphere and surrounding plasma, for signs of magnetic reconnection. These phenomena occur when magnetic field lines converge, break apart and reconnect, explosively converting magnetic energy into thermal and kinetic energy. In 2017, MMS observed signs of magnetic reconnection in the magnetotail but not the normal signs of a substorm that accompany reconnection, such as strong electrical currents and perturbations in the magnetic field.

"We want to see how the local physics observed by MMS affects the entire global magnetosphere," said SwRI's Dr. Andy Marshall, a postdoctoral researcher. "By comparing that event to more typical substorms, we are striving to improve our understanding of what causes a substorm and the relationship between substorms and reconnection."

During the one-year project, SwRI will compare in situ MMS measurements of reconnection affecting local fields and particles to global magnetosphere reconstructions hosted by the Community Coordinated Modeling Center at NASA's Goddard Space Flight Center using the University of Michigan's Space Weather Modeling Framework.

"It's possible that significant differences exist between the global magnetotail convection patterns for substorms and non-substorm tail reconnection," Marshall said. "We have not looked at the movement of the magnetic field lines on a global scale, so it could be that this unusual substorm was a very localized occurrence that MMS happened to observe. If not, it could reshape our understanding of the relationship between tail-side reconnection and substorms."

100113

Aboard a parabolic flight, SwRI Research Engineer Dr. Eugene Hoffman floats in partial gravity while conducting a fluids engineering experiment to better understand how liquids boil in low gravity.

IMAGE COURTESY ZERO-G

BOILING LIQUIDS IN LOW GRAVITY

To study how liquids boil in partial gravity, SwRI conducted experiments aboard two parabolic flights in April. The internally funded project, conducted in collaboration with Texas A&M University, is exploring how different surfaces affect the boiling process in low gravity.

Future extended space missions to the Moon or Mars will likely need to boil liquids for power generation, life support, cryogenic fuel production and in situ resource utilization, which uses local materials to support human exploration. On Earth, gravity helps separate liquids and gases through buoyancy. On the lunar or Martian surface, the lower buoyancy will affect boiling behavior, but simulating these conditions on Earth is challenging. Parabolic flights offer researchers brief periods of partial gravity to gain more insight into efficient and safe heat transfer processes at low gravity.

“We have so little data about how boiling works in reduced gravity,” said SwRI’s Kevin Supak, who leads the project. “Our experiment studies boiling in conditions that simulate lunar and Martian gravity levels using four different surfaces to examine how bubbles initiate and detach.”

The experiments will demonstrate whether engineered surfaces could improve boiling and bubble detachment in reduced gravity. At the microscopic level, rougher surfaces tend to form smaller bubbles and initiate boiling faster than smoother ones. SwRI’s Materials Engineering Department modified surface characteristics to study their effect on bubble sizes and distribution at different temperatures. The payload includes one plastic and three stainless-steel surfaces submerged in a specialized fluid that boils at the relatively low temperature of 135 degrees Fahrenheit.

SWORD™

SWORD: Robotics Programming, Simplified

SwRI is simplifying robotics programming with a new toolkit that integrates robotics motion planning, modeling and execution tools into a computer-aided design (CAD) application. The SwRI Workbench for Offline Robotics Development™ (SWORD™) features a user-friendly graphical interface to demystify the fundamental coding required in robot operating system (ROS) application development.

Informed by feedback from the ROS-Industrial community, engineers developed SWORD so manufacturing engineers can leverage advanced ROS capabilities in a familiar CAD environment. SwRI manages the ROS-Industrial Americas consortium and supports ROS-I software repositories, executing training and developer events.

“The traditional ROS workflow is programming-intense, requiring developers to be deeply familiar with available ROS libraries and tools. Even experienced ROS developers can spend significant time on initial setup and configuration,” said Matt Robinson, an SwRI engineer who manages the ROS-Industrial Americas consortium. “We listened to ROS experts and consortium members to develop SWORD and provide easier access to the ROS motion-planning tools, while sticking to a CAD-based environment familiar to non-developers.”

SWORD features a graphical toolkit for setting up motion planning environments and collision geometries. It can also test advanced robotic motion-planning applications and provides a graphical interface to many powerful motion-planning libraries. The goal is to adapt ROS to be more approachable for manufacturing and industrial audiences in a familiar environment.

“SWORD is designed for both robotics developers and manufacturing engineers familiar with CAD processes and programs on process-oriented systems,” said SwRI’s Jeremy Zoss, who helped to develop the software.

SWORD contains environmental modeling tools that allow a user to fully describe the robot, fixtures, and end-of-arm tooling, using either imported geometry or locally created CAD features. SWORD generates motion plans using a selection of advanced planning libraries, creating custom pipelines for application-specific behavior while predicting and avoiding collisions.

100122

PREPARING FOR EUROPA MISSION

SwRI is leading two teams to understand critical topics in advance of NASA's Europa Clipper mission to the Jupiter moon. Both Precursor Science Investigations for Europa (PSIE) projects are investigating the connection between Europa's icy surface and its subsurface, which is thought to contain a potentially habitable ocean.

Scheduled to launch in October 2024 and arrive in the Jupiter system in 2030, NASA's Europa Clipper mission will place a spacecraft in orbit around Jupiter to perform a detailed investigation of Europa, one of the largest of Jupiter's 90 moons. This precursor work will provide critical context to enable more efficient scientific analysis of Europa Clipper data, driving new discoveries. The projects may influence mission planning for the latter half of the prime mission and for any potential extended mission.

"Europa is considered one of the most likely sites in our solar system to potentially find life," said SwRI's Dr. Kelly Miller, who is leading one of the teams. "The most habitable environments at Europa are underneath the surface where there is liquid water. We need to measure and understand the relationship between the properties we measure and observe at the surface, and the properties in those interior environments."

The availability of chemical energy sources depends on the history of the interior ocean and the abundance of organic and inorganic compounds it contains. The team will look at the evolution of chemical signatures from Europa's interior to understand how we can distinguish between different possible interior environments without measuring those environments directly.

"We will combine models, observations, experiments and data science methods with the ultimate goal of improving the interpretation of Europa Clipper datasets," Miller said. "The last steps of the research will use machine learning to process laboratory data collected from related chemical mixtures by the MAss Spectrometer for Planetary EXploration, or MASPEX, engineering model located at SwRI."

The second SwRI-led team will specifically track ice shell evolution and material exchange between the surface and subsurface to predict the features likely to provide the best information and context for interpreting Europa Clipper data.

"Ahead of Europa Clipper, what we really need to know is how much the surface can tell us about Europa's interior and ocean, and that's the primary motivation of our project," said Dr. Alyssa Rhoden, a principal scientist with SwRI and leader of the second team. "The breadth of this project lets us go after complex problems in our understanding of Europa — where surface geology, interiors and orbital dynamics are tightly coupled."

The team will also incorporate recent laboratory experiments and Earth-based radar observations to reinterpret data collected by NASA's Galileo mission to Jupiter (in orbit 1995–2003). Improving the understanding of Europa's ice shell and its spectral properties will allow more rapid and accurate interpretation of Europa Clipper spectrometer data, characterizing Europa's surface composition in detail, and provide a basis for identifying changes in Europa's surface since Galileo.

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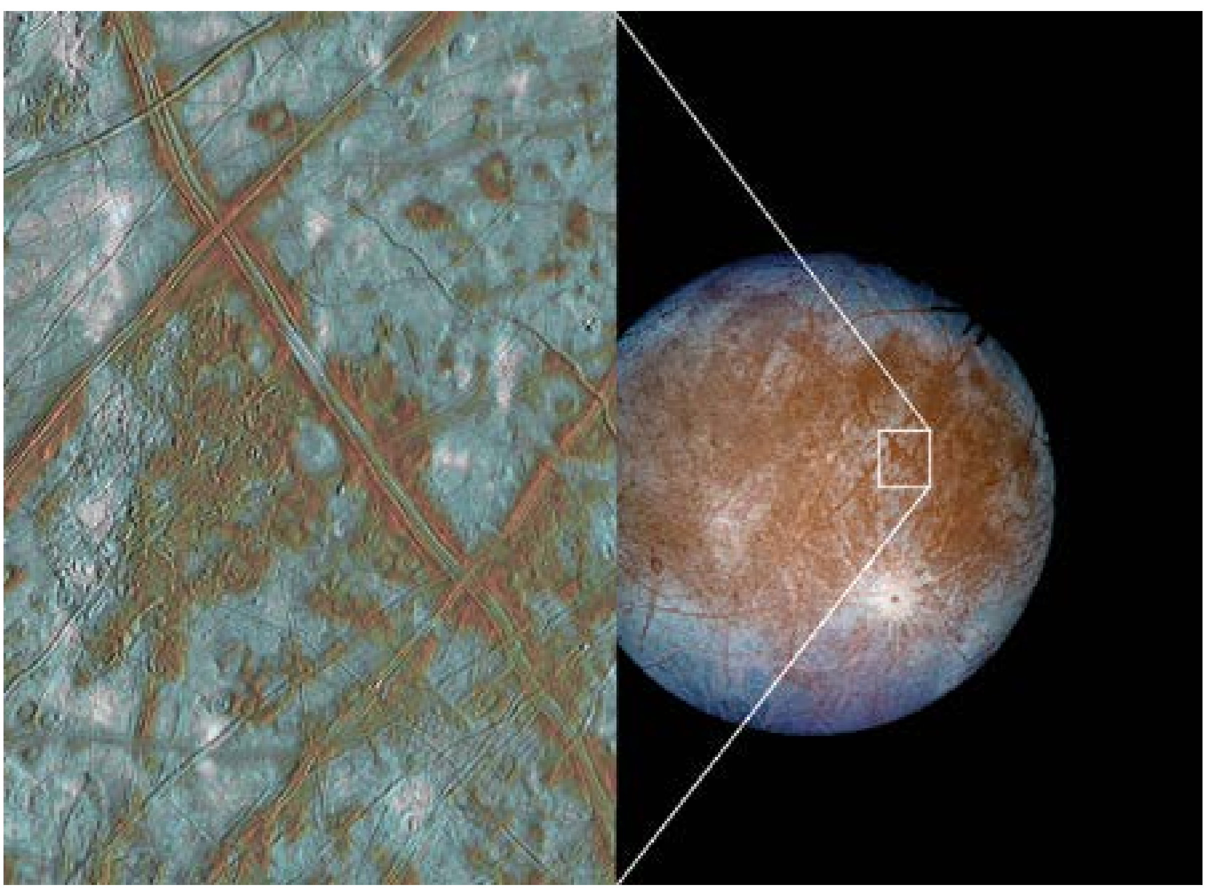


IMAGE COURTESY NASA/JPL/UNIVERSITY OF ARIZONA

SwRI is leading two Precursor Science Investigations for Europa teams to understand critical topics in advance of NASA's Europa Clipper mission to the Jupiter moon. Both projects are investigating the connection between Europa's icy surface and its subsurface, which is thought to contain a potentially habitable ocean.

RAD MEASURES RECORD RADIATION ON MARS

As principal investigator of the Radiation Assessment Detector (RAD) aboard NASA's Curiosity rover, SwRI's Dr. Don Hassler has been anticipating how epic events associated with solar maximum might play out on the surface of Mars.

Solar maximum, the regular period of high activity during the Sun's 11-year solar cycle, is associated with large numbers of sunspots and solar storms. The resulting solar flares and coronal mass ejections produce solar energetic particles, high-energy protons that can penetrate planetary atmospheres. RAD is a coffee-can-sized instrument designed to ascertain the radiation exposure astronauts could encounter en route to and on the surface of Mars.

"RAD primarily measures two types of radiation on the surface of Mars, solar energetic particles produced by solar storms and galactic cosmic rays (GCRs), a continuous influx of high-energy particles that originate outside of the solar system, likely from explosive events like supernovae," Hassler said.

The most significant event in the 12 years RAD has been roving the Red Planet occurred on May 20 when a solar flare expelled X-rays and gamma rays toward Mars, while a subsequent coronal mass ejection launched high-energy charged particles. Moving at the speed of light, the X-rays and gamma rays from the flare arrived first, while the charged particles trailed slightly behind, reaching the planet in just tens of minutes.

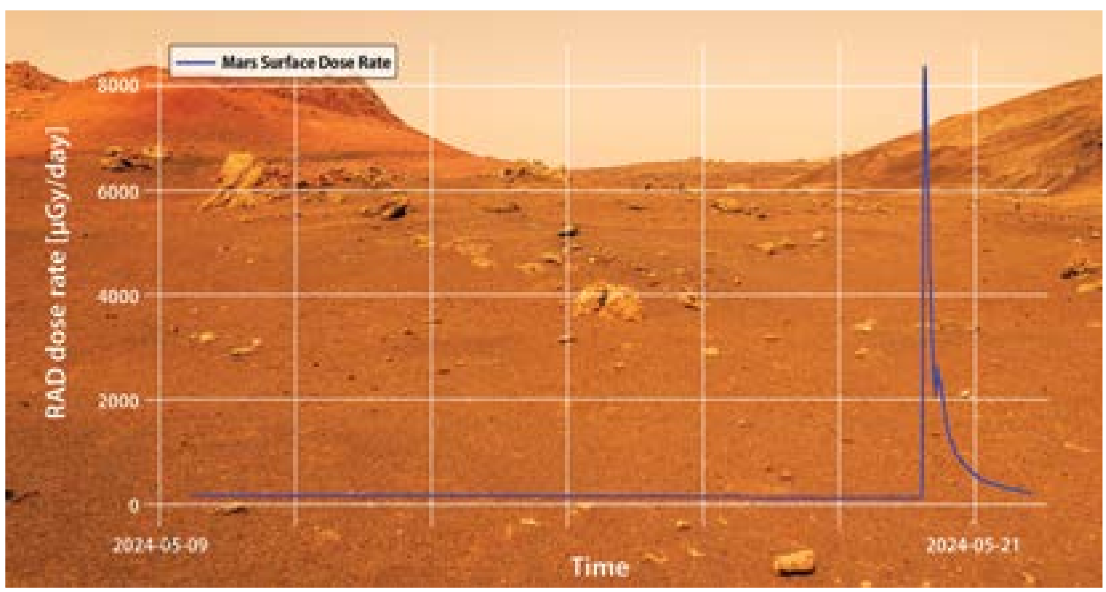
"If astronauts had been standing next to NASA's Curiosity Mars rover at the time, they would have received a radiation dose of 8,100 micrograys — equivalent to 30 chest X-rays," Hassler said. "While not deadly, it was the biggest surge measured by RAD so far, producing a spike of radiation eight times higher than normal."

During solar events, the Sun releases a wide range of energetic particles. Only the most energetic can reach the surface to be measured by RAD. RAD's data will help scientists plan for the highest level of radiation exposure that might be encountered by astronauts, who could use the Martian landscape for protection.

"Cliffsides or lava tubes would provide additional shielding for an astronaut from such an event. In Mars orbit or deep space, the dose rate would be significantly more," said Hassler.

During the May 20 event, energy from the storm caused black-and-white images from Curiosity's navigation cameras to dance with "snow" — white streaks and specks caused by charged particles hitting the cameras. Similarly, the star camera on NASA's 2001 Mars Odyssey orbiter was inundated with energy from solar particles, momentarily going out. NASA's MAVEN (Mars Atmosphere and Volatile EvolutioN) orbiter captured global glowing auroras over the planet.

"This active region on the Sun continued to erupt," Hassler said. "We saw more solar storms at both Earth and Mars in the following weeks, as the Sun rotated back around. These storms weren't quite as large as in May, but the solar maximum 'season' is just beginning. It will be exciting to see what lies ahead."



During a May 20 solar storm, the Radiation Assessment Detector, or RAD, saw a spike eight times higher than normal in the radiation dose measured on the surface of Mars. This is the highest dosage RAD has measured in the 12 years it has been roving the Red Planet aboard Curiosity.

10011/100133

Proving Pressure Relief Valve Performance

SwRI helped determine the viability of pressure relief valves for liquid natural gas tanks under train derailment conditions for the Federal Rail Administration (FRA). The SwRI research demonstrated that the pressure relief valves work as designed to prevent overpressurization and explosion in derailment scenarios.

"The pressure relief valves on tanks that transport liquid natural gas via rail are designed to vent the headspace of the liquid natural gas in the event of a derailment or a fire," said SwRI's Matt Gacek, who led the testing.

According to the Bureau of Transportation Statistics, trains derail on average more than 1,000 times each year, though they rarely result in fatalities or considerable damage.

"SwRI sought to determine if valves would still properly vent fluid after a railcar derails and flips over, causing the tank's cryogenic liquid to flow through the valves," Gacek said.

For safety reasons, SwRI used liquid nitrogen as a substitute for liquid natural gas and simulated the conditions the safety pressure valve would undergo in a train derailment.

SwRI determined the flow rates under various conditions and installed sensors measuring pressure, temperature and flow rate to the liquid nitrogen tank's discharge line.

Then the project evaluated the impact of a potential fire from an operating pressure relief device. To accomplish this, SwRI created a pressurized natural gas flame and measured temperatures and heat fluxes at several safe distances.

"We discharged the natural gas at a variety of flow rates, ignited it and characterized the environment around the flame," said Principal Engineer Jason Huczek of SwRI's Fire Technology Department.

The fire testing data will validate computer modeling calculations, allowing future researchers to investigate a variety of accident scenarios. The project was conducted by the FRA-sponsored team, led by prime contractor Friedman Research Corporation, over 13 months between 2022 and 2023.

100114

DEVELOPING TOMORROW'S AIRCRAFT PROTECTION TECHNOLOGY

The U.S. Air Force is tapping into SwRI's advanced electronic warfare expertise with a $6.4 million contract to explore cognitive electronic warfare (EW) techniques to accurately detect and respond to unknown enemy radar threats in real time. SwRI engineers are conducting research to develop a reliable algorithm that will advance the Air Force's cognitive EW capabilities to better protect aircrews.

"How do we get to the point where an EW system thinks like a human?" said SwRI Staff Engineer David Brown, who is leading the project. "A pilot can fly into an area and not know what's there, but by analyzing the environment and signals, the pilot can choose a proper response to a threat. We are developing an algorithm that can analyze its environment the same way. It will sift through information with the reliability of a human but with higher accuracy and faster reaction times."

Traditional EW processes use intelligence gathered before aircraft fly into an area to provide advance knowledge of the adversaries they might encounter and preload that information into aircraft electronic warfare systems. These systems alert pilots to detected threats and automatically respond to protect the aircraft.

In the past, the Air Force has relied on matching detected signals to a library of recognizable or comparable signals. A cognitive EW and machine learning approach can instantly identify new signals and respond with appropriate countermeasures.

SwRI's cognitive EW work began as a multiyear, multimillion-dollar internal research and development (IR&D) project. Through its IR&D program, the Institute invests in tomorrow's concepts to advance technology for government and industry clients.

100087

IMAGE COURTESY U.S. AIR FORCE/JAKE MELAMPY

Cognitive EW systems will accurately detect and respond to unknown enemy radar threats in real time, to disrupt or deceive enemy air attacks such as surface-to-air missiles or anti-aircraft artillery, as illustrated by the U.S. Air Force F-16 EW training exercise pictured.

100083

SwRI BUILDING SPACECRAFT FOR IN-SPACE REFUELER

SwRI will build, integrate and test a small demonstration spacecraft as part of a $25.5 million Space Mobility and Logistics (SML) prototyping project funded by the U.S. Space Force and led by prime contractor Astroscale U.S. The spacecraft, called the Astroscale Prototype Servicer for Refueling (APS-R), will refuel other compatible space vehicles while in geostationary orbit.

"Running low on fuel is a common issue for spacecraft in Earth orbit," said SwRI 's Michael Epperly, the SwRI project manager. "When they have expended all of their fuel, their mission ends — even though the vehicle may be in otherwise excellent health. A refueling vehicle can extend those missions, getting additional lifetime out of spacecraft already in orbit."

The APS-R will operate in geostationary orbit around the Earth. The spacecraft will carry hydrazine propellant from a depot, also in geostationary orbit, to spacecraft in need of fuel. The APS-R can service any spacecraft fitted with a compatible refueling port.

"Recently, other approaches to life extension have emerged, such as a vehicle that can use its thrusters to push another spacecraft where it needs to go after it runs out of fuel," said Randy Rose, SwRI's chief engineer of spacecraft development. "A refueling vehicle broadens life extension options with a flexible alternative."

SwRI will construct the host vehicle for the APS-R in the Institute's new 74,000-square-foot Space System Spacecraft and Payload Processing Facility, which provides rapid response to customers needing to design, assemble and test spacecraft, particularly small satellites.

SwRI will deliver the launch-ready APS-R by 2026.

SPARCI Characterizes Lunar Regolith

SwRI has received a three-year, $2,041,000 grant from NASA's Development and Advancement of Lunar Instrumentation (DALI) program to further develop a novel ground-penetrating radar instrument. The Synthetic Pulse Artemis Radar for Crustal Imaging (SPARCI, pronounced "sparky") instrument is designed to characterize the depth of the regolith and upper megaregolith, the upper broken-up layers of lunar crust associated with impact cratering.

SwRI is one of five teams awarded funding by NASA's DALI program, which supports the development of instruments for future lunar missions, including Commercial Lunar Payload Services and Artemis. DALI's goal is to develop and demonstrate instruments that are technically ready to propose for upcoming flight opportunities. These instruments must significantly improve measurement capabilities for high-priority lunar science objectives.

When astronauts return to the Moon during the second half of this decade, their tasks will include deploying lunar instruments and using new technology to characterize the Moon. SPARCI's two large transmitting antennas —172 and 40 meters in length — are designed for astronaut deployment. A robotic rover with much smaller antennas will then receive radar signals that penetrate the Moon's subsurface. The ground-penetrating radar will measure the thickness and structure of the lunar megaregolith. Believed to be between 0.4 and 5 kilometers deep, the megaregolith formed just after the Moon solidified and likely experienced heavy bombardment from other objects during the early formation of the solar system.

"Learning more about the lunar megaregolith will help us gain a wider understanding of the Moon's formation and that of similar bodies with thin, sparse atmospheres," said SwRI's Dr. David Stillman, the project's principal investigator. "If we are able to pinpoint exactly where this layer begins, we can use that to create more accurate formation and evolution models."

IMAGES COURTESY SwRI/BRYAN PYKE AND ASTROSCALE U.S. 100124

OXYGEN PRODUCTION ON JUPITER'S MOON EUROPA

NASA's Juno spacecraft has directly measured charged oxygen and hydrogen molecules from the atmosphere of one of Jupiter's largest moons, Europa. According to a new study co-authored by SwRI scientists and led by Princeton University, these observations provide key constraints on the potential oxygenation of its subsurface ocean.

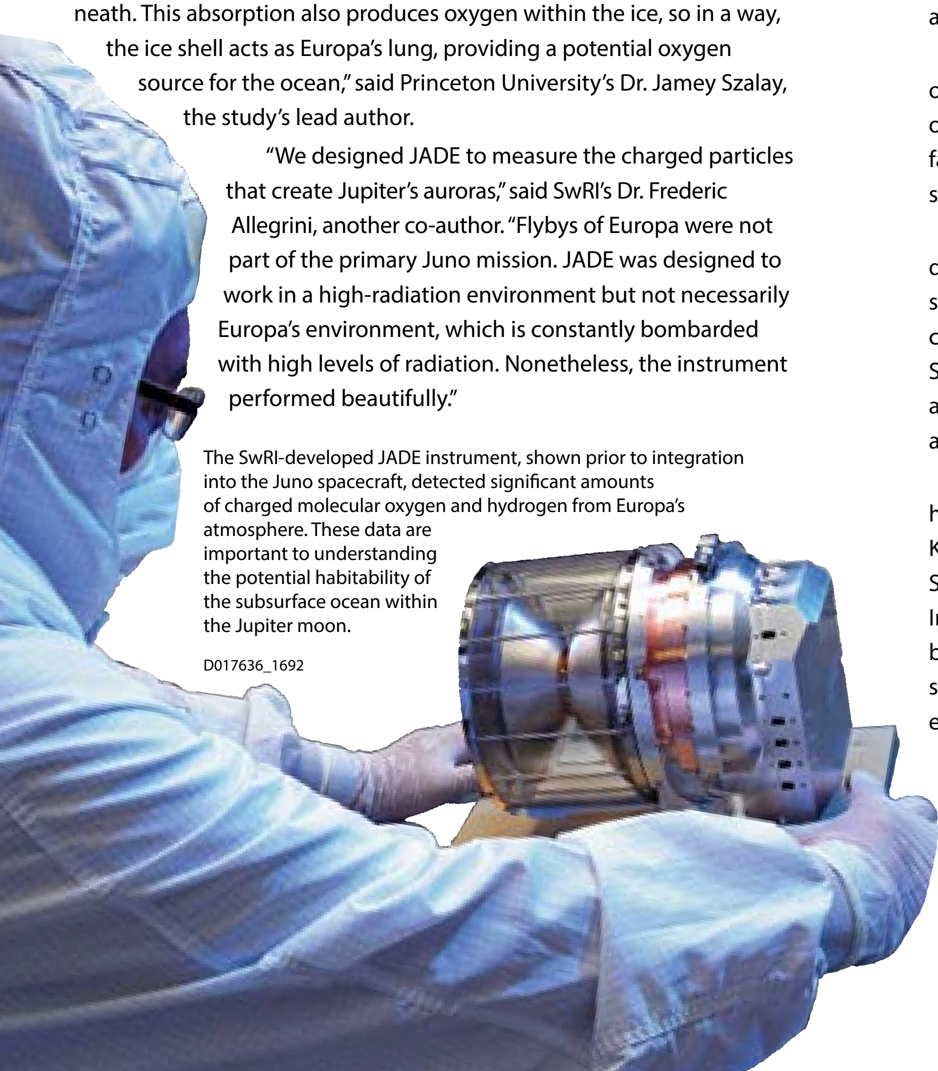
"These findings have direct implications on the potential habitability of Europa," said Juno Principal Investigator Dr. Scott Bolton of SwRI, a co-author of the study. "This study provides the first direct in situ measurement of water components existing in Europa's atmosphere, giving us a narrow range that could support habitability."

In 2022, Juno completed a flyby of Europa, coming as close as 352 kilometers to the moon. The SwRI-developed Jovian Auroral Distributions Experiment (JADE) instrument aboard Juno detected significant amounts of charged molecular oxygen and hydrogen lost from the atmosphere.

"For the first time, we've been able to definitively detect hydrogen and oxygen with in-situ measurements and further confirm that Europa's atmosphere is made primarily of hydrogen and oxygen molecules," said SwRI's Dr. Robert Ebert, a co-author. The source of these molecules is thought to be water ice on Europa's surface.

"Europa's ice shell absorbs radiation, protecting the ocean underneath. This absorption also produces oxygen within the ice, so in a way, the ice shell acts as Europa's lung, providing a potential oxygen source for the ocean," said Princeton University's Dr. Jamey Szalay, the study's lead author.

"We designed JADE to measure the charged particles that create Jupiter's auroras," said SwRI's Dr. Frederic Allegrini, another co-author. "Flybys of Europa were not part of the primary Juno mission. JADE was designed to work in a high-radiation environment but not necessarily Europa's environment, which is constantly bombarded with high levels of radiation. Nonetheless, the instrument performed beautifully."



The SwRI-developed JADE instrument, shown prior to integration into the Juno spacecraft, detected significant amounts of charged molecular oxygen and hydrogen from Europa's atmosphere. These data are important to understanding the potential habitability of the subsurface ocean within the Jupiter moon.

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IMAGE COURTESY PIEPER O'BRIEN HERR ARCHITECTS 100132

SwRI Constructing First Facility Outside of Texas

For the first time in its 76-year history, SwRI has purchased land and is constructing a facility outside of its San Antonio home base. To support defense and intelligence programs, the Institute began construction on an $18.5 million, 33,000-square-foot facility on more than 8 acres in Warner Robins, Georgia, about three miles from Robins Air Force Base.

The new single-story building will house more than 50 SwRI staff members and consultants and will include new laboratory areas for the development of advanced aerospace and defense technology.

"We currently manage some of our government projects off-site at Robins Air Force Base," said Winfield Greene, director of SwRI's Advanced Electronic Warfare Department. "The new facility will allow us to handle this type of work in our own space to expand our support of the United States Air Force."

Most SwRI staff members in the Warner Robins office are developing electronic warfare technology, countermeasure systems to protect aircraft from enemy weapons fire. The staff currently operates in a 15,000-square-foot, leased building. SwRI opened a Warner Robins office more than three decades ago to expand business opportunities and better serve clients at Robins Air Force Base.

SwRI operates 10 U.S. locations outside of its San Antonio headquarters as well as an international office in the United Kingdom. The Institute has a wholly owned subsidiary, Signature Science LLC, in Austin, Texas. Traditionally, the Institute leases office and laboratory space away from its home base, but purchasing property and building was the best solution to meet client needs in Warner Robins. The facility is expected to be complete by mid-2025.

"While we expand our footprint, we're doing something good in the Warner Robins community, hiring and growing the local economy as well as keeping our warfighters safer," Greene said.

UPCOMING

WEBINARS, WORKSHOPS and TRAINING COURSES HOSTED by SwRI:

Fundamentals of Centrifugal Compressor Performance Testing, August 07, 2024, virtual.

Manufacturing Supervisor Certification Program, August 15, 2024, in-person, San Antonio.

Rotordynamics Tutorial, August 21, 2024, virtual.

Fatigue Life Modeling for Gas Turbine Applications, September 04, 2024, virtual.

Turbomachinery Design Training Week, September 09, 2024, in-person, San Antonio.

Operations and Supply Chain Management, September 16, 2024, virtual.

Purchasing and Supply Management, September 17, 2024, virtual.

Field Services: Pulsation and Vibration Problem Solving for All Applications, September 18, 2024, virtual.

International Human Performance Summit, September 19, 2024, in-person, San Antonio.

Lean Manufacturing Certification Program, October 1, 2024, in-person, San Antonio.

TRADESHOWS:

Life Cycle Industry Days (LCID) & Wright Dialogue with Industry (WDI), Dayton, Ohio, July 29, 2024, Booth No. 317/319.

Small Satellite Conference, Logan, UT, August 3, 2024.

American Society of Biomechanics (ASB) Annual Conference, Madison, WI, August 5, 2024.

National Strength & Conditional Association (NSCA) Tactical Annual Training, Norfolk, VA, August 5, 2024, Booth No. 409.

The 15th Waste Conversion Technology Conference & Trade Show, San Diego, CA, August 12, 2024.

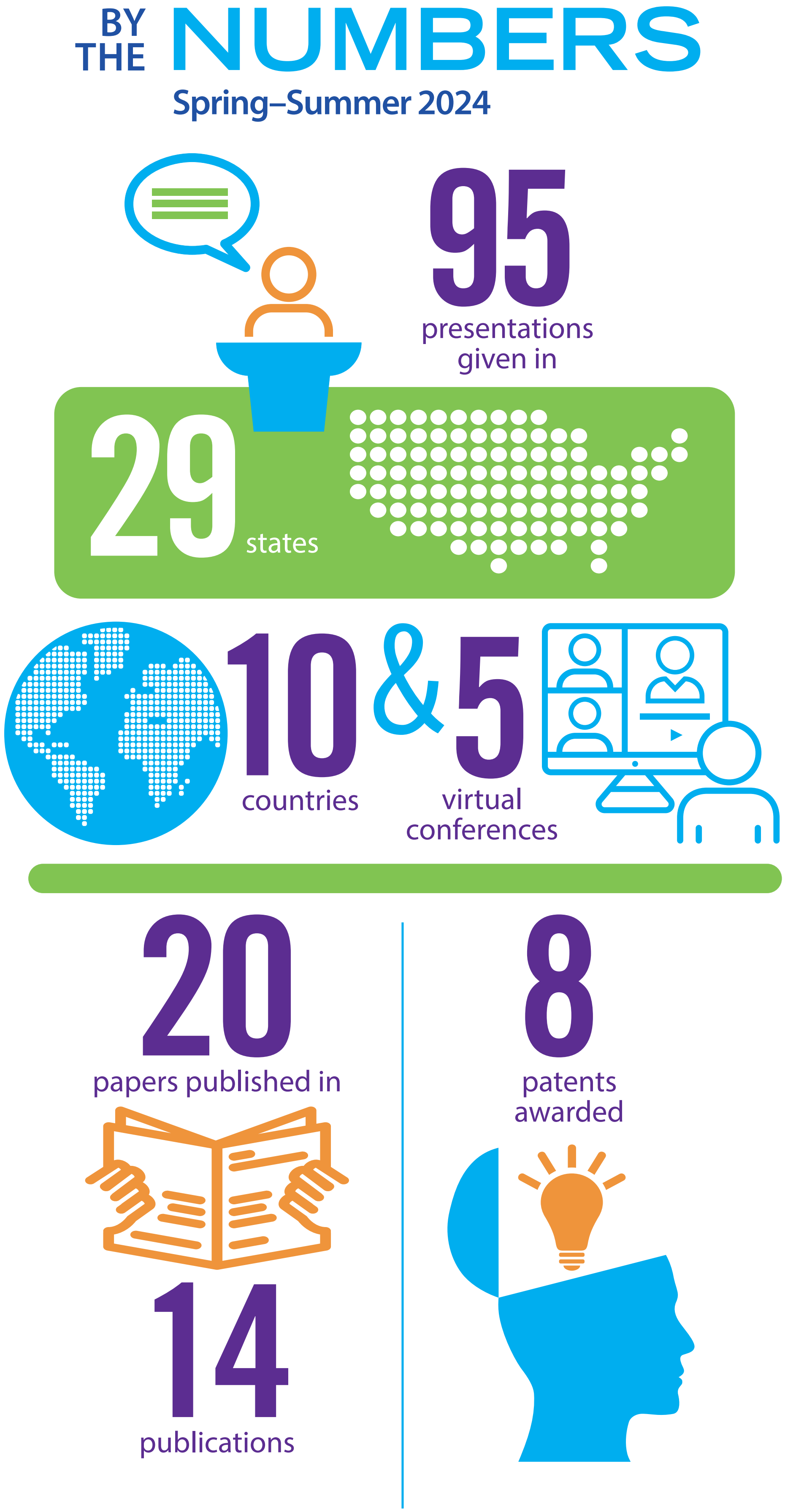
Ground Vehicle Systems Engineering & Technology Symposium (GVSETS), Novi, MI, August 13, 2024, Booth No. 523.

Turbomachinery & Pump Symposia, Houston, TX, August 20, 2024, Booth Nos. 2735 & 2737.

IEEE AUTOTESTCON, National Harbor, MD, August 26, 2024, Booth No. 127.

IMAGE (DEG/AAPG) International Meeting for Applied Geosciences & Energy, Houston, August 28, 2023, Booth No. 306.

For more information on upcoming events visit newsroom.swri.org.

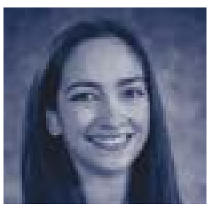



100358

Dr. Abdullah Bajwa, a senior research engineer who joined the Powertrain Engineering Division in January, received an SAE International Award for an Outstanding Student Paper, recognizing a paper he co-authored as a Fulbright scholar at Texas A&M University.


70820

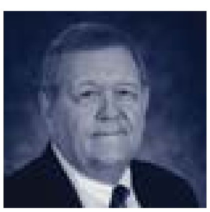
Institute Scientist **Dr. David Ferrill** won first place in the Gordon Atwater Best Professional Poster Award category from the Gulf Coast Association of Geological Societies. The award recognized the "Synsedimentary slump folding in Cretaceous Eagle Ford Formation, Southwest Texas" poster presented at GeoGulf 2023.


100356

Senior Research Scientist **Dr. Rohini Giles** has received the NASA Early Career Achievement Medal. The award recognizes unusual and significant performance supporting NASA's mission during the first 10 years of a scientist's career. Giles was cited for "significant early career achievements in the analysis of Juno data to study Jovian Transient Luminous Events and the distribution of constituents in Jupiter's atmosphere."


100359

The American Society of Safety Professionals (ASSP) has named Lead Safety Engineer **Matthew Herron** its 2024 Safety Professional of the Year. The award is presented annually to an ASSP member who demonstrates outstanding achievement in the occupational safety and health (OSH) field while also advancing the profession overall.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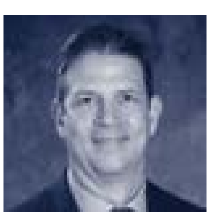
Institute Engineer **Dr. Marc Janssens** was named a "DiNenno Prize Laureate" for his role in the widespread adoption of the cone calorimeter, a fire-testing tool that accurately measures heat release and material flammability. The National Fire Protection Association® recognized the cone calorimeter, which was developed in 1982, with the 2024 Philip J. DiNenno Prize for its lasting impact on fire safety.


65517

SwRI's Institute Engineer **Dr. Peter Lee**, Executive Director **Matt Jackson** and Lead Engineer **Dr. Carlos Sanchez** wrote a chapter on electric vehicle fluid testing for a recently published book titled "Electric Vehicle Tribology: Challenges and Opportunities for a Sustainable Transportation Future."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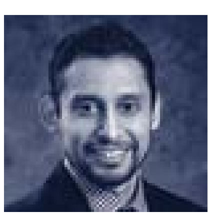
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TODAY

Director of Communications
Maria Stothoff

Editor
Deb Schmid

Assistant Editor
Mike Thomas

Contributors
Camaron Brooks
Jesús Chávez
Robert Crowe
Lisa Peña
Joanna Quintanilla

Design
Jessica Vidal

Illustration
Todd Pruetz

Photography
Jesús Chávez
William Luther
Ian McKinney

Circulation
Cecilia Novak

Address correspondence to the Editor,
Communications Department,
Southwest Research Institute,
6220 Culebra Road
San Antonio, Texas 78238-5166,
or e-mail **dschmid@swri.org**.
To be placed on the mailing list or to make address changes,
call 210.522.2257 or visit **update.swri.org**.

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