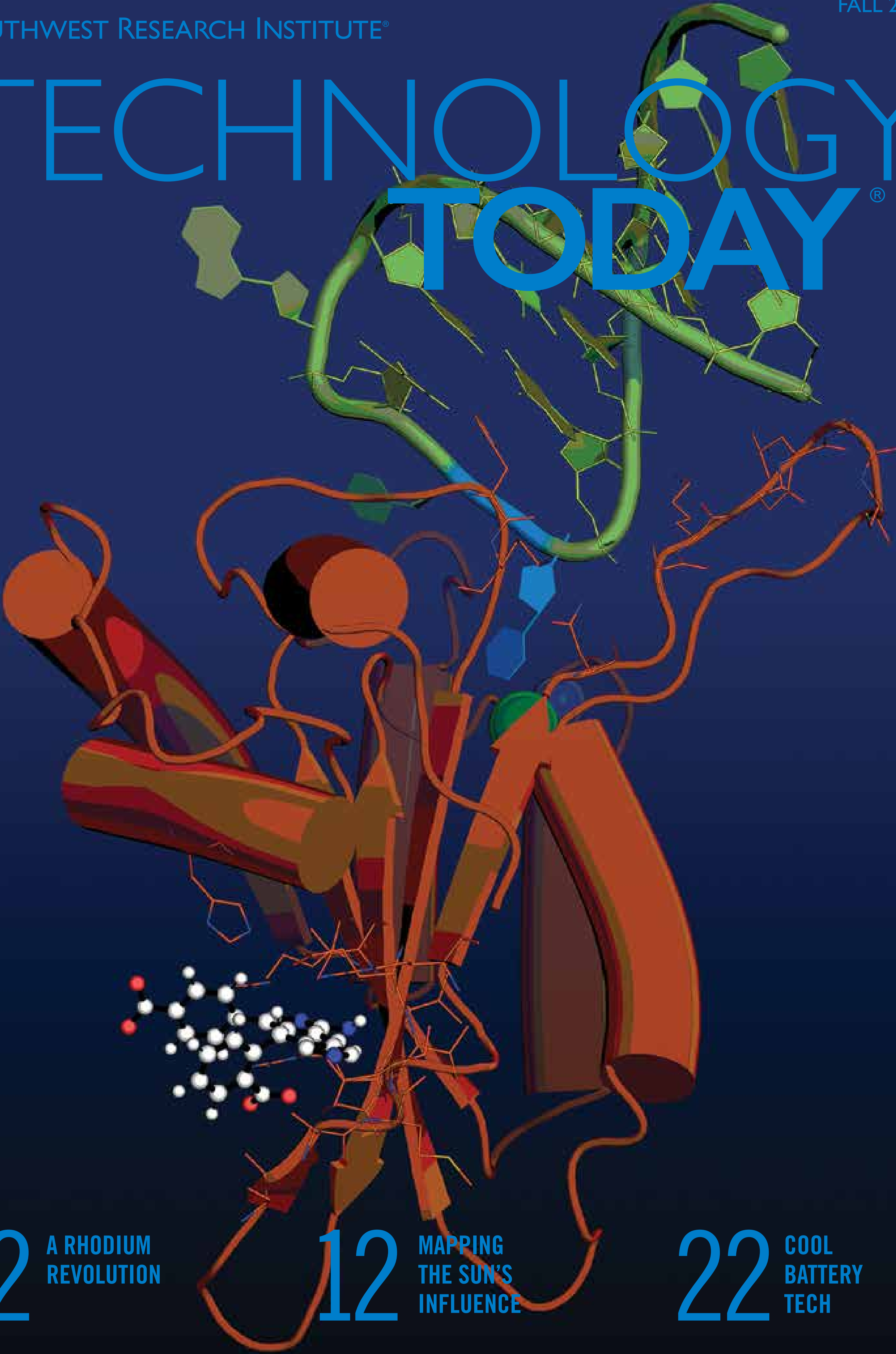
Southwest Research Institute®

FALL 2025

TECHNOLOGY TODAY®



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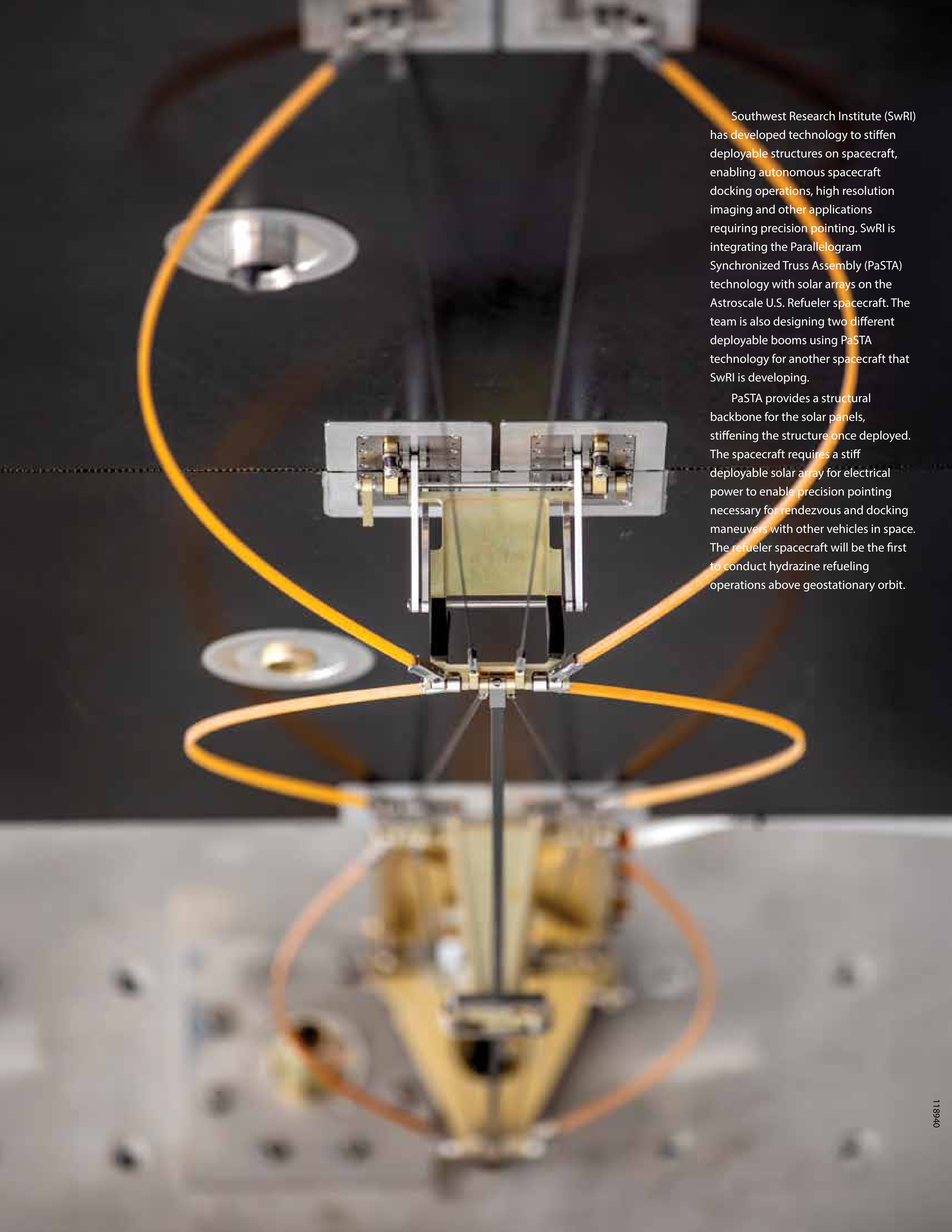

Southwest Research Institute (SwRI) has developed technology to stiffen deployable structures on spacecraft, enabling autonomous spacecraft docking operations, high resolution imaging and other applications requiring precision pointing. SwRI is integrating the Parallelogram Synchronized Truss Assembly (PaSTA) technology with solar arrays on the Astroscale U.S. Refueler spacecraft. The team is also designing two different deployable booms using PaSTA technology for another spacecraft that SwRI is developing.

PaSTA provides a structural backbone for the solar panels, stiffening the structure once deployed. The spacecraft requires a stiff deployable solar array for electrical power to enable precision pointing necessary for rendezvous and docking maneuvers with other vehicles in space. The refueler spacecraft will be the first to conduct hydrazine refueling operations above geostationary orbit.

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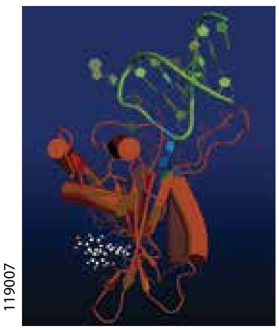

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Rhodium software enables computer-aided drug design and structure-based virtual screening to accelerate drug discovery. This Rhodium image shows how various small-molecule keys bind with a large, disease-causing molecule, allowing chemists to find the best drug candidates for halting or treating infections.

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IN THIS ISSUE

For 78 years, SwRI has conducted research and development benefiting government, industry and the public through innovative science and technology. One of the keys to our success is our deep understanding of the challenges our clients face and how addressing these challenges can benefit the public as well. We identify these pain points, and our multidisciplinary teams use innovative, multifaceted approaches to take clients from pain to peak performance.

This issue of Technology Today demonstrates this R&D sweet spot. For instance, when the Department of Energy put out a challenge to solve an inspection problem for huge underground double-shell tanks holding hazardous waste, our nondestructive evaluation specialists adapted technology previously used in related applications. Then they reached out to the SwRI automation team across campus to develop a robotic delivery system. The resulting system slips through a pipe and deploys a sensor in a 30-inch space between the tank's inner and outer shells to identify problems with tank materials before hazardous leaks can occur, protecting the environment and the people living nearby.

For the cover story, SwRI chemists collaborated with computer scientists to use machine learning to accelerate untargeted analyses and characterize every chemical present in a wide range of consumer goods and environmental samples. Before the Highlight™ system was developed, understanding complex analytical data was a highly specialized and time-consuming endeavor that now takes just 2% of the time needed to do it manually. Every chemical present in a sample can now be identified to help understand the public's exposure risks.

The SWORD™ feature addresses a broad industry challenge: the high development and deployment costs for industrial robotics. SwRI developed a new toolkit that integrates several robotics solutions into one intuitive interface. The SwRI Workbench for Offline Robotics Development™ platform is designed to demystify programming for new users and speed up the development process for advanced integrators.

By leveraging the multidisciplinary expertise available at SwRI, we are solving these and many more complex problems to benefit government, industry and humankind.

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

By
Jonathan
Bohmann,
Ph.D.

A RHODIUM REVOLUTION

DRUG DISCOVERY ACCELERATED

The search for solutions to human suffering dates back to the beginnings of civilization.

The earliest treatments were typically based on observations of nature and superstitions, consisting largely of some combination of ritual and plant- or animal-based ingredients. Modern drug discovery began in the 1800s, when scientists began to isolate compounds from natural sources to create the first drugs. The 1900s saw advancements in synthetic chemistry, antibiotics and an understanding of drug mechanics.

In the early 2000s, the onerous drug discovery process developed in the 20th century remained largely unchanged. While scientists no longer manually screened thousands of compounds in search of viable drug candidates, high-throughput screening methods developed in the 1990s only automated screening for a few hundred to a few thousand compounds at a time.

Developing viable candidates into a clinical drug remained a 10- to 15-year endeavor. For context, Alexander Fleming's 1928 discovery of penicillin did not start saving patient lives until the 1940s. The cancer-fighting drug Keytruda® developed in the early part of the 21st century, took about as long to arrive on pharmacy shelves in 2014.

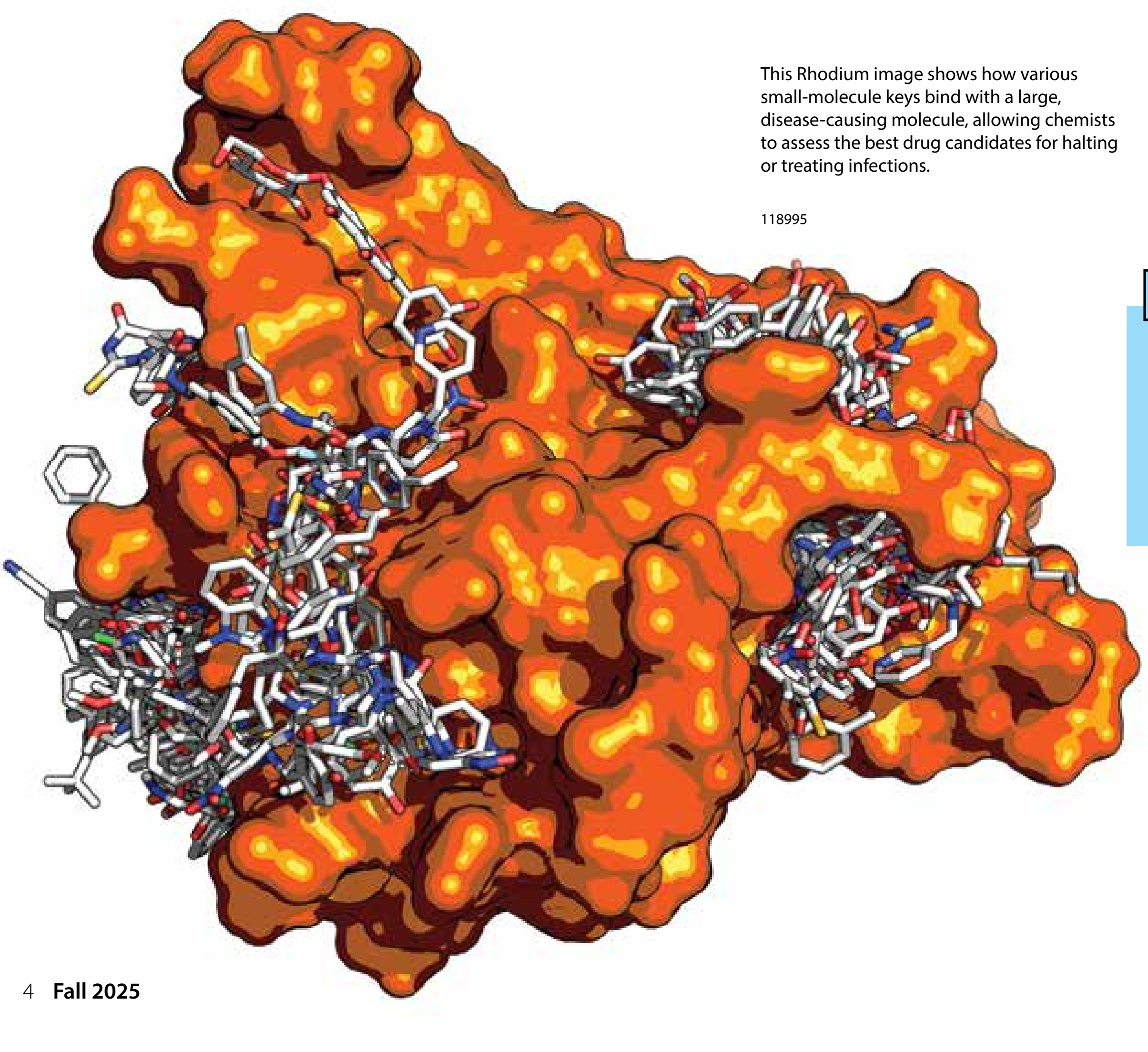
Around 2010, Southwest Research Institute tapped its multidisciplinary expertise in computer science and chemistry to develop a rudimentary version of Rhodium™, SwRI's proprietary molecular docking platform.

A grandfather clock offers an apt analogy for drug discovery that connects the contexts for antivirals or cancer therapeutics. The clock represents a large disease-causing molecule such as a protein produced by a virus or tumor needed to spread or grow. The protein requires special keys, or small molecules, that fit precisely into a keyhole or binding site to cause undesirable replication. For a clock, the key winds the mechanism that keeps it running. Viruses or invasive tumors will spread or grow unless the replicating agent is locked out. In the context of antivirals, drug developers look for "inhibitor" keys or ways to stop the "clock" and thwart infected cells. These inhibitors may compare to tipping the clock over, jamming its hands or filling in the keyhole. Rhodium identifies inhibitors to stop the clock and ranks how well those small molecules will perform against viruses or, for oncology, address rapid, uncontrolled cell growth.

Rhodium software enables computer-aided drug design and structure-based virtual screening to accelerate drug discovery and allow for strategic development of pharmaceuticals.

Molecular docking uses computational methods to predict the preferred orientation of one molecule to another, like a ligand binding to a protein. It essentially predicts how a small molecule, the ligand, will meld with the binding site of a larger molecule, the protein, similar to a lock and key.

Scientists began using Rhodium for SwRI's medical countermeasures research to speed up the search for viable antidotes for nerve agents and pesticide exposure. With Rhodium, picking winning compounds was no longer a lengthy process of elimination nor a matter of



This Rhodium image shows how various small-molecule keys bind with a large, disease-causing molecule, allowing chemists to assess the best drug candidates for halting or treating infections.

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DETAIL

A protein crystal structure depicts the three-dimensional structure of molecules, determined through crystallography, that reveals the protein's atomic structure.

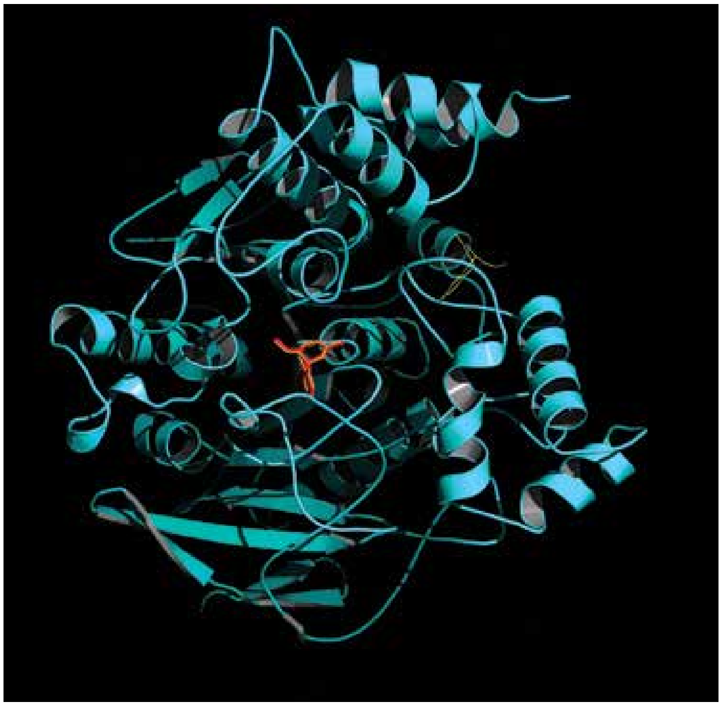
chance. The initial code for Rhodium provided a springboard for further development.

RHODIUM EDGE

Rhodium pinpoints and predicts precisely where a drug will likely bind to a protein associated with a disease based on its 3D structure. When a drug molecule binds with a protein, it can block or modify the functionality of the protein to circumvent disease.

SwRI's pharmaceutical and bioengineering researchers support every facet of drug discovery and development through clinical trials, following Current Good Manufacturing Practices. Rhodium molecular docking services supercharge what's possible for clients, allowing comprehensive 3D analysis of the protein crystal structure of target molecules, such as proteins key to diseases. It is particularly advantageous during the initial drug discovery phase, because conducting early screening for new medications is expensive, time consuming, and may be limited by specialized lab access, such as biosafety constraints in discovery of new anti-infective drugs. Eventually new drugs are tested in clinical trials. But first, meeting strict potency and purity standards is required for obtaining FDA approval for a trial.

Rhodium can narrow down the list of potential treatments for disease, scouring massive *in silico* compound libraries for those with a high probability of effectiveness (or potency, using fully traceable simulations. SwRI offers small molecule protein docking simulations as a service to SwRI clients and collaborators to support their drug development programs.



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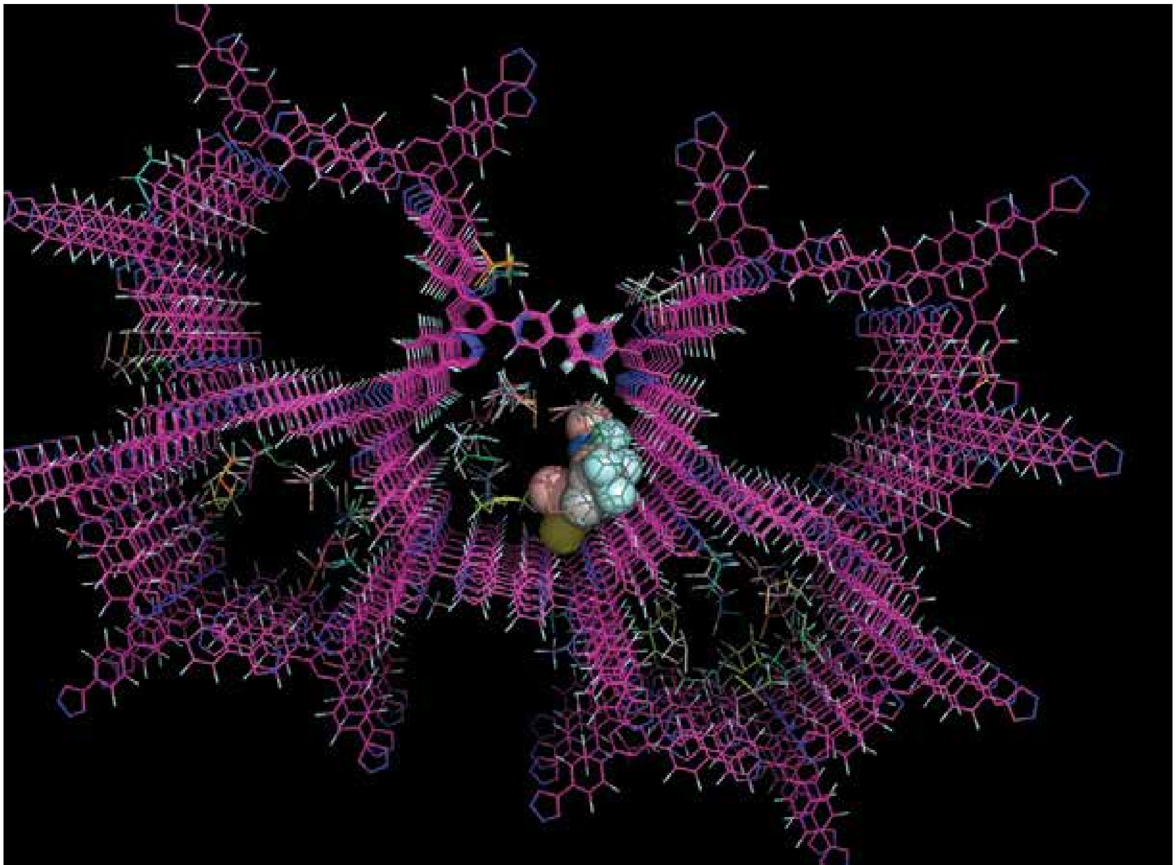
In 2013, chemists used Rhodium software to screen potential treatments for Alzheimer's disease (red), shown here interacting with a neural enzyme (cyan).

DETAIL

In silico means "in silicon" referring to the silicon often used to make computer chips. *In silico* means in or on a computer.

In 2017, SwRI tapped into mobile communications technology to turbo-charge Rhodium software, accelerating its processing capabilities. The resulting optimized "supercomputer" enabled streaming up to four times faster to visualize in 3D how an organic structure captures a powerful anesthetic.



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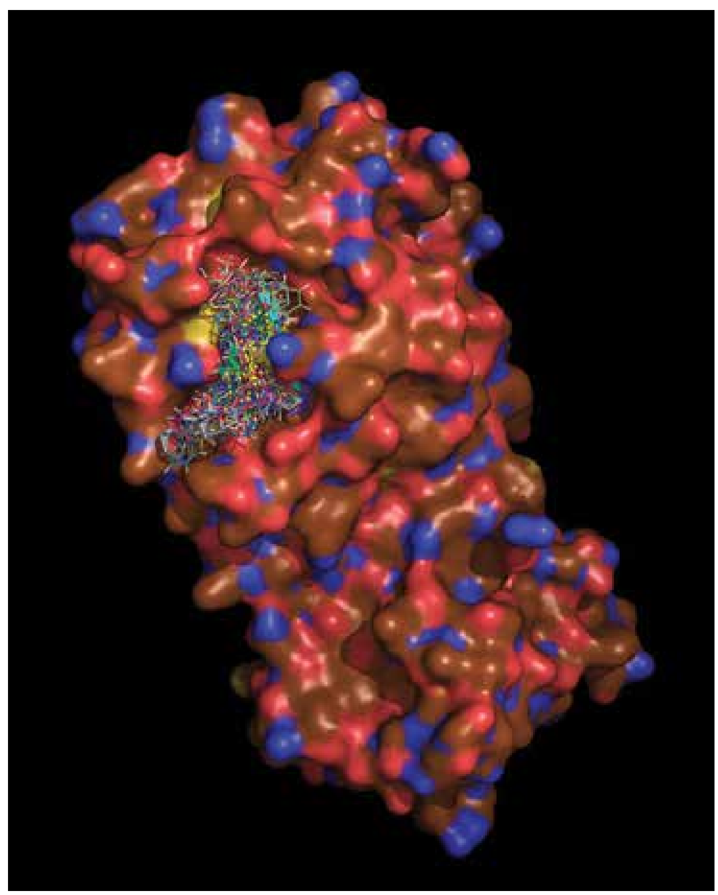
SwRI's drug discovery team wears 3D glasses to visualize the protein crystal structure of diseases in three dimensions to understand how an inhibitor compound may bind to the disease to prevent spread. The 3D analysis of the disease structure is performed using Rhodium software.

A DECADE OF DEVELOPMENT

In 2014, Rhodium could screen around 25,000 compounds a day. Even those early iterations were a breakthrough for scientists. Through the integration of machine learning, graphical processing and expanded computer capacity over the last decade, Rhodium can now screen 250,000-plus compounds each day, increasing the number of candidates screened and the likelihood of success. A direct-search grid pattern algorithm delivers a "first-pass" solution in one-tenth of a second, which is subsequently refined to provide accurate and speedy results making it possible to find the proverbial needle in a haystack.

The software also complements the development of laboratory assays, procedures that measure the biological effect of a drug candidate in a research setting. In connection, Rhodium can help assess compounds as control drugs or tools to study diseases. Virtual screening also saves on capital equipment and laboratory space, which is of particular concern when exploring treatments for highly infectious diseases or antidotes for toxic nerve agents, where testing is limited by biosafety constraints.



SwRI's Rhodium virtual screening software used this 3D model of a SARS-CoV-2 protein to evaluate millions of drug compounds to identify therapies effective against COVID-19.

IMAGE COURTESY SwRI/PROTEIN DATABANK (RCSB.ORG), ENTRY 6LU7

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COVID'S WAKE

Somehow the COVID-19 pandemic simultaneously feels as if it happened in the distant past and much more recently. More than five years ago, SwRI joined worldwide efforts to rapidly find coronavirus cures to save lives. First, SwRI's drug discovery and development team increased Rhodium's processing power to evaluate treatments. Using internal research funding, the team expanded the software, allowing it to take advantage of high-performance supercomputers to screen 40 million drug compounds based on the structure of the Sars-CoV-2 virus main protein. SwRI continues to use Rhodium to search for broad-spectrum antiviral treatments, prepare for future pandemics and support other medical countermeasures. In 2024, SwRI received two patents for inhibitors to target coronavirus spike receptors for SARS-CoV-1, SARS-CoV-2, MERS-CoV and other variants and antiviral drugs designed to target the N-terminal domain, found at the beginning of the protein chain, for the spike receptor binding domain of the coronavirus. Additional research continues for antiviral drugs treating Dengue virus and Lassa fever.

DNA DOMAIN

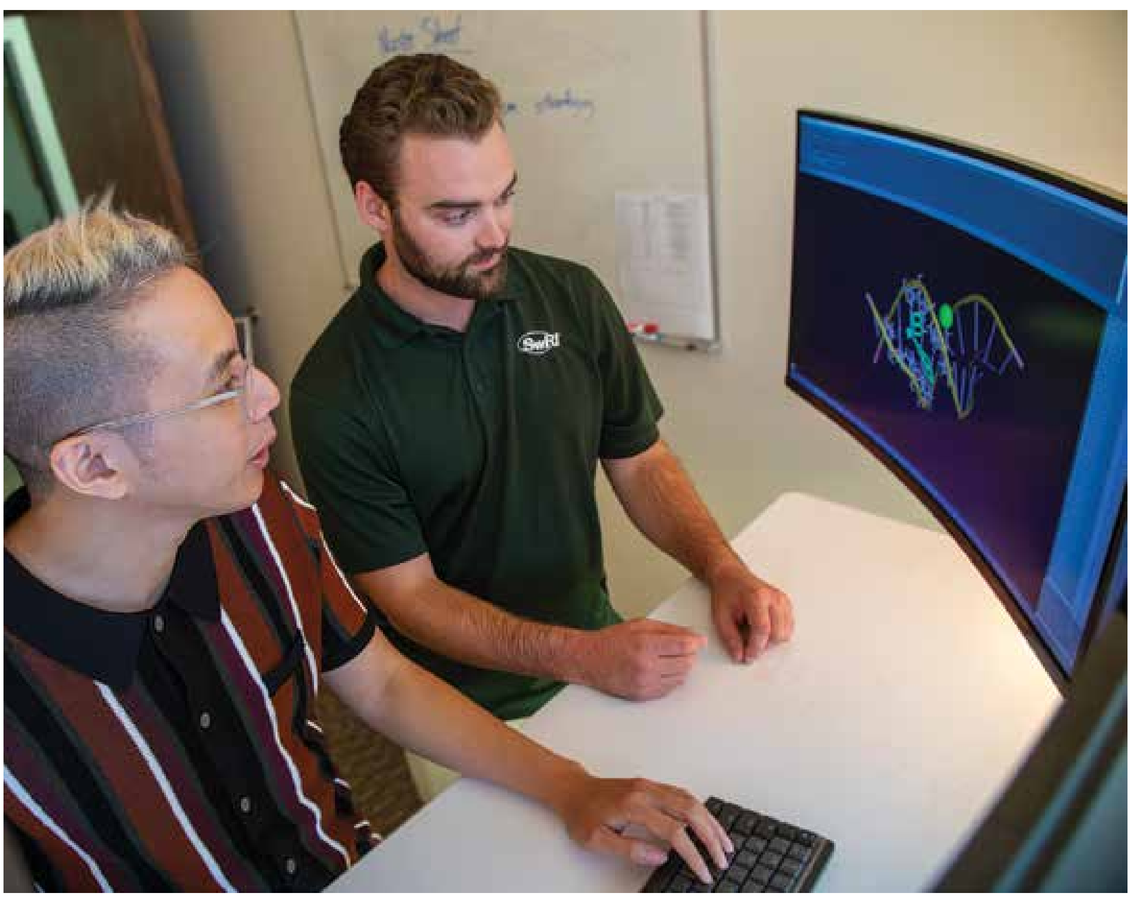
In 2024, SwRI expanded Rhodium's capabilities beyond proteins to screen DNA-targeting compounds and visualize and rapidly predict how DNA-targeting therapeutics can attack cancer cells as well as other diseases. While a number of drug development platforms and machine learning methods virtually screen drugs that target proteins, fewer methods exist for screening drugs that target DNA.

According to the World Health Organization, cancer is a leading cause of death worldwide, responsible for one in six deaths globally. Chemotherapy uses a combination of drugs to slow or stop the growth and spread of cancer cells and shrink tumors. Many of these chemotherapeutics directly target DNA, slowing cancer growth but potentially damaging the DNA in healthy cells and causing severe side effects, medical complications and even secondary metastases. Cancer cells often have mutated DNA repair machinery and replicate much faster than healthy cells, which makes DNA a viable target for selective cancer treatment.

SwRI has now successfully demonstrated a virtual screening application to design more selective DNA-targeting therapeutics to combat different types of cancer and infectious diseases. Researchers virtually screened numerous cancer-fighting compounds, ranked their potential effectiveness as treatments and are now applying the software to design next-generation chemotherapies.

MEASLES MISSION

SwRI collaborated with The University of Texas at San Antonio, Texas Biomedical Research Institute and the UT Health Science Center, to identify more than two dozen viable treatments for zoonotic pathogens that can jump from animal hosts to infect



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SwRI scientists used Rhodium's molecular docking platform to predict the DNA binding affinity and cell toxicity of cancer-fighting drugs.

DETAIL

A zoonotic disease is transmitted between animal and human hosts. These infections are caused by pathogens, such as bacteria, viruses, parasites or fungi.

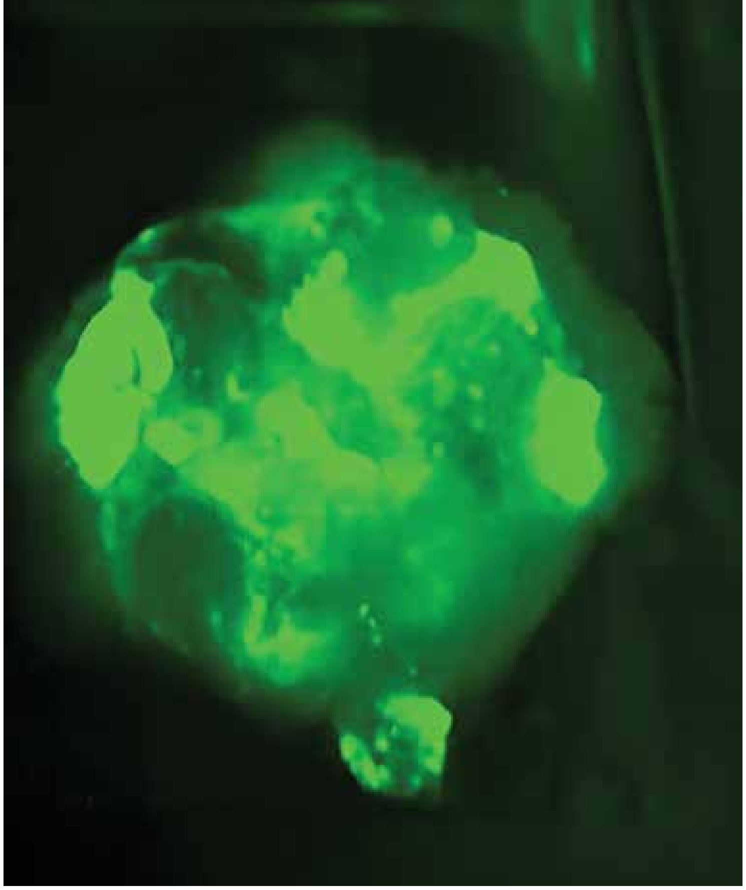

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IMAGE COURTESY TEXAS BIOMEDICAL RESEARCH INSTITUTE

Researchers at SwRI, UTSA and Texas Biomed used SwRI's Rhodium software to identify viable compounds to treat emerging zoonotic pathogens, such as this Nipah virus infection growing in this humanized organoid. These emerging viral threats can jump from animals to humans, where they are particularly lethal.

humans. The team used Rhodium software to map the protein structure of the measles virus, searching for a broad-spectrum treatment that could potentially treat Hendra and Nipah viruses. The measles virus is closely related to these deadly bat-borne henipaviruses, which are endemic to some parts of the world and cause particularly lethal infections in humans.

Researchers are particularly interested in these viruses because they frequently spillover from animals to humans, which elevates their pandemic potential. Out of 40 million compounds, Rhodium identified 30 potentially viable viral inhibitors that attach to a protein present on henipaviruses. Virtual screening narrows the list of potential treatments while reducing demands for high-containment laboratories and saving time and resources. More research is needed to validate and develop the viral inhibitors Rhodium identified. In early 2025, a measles outbreak in Texas highlighted the need for broad-spectrum treatments.

PLAYING GAMES

In 2025, SwRI continued its expansion of the Rhodium platform with the Generative Approaches for Molecular Encodings (GAMES) model. Through multidisciplinary research, SwRI's drug discovery experts collaborated with Institute engineers specializing in artificial intelligence to develop the model. GAMES generates valid Simplified Molecular Input Line Entry System (SMILES) characters, which are text-based language encodings for candidate drugs. Researchers trained the GAMES model to understand and generate accurate new combinations of SMILES characters. SwRI scientists use the SMILES language to encode this information for use by Rhodium.

SwRI's LAMP initiative, an internal research program focused on the adoption and advancement of large language models (LLMs), funded the program. Using LLMs with drug discovery and generative artificial intelligence offers the potential to deliver an almost infinite number of new treatments. These candidates could be synthesized to produce viable drug candidates.

GAMES demonstrates a systematic way to build databases of molecules for AI processing and comparison using a language-based method. This offers advantages over traditional data science methods such as Quantitative Structure Activity Relationships (QSARs). Developed in the 1960s, QSARs use linear mathematical models to connect chemical structures with biological properties, relying on mathematical representations called descriptors or fingerprints. Mathematical and graphical representations are already integrated into Rhodium. Incorporating non-linear GAMES into the Rhodium workflow offers a way to go beyond traditional descriptors to explore the generative possibilities available through large language models.

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ABOUT THE AUTHOR:

Dr. Jonathan Bohmann is a staff scientist who pioneered the development of SwRI's high-performance Rhodium molecular docking platform. This novel simulation program has proven applications in diverse areas of drug discovery, including neuroscience, virology, oncology and anti-infectives.

Bohmann presented a poster about research into henipavirus countermeasures at the Hendra@30 conference sponsored by the Australia's National Science Agency CSIRO. Bohmann co-authored the work with Dr. Stanton McHardy of The University of Texas at San Antonio and Dr. Olena Shtanko of Texas Biomedical Research Institute.

TIMELINE

2011 — Rhodium software development begins

2012 — Internal research program adds GPU processing capability

2015 — Grand Challenge docking contests demonstrate accuracy

2020 — Rhodium used to screen for drug treatments for coronavirus and other infectious diseases

2023 — Machine learning is integrated into Rhodium software

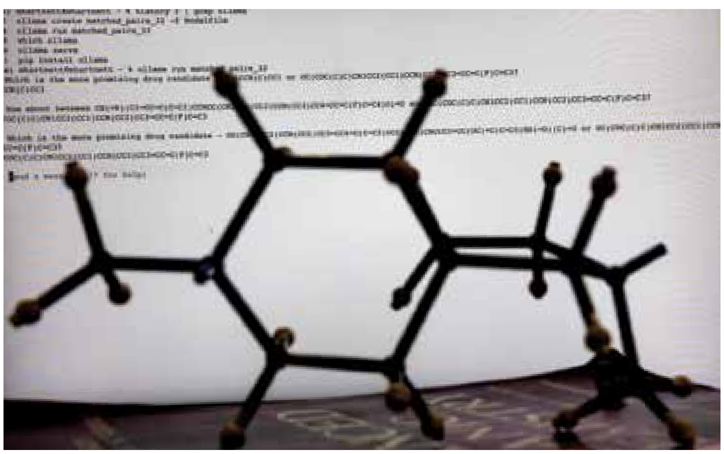
2024 — Nipah and Hendra antiviral poster presented in Australia

2025 — GAMES model created

2025 FORWARD

Accuracy, selectivity and proven results all top the list of reasons Rhodium continues to play an integral part in SwRI's comprehensive drug discovery and development process. With its world-class computer-aided drug design and virtual screening, Rhodium software provides fully traceable simulations and comprehensive 3D protein crystal structure analysis to continuously push new therapeutics forward. Rhodium's revolutionary capabilities have enabled numerous pilot projects and large multiyear research programs. Over the next 10 years, SwRI hopes to continue to discover new and viable pharmaceuticals and biologics key for treating cancer and infectious diseases while anticipating how to conquer the next possible pandemic. SwRI's Rhodium software is a 21st century solution for accelerating drug development with the ultimate goal of alleviating suffering and saving lives.

Questions about the story? Contact Dr. Jonathan Bohmann at 210-522-5219 or jonathan.bohmann@swri.org.



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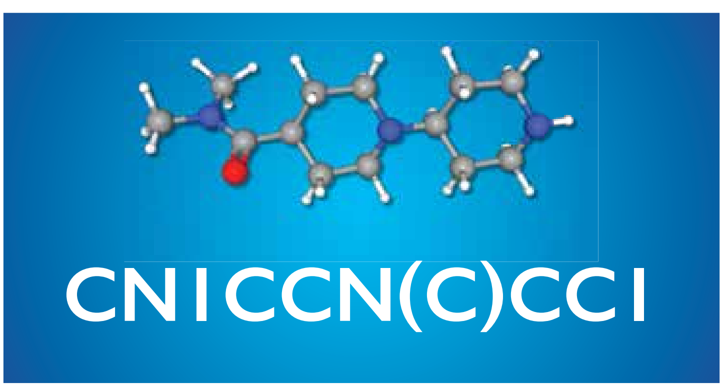
SwRI developed the GAMES machine-learning application to generate valid SMILES characters (background), text-based language encodings for candidate drugs. GAMES provides a systematic technique for building databases of molecules, represented by the chemical structure in the foreground, for AI processing within the Rhodium platform.



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SwRI developed a large language model known as GAMES to generate Simplified Molecular Input Line Entry System strings. The lower text-based string represents the structure of the chemical molecule above.

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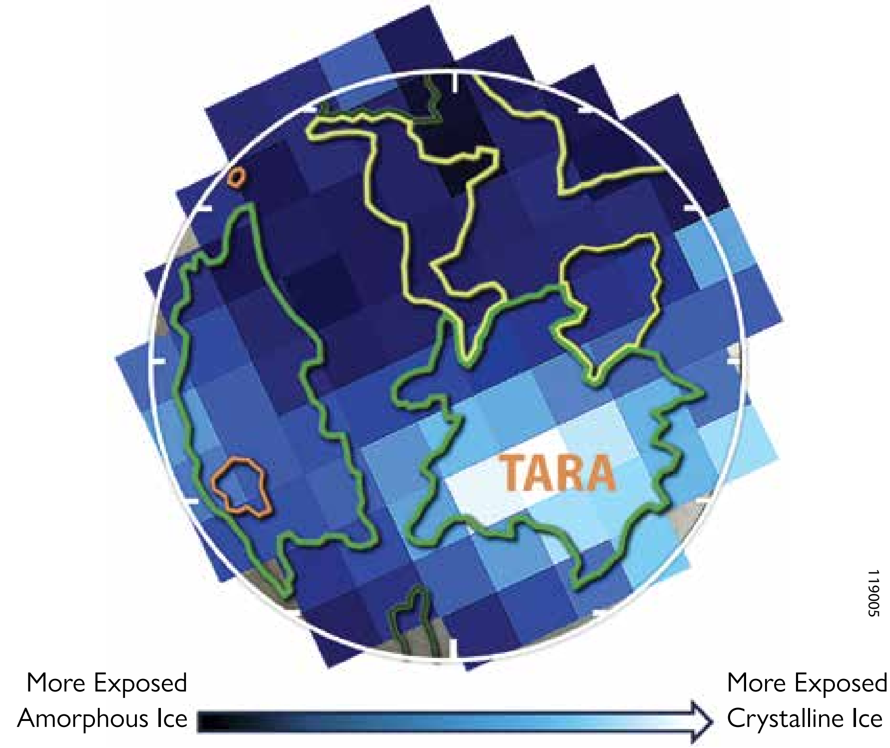
Rhodium accelerates the drug development process by narrowing down the best candidates for conventional development and evaluation processes.

ONGOING SURFACE MODIFICATIONS ON EUROPA



SwRI experiments produced evidence to support spectral data recently collected by JWST showing that the icy surface of Jupiter's moon Europa is constantly changing. Ice on Europa is developing at different rates in different places, such as Tara Regio, where crystalline ice (lighter colors) is found both on and below the surface.

A series of experiments conducted at SwRI's Center for Laboratory Astrophysics and Space Science Experiments (CLASSE) facility supports observations of Jupiter's icy moon Europa by the James Webb Space Telescope (JWST).

One study showed that Europa's surface is constantly changing, as ice crystallizes at different rates in different places, resulting from a complex interplay of thermal and radiation-driven processes. Another study provided insights into the origin of elevated hydrogen peroxide (H_2O_2) near the moon's equatorial chaos regions.

CRYSTALLINE CHAOS ICE

In one study, the team conducted extensive laboratory experiments to assess time scales for the amorphization and recrystallization of ice on Europa, particularly in chaos terrains where features such as ridges, cracks and plains are jumbled together. A new paper co-authored by SwRI's Dr. Ujjwal Raut weaves the JWST spectral data and SwRI experiments to understand crystallization dynamics of chaos ice.

For the past couple of decades, scientists have thought that Europa's surface was covered by a very thin layer of amorphous ice protecting crystalline ice beneath this upper veneer (~ 0.5 mm depths). This new study found crystalline ice on the surface as well as at depth, especially at Tara Regio, a prominent chaos region in Europa's leading hemisphere.

"We think that the surface is fairly porous and warm enough in some areas to allow the ice to recrystallize rapidly, outpacing radiation-induced amorphization," said Dr. Richard Cartwright, lead author of the paper from Johns Hopkins University's Applied Physics Laboratory.

PUZZLING PEROXIDES

In a separate study, SwRI scientists conducted lab experiments to address a mystery about the distribution of frozen hydrogen peroxide on Europa. Scientists studying the telescope data noticed elevated levels of hydrogen peroxide on Europa in unexpected areas — the highest peroxide concentrations were found in the warmer equatorial chaos terrains rather than the colder regions towards the poles. Further research revealed that areas with enhanced peroxide also showed elevated levels of CO2, which may be seeping up through cracks in the ice shell from a presumed subsurface ocean.

"We simulated the surface environment of Europa inside a vacuum chamber by depositing water ice mixed with CO_2 and irradiated this ice mixture with energetic electrons," said Bereket Mamo, a graduate student at The University of Texas at San Antonio and an SwRI contractor. He conducted the research through a Future Investigators in NASA Earth and Space Science and Technology grant, with results highlighted in a Planetary Science Journal paper.

"The SwRI experiments demonstrated that trace amounts of CO_2 in water ice can significantly enhance hydrogen peroxide production through radiolysis, helping explain the new JWST observations that show CO_2 and H_2O_2 are spatially linked, co-existing in the chaos regions," Raut concluded.

SwRI experiments offer insight into a hydrogen peroxide chemical cycle on Europa. Carbon-bearing species rising to Europa's icy surface from a subsurface ocean are irradiated by Jupiter's energetic plasma, synthesizing peroxide that may be cycled back down to the ocean, releasing chemical energy that may contribute to the ocean's habitability.

IMAGE COURTESY NASA/JPL-CALTECH 118972

SOLAR WIND PARTICLES POINT TO RECONNECTION

Research led by an SwRI scientist identified a new source of energetic particles near the Sun. Instruments aboard NASA's Parker Solar Probe made these definitive observations, detecting the powerful phenomena as the spacecraft dipped in and out of the solar corona.

These new results offer fresh perspectives on how magnetic reconnection could heat the solar atmosphere, which then transitions into the solar wind, and also how solar flares accelerate a small fraction of charged particles to near-relativistic speeds.

"Through the SwRI-led Magnetospheric Multiscale mission, scientists made the first direct detection of the source of magnetic reconnection near Earth, observing how this explosive physical process converts stored magnetic energy into kinetic energy and heat," said SwRI's Dr. Mihir Desai, lead author of a new paper about this research. "Now Parker has made direct observations of how magnetic reconnection at the heliospheric current sheet (HCS), where the interplanetary field reverses its polarity, energizes charged particles to extremely high energies."

As Parker crossed the HCS, scientists discovered a sunward-directed reconnection jet and sunward-propagating highly energetic protons, establishing their origin from HCS reconnection sites and not from unrelated processes at the Sun. Within the core of the reconnection exhaust, Parker detected trapped energetic protons with energies a thousand times greater than the available magnetic energy per particle.

"These findings indicate that magnetic reconnection in the HCS is an important source of energetic particles in the near-Sun solar wind," Desai said. "Everywhere there are magnetic fields there will be magnetic reconnection. But the Sun's magnetic fields are much stronger near the star, so there's a lot more stored energy to be released."

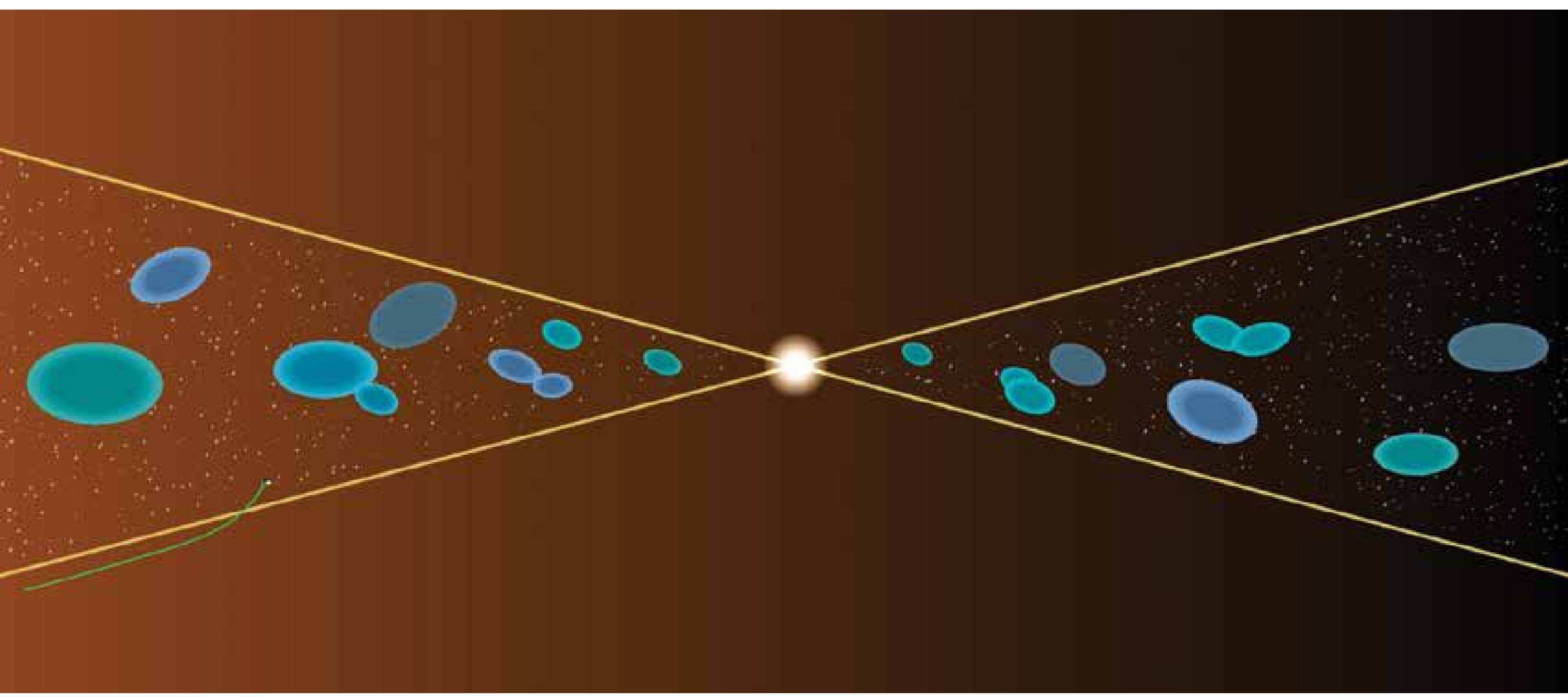
Magnetic reconnection — when magnetic field lines converge, break apart and reconnect in an explosive physical process — energizes particles and generates high-speed flows. At the heart of space weather, reconnection is responsible for powerful solar events, such as solar flares and coronal mass ejections (CMEs), and drives disturbances in Earth's space environment. Such disturbances produce spectacular auroras but can also shut down electrical power grids and disrupt satellite-based communication and navigation systems.

"Reports from the American Meteorological Society indicated that the powerful solar events in May 2024 wreaked havoc on farmers when extreme geomagnetic storms disrupted the precise GPS-guided navigation systems used to plant, fertilize and harvest rows of seeds, causing an estimated loss of up to $500 million in earning potential," Desai said. "Parker's access to this new data is critical, particularly as we remain in the midst of a very active solar cycle."

Parker was able to make these measurements due to its record-breaking proximity to the Sun, flying through its corona up to three times a year. Of particular interest is understanding how the Sun's atmosphere heats up and accelerates the solar wind. Understanding these processes can also help scientists develop ways to predict and mitigate the effects of solar flares and CMEs, as well as provide new insights for laboratory fusion research.

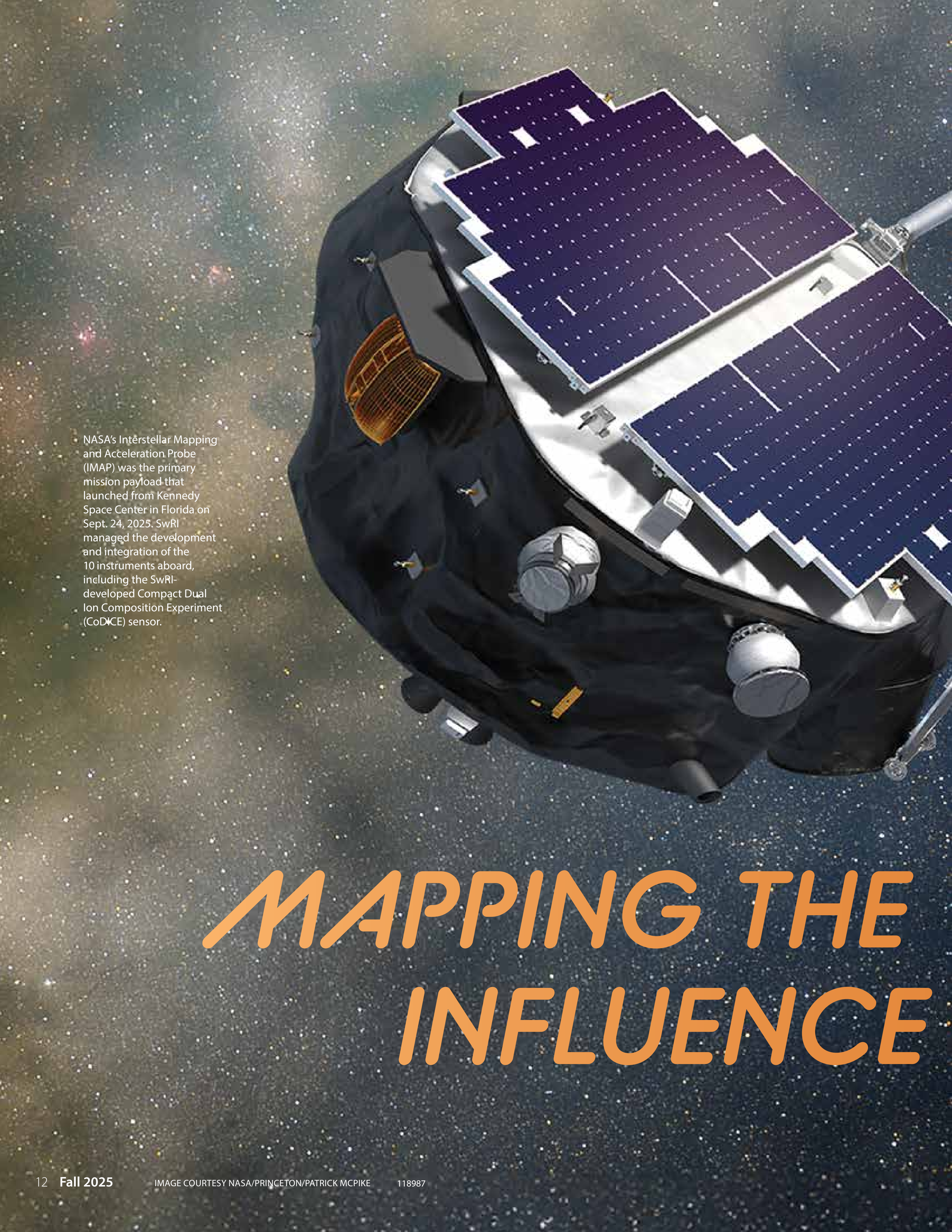
The Parker Solar Probe was developed as part of NASA's Living With a Star program.

IMAGE COURTESY JHUAPL 118988



An SwRI-led study identified particles accelerated to extremely high energies by magnetic reconnection near the Sun. As NASA's Parker Solar Probe (trajectory shown in green) crossed the heliospheric current sheet, it encountered merging magnetic islands (blues) and protons accelerated toward the Sun, establishing reconnection as their source, distinct from unrelated solar processes.

MAPPING THE INFLUENCE



NASA's Interstellar Mapping and Acceleration Probe (IMAP) was the primary mission payload that launched from Kennedy Space Center in Florida on Sept. 24, 2025. SwRI managed the development and integration of the 10 instruments aboard, including the SwRI-developed Compact Dual Ion Composition Experiment (CoDICE) sensor.

IMAGE COURTESY NASA/PRINCETON/PATRICK MCPIKE 118987

Space is a vast, near-perfect vacuum largely devoid of matter — but it's not entirely empty. It just contains very few particles compared to Earth's atmosphere. On average, a dice-sized cube of Earth's atmosphere contains billions and billions of air particles, but in space, the same-sized cube contains only one or two particles.

This sparse population is mostly hydrogen and helium atoms as well as other gases, in both charged and neutral forms. This medium also contains dust, tiny particles of various elements, including carbon and silicon, scattered throughout.

SUN'S ACROSS SPACE

The trio of spacecraft designed to monitor and map the heliosphere and the solar wind that defines it are shown here prior to integration in the rocket fairing at left. SwRI played key roles in both NASA's IMAP mission, the primary spacecraft on top, and SWFO-L1, the NOAA satellite on the right. The Carruthers Geocorona Observatory on the left is the third ride-share payload.

IMAGE COURTESY SPACEX 119089

Of particular interest are high-energy particles called cosmic rays — primarily protons and the nuclei of atoms — traveling through space at nearly the speed of light. Cosmic rays come from various stars including our Sun, as well as from supernovae, colliding galaxies and more. And these high-energy particles are of particular interest because of how they can affect humans and modern life. In the near-Earth environment, exposure to this space radiation can affect astronauts and spacecraft, including the GPS technology that is ubiquitous to navigating life on Earth, including aviation and agriculture. It can also affect electric grid technology.

Exposure to space radiation is regulated by many things, including the Earth's magnetic field as well as the solar cycle. During solar maximum, the "balloon" around our solar system is fully inflated, offering better protection from galactic cosmic rays. But these active periods produce more powerful and frequent solar activity such as bursts of solar energetic particles associated with coronal mass ejections and solar flares, allowing more of these particles to penetrate the Earth's magnetic field. For instance, reports from the American Meteorological Society indicated that the powerful solar events in May 2024 wreaked havoc with farmers. Extreme geomagnetic storms disrupted the precise GPS-guided navigation systems used to plant, fertilize and harvest rows of seeds, causing an estimated loss of up to $500 million in earning potential.

In contrast, at solar minimum, when our Sun is least active, the boundary between the influence of the solar wind and the interstellar medium contracts. This deflated balloon provides less shielding from the background galactic cosmic rays, characterized by very high radiation, from interstellar space.

On Sept. 24, 2025, NASA launched two spacecraft loaded with Southwest Research Institute technology designed to better understand and predict these high-energy phenomena. NOAA's Space Weather Follow-On Lagrange 1 (SWFO-L1) satellite shared a ride to space with the primary payload, NASA's Interstellar Mapping

The sunrise launch of the SpaceX Falcon 9 rocket with SwRI-developed instruments and technology aboard symbolized the dawn of a new era in heliophysics and space weather research.

IMAGE COURTESY BAE SYSTEMS/BENJAMIN FRY 118986

IMAGE COURTESY NASA JOHNS HOPKINS APL/ED WHITMAN 119091

Technicians perform final integration of the SwRI-developed Compact Dual Ion Composition Experiment (CoDICE) instrument into NASA's IMAP observatory.

119092

SwRI's Jacob Friday (left) and Benjamin Rodriguez install red "remove before flight" protectors from the CoDICE instrument in preparation for delivery. The Sun-facing side of CoDICE is coated in a shiny 'gold' metal to reflect the heat of the Sun. The opposite side has a matte black surface designed to retain as much heat as possible to slow dissipation into the cold vacuum of space.

DETAIL

The enigmatic nature of suprathermal tails stems from their ubiquitous presence across the range of solar wind conditions. These charged particles move at velocities significantly higher than the main populations but do not reach the energies of cosmic rays, even in quiet, undisturbed regions of the solar wind, far from any shocks.

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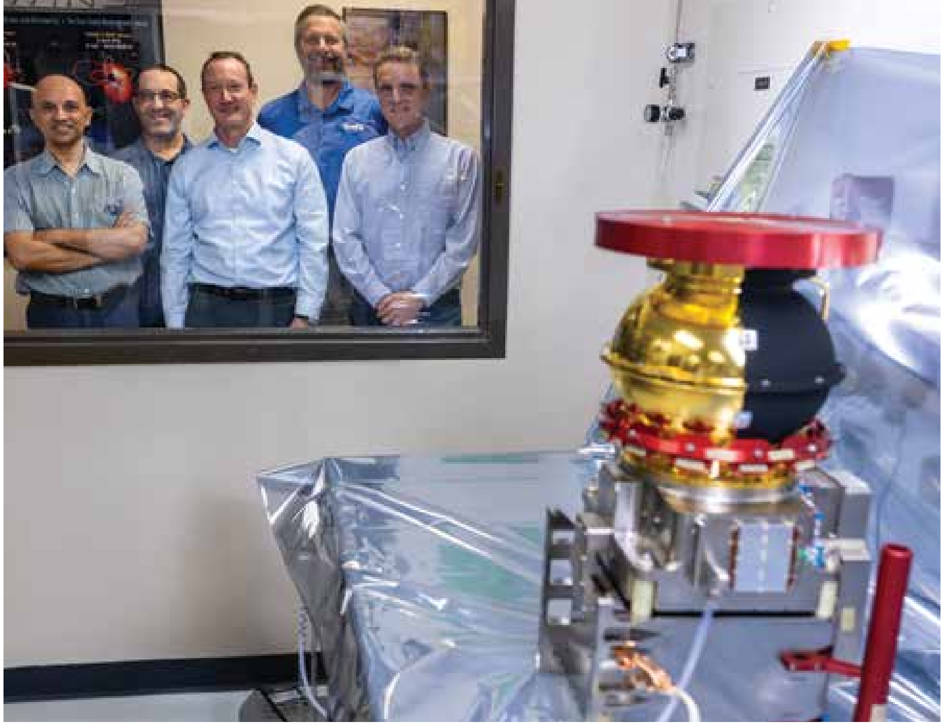

SwRI's CoDICE instrument team included, from left, Deputy Instrument Lead Dr. Mihir Desai, Flight Software Lead Greg Dunn, Quality Assurance Lead Tim Brenner, Project Manager Steve Persyn and Systems Engineer Jeremy Ford.

and Acceleration Probe (IMAP) mission, along with a third ride-share payload, the Carruthers Geocorona Observatory.The sunrise launch of the SpaceX Falcon 9 payload symbolized the dawn of a new era in heliophysics and space weather research.

IMAP

The first satellite to deploy following launch was IMAP. SwRI played a major role in this mission, managing the payload office and providing a scientific instrument and other critical technology. SwRI Space Science Division Executive Director Susan Pope is the mission's payload manager, Institute Scientist Dr. Mark Tapley is the payload systems engineer, and Group Leader Paul Bland is the payload safety and mission assurance lead.

IMAP features the next generation of instruments that will provide improved data to meet mission objectives. SwRI managed the science and technology payload to achieve the mission's goals through coordinated scientific measurements. IMAP will scan the heliosphere, analyze the composition of charged particles, and

After extensive bench testing, SwRI's Dr. Frédéric Allegrini (left) and Ben Rodriguez install IMAP-Hi's Front End Electronics board and IMAP-Hi's detector for vacuum testing inside SwRI's calibration chamber.

IMAGE COURTESY NASA/UNH/JEREMY GASOWSKI

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The University of New Hampshire's Skylar Vogler (left) and SwRI's Amanda Wester use UV light to detect and remove particles from the IMAP-Lo collimator grids and spacers.

IMAGE COURTESY BAE SPACE & MISSION SYSTEMS 119090

The SWFO-L1 satellite, shown following arrival for final preparations, is NOAA's first satellite designed specifically for continuous, operational space weather observations. SwRI provided two of the four science instruments, SWiPS (silver and red instrument, top center) and SWFO-MAG, which will be deployed on an 18-foot boom.

investigate how the particles move throughout the solar system. This will provide insights into how the Sun accelerates charged particles, helping to complete essential pieces of the puzzle needed to understand the space weather environment throughout the solar system.

IMAP will primarily investigate two of the most important overarching issues in heliophysics. Namely, how charged particles from the Sun are energized to form what's known as the solar wind and how that wind interacts with interstellar space at the heliosphere's boundary.

This boundary offers protection from most intense radiation originating outside our heliosphere — key to creating and maintaining a habitable solar system. The physics of the boundary and how it changes over time helps explain why our solar system can support life as we know it.

IMAP has been described as a modern-day celestial cartographer that will fill in blank spots on the map of the heliosphere. The spacecraft will study the Sun's activity and how the heliosphere boundary interacts with the local galactic neighborhood beyond. A major focus for IMAP is to explore the space filled with plasma from the Sun that envelops all the planets in our solar system. Here, the outpouring of solar material collides with the local interstellar medium that fills the space surrounding the heliosphere. This interaction forms a critical barrier for high-energy cosmic rays at a distance of about 10 billion miles from the Sun.

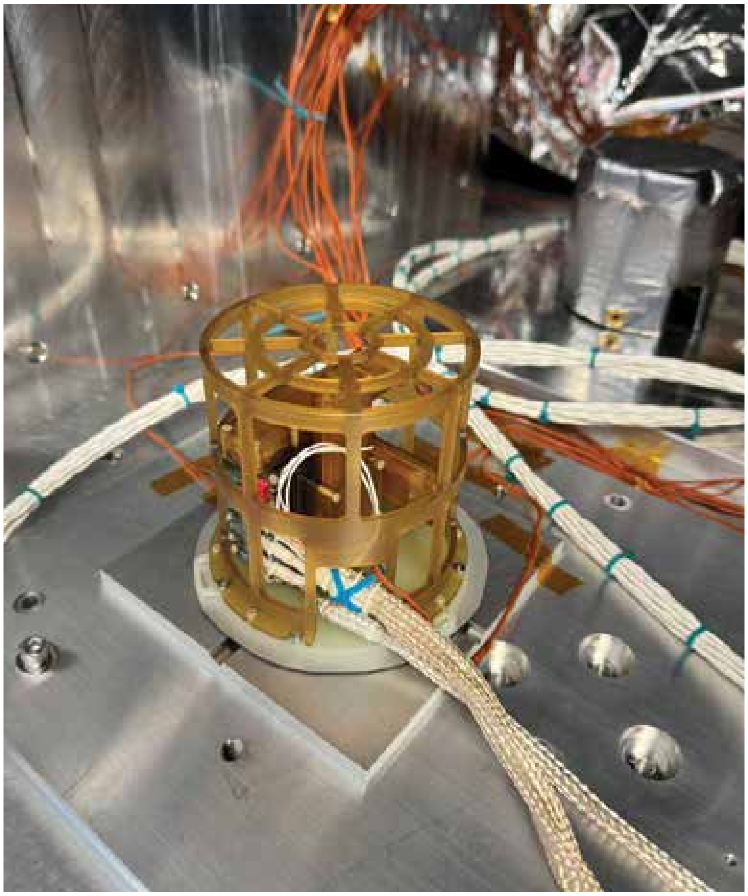
IMAP will also examine the fundamental processes that accelerate particles throughout the heliosphere and beyond. The resulting energetic particles and cosmic rays can harm astronauts and space-based technologies.

The Institute developed the novel CoDICE instrument, which combines the capabilities of multiple instruments into one patented sensor. Initially developed through SwRI internal funding, CoDICE will measure the distribution and composition of interstellar pickup ions, particles that make it through the "heliospheric" filter. Led by Dr. Stefano Livi with support from Drs. Mihir Desai and Keiichi Ogasawara, it will also characterize solar wind ions as well as the mass and composition of highly energized solar particles associated with flares and coronal mass ejections.

CoDICE combines an electrostatic analyzer (ESA) with a time-of-flight versus energy (TOF/E)

DETAIL

IMAP is a follow-on mission to NASA's Interstellar Boundary Explorer, which was led by former SwRI staff member Dr. David J. McComas. Now a Princeton University professor, McComas leads the IMAP mission, which has an international team of 27 affiliated institutions. The Johns Hopkins Applied Physics Laboratory in Laurel, Maryland, built the spacecraft and will operate the mission. IMAP is the fifth mission in NASA's Solar Terrestrial Probes (STP) Program portfolio, managed by Goddard Space Flight Center.



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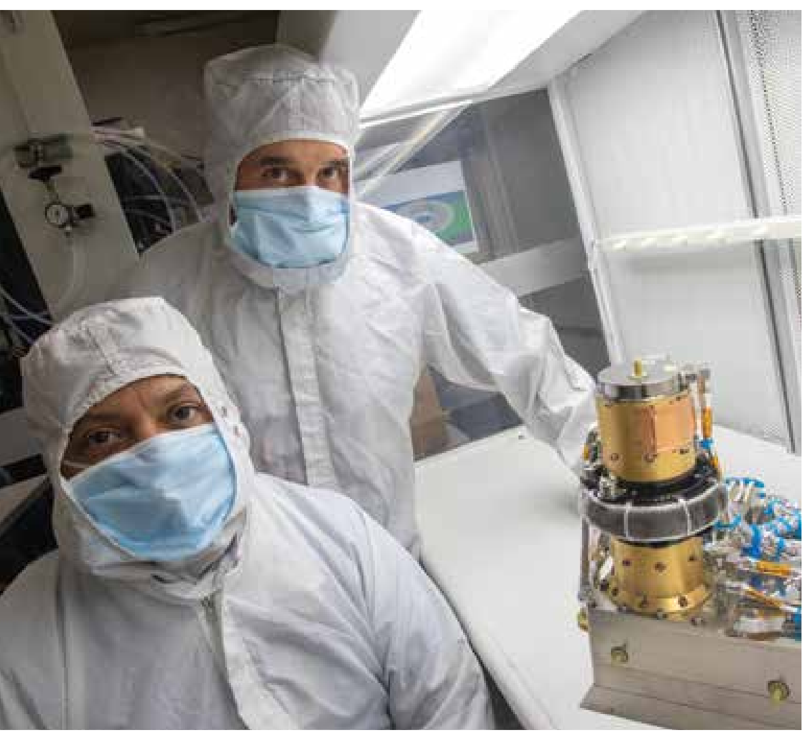
The SWFO-MAG instrument deploys two tri-axial fluxgate magnetometers on an 18-foot boom to measure variations in the interplanetary magnetic field carried by the solar wind.

SwRI's Dr. Robert Ebert and Prachet Mokashi led the development of the SWiPS instrument, one of two SwRI-developed instruments aboard NOAA's SWFO-L1.



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subsystem to simultaneously measure the velocity, arrival direction, ionic charge state and mass of specific species of ions in the local interstellar medium (LISM) surrounding our solar system. CoDICE also has a path for higher energy particles to skip the ESA but still get measured by the common TOF/E system. These measurements are critical to characterizing the composition and flow properties of the LISM, determining the origin of the enigmatic suprathermal tails in the solar wind and advancing the understanding of the acceleration of particles in the heliosphere.

CoDICE is about the size of a 5-gallon paint bucket, weighing about 22 pounds, and has a unique and beautiful thermal management design. The Sun-facing side of the instrument is coated in a shiny 'gold' metal to reflect the heat of the Sun. The opposite side has a matte black surface designed to retain as much heat as possible to slow dissipation into the cold vacuum of space.

SwRI built high-voltage power supplies for the Solar Wind Electron (SWE) instrument, which measures the distribution of thermal electrons in the solar wind, and the Global Solar Wind Structure (GLOWS) instrument, a non-imaging photometer that will observe the solar wind's structure. SwRI also provided digital electronics for four other IMAP instruments.

SWFO-L1

The SwRI-built Solar Wind Plasma Sensor (SWiPS) and SWFO Magnetometer (SWFO-MAG) are two of four instruments integrated into SWFO-L1, NOAA's first satellite designed specifically for continuous, operational space weather observations. From its unique vantage point at Lagrange Point 1 (L1), SWFO-L1 will monitor the Sun's activity without interruption, providing quicker and more accurate space weather forecasts than ever before.

SWiPS, an instrument led by SwRI's Dr. Robert Ebert, will measure the solar wind and detect solar transient events such as coronal mass ejections and interplanetary shocks that can cause adverse effects for Earth and its space environment. SwRI supports operations and data analysis for its onboard instruments. SWFO-L1 shared a ride to space with NASA's IMAP mission before separating and traveling to the Earth's L1 point, a point nearly one million miles (1.5 million kilometers) from Earth.

As part of SWFO-L1's suite of space weather-observing instruments, SWiPS and SWFO-MAG will capture 24/7 observational data in real-time to monitor abrupt changes in the solar wind often associated

DETAIL

Gravitational forces from the Sun and the Earth hold objects at Lagrange 1 (L1) in a stable position that offers an uninterrupted view of the Sun.

IMAGE COURTESY BALL/NASA-SOHO 119002

SwRI developed the SWFO-L1 MAG instrument, two sensors 13 feet (4 meters) and 18 feet (5.6 m) away from the spacecraft, mounted on deployable boom. The instrument will monitor the Sun's magnetic field for abrupt changes that are often precursors for geomagnetic storms that can interact with the interplanetary magnetic field and affect life on Earth.

DETAIL

The SWFO-L1 mission is a partnership between NOAA and NASA. The NASA Goddard Space Flight Center managed the development of the SWFO-L1 observatory on NOAA's behalf and to NOAA's specifications. NOAA will operate SWFO-L1 from its Satellite Operations Facility in Suitland, Maryland, and process the space weather data at its Space Weather Prediction Center in Boulder, Colorado.

with coronal mass ejections and other space weather phenomena. When these phenomena interact with Earth's magnetic field, they can have adverse effects on Earth and near-Earth technology. These effects can include electrical power grid disruptions, Global Positioning System navigation errors, spacecraft damage or potential harmful radiation exposure to astronauts. The SWFO-L1 data will support NOAA's Space Weather Prediction Center and help predict and prepare for potential space weather impacts.

SWiPS has two identical top-hat electrostatic-analyzer-based sensors, each capable of measuring the velocity, density and temperature of solar wind ions. The real-time, around-the-clock observations measure the plasma structures directed toward Earth, monitoring the solar wind for abrupt changes from interplanetary shocks, coronal mass ejections, corotating interaction regions, high-speed solar wind, etc.

Geomagnetic storms can reconfigure Earth's magnetosphere, the protective bubble surrounding Earth, which is disturbed by changes in the solar wind. SWiPS provides in-situ observations of the solar wind plasma directly upstream from Earth, providing an early warning of geomagnetic activity. SWiPS velocity measurements allow scientists to predict the arrival time of adverse space weather conditions. With this forewarning, public and private organizations affected by space weather can take actions to protect their assets.

Predicting the severity of geomagnetic storms is possible using measurements of the solar wind velocity, density, and temperature provided by SWiPS, along with information from the SWFO-MAG.

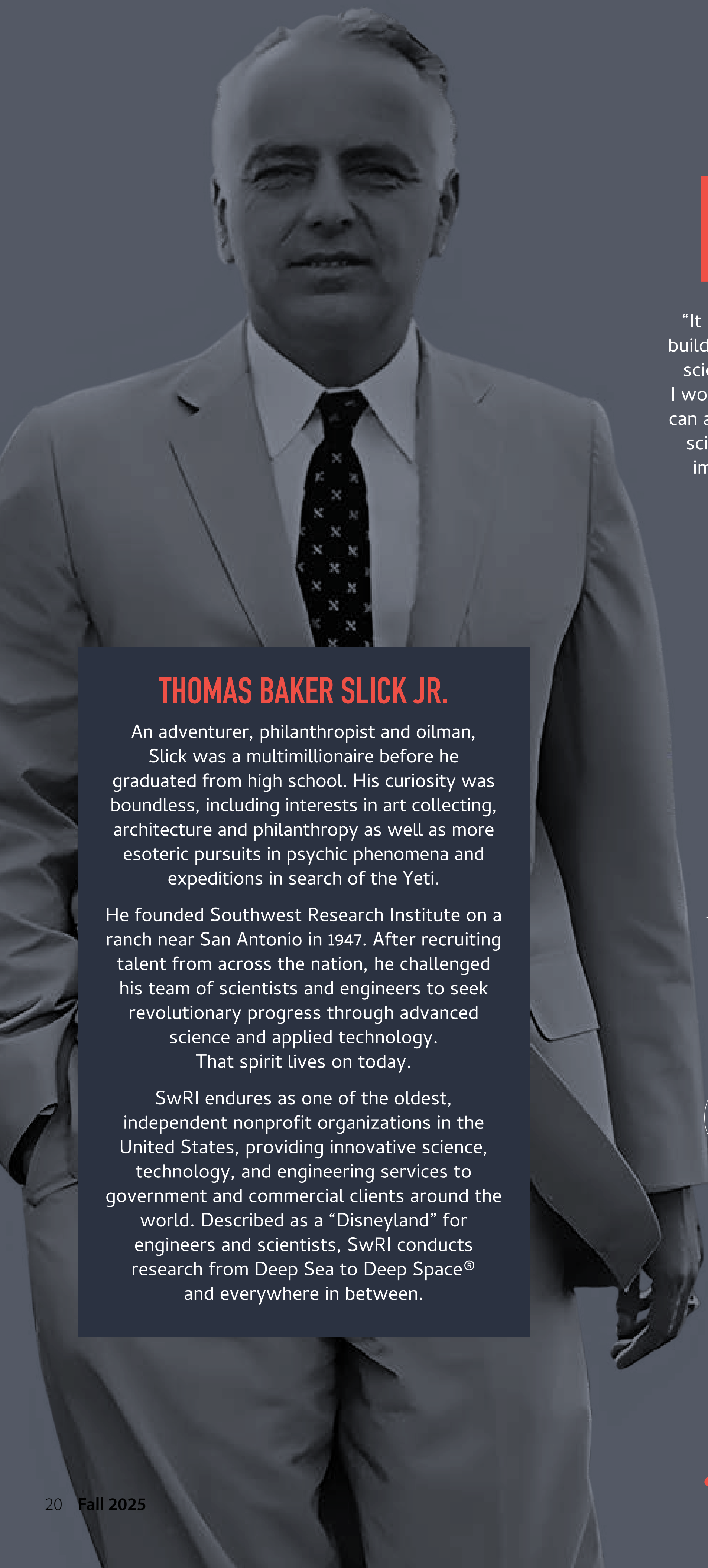
The SWFO-MAG instrument, led by SwRI's Dr. Roy Torbert out of the University of New Hampshire location, consists of two tri-axial fluxgate magnetometers that each measure the three components of the interplanetary magnetic field carried by the solar wind. The SWFO-MAG sensor's elongated racetrack shape distinguishes it from the traditional circular ring-shaped magnetometers. The elongated design provides three benefits: it reduces noise by focusing the magnetic field along its length, has more definite orientation by aligning the magnetic axis with the mechanical axis, and enhances thermal stability by distributing heat more uniformly along each axis.

The two SWFO-MAG sensors are 13 feet (4 meters) and 18 feet (5.6 meters) away from the spacecraft, mounted on deployable boom. The boom isolates the magnetometers from any spacecraft-generated fields, providing a quiet operational environment. By observing the solar wind, MAG provides real-time, around-the-clock observations of the magnetic structures directed toward Earth. The Space Research Institute of the Austrian Academy of Sciences provided SWFO-MAG's front-end electronics and its core electronics microchip.

SWFO-MAG is designed to provide NOAA and the scientific community at large with important data about the solar wind as it approaches Earth. The magnetic field variations are a key parameter in predicting the severity of a solar storm's impacts on Earth's magnetosphere. SWFO-MAG, which was built and tested in conjunction with UNH, will produce data to help mitigate space weather impacts.

PATHWAY BACK TO THE MOON

IMAP and SWFO-L1 will join a fleet of NASA heliophysics missions that seek to understand how the Sun affects the space environment near Earth and across the solar system. In a very real way, these spacecraft and instrument packages are blazing the trail for further human exploration of the Moon and eventually Mars. We haven't visited the Moon in over 50 years, and NASA is committed to making sure astronauts can safely explore our neighbors, with early warning systems in place to forecast potentially harmful space weather and galactic cosmic rays.



SwRI's FOUNDER

"It has always been my intention to work towards the building up of a great center for human progress through scientific research at our Southwest Research Center. I would like this effort to grow to be as big as it soundly can and, at the same time, to embrace as wide a range of scientific research as is practical. Equally, if not more important than size and scope, should be efforts to achieve the highest quality of accomplishment."

–Thomas Baker Slick Jr.

THOMAS BAKER SLICK JR.

An adventurer, philanthropist and oilman, Slick was a multimillionaire before he graduated from high school. His curiosity was boundless, including interests in art collecting, architecture and philanthropy as well as more esoteric pursuits in psychic phenomena and expeditions in search of the Yeti.

He founded Southwest Research Institute on a ranch near San Antonio in 1947. After recruiting talent from across the nation, he challenged his team of scientists and engineers to seek revolutionary progress through advanced science and applied technology. That spirit lives on today.

SwRI endures as one of the oldest, independent nonprofit organizations in the United States, providing innovative science, technology, and engineering services to government and commercial clients around the world. Described as a "Disneyland" for engineers and scientists, SwRI conducts research from Deep Sea to Deep Space® and everywhere in between.

Celebrating 78 Years

SwRI'S WARNER ROBINS BUILDING OPENS

SwRI has built its first facility outside of its San Antonio headquarters in Warner Robins, Georgia located 3 miles from Robins Air Force Base. The 33,000-square-foot, $18.5 million building is designed to advance national defense technology and bolster SwRI's longstanding support for the U.S. Air Force.

SwRI employees based in Warner Robins develop advanced aerospace technology and electronic warfare (EW) solutions to detect, intercept and thwart enemy radar signals. The facility offers space for technological evaluations previously conducted off-site.

"We are proud to expand our presence in the dynamic city of Warner Robins to serve the U.S. Air Force and our nation's warfighters," said Winfield Greene, director of SwRI's Advanced Electronic Warfare Department, who oversaw construction and the department's relocation. "Warner Robins and the entire middle Georgia area is looking toward the future with the Air Force base driving progress. We are eager to broaden our impact on this community with this modern, high-tech facility."

SwRI established a Warner Robins office in 1990, occupying leased space for decades. However, daily operations, a growing staff and increased workload created the demand for a larger building to support defense research and development. A groundbreaking ceremony was held at the site in May 2024, marking a new era in SwRI's 78-year history.

"As SwRI's first property outside of San Antonio, it represents an investment to support our longtime clients at Robins Air Force Base, recognizing the growing importance of its mission in national defense," said SwRI Executive Vice President and COO Walt Downing, P.E., who was instrumental in establishing the original Warner Robins location. "We are committed to developing the most advanced technology for national defense applications. Our new facility adds resources to fulfill this mission for the base and beyond."

119018

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A new $250 million Indefinite Delivery Indefinite Quantity contract will continue aircraft life extension programs, which include fatigue testing in SwRI's structural testing laboratory.

SUSTAINING AGING AIR FLEETS

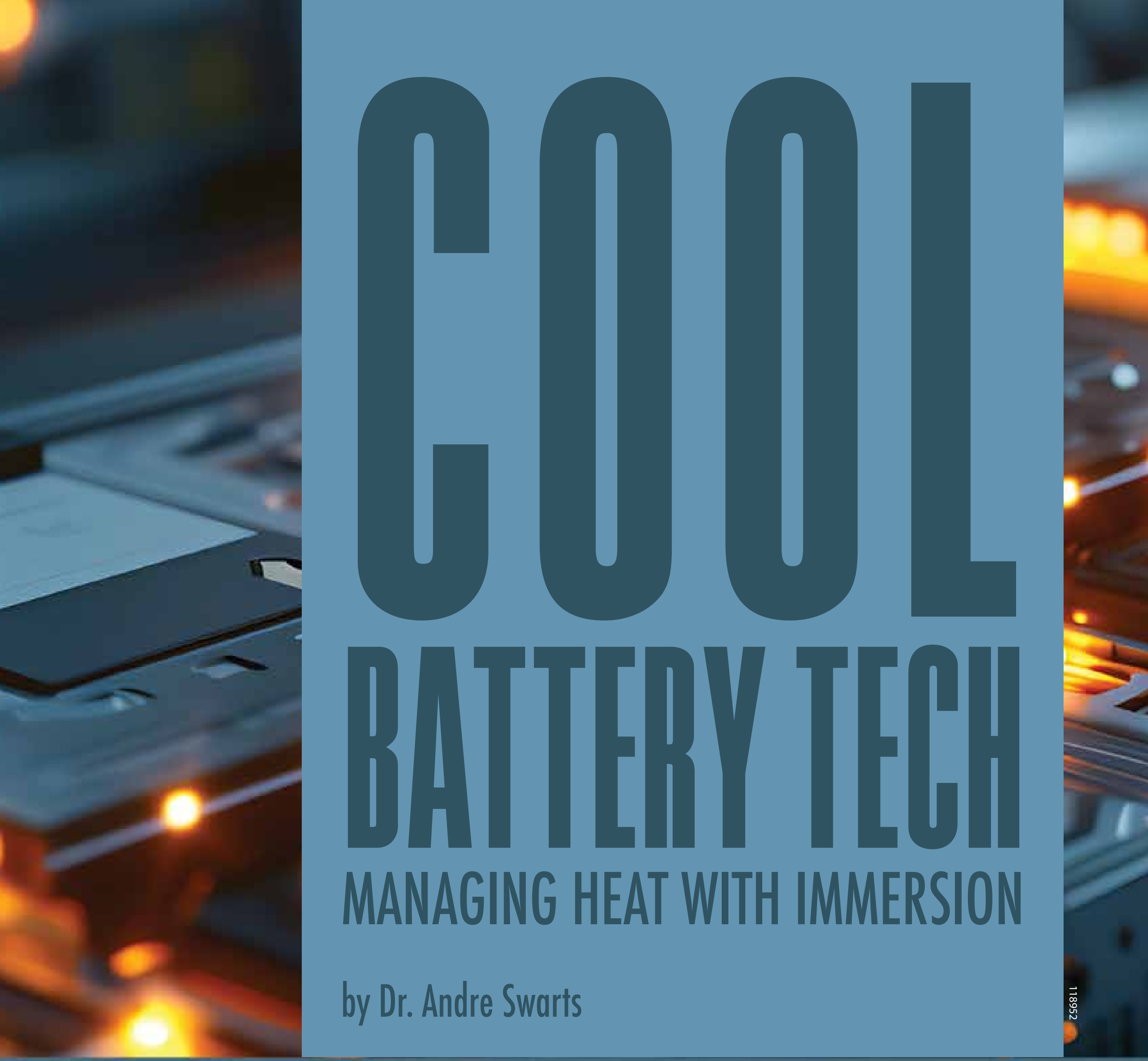
SwRI is continuing its decades-long program to extend the life of aging military aircraft through a new U.S. Air Force contract worth up to $250 million. This Indefinite Delivery Indefinite Quantity (IDIQ) contract award supports the U.S. Air Force Academy Center for Aircraft Structural Life Extension (CAStLE), created to address aging structures and materials. IDIQs are contract vehicles that fund work over specified periods of time, in this case up to eight years.

Through the contract, SwRI will evaluate and help sustain the A-10 Thunderbolt II attack aircraft, the T-38 Talon supersonic trainer, the C-5 cargo carrier and the B-52 Stratofortress bomber, among others, introduced in the 1960s and '70s. SwRI will also provide technical engineering support for small fleets managed by Hill Air Force Base, including the T-41 and the T-52, both trainer aircraft, and the E-9 surveillance aircraft.

"While Air Force aircraft are the primary focus, the contract allows the Navy, Army and Coast Guard to utilize the program as well," said David Wieland, who oversees SwRI's Aerospace Structures Section. "Due to the effectiveness of SwRI's program, the scope of work under the current contract has grown to cover more aircraft fleets."

To better understand how cracks originate and grow in materials, SwRI assesses the structural integrity of aircraft, using component and full-scale testing, usage monitoring, and stress and damage tolerance analyses. Additionally, SwRI will conduct teardown inspections and material failure analyses to assess risk and help ensure the airworthiness of the aircraft.

The contract will also allow SwRI to continue to support the Air Force's ongoing digital transformation.



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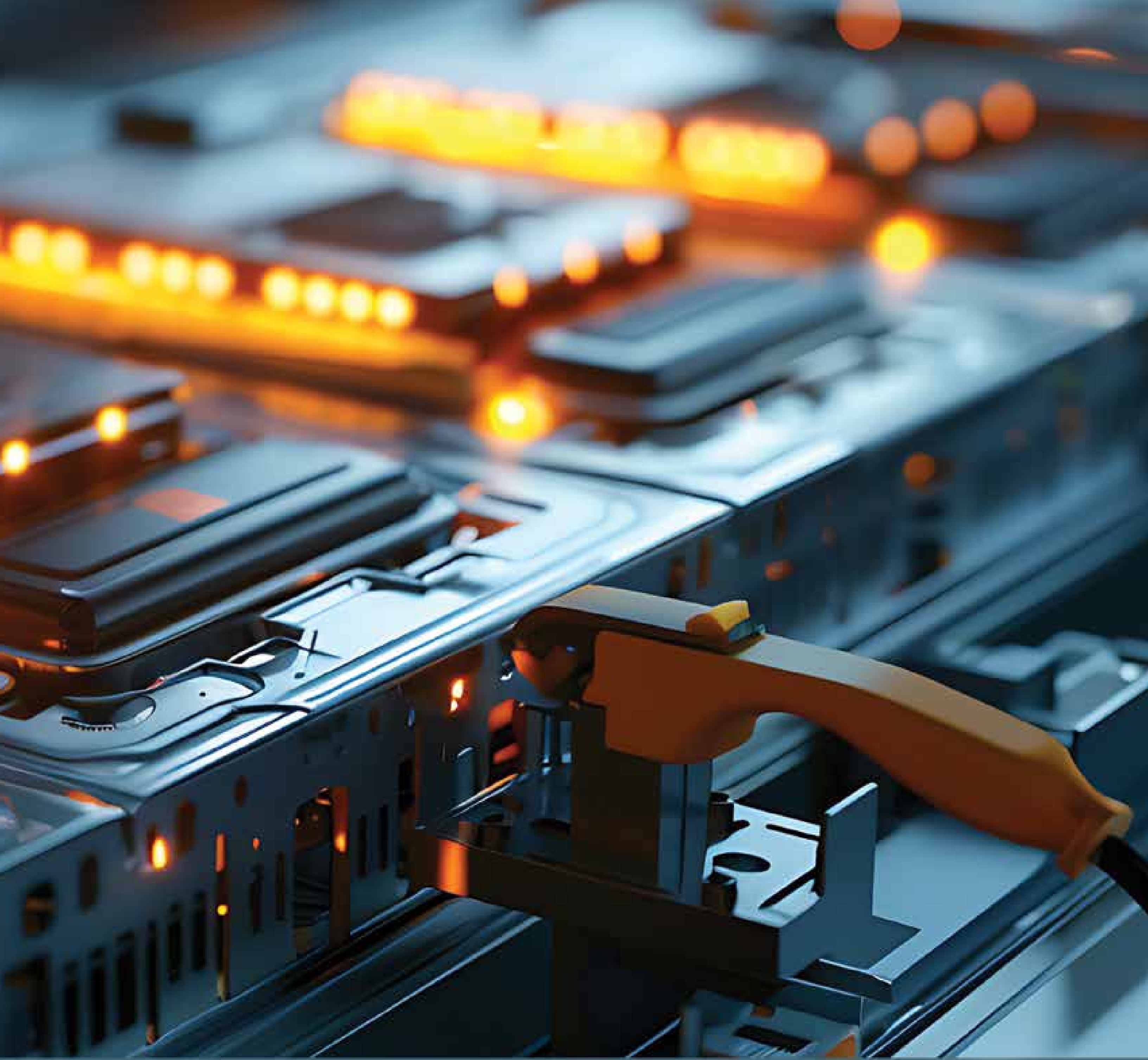
COOL BATTERY TECH

MANAGING HEAT WITH IMMERSION

by Dr. Andre Swarts

Batteries, like people, don’t want to be too hot *or* too cold.

Like the heroine of the classic bedtime story Goldilocks and the Three Bears, batteries prefer their temperatures to be “just right.” The lithium-ion batteries used by nearly every consumer device and electric vehicle on the road tend to degrade or age more quickly when they are outside of this “Goldilocks” temperature range. When it’s too cold or too hot, battery performance suffers.



For instance, during a hot Texas summer, drivers might hear the dreaded "click-click-click" indicating a dead battery. For gas-powered cars, this is typically a minor inconvenience, easily resolved with a set of jumper cables or a relatively inexpensive replacement. But with electric vehicles, it can be much more expensive and potentially dangerous to have a damaged battery powering a vehicle. As electric vehicles become more common, it's important for longevity and safety reasons to find more effective ways to protect batteries from temperature extremes.

Fortunately, Southwest Research Institute is up to the challenge.

EV THERMAL MANAGEMENT

In EVs, multiple battery cells are assembled into modules and packs in the smallest possible space, which limits air cooling and amplifies thermal management challenges. Battery temperatures are also affected by environmental conditions, such as ambient and road temperatures and the effects of rain, wind or snow.

A cold battery will use its own energy to generate heat, limiting the power available to the vehicle until it reaches optimal temperatures, and ultimately reducing range. Conversely, in hot weather, the vehicle's cooling system reduces battery temperatures, consuming more energy and, again, limiting range.

Hot temperatures can also lead to battery failures and thermal runaway propagation (TRP). This is a dangerous, cascading failure in a battery pack where thermal runaway in one cell triggers a chain reaction, causing adjacent cells to overheat and so on. This can cause battery pack failures, fires and even explosions.

Other types of battery failure are often associated with manufacturing defects that lead to internal short-circuits or as the result of abuse, such as car crashes or penetration by a foreign body.

The earliest electric vehicles tried to manage temperatures by using air flowing directly from the cabin to heat and cool the battery. However, they soon determined that this direct connection between the battery and the people in the vehicle was not a good idea, and that technique has been relegated to history.

LIQUID COOLING

These days, most electric vehicles use indirect liquid cooling to regulate battery temperatures. During this process, a thermal management fluid, or coolant, flows through channels embedded in cooling plates or cooling ribbons that are in contact with the battery cells. The coolant absorbs heat from the battery, transferring it away from the cells. The heated coolant is circulated to a heat exchanger to release the heat and then returned to the cooling ribbon to repeat the process. When the battery is cold, the same fluid is heated externally and uses a reverse process to heat the battery, using either waste heat or an auxiliary electric heater. The fluids used for these applications are typically a mixture of water and ethylene glycol, but pose the risk of hydrogen production through electrolysis should there be accidental contact between the coolant and the high-voltage components.

Battery thermal management systems are integrated with vehicle systems that cool electronic components, such as inverters and electric motors. Hot fluids from the battery are often used in occupant comfort systems for cabin heating, albeit by less direct means than legacy shared-air systems. Different manufacturers and applications achieve integration by different means. These applications may share single fluid throughout the vehicle, using valves to direct the fluid to the correct locations, or multiple systems using similar or different fluids to achieve the desired results.

As battery power increases, so do the current requirements, or "C-rates," which are the ratio of the charge/discharge current relative

DETAIL

Ethylene glycol coolant has been used for decades as an antifreeze agent in vehicle and heating, ventilation and air conditioning systems. As a liquid, it is colorless, odorless and combustible. Pure ethylene glycol freezes at –12.8 C (9 F), but, when mixed with water, its freezing temperature drops further, up to a point.

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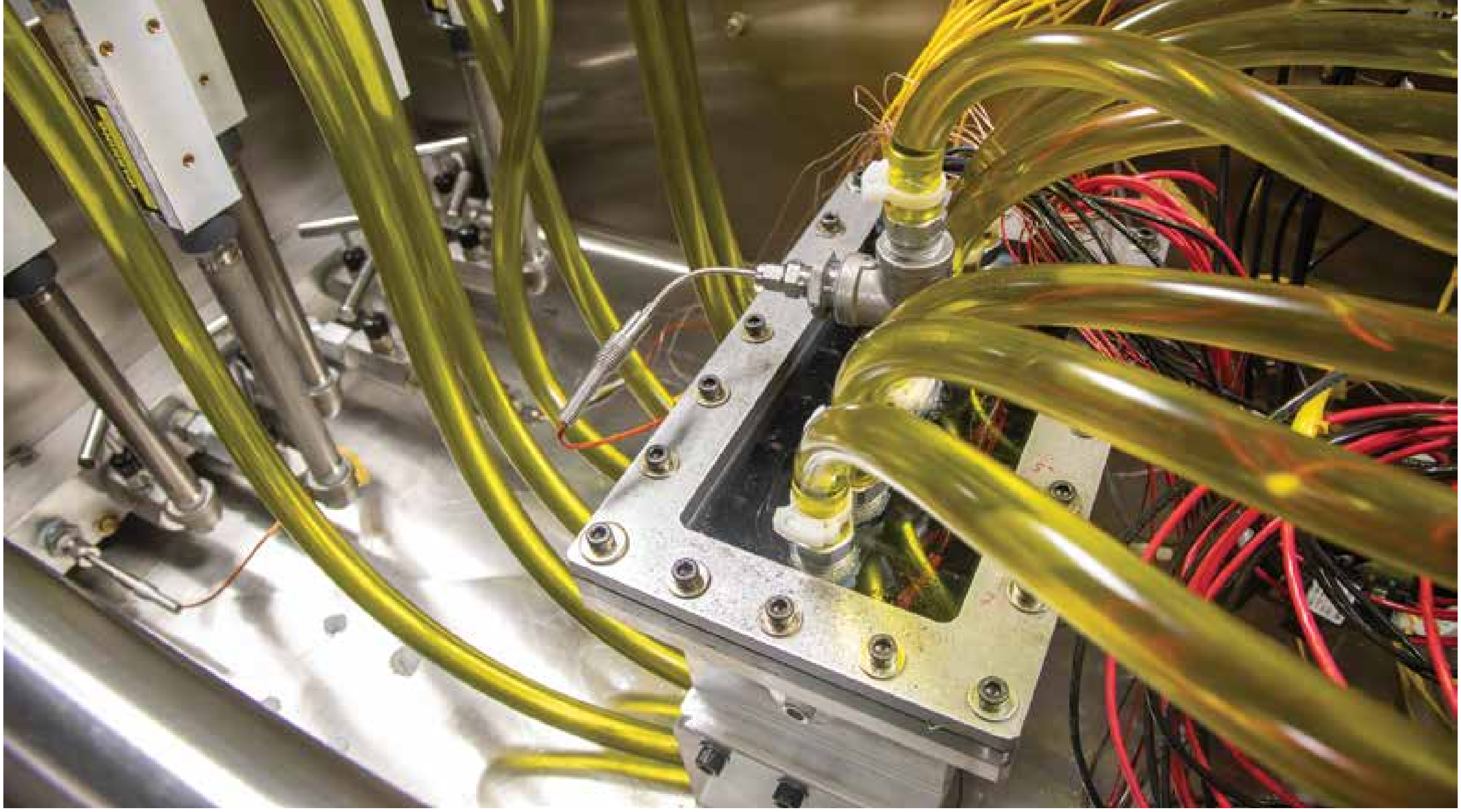
From left, Senior Research Engineer Daniel Robles, Staff Engineer Andre Swarts and Senior Research Engineer Swapnil Salvi developed an immersion cooling demonstration unit to provide customers with a simulated experience of battery abuse tests.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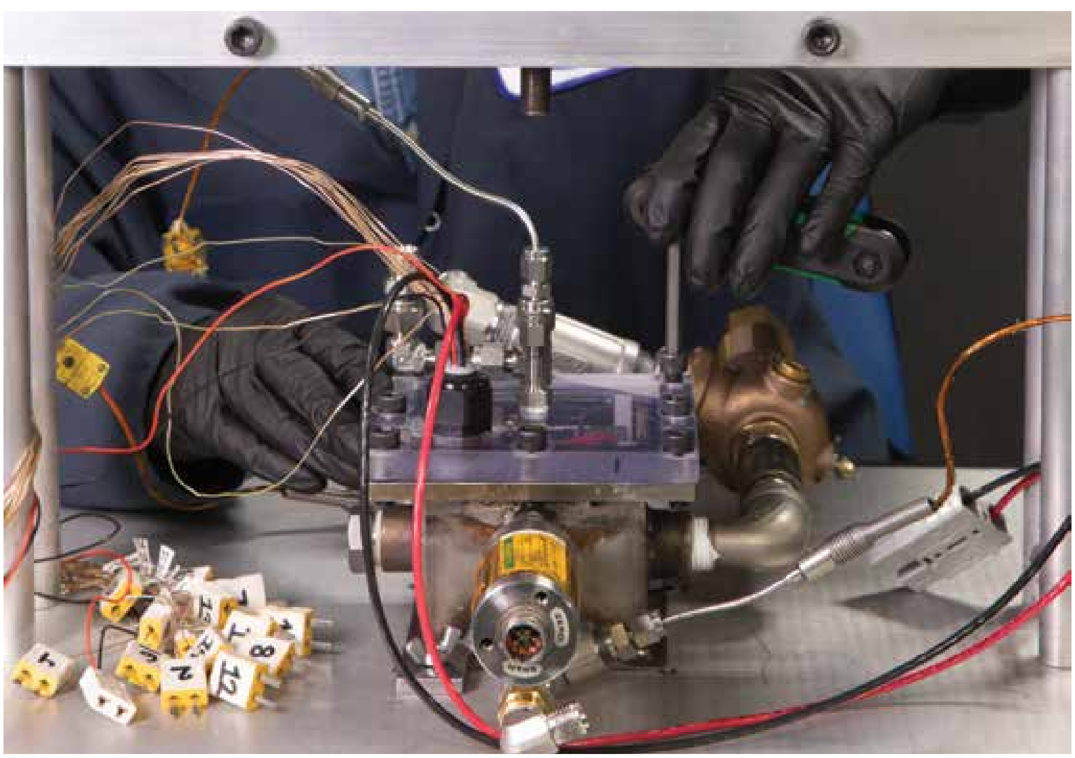
SwRI has developed immersion cooling testing technology, including this mini module. The tubing delivers coolant to the device during performance testing.

to its maximum capacity. C-rates are particularly significant for Direct Current Fast Charging (DCFC) technology. DCFC is the fastest way to charge an electric vehicle, allowing some EVs to reach an 80% charge in as little as 20 minutes. DC fast chargers convert high-power alternating current grid electricity to DC power and deliver it directly to the vehicle's battery. Fast charging puts additional stress on thermal management technology and may overwhelm indirect liquid cooling, because performance is limited by the thermal conductivity of the cooling pathway. The heat generated from fast charging can degrade the lithium-ion batteries in EVs, so dissipating or managing that heat is vital.

COLD PLUNGE

SwRI began looking at battery immersion cooling in 2020 during the first Electrified Vehicle and Energy Storage Evaluation (EVESE) consortium, an offshoot of the long-running Energy Storage System



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This SwRI-developed mini-module measures the effectiveness of immersion cooling during nail penetration abuse tests.

DETAIL

Dielectric strength is the ability to resist electrical breakdown in the presence of an electrical field. Insulators, for instance, have a high dielectric strength, while conductors have low strength.

Evaluation and Safety (EssEs) consortium. During the four-year consortium, SwRI developed technology to evaluate battery in-service cycling performance and behavior under various conditions.

Direct liquid immersion cooling involves circulating a coolant between the battery cells to enhance heat transfer by several orders of magnitude. Some studies found 50 to 100 times improvement in the heat transfer coefficient with this method over conventional indirect cooling solutions. Cooling electric systems by immersing them in dielectric fluids began in the late 1800s and is commonly used today to cool electronics and high-end computing technology. Dielectric fluids are designed to prevent or quench electric discharges. Their fluid properties include low electrical conductivity, a high dielectric strength and good heat transfer properties. These dielectric characteristics prevent current leakage that can lead to electrical losses.
Because no specific test methods for evaluating immersion cooling or fluids exist, SwRI developed several test setups that circulate a test fluid around a mini module comprised of seven cylindrical cells, while continuously charging and discharging the batteries. These tests can run for as long as 20 weeks. During these tests, SwRI monitors the health of the mini module, tracking any capacity and internal resistance changes. SwRI also evaluates interactions between the fluids, the battery cells and the mini module's construction materials by monitoring fluid changes over time. A thorough end-of-test inspection includes destructive physical analysis of the batteries to look for any signs of fluid ingress.

ABUSE RESEARCH

SwRI has developed numerous battery test methods through EVESE and EVESE-II. The SwRI Energy Storage Technology Center®, established in 2018, is one of the few places in the country capable of performing all regulatory safety tests on cells, modules and complete battery packs.

Probably the most dramatic test available is a battery abuse test that involves driving a nail into a mini module immersion chamber.

As the nail pierces the battery, SwRI also measures temperatures and monitors for evidence of TRP. The lithium-ion batteries in the cell heat up quickly once one is punctured, and the heat spreads rapidly through the rest of the module. SwRI then monitors the emissions produced by the failing batteries and characterizes the dielectric fluid's mitigating effects. Immersion cooling generally provides improved outcomes, with lower temperatures and better containment, although potential secondary reactions associated with vaporized fluids requires careful monitoring.

SwRI's cycling and abuse testing is complemented by the development of unique fluid tests aimed at understanding fluid performance, such as heat transfer tests and fluid combustibility tests that produce data beyond what simple lab-scale fluid property tests can provide. SwRI has applied this type of testing to multiple fluid clients to help them understand potential performance benefits and fluid characteristics in battery immersion cooling applications.

DETAIL

SwRI manages the Electrified Vehicle and Energy Storage Evaluation-II (EVESE-II) consortium, which is the current evolution of its highly successful EVESE program. Launched in August 2024, EVESE-II expands focus to include module and pack research, with an emphasis on immersion cooling research, test standards, safety testing and applications beyond electric vehicles, such as charging and vehicle-to-everything connected vehicle systems.

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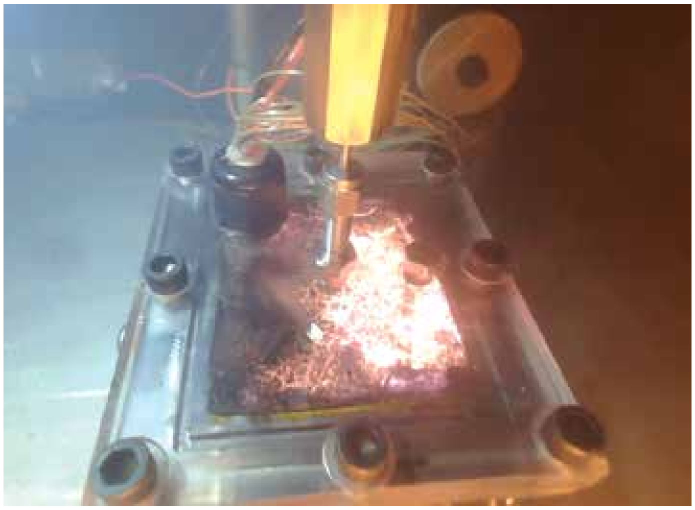
SwRI Senior Research Engineer Swapnil Salvi fixes a nail onto one of the battery abuse test rigs for a penetration test. The nail will be driven into a battery cell beneath it to simulate potential real-world abuse and effects.



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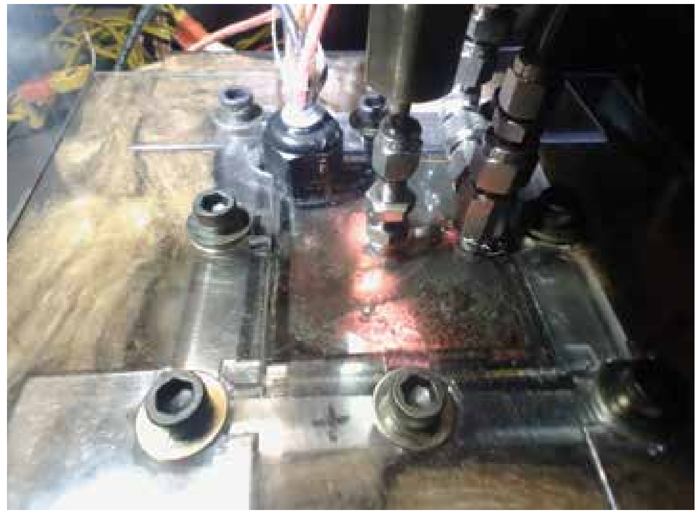

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These images demonstrate the benefits of immersion cooling during a penetration test. The left image shows flame spread without immersion cooling three seconds after penetration. The right image shows how immersion cooling is quenching the fire three seconds after penetration.

IMMERSION COOLING

Immersion cooling is an attractive technology for many reasons, particularly for ultra-high-power applications, such as motor sports or high-end sports cars. The energy storage system in some Formula 1 cars, for example, comprises a battery pack with direct immersion cooling and a highly specialized dielectric fluid. The powerful engines, high speeds and designs of F1 vehicles require heightened levels of cooling. Today's standard electric vehicles do not justify the cost and complexity of implementing immersion cooling systems. Tomorrow's heavy-duty and longer-range vehicles, however, may need it.

Other applications that do not require immersion cooling include Battery Energy Storage Systems (BESS), which use repurposed EV batteries to support electrical grids, providing back-up power. These BESS applications do not have weight and volume restrictions while their cell-level power demands are not excessive, so immersion cooling is unnecessary. Even heavy-duty and off-highway applications that use "megawatt" charging solutions are self-correcting with reasonable C-rate levels.

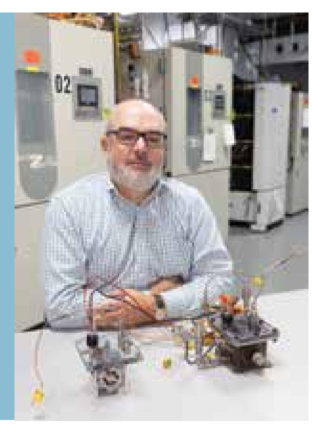
While battery immersion cooling is not currently used in mainstream vehicle applications, high charging rates, high-power duty cycles and ever-shrinking battery packs for certain off-highway and performance applications may yet leave a niche for battery immersion cooling to fill. The Institute is also investigating immersion cooling benefits and advancement in other applications. SwRI is exploring a related direct cooling application for data centers. These crucial facilities are proliferating to house servers and networking equipment that enable organizations to store, manage and distribute data. They power online activities from web searches to cloud storage and artificial intelligence. Data centers consume significant amounts of energy for information technology and cooling equipment, with consumption expected to increase significantly with the growth of artificial intelligence. Data centers consumed about 4.4% of total U.S. electricity in 2023 and are expected to consume approximately 6.7 to 12% of total U.S. electricity by 2028, and much of that goes toward cooling.

SwRI is launching a consortium aimed at advancing understanding how immersion cooling and other advanced techniques could address some of the challenges facing data centers and their growing need for power.

SwRI complements testing with a comprehensive battery systems design, analyses and integration service, taking client requirements from concept to validated solution. This includes component, subsystem, system and even final application design, evaluation, prototyping, building and testing. SwRI expertise puts it in a strong position to serve those needs, while continuing to provide extensive research and development for the mobility industry.

Questions about the story? Contact Andre Swarts at 210-522-6631 or andre.swarts@swri.org.

ABOUT THE AUTHOR:
Dr. Andre Swarts is the program manager for the Electrified Vehicle and Energy Storage Evaluation-II (EVESE-II) research consortium and a leading member of SwRI's Battery Systems Research and Innovation efforts. Swarts has more than 30 years of experience in the energy industry.



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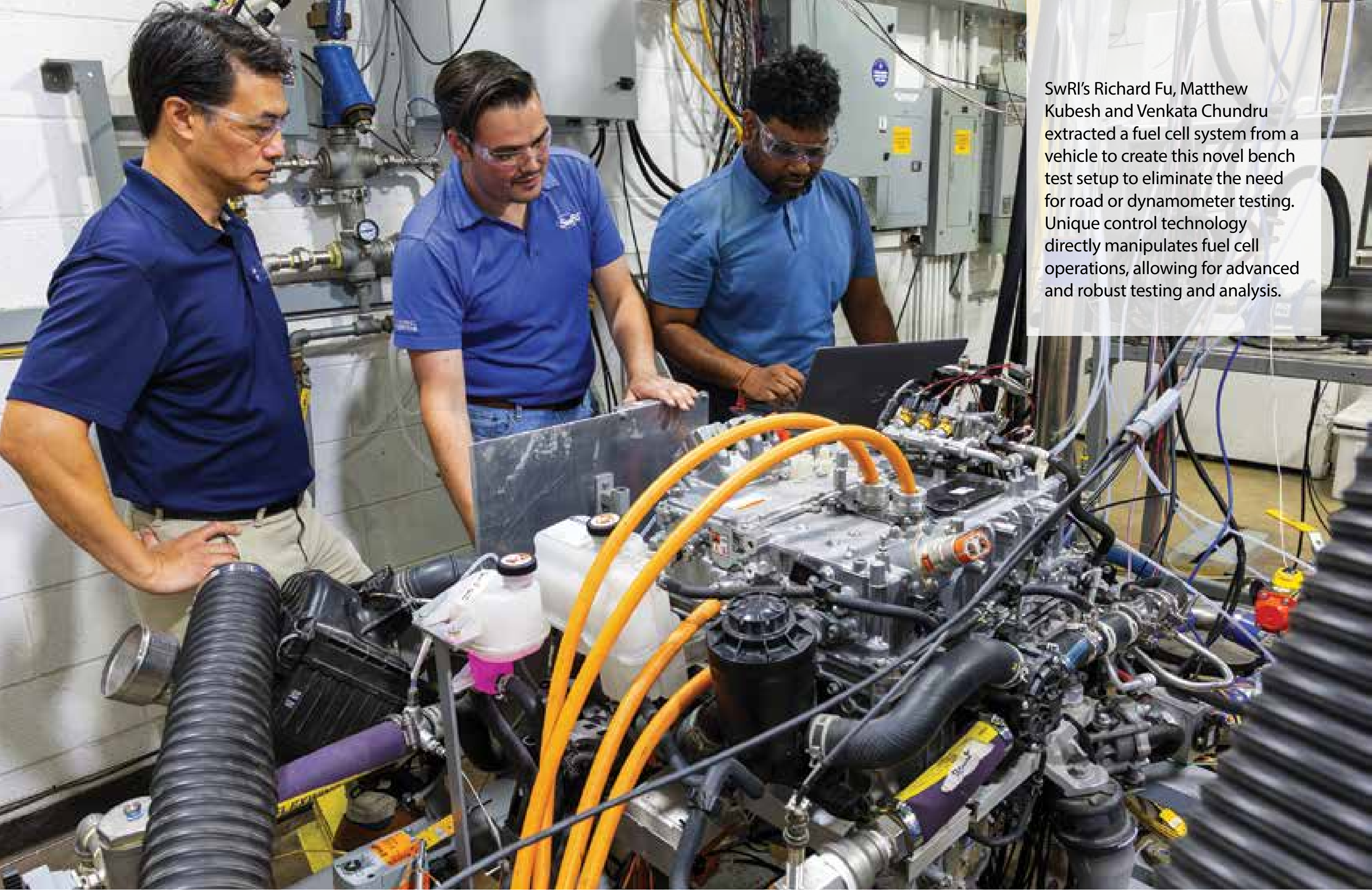


SwRI's Richard Fu, Matthew Kubesh and Venkata Chundru extracted a fuel cell system from a vehicle to create this novel bench test setup to eliminate the need for road or dynamometer testing. Unique control technology directly manipulates fuel cell operations, allowing for advanced and robust testing and analysis.

118978

ADVANCING FUEL CELL TESTING

SwRI has developed new methods for evaluating the performance and efficiency of fuel cell technology in hydrogen-powered vehicles without the need for test tracks or dynamometers.

SwRI created a novel controller system for hydrogen-powered vehicles that grants full authority over their fuel cell engines. Now, engineers can extract fuel cell stacks from a vehicle and rigorously test their reactions to both normal and extreme driving conditions without physically running the vehicle. These tests are driving the creation of algorithms to help ensure the performance and efficiency of these vehicles.

In hydrogen-powered vehicles, fuel cells stacked together convert hydrogen gas into electricity through a chemical reaction. Water and heat are the only byproducts. This makes these vehicles attractive for reducing carbon emissions while ensuring long range and short refueling times. SwRI's controller system precisely manages the full range of the system's operations, such as its fuel flow rates, air flow rates and temperatures. Simulating different operations directly on the engine eliminates the need for conventional road testing.

The internally funded project initially analyzed a hydrogen fuel cell-powered consumer vehicle to understand the internal mechanisms that run its system. The team then extracted the fuel stack from the vehicle and installed it in a controlled environment to assess performance.

"Using our controller to manipulate functions, we can run the stacks under more extreme conditions than what the vehicle's safety controls normally allow. This gives us a sense of how it might perform under stressors we couldn't otherwise evaluate," said Matthew Kubesh, one of the project's lead investigators in SwRI's Low Carbon Technologies Section. "Using this knowledge, we can scale up the results and apply them to help evaluate and improve the fuel cell stacks used for heavy-duty applications."

The SwRI team is now focusing on developing predictive control models to improve fuel cell humidity management to enhance fuel cell performance.

"Too much humidity can lead to flooding and performance deterioration. Too little moisture creates high internal resistance in the fuel cell stack, which can lead to inefficiencies, degradation and potential catastrophic events," said Venkata Chundru, a senior research engineer in SwRI's Advanced Algorithms Section. "Our focus is replicating and extending the stack's existing performance by dynamically adjusting the fuel-to-air ratio to achieve better humidity management."

As the project continues, SwRI is exploring new control models and potential collaboration with commercial clients to test more complex, multi-stack setups designed for heavy-duty vehicles.

"The future of fuel cells largely lies in heavy-duty applications," said Chundru. "To make them commercially viable, we need controllers that can manage the system efficiently and reliably under extreme operational conditions. This project is helping us get there."

370-MILLION-MILE HAIL MARY SAVES JUNOCAM

The SwRI-led mission team of NASA's Jupiter-orbiting Juno spacecraft executed a deep-space save in December 2023 to repair its JunoCam imager just in time to capture photos of the Jovian moon Io.

JunoCam is a color, visible-light camera. Initially included in the payload to engage the public as a citizen science program, its images have led the way to several important scientific discoveries as well. The optical unit for the camera is located outside a titanium-walled radiation vault, which protects sensitive electronic components for many of Juno's engineering and science instruments.

This location was risky, because Juno's journey carries it through the most intense planetary radiation fields in the solar system. While mission designers were confident JunoCam could operate through the first eight orbits of Jupiter, no one knew how long the instrument would last after that.

Throughout Juno's prime mission of 34 orbits, JunoCam operated nearly flawlessly, returning images that the team routinely incorporated into Juno's science papers. Then, during its 47th orbit, the imager began showing hints of radiation damage.

The team thought the issue could be tied to radiation, but pinpointing what, specifically, was damaged within JunoCam was difficult from hundreds of millions of miles away. Clues pointed to a damaged voltage regulator for JunoCam's power supply. With few options for recovery, the team turned to a process called annealing, where a material is heated for a specified period before slowly cooling. Although the process is not well understood, heating has been observed to reduce defects in some materials.

Soon after the initial annealing process started, JunoCam began cranking out crisp images for the next several orbits. But as Juno flew deeper and deeper into the heart of Jupiter's radiation fields, its imagery began showing problems again. By orbit 56, nearly all images were corrupted.

"After orbit 55, our images were full of streaks and noise," said JunoCam instrument lead Michael Ravine of Malin Space Science Systems. "With the close encounter of Io bearing down on us in a few weeks, it was Hail Mary time: The only thing left we hadn't tried was to crank JunoCam's heater all the way up and see if more extreme annealing would save us."

Test images sent back to Earth during the annealing showed little improvement the first week. Then, with the close approach of Io only days away, images began to improve dramatically. By the time Juno came within 930 miles (1,500 kilometers) of the volcanic moon's surface on Dec. 30, 2023, the images were almost as good as the day the camera launched, capturing detailed views of Io's north polar region that revealed mountain blocks covered in sulfur dioxide frosts rising sharply from the plains and previously uncharted volcanos with extensive flow fields of lava.

"Juno is teaching us how to create and maintain spacecraft tolerant to radiation, providing key insights that will benefit not only Juno, but also satellites in orbit around Earth," said SwRI's Dr. Scott Bolton, Juno's principal investigator. "I expect the lessons learned from Juno will be applicable to both defense and commercial satellites as well as other NASA missions, such as the Europa Clipper mission currently en route to the Jovian system."

The team recently reported the results from the long-distance save at the Institute of Electrical and Electronics Engineers Nuclear & Space Radiation Effects Conference.

IMAGE COURTESY NASA/JPL-CALTECH/SwRI/MSSS 118985

Following a Hail Mary attempt to repair the Juno mission's imager, JunoCam captured this clear closeup of the north polar region of Jupiter's volcanic moon Io. The repair team recently shared how annealing repaired radiation damage to the camera just in time to capture this image on Dec. 30, 2023.

SPHERICAL NEAR-FIELD ANTENNA EVALUATION

SwRI is expanding its antenna measurement capabilities with a state-of-the-art spherical near-field antenna range. The 1,260-square-foot indoor range, lined with radio frequency and microwave foam absorbers, is equipped to accurately sample the near field of an antenna, which can be mathematically transformed into far-field data.

"Near field" refers to the complex electromagnetic fields close to an antenna, while the "far field" encompasses the predictable planar waves farther away. Analyzing both fields allows a more complete performance evaluation of an antenna under test. Near-field measurements are typically collected in a planar, cylindrical or spherical formation.

"Spherical data collection is the most comprehensive and flexible method of measuring radiation patterns for all antenna types," said Dr. Jimmy Li, a lead engineer in SwRI's Defense and Intelligence Solutions Division. "We get the full 3D radiation pattern data for an antenna — not just limited perspectives obtained with other methods."

Antennas enable the transmission and reception of signals and are the interface between electromagnetic waves and electronic devices. Testing is necessary to evaluate performance and ensure compliance with industry standards and regulations. Antennas are crucial for a wide range of technologies, including cellular networks, Wi-Fi, radar, satellite communications and positioning and navigation systems.

SwRI's spherical near-field antenna range includes several new advantages:

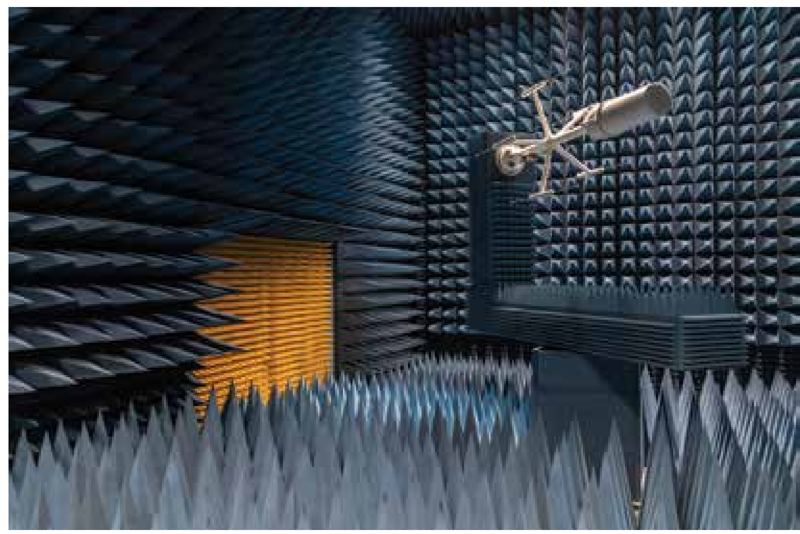
- No restrictions associated with antenna far-field distances exceeding the size of the range
- A built-in, overhead, half-ton hoist to install large antennas up to 10 feet in diameter and 1,000 pounds
- Operation at frequencies from 200 megahertz to 40 gigahertz
- Faster data collection enabled by continuous rotation sampling
- Full characterization of antenna-radiated patterns, including multi-polarization 3D patterns across all angles
- Faulty antenna element diagnostics, array performance evaluations, radome systems tuning and reflector surface area mapping
- No limitations due to weather fluctuations that impact outdoor ranges
- No limitations from Federal Communications Commission (FCC) regulations that impact outdoor ranges

"Because the range is indoors, we do not have to follow FCC requirements regarding antenna height and other transmission restrictions for outdoor antenna testing," said Nils Smith, vice president of SwRI's Defense and Intelligence Solutions Division. "We can now perform thorough testing of antennas on-site at SwRI with more versatility for our clients."

The facility will support emerging millimeter wave technologies in the next phase of development, a crucial component for ultra-fast 5G data transmission.

SwRI designs, develops and tests antennas and signal processing software for government and industry clients, including the Navy, Air Force, Marines and intelligence entities.

118954



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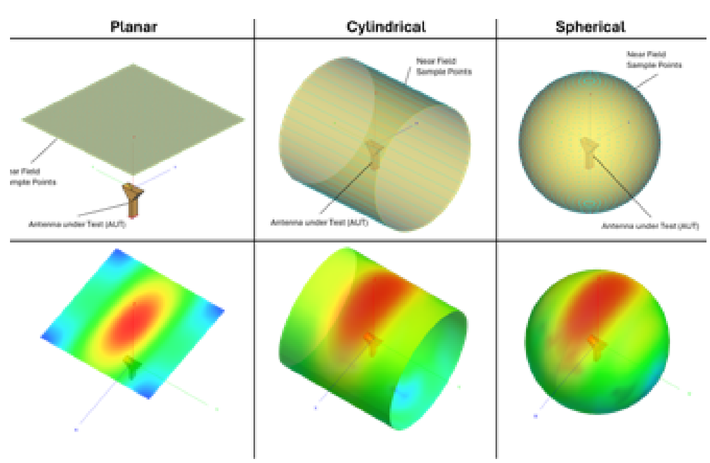
SwRI's 1,260-square-foot indoor spherical near-field antenna range evaluates the R&D 100 Award-winning AS-750 Wideband Conformal Continuous-Slot Antenna Array. The antenna testing chamber, lined with radio frequency and microwave foam absorbers, is equipped to accurately sample the near field of an antenna, which can be mathematically transformed into far-field data. Analyzing both fields allows a more complete performance evaluation of an antenna under test.



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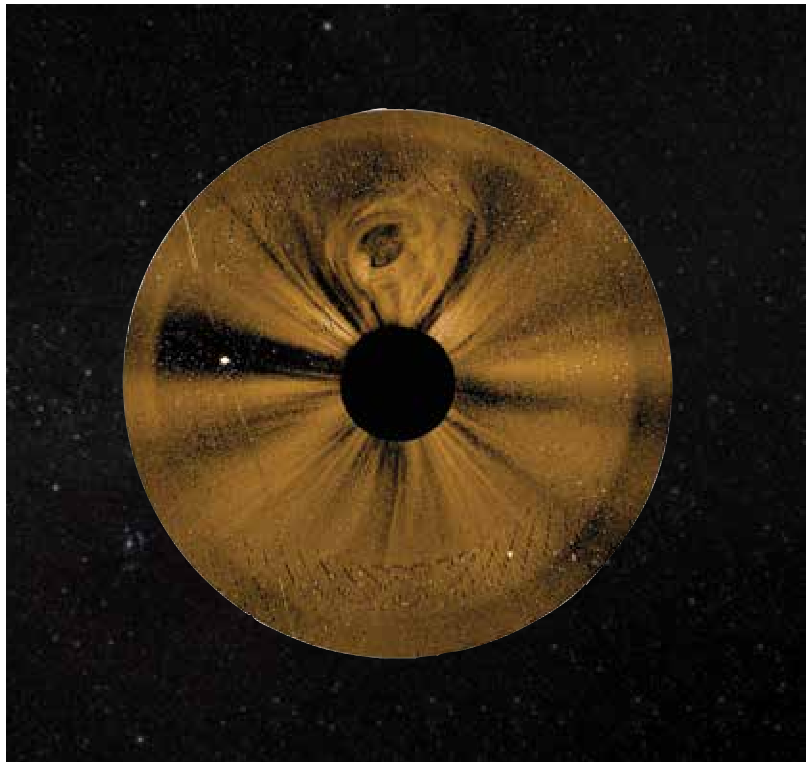
SwRI's new indoor antenna range supports 3D spherical data collection (right), the most comprehensive and flexible method of measuring antenna patterns for all antenna types. Other techniques, such as planar (left) or cylindrical (center) collection methods, offer more limited perspectives.

IMAGE COURTESY NASA'S CONCEPTUAL IMAGE LAB 118997 118996

This visualization shows the four PUNCH spacecraft in their science orbits. Spread around Earth along the day-night line, the four spacecraft provide a continuous, unobstructed view of the Sun and its surroundings.



NASA's PUNCH mission, led by SwRI, used its Narrow Field Imager to collect images of solar activity. By blocking the Sun's bright face, NFI captures the Sun's atmosphere in unprecedented detail. The June 3 CME shown at the top of the image grew to enormous size, 100 times that of the Sun, as it traveled across the solar system.

PUNCH Completes Commissioning

All four spacecraft of the SwRI-led PUNCH (Polarimeter to Unify the Corona and Heliosphere) mission have successfully maneuvered into their final science orbits as of Aug. 7.

The NASA spacecraft launched into Earth orbit on March 11 and are now spread out along the planet's day-night boundary, giving the mission a continuous, unobstructed view of the Sun and its surroundings. This allows the mission to study how the Sun's outer atmosphere, or corona, turns into a constant outflow of material that travels across the solar system, called the solar wind. PUNCH's four suitcase-sized spacecraft act as a single virtual instrument 8,000 miles across. They image the solar corona, the Sun's outer atmosphere, as it transitions into the solar wind that fills and defines our solar system.

"We want to measure the solar wind globally around the star in near real time," said PUNCH's principal investigator, Dr. Craig DeForest, from SwRI's Space Science and Exploration Division in Boulder, Colorado. "The planet gets in the way from the point of view of any one spacecraft, so we had to spread them around the planet to look everywhere all at once."

During a media event at the 246th American Astronomical Society meeting in Anchorage, Alaska, DeForest discussed early accomplishments. Even before the spacecraft constellation had completed commissioning, early PUNCH data showed coronal mass ejections, or CMEs, erupting from the Sun and traveling across the inner solar system.

"These preliminary movies show that PUNCH can actually track space weather across the solar system and view the corona and solar wind as a single system," said DeForest. "This big-picture view is essential to helping scientists better understand and predict space weather driven by CMEs, which can disrupt communications, endanger satellites and create auroras at Earth."

One satellite carries the Narrow Field Imager (NFI), while the other three each carry a Wide Field Imager (WFI). The U.S. Naval Research Laboratory developed the NFI coronagraph, which blocks out the bright light from the Sun to better reveal details in the Sun's corona. The SwRI-developed WFIs capture images of the outermost portion of the solar corona and the solar wind in the inner solar system. The mission then combines these individual views into a wide-field mosaic that allows PUNCH to track space weather events from the Sun all the way to Earth.

PUNCH's early combined views are now available publicly as "Level 2" science data. To bring out details in the faint corona and solar wind, the PUNCH images require multiple steps or "levels" of processing, from 0 (least processed) to 3 (fully processed). The level 2 data stitches together images from the different spacecraft into a mosaic, as if they were taken by a single science instrument at the same time.

The processed PUNCH images are available for download from NASA's Solar Data Analysis Center, and more information about the data is available at SwRI's data access page.

118955

TARGETING MALARIA SOURCE

SwRI used its drug formulation and manufacturing expertise to fabricate two bed netting prototypes that target malaria-causing blood parasites. In collaboration with researchers at the Harvard T.H. Chan School of Public Health and Oregon Health & Science University (OHSU)/Portland Veterans Affairs Medical Center (PVAMC), SwRI chemists designed netting systems to deliver antimalarial drugs called Endochin-like Quinolones (ELQs), destroying Plasmodium parasites transmitted by mosquitoes.

"If an infected mosquito hits or lands on either type of netting, it's essentially disinfected," said Institute Scientist Dr. Mike Rubal, who contributed to an article in Nature about this research. "The best defense against malaria has been insecticide-treated bed nets or those coated with larvicides, but mosquitoes are developing resistance to those prevention methods. This novel approach targets the source of the disease."

In 2023, the World Health Organization reported 263 million cases of malaria and nearly 600,000 deaths worldwide. The disease remains pervasive even with preventative measures and available treatments. Resistance to larvicides and pesticides is a growing concern.

Rubal's team coated a commercially available polyester bed net with an ELQ solution synthesized at OHSU/PVAMC. SwRI also developed a second solution, blending ELQ into a hot-melt extrusion of high-density polyethylene filaments. These filaments can be woven into yarn for netting. The team at Harvard evaluated both netting systems for efficacy.

"We desperately need innovation in malaria control. This study offers a new, effective way to stop the transmission of malaria parasites, which we hope will reduce the burden of this devastating disease in Africa and beyond," said co-author Dr. Flaminia Catteruccia, Irene Heinz Given Professor of Immunology and Infectious Diseases at Harvard and a Howard Hughes Medical Institute investigator.

IMPROVING OIL RECOVERY, CARBON SEQUESTRATION

SwRI and The University of Texas at Austin (UT Austin) have evaluated a promising approach to improve long-term carbon storage in depleted oil and gas reservoirs. The team proposes using foam-entrapped supercritical carbon dioxide (sCO_2) to prevent stored and captured carbon from moving back to the surface. The project is supported by the Energize program, a joint effort between SwRI and UT Austin to enhance scientific collaboration.

Carbon capture, utilization and sequestration (CCUS) involves using captured CO_2 to extend its usefulness before it's stored underground.

"Injecting CO_2 into wells to enhance oil recovery allows it to perform work underground while being captured and stored," said SwRI's Angel Wileman, a co-principal investigator of the project. "Unlike fresh water or oil — which we'd rather not use — CO_2 is a substance we already aim to keep underground."

To ensure that stored CO_2 remains stable underground and doesn't migrate to the surface, SwRI applied principles from traditional CO_2-enhanced oil recovery methods to investigate the stability and behavior of foam-entrapped CO_2 at high-temperature and high-pressure reservoir conditions. Under these conditions, the CO_2 reaches its supercritical state, exhibiting gas-like viscosity and liquid-like density, which influences its mobility and storage behavior.

Supercritical CO_2 foams exhibit a behavior known as shear thinning, meaning their viscosity decreases under higher shear rates. This allows them to flow more easily through low-permeability zones while limiting flow into high-permeability regions. As a result, they improve sweep efficiency for oil recovery and help reduce the risk of CO_2 migration by limiting channeling and preferential flow through fractures.

The project expanded SwRI's small foam generator facility, making it possible to evaluate unconventional technology at a much wider scale.

118977

DETECTING DEBRIS ON-ORBIT

SwRI has developed and tested a micrometeoroid and orbital debris (MMOD) detection and characterization system designed for satellites and spacecraft to monitor impacts from space debris. The system provides critical post-impact data, ensuring awareness of an impact even when damage is not immediately apparent.

Space debris around Earth is a growing problem, a result of commercial satellites exploding, anti-satellite missile tests and accidents that contribute to a growing junk field. Depending on its location, debris can remain in orbit for years, posing a threat to operational spacecraft.

The MMOD system can be mounted onto a spacecraft or integrated into its design. It consists of a structural element embedded with sensors that collect data for software analysis to identify impact details. These data can provide insights into the size and volume of particles orbiting Earth, including many that are too small to be seen from the planet's surface. It can also alert operators if their spacecraft or satellite has been hit.

"Most spacecraft survive minor impacts without systems breaking or operators on Earth knowing," said SwRI Institute Scientist Dr. Sidney Chocron, who led development of the MMOD detection and characterization system. "Our device is designed to send data back to Earth with important insights before any damage is apparent."

These data could help NASA and the industry develop more resilient future spacecraft. While it doesn't help existing spacecraft directly avoid collisions, it could play a role in early warning systems. If a satellite detects a debris strike, it could warn others in the same orbit to move out of the way, if possible.

"Ultimately, our primary goal is to map and characterize the MMOD debris field around the Earth to better protect future missions," Chocron said. "Our MMOD detection and characterization system is a step toward better understanding and mitigating those risks."

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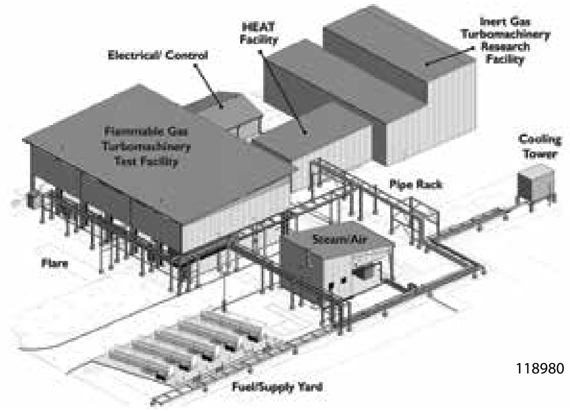


118980

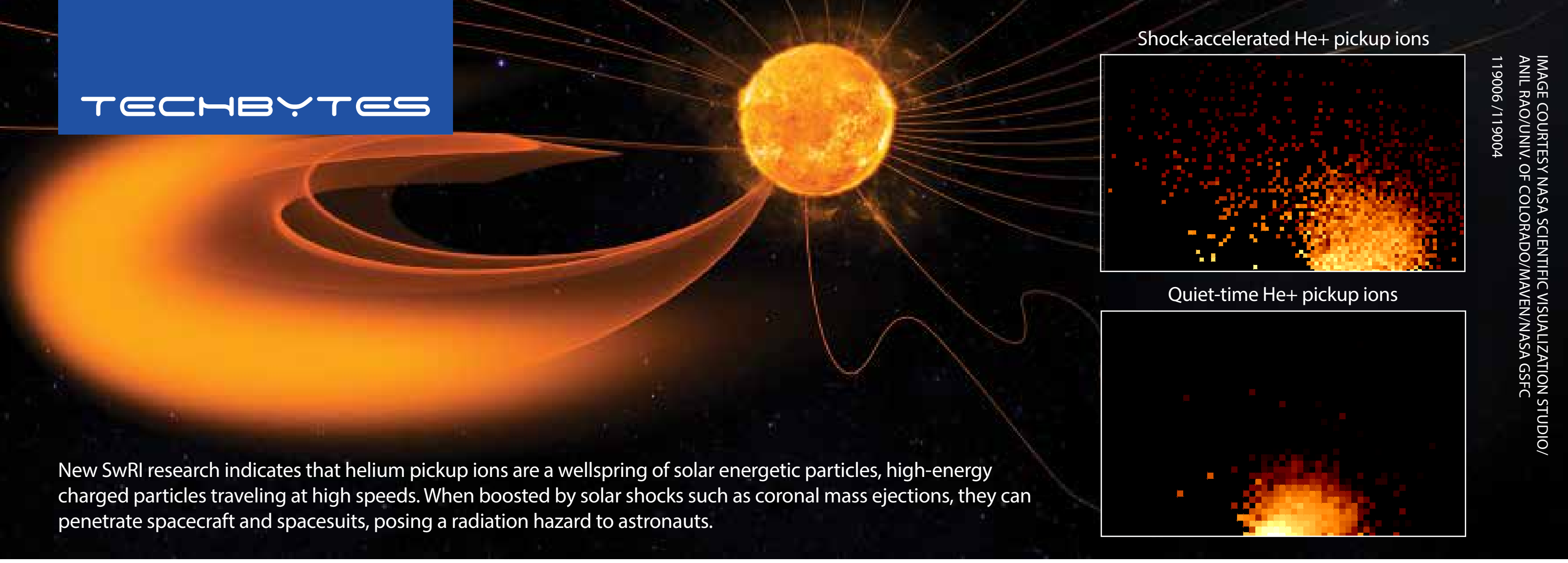
EXPANDING FLAMMABLE GAS MACHINERY TESTING

SwRI is significantly expanding its testing and research capabilities with a new hydrocarbon research facility. It will provide megawatt-scale testing of machinery and energy systems powered by hydrocarbons and other flammable gases. The 90,000-square-foot facility will evaluate a wide range of equipment for efficiency, safety and durability.

The facility is designed to safely use flammable gases including hydrogen, hydrocarbons, organic fluids and refrigerants. Hydrocarbons like natural gas are organic compounds composed of hydrogen and carbon atoms and serve as a fundamental building block for many fuels, including petrochemicals. Some heat pumps utilize advanced refrigerants including hydrofluorocarbons or ammonia. SwRI's new hydrocarbon research facility will enable testing of machinery such as gas turbines, turbo compressors, reciprocating compressors, industrial heat pumps and many other systems that use these fluids in power generation or conversion applications.

"Natural gas fuels over a third of the U.S. power supply and can be produced, stored and transported affordably relative to other sources of energy," said Dr. Tim Allison, director of SwRI's Machinery Department. "It offers significantly reduced carbon emissions in comparison to other fossil fuels. Our new testing capabilities will facilitate technology development to improve the efficiency, emissions, reliability, affordability and safety of natural gas machinery and systems."

The new complex will operate out of three buildings, including an open-sided facility for testing large machinery. The electrical and control building provides up to 5 megawatts of electric power to support testing activities and includes fiber-optic connections for fast data transfer across the facility. The third building will house a steam generator to facilitate advanced testing scenarios requiring compressed air or steam. Additionally, the facility will have a fuel yard to safely store and handle various flammable gases. Construction will be completed in 2025.



New SwRI research indicates that helium pickup ions are a wellspring of solar energetic particles, high-energy charged particles traveling at high speeds. When boosted by solar shocks such as coronal mass ejections, they can penetrate spacecraft and spacesuits, posing a radiation hazard to astronauts.

IMAGE COURTESY NASA SCIENTIFIC VISUALIZATION STUDIO/ANIL RAO/UNIV. OF COLORADO/MAVEN/NASA GSFC
119006 / 119004

SOLAR EVENTS IMPACT VELOCITY OF PICKUP IONS

SwRI scientists have discovered how solar activity affects the velocity distribution and evolution of helium pickup ions. These charged particles are created when neutral particles originating outside of our solar system are ionized by solar ultraviolet radiation and captured by the interplanetary magnetic field.

A new study led by SwRI's Dr. Keiichi Ogasawara indicates that these pickup ions are a wellspring of solar energetic particles (SEPs). These high-energy accelerated particles include protons, electrons and heavy ions produced by solar events like flares and coronal mass ejections (CMEs). Using data from NASA's Solar TErrestrial RElations Observatory, SwRI detected the initial characteristics of helium pickup ion acceleration through several CME events.

"We carefully identified the specific properties of the ions and used them to trace the physical energy transfer processes," Ogasawara said. "We also considered the roles played by different types of interplanetary shocks, such as when fast-moving solar wind disturbances collide with slower-moving solar wind plasmas."

Understanding how and when SEPs occur is critical because, at higher energies, they can penetrate spacecraft and spacesuits, posing a radiation hazard to astronauts. SwRI also studied the velocities of individual helium pickup ions in relation to their local magnetic field orientations and identified characteristic behaviors associated with various shocks associated with CMEs.

"The velocity distribution of pickup ions is quite different from that of the solar wind," Ogasawara said. "In fact, they can be twice as fast as the solar wind even during relatively quiet times. Because of this difference, pickup ions are more effectively accelerated to even higher energies than normal solar wind particles."

In comparison to SEPs, the solar wind is a continuous lower-energy flow of plasma emitted by the corona, the Sun's outer atmosphere.

119015

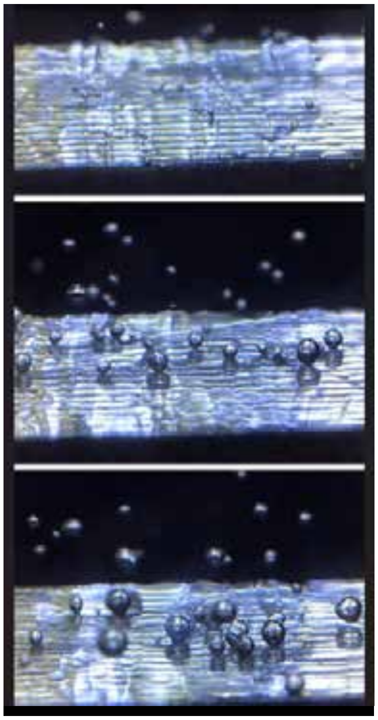
MEGAWATT-SCALE HEAT EXCHANGER EVALUATIONS

SwRI is expanding its heat exchanger testing capabilities to include megawatt-scale performance evaluations, a capability matched by only a handful of facilities worldwide. Heat exchangers efficiently transfer heat between two or more fluids without mixing for a wide variety of heating and cooling applications. These efforts are being led by Dr. Ashok Thyagaragan and Dr. Eugene Hoffman.

"SwRI's expanded heat exchanger testing capabilities will address a significant market gap for high-heat transfer rates involving high-temperature and -flowrate applications," said Research Engineer Dr. Eugene Hoffman of SwRI's Fluids Engineering Department. "This was the perfect time to advance our capabilities and expertise to meet increasing demands for specialized and custom heat exchanger testing capabilities that few facilities can accommodate."

The rapidly growing heat exchanger market is projected to reach more than $30 billion over the next decade. Heat exchange technology is vital in automobiles, data centers, aerospace technology and defense applications. Rather than relying on a one-size-fits-all approach, SwRI has adapted existing equipment and infrastructure to offer customized heat exchanger testing to clients. The facilities offer a wide range of unique and complex testing requirements to meet diverse and robust market demands.

"Our testing capabilities apply to many different systems needing thermal management," Hoffman said. "From drones to heavy-duty vehicles and power systems, we provide a comprehensive equipment suite to help clients manage a variety of thermal systems while supporting their design and testing needs."



118981

NASA's TechLeap Prize competition selected an SwRI/UTSA team to evaluate electrolyzer technology designed to improve the production of propellants and life support compounds on other worlds. This image illustrates how gas bubbles evolve at different rates at Earth (top), Martian (middle) and lunar (bottom) gravity.

EVALUATING ELECTROLYZER AT LOW GRAVITY

SwRI and The University of Texas at San Antonio (UTSA) have received a NASA TechLeap Prize to flight test novel electrolyzer technology designed to improve the production of propellants and life-support compounds on the Moon, Mars or near-Earth asteroids. The project, known as the Mars Atmospheric Reactor for Synthesis of Consumables (MARS-C), is led by SwRI's Kevin Supak and Dr. Eugene Hoffman and UTSA's Dr. Shrihari "Shri" Sankarasubramanian.

SwRI and UTSA will evaluate the performance of a patent-pending electrolyzer developed with NASA support by Sankarasubramanian, assistant professor in UTSA's Department of Biomedical and Chemical Engineering, and his team. The device applies a voltage across two electrodes to drive the electrochemical conversion of a simulated Martian brine and carbon dioxide into methane and other hydrocarbons. This technology is designed to use local resources on the Moon or Mars to produce fuel, oxygen and other life support compounds needed for long-term human habitation.

The work builds on previous research conducted by SwRI that involved studying boiling processes under partial gravity aboard parabolic flights, which simulate low gravity conditions. Designed to understand how liquids might behave on lunar or Martian surfaces, the research demonstrated that partial gravity affects surface bubble dynamics, which can impact gas production rates.

"In a partial gravity environment, like the Moon or Mars, a reduced buoyancy effect on gas bubbles in an electrolyzer poses challenges that aren't present on Earth," Supak said. "We lack an understanding about chemical processes that leverage bubble nucleation in low gravity, which is the gap we aim to fill."

To address this, SwRI and UTSA will integrate the technology into an existing SwRI-built flight rig and test it aboard a parabolic flight, capitalizing on the Institute's successful history of testing technology in reduced gravity aircraft and suborbital spacecraft. The flight is currently planned for 2026.

DETERMINING HOW GAS BLENDS AFFECT STORAGE TANKS

SwRI is addressing the challenges of a hydrogen-powered future. In collaboration with NYSEARCH, SwRI is investigating how blending hydrogen into liquid natural gas (LNG) could affect the integrity of the LNG storage tanks.

Natural gas is widely used to power appliances and heat homes. By blending hydrogen into these existing natural gas streams, utilities can reduce the carbon footprint of energy delivery while leveraging current natural gas infrastructure. In the next decade, some gas companies are planning to use hydrogen-natural gas blends to curb carbon emissions.

LNG peak sharing facilities help stabilize energy supply and pricing during periods of high demand. In these systems, natural gas is liquified and stored in massive cryogenic tanks during times of low usage, typically in summer, and regasified during winter months when demand surges. The potential introduction of hydrogen into these systems raises important safety questions.

"A new challenge for blending hydrogen into natural gas distribution lines concerns energy storage mechanisms," said Angel Wileman, who leads SwRI's Thermofluids Section. "We are investigating what happens to these tanks when hydrogen-natural gas blends undergo the liquefaction process, which transforms gas into its liquid phase, and stored for months."

The industry is concerned that natural gas-hydrogen blends may dip below the storage tank's temperature rating, affecting its safety and pressure integrity. SwRI is conducting experiments to determine if these tanks can endure lower temperatures. To simulate hydrogen bubbling into liquid natural gas inside the tanks, engineers are building a custom test rig that introduces hydrogen into an LNG-filled tank.

118981

UPCOMING

WEBINARS, WORKSHOPS and TRAINING COURSES HOSTED by SwRI:

Compressor Skid Design and Foundation Considerations, November 5, 2025, virtual

Introduction to Microencapsulation, November 5, 2025, in person

ISO 9001 Internal Auditor, November 10, 2025, in person

Field Services: Pulsation and Vibration Problem Solving for All Applications, November 19, 2025, virtual

Introduction to Propulsion Simulation Using NPSS – Winter Short Course, December 2, 2025, in person

Developments in Non-Battery Grid-Scale Energy Storage Webinar, December 3, 2025, virtual

Pulsation Analysis – API 618 Requirements, Modifications to Legacy Units, Mixed Compression, December 10, 2025, virtual

Penetration Mechanics Short Course, March 2, 2026, in person

Supercritical CO_2 Energy Technologies Symposium, March 2, 2026, in person

TRADESHOWS:

AIChE Annual Meeting, Boston, November 2, 2025

Methane Pyrolysis Summit, League City, TX, November 3, 2025

Indo Pacific International Maritime Exposition, Sydney, Australia, November 4, 2025

American Association of Pharmaceutical Scientists (AAPS) PharmSci 360, San Antonio, November 9, 2025

F-15 TCP Worldwide Review (WWR), Orlando, FL, November 10, 2025

CyberSat, Reston, VA, November 17, 2025

Aircraft Structural Integrity Program (ASIP) Conference, Austin, December 1, 2025

International Workboat Show (IWBS)/Underwater Intervention, New Orleans, December 3, 2025

American Geophysical Union (AGU), Colorado Springs, CO, December 15, 2025

Feedwater and Secondary Systems Reliability Users Group (FSRUG), San Antonio, January 19, 2026

Conference on Composites, Materials, and Structures, New Orleans, January 25, 2026

Counter UAS Homeland Security USA Conference, Arlington, VA, February 4, 2026

Society of Chemical Manufacturers and Affiliates Show, Nashville, TN, March 4, 2026

Pittcon Conference and Expo, San Antonio, March 7, 2026

Dixie Crow Symposium, Warner Robins, GA, March 22, 2026

BY THE NUMBERS

July — September 2025

46 presentations given in 16 states

5 COUNTRIES &

5 virtual conferences

46 papers published in 25 DIFFERENT PUBLICATIONS

4 patents awarded

118963

Adam Cawood, Ph.D., was selected as a 2025-26 Distinguished Lecturer for the American Association of Petroleum Geologists (AAPG). The Distinguished Lecturer program has been run by AAPG since 1941. Cawood was also named president of the Petroleum Structure and Geomechanics Division within AAPG for a two-year term.

119019

Zachary Cushenberry was named one of the Future 5 Award winners for 2025 by the Association of Old Crows (AOC) Foundation. The award recognizes the rising stars representing diverse, cutting-edge approaches to modern warfare challenges. Cushenberry was singled out for his work in electromagnetic warfare test engineering.

118973

Paul Evans was recognized by the Advanced Robotics for Manufacturing Institute with its ARM Champion Award during its recent annual meeting. The award recognizes individual members who have gone above and beyond the norm in promoting the interests and goals of the Institute.

119606

David Ferrill, Ph.D., received a Distinguished Service Award from AAPG recognizing his 40-plus years of service to the organization. He also received a Best Seminal Publication Award from AAPG's Petroleum Structure and Geomechanics Division for a paper titled "Fault zone deformation controlled by carbonate mechanical stratigraphy, Balcones fault system, Texas."

118961

Christopher Glein, Ph.D., was selected by the American Geophysical Union to present the Carl Sagan Lecture at its Fall meeting in New Orleans. The Carl Sagan Lecture is presented annually and recognizes a scientist who embodies the late Carl Sagan's interest in astrobiology as well as his effective science communication skills.

119526

Mónica Trollinger won a Magna Stella Award from the Texas General Counsel Forum for in-house excellence in Texas corporations, organizations and government agencies. The award recognizes leadership in the legal profession, particularly as an in-house general counsel for a nonprofit organization.

118953

Angel Wileman was named one of 2025's Women in Hydrogen 50 by the Women's Global Leadership Conference in Energy. The list recognizes 50 women, nominated by their colleagues and peers, as the current and future leaders of the hydrogen economy. This distinction honors Wileman as one of the most accomplished figures in the industry, with the potential to affect real change.

TECHNOLOGY
TODAY

Director of Communications
Maria Stothoff

Editor
Deb Schmid

Assistant Editor
Mike W. Thomas

Contributors
Camaron Brooks
Jesus Chavez
Lisa Peña
Joanna Quintanilla

Design
Jessica Vidal

Photography
William Luther
Ian McKinney

Illustration
Todd Pruetz

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, visit **update.swri.org**.
To make address changes, call 210.522.2257
or email **solutions@swri.org.**

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