SPRING 2025

SOUTHWEST RESEARCH INSTITUTE®

TECHNOLOGY TODAY®

Southwest Research Institute is expanding software normally used to model electrolytes and predict corrosion to help determine whether ice-covered worlds have the right conditions to support microbial life. Supported by NASA's Habitable Worlds program, the research uses historical knowledge of life on Earth to understand processes and conditions that could create and maintain habitable environments on other worlds. SwRI's Dr. Florent Bocher collaborated with Dr. Charity Phillips-Lander to apply an existing model to predict the presence of pores in ice mixed with organic molecules to study how it reacts in simulations of extreme conditions on other worlds. Laboratory investigations performed at SwRI, shown in this cross-polarized light microscope image, have found pores in ice mixed with amino acids, demonstrating potential habitable niches for microbial life in icy moons.

The researchers are collaborating with SwRI's Mike Rubal, NASA's Jet Propulsion Laboratory and a software provider to expand and improve their tools to more accurately model the conditions on icy worlds like Enceladus. Scientists think this Saturn moon contains a subsurface ocean with the potential to harbor microbial life.

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TECHNOLOGY TODAY

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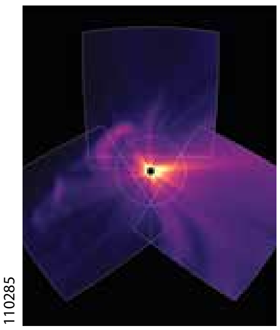

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The SwRI-led PUNCH (Polarimeter to UNify the Corona and Heliosphere) mission will study the Sun and the solar wind. PUNCH's four suitcase-sized spacecraft, built in SwRI's new Space Systems Integration Facility, carry three identical instruments to collect images forming a trefoil in the sky while the fourth instrument collects the center field of view, except for a "hole" obscuring the Sun itself.

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IN THIS ISSUE

This edition of Technology Today magazine features two topics central to the human experience. The first is the Sun, the center of the solar system, which fuels life on Earth. The second is our brain, the command center for the human body.

The Sun is a 4.5-billion-year-old yellow dwarf star — a hot glowing ball of hydrogen and helium. It's the source of heat and light, and its massive gravity holds the planets in place. Despite its ubiquitous presence, our star still holds many mysteries, including why its outer atmosphere, or corona, is so much hotter than the Sun's surface and where the solar wind that fills and defines our solar system originates. The SwRI-led Polarimeter to UNify the Corona and Heliosphere (PUNCH) mission is designed to get to the bottom of these mysteries. The PUNCH constellation, managed by SwRI's Boulder, Colorado, office, includes four small satellites and three instruments built at our San Antonio headquarters. This clever configuration overcomes challenges to make the invisible visible. The constellation launched March 11 and, after commissioning, will commence operations to study how the Sun's outer atmosphere transitions to become the solar wind.

The second feature focuses on the brain, the seat of intelligence, the interpreter of the senses, the manager of movement and the boss of behavior. And it's a relatively new area of research for the Institute. A multidivisional working group focused on brain research formed in 2024 with the goal of supporting and synergizing these activities. This article features a range of brain health projects studying neuron growth, cognitive load, traumatic brain injury (TBI) prevention, TBI screening using scents and breath, and cognitive decline detection.

Other articles in the magazine are addressing an endangered spring system, overcoming antibiotic resistance and accurately assessing bone strength and risk of fracture.

As these stories attest, SwRI continues its central mission, laid out in its charter in 1947, to conduct research and development to benefit our clients, the government and humankind.

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

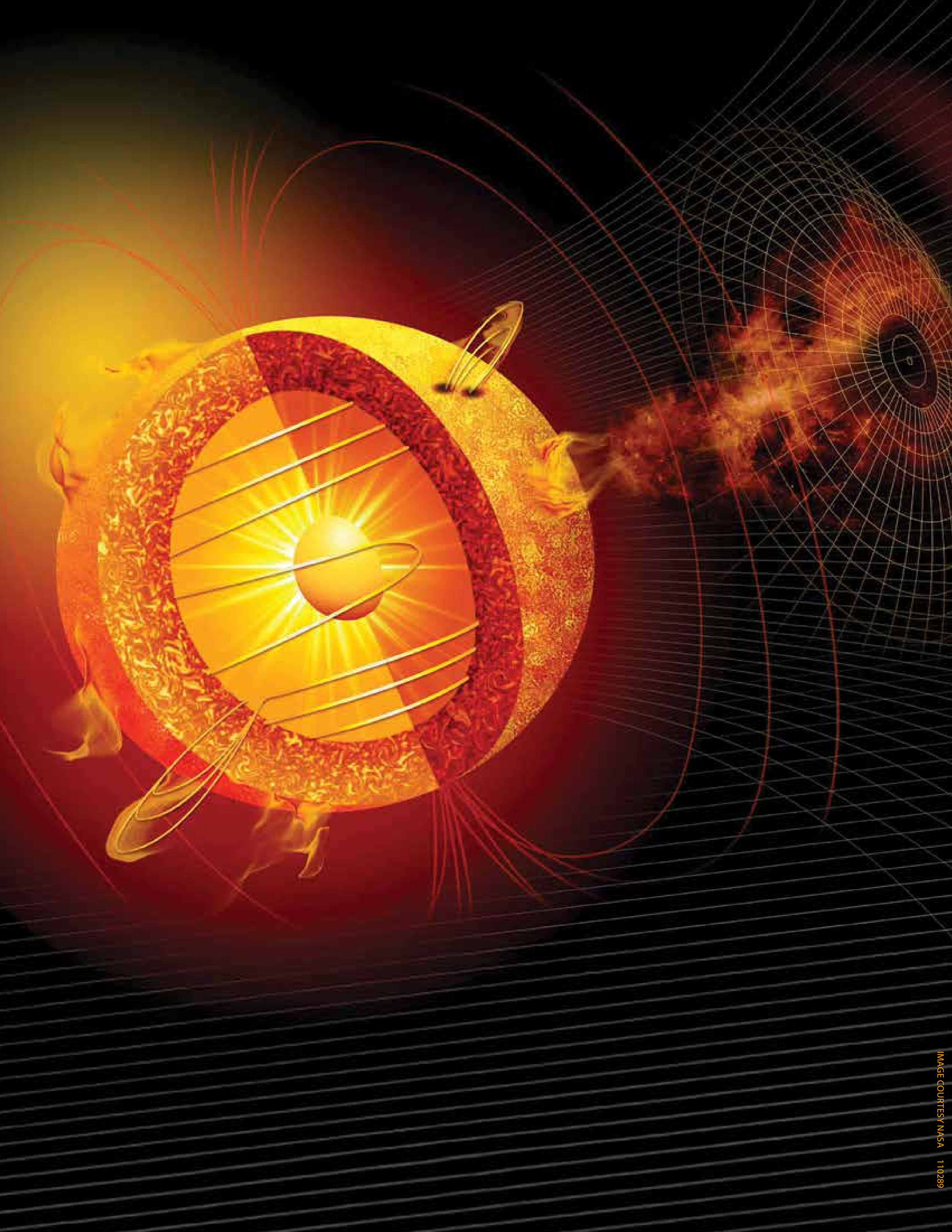
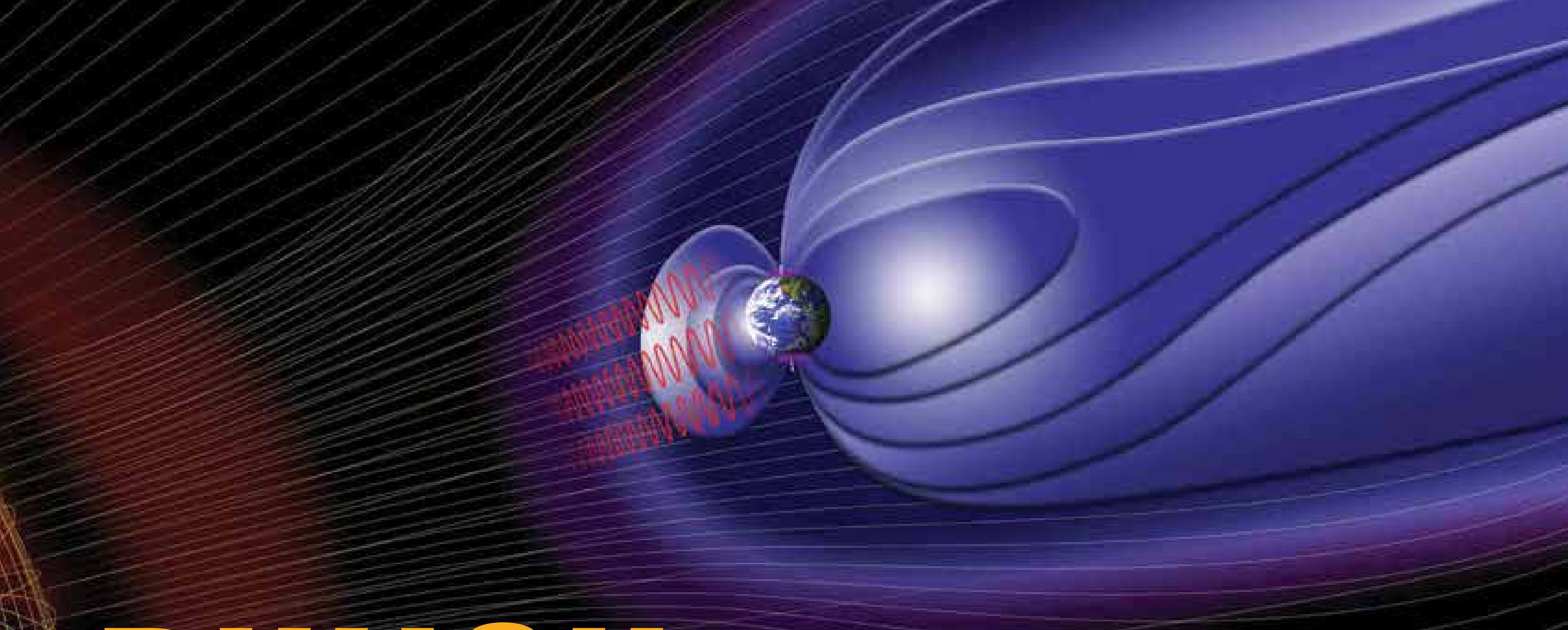


IMAGE COURTESY NASA 110289



PUNCH makes the invisible VISIBLE

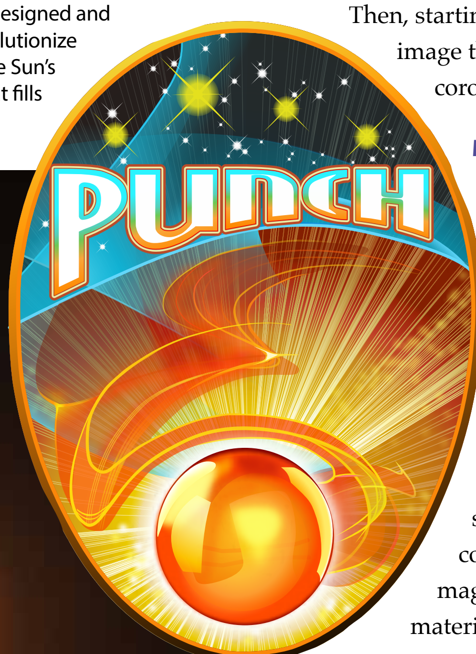
By Craig DeForest, Ph.D.

Every second, the Sun hurls over 300,000 tons of material in every direction at half a million miles per hour. This mixture of ionized atoms and free electrons becomes the solar wind. It permeates the solar system, washing over the planets and defining the heliosphere, our stellar neighborhood in the vast Milky Way. The solar wind includes gusts, surges, shocks and large structures like coronal mass ejections (CMEs) that cause space weather here at Earth.

110289

Prior to launch, the PUNCH spacecraft were attached to the gold-colored ESPA ring designed to deploy secondary payloads, below NASA's SPHEREx observatory, to cost-effectively share a ride to space. PUNCH's four small suitcase-sized spacecraft, designed and built by Southwest Research Institute, will revolutionize our understanding of how the solar corona, the Sun's outer atmosphere, becomes the solar wind that fills and defines our heliosphere.

IMAGE COURTESY BAE SYSTEMS/BENJAMIN FRY



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A SpaceX Falcon 9 rocket, carrying NASA's SPHEREx (Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer) observatory and the PUNCH satellites, launched from Space Launch Complex 4 East at Vandenberg Space Force Base in California on Tuesday, March 11, 2025.

IMAGE COURTESY NASA/JIM ROSS

IMAGING ALMOST NOTHING AT ALL

PUNCH, the Polarimeter to UNify the Corona and Heliosphere, is a NASA Small Explorer mission. It's the latest in a long line of space instruments and missions built by Southwest Research Institute (SwRI) to study the Sun and the solar wind. The four suitcase-sized spacecraft were built in SwRI's new Space Systems Integration Facility and launched together into Sun-synchronous low Earth orbit over the dawn/dusk line. The four satellites are synched to work as a single "virtual" instrument 8,000 miles across to collect wide-field, 3D movies of the entire inner solar system.

The SwRI-led PUNCH mission will integrate our understanding of the Sun's corona — the outer atmosphere visible during total solar eclipses — and the "solar wind" that fills and defines the solar system. With it, we'll be able to routinely see and understand the solar wind itself, as it streams out from our star and washes over the Earth.

PUNCH is an imaging mission, but it does not use a telescope. Its four ordinary cameras together have a broad field of view 90 degrees across, focused on the medium that surrounds and washes over us. Launched on March 11, PUNCH has a 90-day commissioning interval. Then, starting in June 2025, the four spacecraft will work together to image the solar wind as it accelerates through the Sun's outer corona and streaks toward our home planet.

MERGING SOLAR WITH HELIOSPHERIC SCIENCE

Until recently, solar physics and heliospheric physics were divided by technology. Solar physics, which studies the Sun itself, mainly use remote sensing technology, such as telescopes or spectrometers, to view our star and its corona on scales from a few hundred miles to a million miles. Heliospheric physics, which studies the protective bubble around the solar system and the solar wind itself, mainly uses direct, in-situ sampling. As the solar wind sweeps over a spacecraft, the probe collects samples that reveal the composition, temperature, speed, magnetic field and even magnetic connectivity of individual parcels of the tenuous material on scales as small as 100 yards.

With PUNCH, those two fields are merging. Three times per year, NASA's Parker Solar Probe carries its instruments through the outer solar corona to use in-situ techniques on the Sun itself. PUNCH works in the other direction, bringing coronal imaging outward to apply solar physics techniques to the solar wind between planets.

At over 1.5 million degrees Fahrenheit, the solar corona is so hot that it is a plasma — a fluid made up of a mixture of ions and free electrons, shaped and structured by the Sun's magnetic field. The free electrons scatter sunlight, which makes the corona spectacularly visible during a total solar eclipse. The plasma is so hot that it continuously escapes the Sun's gravitational pull, constantly flying off into space as the solar wind and streaking across the solar system.

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The SwRI-developed Wide Field Imagers have deep baffles that reject stray light to image the faint glimmer of the solar wind.

The Narrow Field Imager is a coronagraph built by the Naval Research Laboratory, specifically to work together with the WFIs and image the brightest portion of the solar corona.

Four 140-pound spacecraft are spread out in polar orbit and synchronized to act as a single "virtual instrument" 8,000 miles across. Three Wide Field Imagers (left) and one Narrow Field Imager capture the faint glimmer from particles escaping the solar corona to form the solar wind, producing a 90-degree portrait of the sky centered on the Sun.

The solar wind is so tenuous by the time it reaches Earth that, statistically speaking, none of the particles will ever collide. They do, however, trade momentum and kinetic energy, via electric and magnetic forces. That means the solar wind follows the same fluid equations as supersonic airflows here on Earth, with the addition of electromagnetic forces. It supports waves, turbulence and shocks — just like any other fluid or plasma system. PUNCH images will allow us to distinguish large-scale fluid phenomena that are hard to analyze with in-situ sampling, even as other SwRI missions, like the Magnetospheric Multiscale (MMS) mission., analyze the microphysics of the same material near the Earth.

PLANET-SIZED "VIRTUAL" INSTRUMENT

PUNCH will generate a lot of data — about one image every 17 seconds over its two-year mission. So, it needs to be close to ground-system antennas to downlink those data. Unfortunately, that also places the cameras close to a large planet — the Earth — which blocks nearly half of the view around the Sun. To see in all directions around the Sun requires building an instrument as large as the Earth. That wasn't possible, so the team used four small spacecraft, synchronized and spread around the Earth, to create a virtual instrument 8,000 miles wide, imaging a 90-degree-wide swath of sky centered on the Sun.

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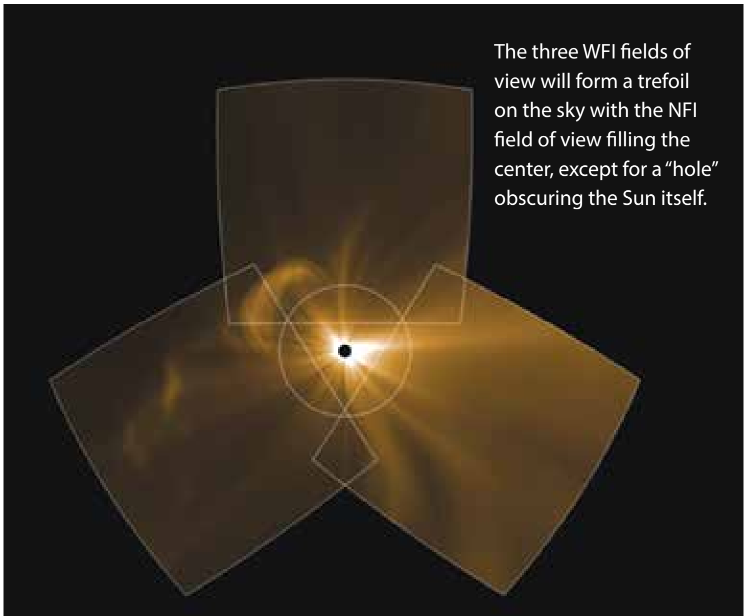


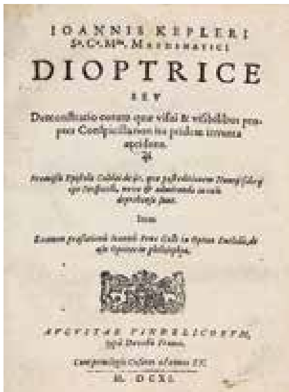
The three WFI fields of view will form a trefoil on the sky with the NFI field of view filling the center, except for a "hole" obscuring the Sun itself.

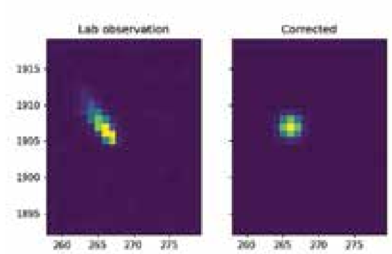
One of the four PUNCH spacecraft carries a "Narrow Field Imager" (NFI), while the other three spacecraft each carry a "Wide Field Imager" (WFI). The corona varies in brightness by a factor of nearly 10,000 across the PUNCH field of view. Dividing each image between NFI and WFI reduces that to a factor of 100 across each camera's field. Three WFIs are needed to ensure that the constellation as a whole can look outward from the Sun in all directions at all times.

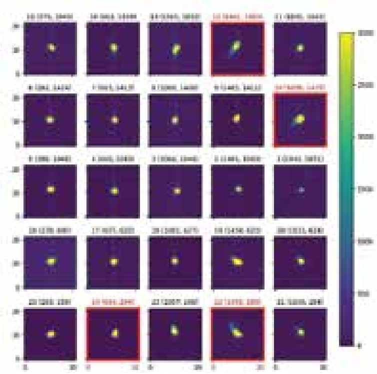
Once the four spacecraft are fully deployed, the three WFI fields of view will form a trefoil on the sky and the NFI field of view will fill the center, except for a "hole" obscuring the Sun itself. Every camera intersects the field of view of every other camera, allowing the instruments to be cross calibrated. The trefoil rotates as the spacecraft orbit the Earth once every 104 minutes. They travel in a low-altitude Sun-synchronous polar orbit that keeps all four spacecraft in sunlight.

REVEALING WHAT'S HIDDEN IN PLAIN SIGHT

The features that PUNCH studies are extremely faint, with the glimmer from the solar wind less than 0.1% as bright as the Milky Way galaxy backdrop. So, PUNCH raw images contain mostly stars and "zodiacal light" — a haze caused by dust orbiting the Sun in the inner solar system. Eliminating the starfield and the zodiacal light, while preserving the very faint solar wind signal, requires extraordinary







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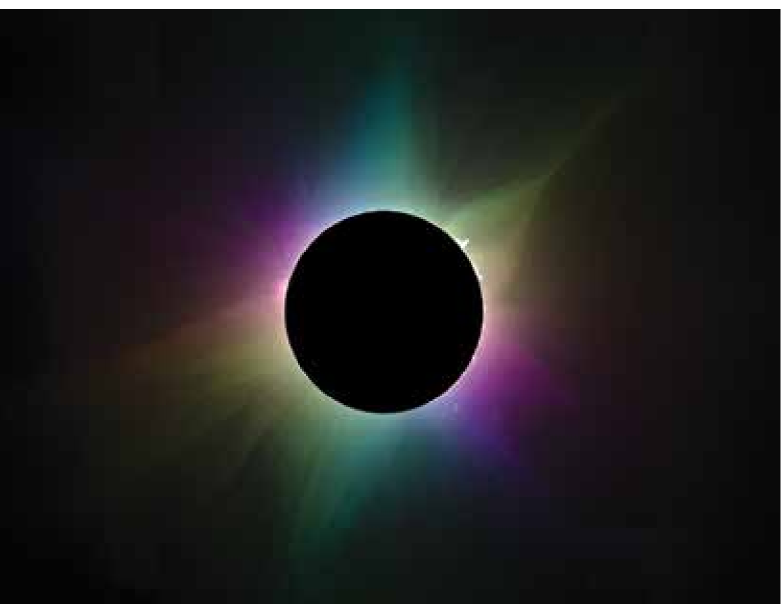
PUNCH scientists solved a 400-year-old problem in telescope design, first identified by Galileo Galilei and Johannes Kepler in 1611. The ground team adjusts the point-spread function of each image, to produce starfields from an idealized instrument with absolutely uniform focus.



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This processed image of the April 8, 2024, eclipse shows the Sun's corona in artificial colors that indicate the degree and direction of the light's polarization. Citizen scientists in Dallas collected these data through the SwRI-led Citizen Continental-America Telescopic Eclipse 2024 experiment.

DETAIL

Polarization describes light waves that vibrate in a single direction. Polarized sunglasses work because many sources of glare polarize light horizontally. By admitting only vertically polarized light, the glasses eliminate glare.

care because the smallest artifact or miscalibration would swamp the solar wind signal.

The PUNCH team has developed the most complex data processing pipeline for any NASA Explorer mission to date. The process includes precision photometric background removal and tracks the polarization of light through the entire calibration process. In addition, the PUNCH mission design merges data from four different cameras, essentially forming one "virtual instrument" with absolutely uniform imaging properties.

DETAIL

Hipparcos was a European Space Agency (ESA) satellite that mapped the positions, distances and motions of stars from 1989 to 1993.

This requires both extreme photometric precision and near-perfect co-alignment of the images. Novel resampling and correction steps compensate for optical distortion and focus effects to produce uniform data from across the constellation. The team uses a combination of precision star maps from the existing Hipparcos mission dataset and image cross-correlation to co-align PUNCH images across the entire field of view.

PUNCH uses polarization of light to measure 3D structures in the solar wind. The corona and solar wind contain free electrons, which are not attached to any particular atom. These free electrons scatter sunlight via the "Thomson scattering" process. Thomson scattering polarizes the sunlight, so that the electric field of the light oscillates or wriggles in a particular direction. The purity of the polarization encodes 3D information about the location of each feature PUNCH sees.

DETAIL

Thomson scattering describes how electromagnetic radiation is scattered by charged particles, illustrated by trajectory of electrons in visible light during a solar eclipse.

Measuring the linear polarization of light from the solar wind is challenging, because the solar wind is so faint compared to other sources of background light. The ground team developed a novel mathematical structure for measuring and manipulating the brightness of polarized light, applying color coordinates relevant to solar observing, while representing and removing each fixed background signal.

SwRI PRODUCES PUNCH

PUNCH is SwRI's third constellation mission and the second constellation integrated completely onsite. Prior missions include NASA's MMS mission, led by Dr. Jim Burch, senior vice president of SwRI's Space Sector, and built at NASA's Goddard Space Flight Center. MMS studies magnetic reconnection in Earth's magnetosphere using in-situ sampling. SwRI's first foray into spacecraft development was the Cyclone Global Navigation Satellite System (CYGNSS), an eight-spacecraft mission led by the University of

SwRI designed and built the four PUNCH spacecraft in its new Space Systems Integration Facility in San Antonio.

SwRI evaluated the PUNCH spacecraft in a new electromagnetic compatibility and interference test chamber. This vital testing happens just feet from the fabrication area, saving costs, increasing efficiency and decreasing risk of damage in transit.

Michigan and built at SwRI. CYGNSS assesses wind speeds and hurricane intensification by studying ocean waves using reflected GPS signals.

Like CYGNSS, the PUNCH mission aggressively leveraged commercially available subsystems and standardization to fit within the low-cost profile of NASA's Small Explorers line. The attitude determination and control system, radio uplink/downlink, GPS navigation, propulsion, solar arrays and battery are all commercially procured and integrated with SwRI-designed structure and command and data handling systems. The primary instruments are electrically identical and use identical subsystems to further simplify the design process.

SwRI collaborated with the U.S. Naval Research Laboratory, which built the Narrow Field Imager and polarizing filter wheels for all the PUNCH instruments, and RAL Space, which built the detector systems.

PUNCH is the first mission to be fabricated entirely in SwRI's new Space Systems Integration Facility. These expansive and vertically integrated facilities include ISO class 5, 6 and 7 clean facilities as well as multiple electrical and electromechanical laboratories, separated control rooms, an acoustic test facility, and electromagnetic compatibility and interference facilities.

PUNCH IMAGING

One of the four PUNCH spacecraft carries the Narrow Field Imager (NFI), a "coronagraph" with an external occulter designed to create an artificial eclipse of the Sun's disk. This multi-disk assembly images the far fainter corona, avoiding stray light from the Sun swamping the camera and "overexposing" the images. The NFI views in all directions around the Sun simultaneously, imaging a relatively narrow ring of light encompassing the Sun's outer atmosphere, where the solar wind is born.

The other three PUNCH spacecraft each carry identical WFIs, "heliospheric imagers" that incorporate conventional optics and deep baffles to attenuate stray light, allowing them to image visible light scattered by free electrons in the outer corona and young solar wind. Light trap and lunar baffles are nested around the camera aperture, reducing stray light in the instrument by over 16 orders of magnitude or a factor of 10 million billion — the ratio between the mass of a human and the mass of a cold virus. The state-of-the-art processing on the ground described above removes the background starfield, over 99% of the light in each image, to reveal the extremely faint solar wind.

The SwRI-developed Wide Field Imagers have deep baffles that reject stray light to image the faint glimmer of the solar wind.

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The remarkably resilient PUNCH team successfully overcame a number of late-breaking challenges over the last several months of the build to complete integration and environmental testing of the four observatories.

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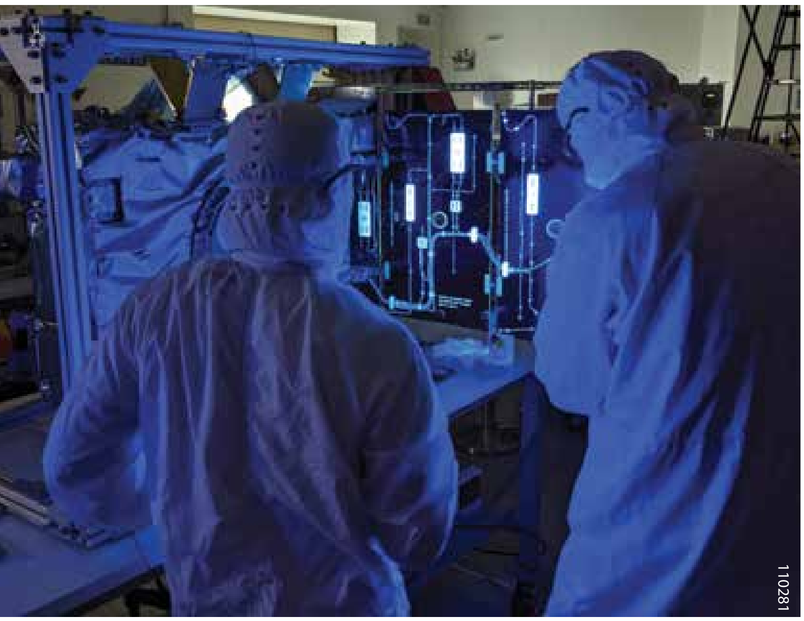

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Technicians conducted integration and testing of NASA's PUNCH satellites during prelaunch operations.

110279

ABOUT THE AUTHOR:

Dr. Craig DeForest, principal investigator of NASA's PUNCH mission, came dressed for success as the team made final preparations to send the four small satellites into orbit, which included pulling the "remove before flight" tags from the payload. As director of SwRI's Heliophsyics Department in the Solar System Science and Exploration Division in Boulder, Colorado, DeForest specializes in solar wind onset and matter-magnetic-field interactions in the solar atmosphere and solar wind.

OPERATIONS

SwRI oversees the PUNCH Mission Operations Center (MOC) from its offices in Boulder, Colorado. The MOC has four operator positions and 12 monitoring and command stations as well as an attached conference room, secure internal data routing, voice loop equipment and trained operators to support shift operations as needed.

Data from ground passes are transferred from the MOC to the Space Operations Center (SOC) for processing and then forwarded to the Solar Data Analysis Center at NASA's Goddard Space Flight Center for distribution.

TRACKING SPACE WEATHER

A secondary goal of PUNCH is to provide a new view of space weather such as coronal mass ejections (CMEs) that can drive disturbances in Earth's space environment. These solar events produce spectacular auroras but can also endanger astronauts, shut down electrical power grids and disrupt satellite-based communication and navigation systems.

Each spacecraft includes a camera, developed by RAL Space, to collect three raw images, through three different polarizing filters, every four minutes. In addition, each spacecraft will produce a clear unpolarized image every eight minutes, for calibration purposes. This new perspective will allow scientists to discern the exact trajectory and speed of coronal mass ejections as they move through the inner solar system, improving on current instruments that only measure the corona itself and cannot measure motion in three dimensions.

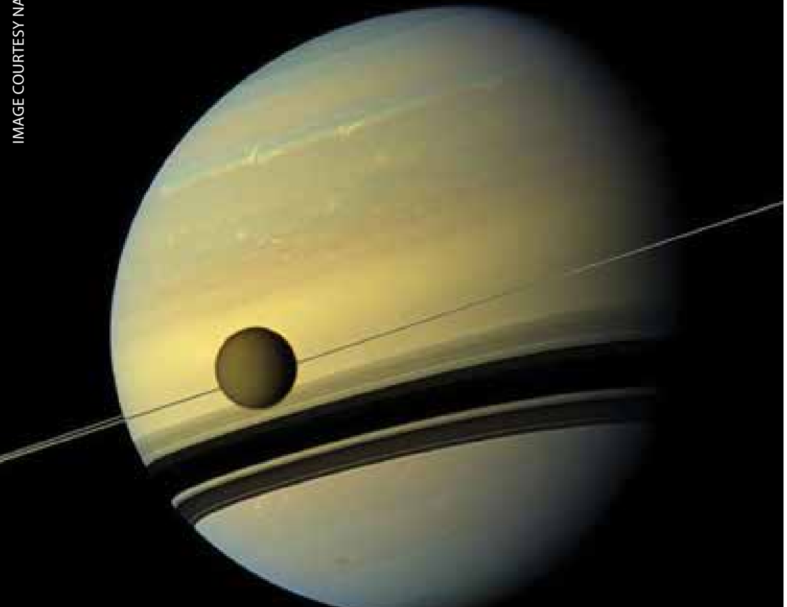
PUNCH will track space storms, or coronal mass ejections, in three dimensions as they approach the Earth — critical to understanding space weather. PUNCH technology and techniques are expected to help revolutionize space weather forecasting in the same way that geosynchronous satellites revolutionized weather forecasting on Earth.

PUNCH's four satellites will provide a new way to visualize a mysterious process happening right here in our own solar system — imaging how the solar corona transitions into the solar wind, which defines our place in the cosmos.

Questions about this story? Contact Dr. Craig DeForest at (303) 546-6020 or craig.deforest@swri.org.

IMAGE COURTESY SwRI

To understand the persistent thick atmosphere on Saturn's largest moon, SwRI worked with the Carnegie Institution for Science Laboratory to create laboratory experiments mimicking conditions at Titan's rocky core. Heating and pressurizing tubes of organics produced nitrogen in the form of ammonia and methane gas, which is necessary to maintain Titan's atmosphere.



Saturn's moon Titan loses energy as it orbits the ringed planet with its massive gravitational force.

UNRAVELING MYSTERIES ABOUT SATURN'S MOON TITAN

SwRI scientists are studying Saturn's moon Titan to assess its tidal dissipation rate, the energy lost as it orbits the ringed planet with its massive gravitational force, as well as how it maintains its unique nitrogen-rich atmosphere. Titan is the second largest moon in our solar system and the only one that has a significant atmosphere.

CONFIRMING THEORY ABOUT ATMOSPHERE

SwRI teamed with the Carnegie Institution for Science to perform laboratory experiments to better understand how Saturn's moon Titan can maintain its unique nitrogen-rich atmosphere.

"While just 40% the diameter of the Earth, Titan has atmospheric pressure that is 1.5 times the Earth's, even with a lower gravity," said SwRI's Dr. Kelly Miller, lead author of a paper about these findings published in the journal Geochimica et Cosmochimica Acta. "Walking on the surface of Titan would feel a bit like scuba diving."

The origin, age and evolution of this atmosphere has puzzled scientists since it was discovered in 1944.

"The presence of methane is critical to the existence of Titan's atmosphere," Miller says. "Reactions caused by sunlight remove methane, so it would disappear in about 30 million years, and Titan's atmosphere might freeze onto its surface. Scientists think an internal source must replenish the methane."

Miller's 2019 paper published in the Astrophysical Journal proposed a model for how the atmosphere may have developed and is replenished. The paper theorizes that large amounts of highly complex organic materials are heated in Titan's rocky interior, releasing nitrogen as well as carbon gases like methane. The gas then seeps out at the surface, where it forms a thick atmosphere around the moon.

TIDAL ENERGY KEY TO COMPOSITION

Understanding tidal dissipation helps scientists infer many other things about Titan, such as the makeup of its inner core and its orbital history.

"When most people think of tides they think of the movement of the oceans, in and out, with the passage of the Moon overhead," said Dr. Brynna Downey, a postdoc in SwRI's Solar System Science and Exploration Division. "However, when the Moon passes overhead, the rock is also responding, just less perceptively than water. But that little bit of gravity that the Moon is imposing is what we call tidal dissipation."

To measure tidal dissipation on Titan, scientists have developed a way to infer dissipation rates based on the difference in its spin axis rotation from what would be expected absent any such force.

"Tidal dissipation in satellites affects their orbital and rotational evolution and their ability to maintain subsurface oceans," Downey says. "Now that we have an estimate for the strength of tides on Titan, we discovered that it's changing very quickly on a geologic timescale."

A Science Advances paper by Downey and her co-author, Dr. Francis Nimmo of the University of California Santa Cruz, considered how the angle of Titan's spin pole orientation relates to a tidal friction parameter, deducing aspects of Titan's history from its current spin state.

STUDYING ENDANGERED SPRING SYSTEM

SwRI hydrologists are conducting a targeted water-sampling campaign of the Las Moras Springs system near Brackettville, Texas. The project will analyze and characterize the system of springs and its relationship to the Pinto Creek watershed to improve water management and conservation efforts.

"Las Moras, like many other Texas spring systems, is at risk and prone to going dry. It is important to clear up uncertainties about their source and relationship with the neighboring Pinto Creek watershed," said SwRI Research Scientist Mauricio Flores, who is leading the project.

Using advanced chemical testing, Flores hopes substances found in the samples will shed light on exactly where the spring water originates and how it arrives at Las Moras Springs. The team will also compare current and historical data to estimate the amount of groundwater that's regularly pumped from the regional water system. Excessive groundwater pumping and recurrent drought, which can reduce water flow and cause subsequent water quality issues, threaten Las Moras Springs and water security in Kinney County.

"Without better understanding of the source area and relationship with neighboring watersheds, it will continue to be difficult to effectively manage those water resources," said Flores.

The Las Moras Springs system flows from the Edwards Aquifer, discharging 12–14 million gallons of water a day, providing water for people living in Kinney County. The surrounding area also provides habitat for an array of plants and wildlife, including the threatened Devils River minnow and endangered golden-cheeked warbler. Las Moras adds to the cultural landscape in Brackettville and surrounding communities, dating back thousands of years.

The project is funded by a $50,000 grant from the Coypu Foundation, which supports environmental research.

110225

IMAGE COURTESY ANNABELL MCNEW/KINNEY COUNTY POST

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SwRI's new semi-anechoic shield enclosure is designed to perform EMC/EMI and radio frequency testing for spacecraft.

NEW CHAMBER TESTS SPACECRAFT

SwRI has added a semi-anechoic shielded enclosure for electro-magnetic compatibility and interference (EMC/EMI) testing for spacecraft. The test chamber is part of the turnkey Spacecraft Integration and Test Center within its 74,000-square-foot Space System Spacecraft and Payload Processing Facility.

The 400-square-foot EMC/EMI chamber is semi-anechoic, or free of echo, and shielded from electromagnetic interference. It performs standard emissions and susceptibility testing with an upper frequency limit of 40 gigahertz (Ka-band). It also supports spacecraft self-compatibility testing, which ensures that spacecraft subsystems and components work correctly and do not interfere with each other. The chamber will also evaluate radio frequency performance and compliance, important capabilities for wireless and telecommunica-tions operations.

"This new chamber performs tests that indicate how a spacecraft will respond to a space environment. It incorporates significant automation, allowing us to test satellites and instruments quickly and efficiently while maintaining appropriate cleanliness levels," said Institute Engineer John Stone. "Locating the EMC/EMI chamber adjacent to other test facilities will also reduce the time lost and risk associated with moving between facilities."

The chamber is part of an 11,000-square-foot environmental testing facility, which includes a high-decibel acoustic test chamber.

NEXT-GEN CORONAGRAPHS

SwRI has won a $60 million contract to build three coronagraphs for the National Oceanic and Atmospheric Administration (NOAA). SwRI's novel Space Weather Solar Coronagraph (SwSCOR) is NOAA's next-generation instrument to provide early detection and characterization of Earth-directed coronal mass ejections (CMEs).

CMEs are huge bursts of coronal plasma threaded with intense magnetic fields ejected from the Sun over the course of several hours. CMEs arriving at Earth can generate geomagnetic storms, which can cause anomalies in and disruptions to modern conveniences such as electrical grids and GPS systems. Coronagraphs are instruments that block out light emitted by the Sun's surface so that its outer atmosphere, or corona, can be observed.

"We're very excited to work with NOAA and NASA to provide this important space weather forecasting infrastructure," said SwRI's Dr. Craig DeForest, who is leading the project. "Routine images of the solar corona are as important to space weather forecasting as spaceborne imagery is to terrestrial weather forecasting. SwSCOR will be an important part of our nation's infrastructure."

SwSCOR will track space weather creating images of the corona every 90 seconds from 2.7 to 22 solar radii, similar to the current CCOR coronagraph recently launched on NOAA's Geostationary Operational Environmental Satellites (GOES). The instrument suite includes both flight hardware and rapid data reduction algorithms, which will deliver processed images to NOAA forecasters within minutes of a solar event.

"SwRI has a long history of developing cutting-edge space instruments and technology, and SwSCOR continues that tradition," said DeForest. "We've simplified the design for longevity and stability and optimized each part of the instrument, including an advanced occulter, for manufacturability and performance."

Stray light is the largest challenge of coronagraph design. Coronal structures a few degrees away from the Sun are a billion times fainter than the Sun itself. Diffraction injects stray light into the optics as sunlight scatters around the occulter in front of the instrument. Multi-disk coronagraph occulters cut stray light by many orders of magnitude. Adding more disks yields more occultation but tightens the machining or assembly tolerance, making them very challenging to create.

"SwSCOR has a novel occulter with specific design features that make it easier to fabricate," DeForest said. "Modern occulters require extremely precise shapes. We've adopted several techniques from optical manufacturing to improve that precision while keeping the process feasible and reliable."

By detecting Earth-directed CMEs shortly after they erupt, the instruments allow the longest possible lead time for geomagnetic storm watchers. With this forewarning, public and private organizations affected by space weather can take actions to protect their assets. The coronagraphs will also provide data continuity from the Space Weather follow-on Lagrange 1 mission.

SwRI designed and prototyped SwSCOR using internal funding, incorporating heritage processes and facilities from the development of the Polarimeter to Unify the Corona and Heliosphere mission's Wide-Field Imager (see story p. 2). SwSCOR will be developed at SwRI's Solar System Science and Exploration Division, in new facilities in downtown Boulder, Colorado.

110286/110287

New NOAA Magnetometers

NASA and the National Oceanic and Atmospheric Administration (NOAA) recently awarded SwRI a $26 million contract to develop magnetometers for NOAA's Space Weather Next (SW Next) program. The magnetometers will measure the interplanetary magnetic field carried by the solar wind for two missions scheduled to launch in 2029 and 2032.

"The instruments provide critical data to NOAA's Space Weather Prediction Center, which issues forecasts, warnings and alerts to help mitigate space weather impacts," said Dr. Roy Torbert, a program director in SwRI's Earth, Oceans, and Space office at the University of New Hampshire (UNH) in Durham, and principal investigator of the instruments. "Space weather refers to the variable conditions on the Sun and in space that can influence the performance of technology we use on Earth, such as electrical power grids, and disrupt satellite-based communication and navigation systems."

The magnetometers will be deployed on satellites that will orbit the Sun at approximately 1.5 million kilometers from the Earth at a point known as Lagrange 1, or L1. Gravitational forces from the Sun and the Earth hold objects at L1 in a stable position and offer an uninterrupted view of the Sun. The instrument will make local measurements of the magnetic field conveyed by the solar wind as it blows toward the Earth.

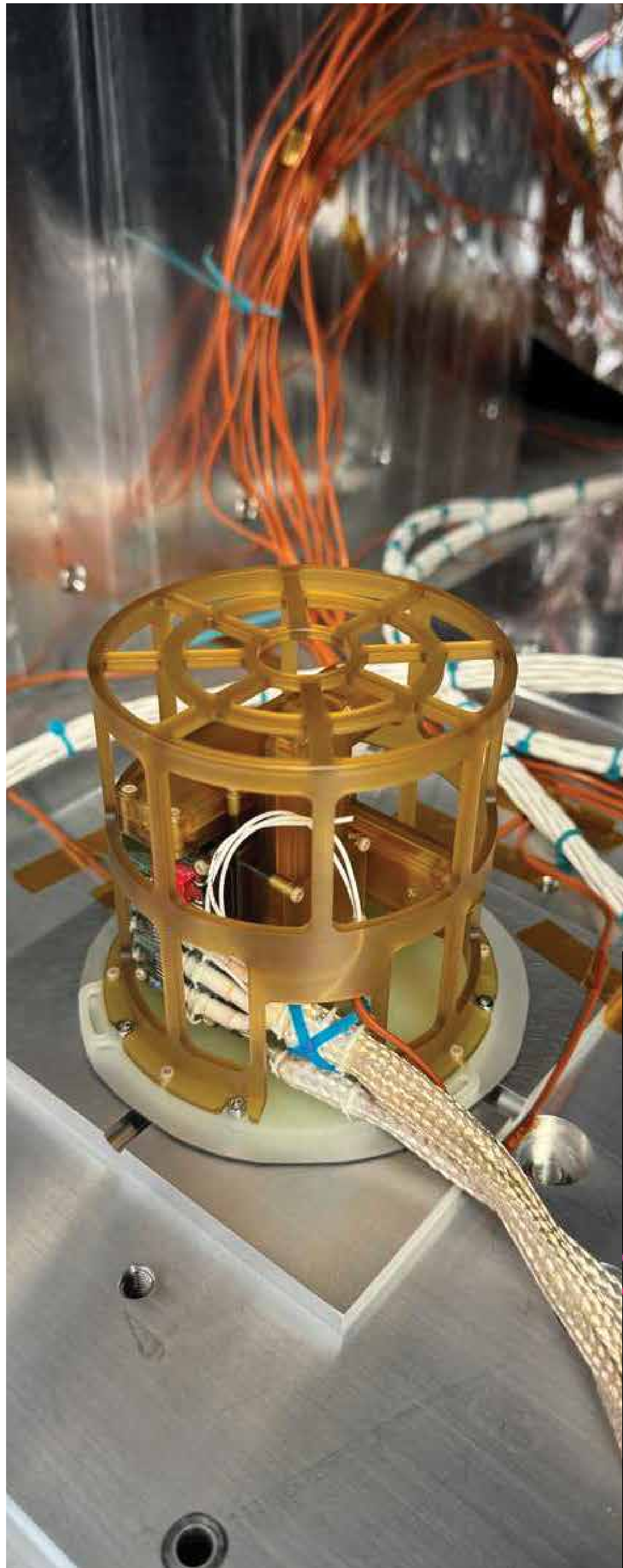
"The instrument, known as SW-MAG, provides key data about the solar wind as it approaches Earth," Torbert said. "The data will be available to the science community but are targeted to the Space Weather Prediction Center."

SwRI will work with UNH to design, develop, fabricate, integrate, calibrate and evaluate the magnetometer instrument. The team will also support launch and on-orbit check-out of the instrument, supply and maintain the instrument's ground support equipment, and support NOAA's mission operations center as needed. SW-MAG includes two three-axis magnetometers and associated electronics to measure the vector interplanetary magnetic field.

"The solar wind magnetic field controls the processes that transfer energy and particles into the Earth's magnetosphere and often initiates geomagnetic storms," Torbert said. "These disturbances can create spectacular auroras but can also shut down electric power grids and disrupt satellite-based communication and navigation systems."

SW NEXT is a follow-up to the SWFO-L1 mission, which also has an SwRI-developed magnetometer in its payload, scheduled to launch in 2025 as a rideshare with the Interstellar Mapping and Acceleration Probe (IMAP) vehicle. SwRI also plays a role in that mission, managing the payload and payload systems engineering for IMAP, which will sample, analyze and map particles streaming to Earth from the edge of interstellar space.

NASA and NOAA oversee the development, launch, testing and operation of all the satellites in the Lagrange 1 Series project. NOAA is the program owner providing the requirements and funding along with managing the program, operations, data products and dissemination to users. NASA and its collaborators will develop and build the instruments and spacecraft and provide launch services on behalf of NOAA. SwRI will work with NASA's Goddard Space Flight Center and Kennedy Space Center to develop the magnetometers.



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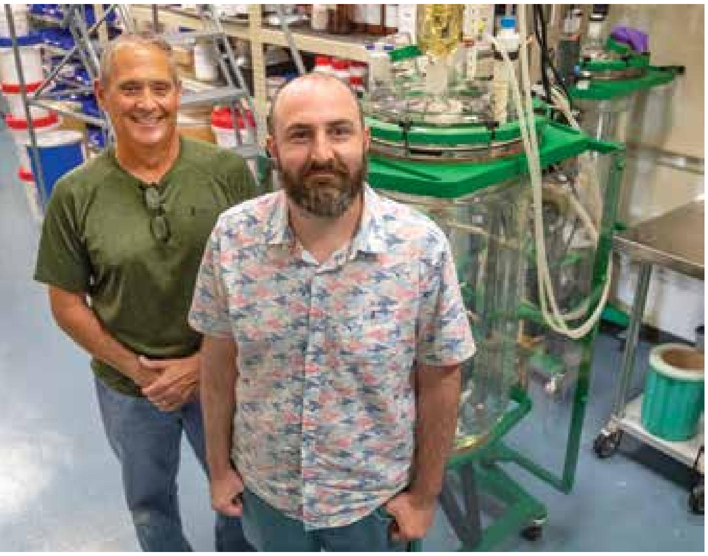
DEVELOPING TOMORROW'S ANTIBIOTICS



110292

SwRI's Dr. Shawn Blumberg (right) and his co-principal investigator, Dr. Stanton F. McHardy of UTSA's College of Sciences, will use funding from the SwRI/UTSA Connect program to develop a synthesis process to create a pipeline of new polycyclic antibiotics.

SwRI is collaborating with The University of Texas at San Antonio (UTSA) to explore and develop a novel platform or chemical process for synthesizing antibiotic compounds. The project is supported by the Connecting through Research Partnerships (Connect) program designed to foster collaboration between SwRI and UTSA.

"SwRI and UTSA will work together to combat the growing threat antimicrobial resistance poses to global health by developing a proof-of-concept platform to potentially create a whole library of new antibiotics," said Dr. Shawn Blumberg, a lead scientist in SwRI's Chemistry and Chemical Engineering Division and co-principal investigator (PI) of the project.

The World Health Organization (WHO) estimates antimicrobial resistance is either a direct cause or a contributing factor in millions of deaths worldwide each year. The crisis is exacerbated by what WHO calls "an antibiotics pipeline and access crisis."

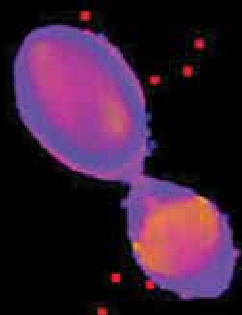
Blumberg and his co-PI, Dr. Stanton F. McHardy of UTSA's College of Sciences, will focus on creating a pipeline of new polycyclic antibiotics. This class of antibiotics includes tetracyclines, commonly used to treat pneumonia; anthracyclines, used to fight cancer; and polycyclic xanthones, natural compounds with known health benefits.

"Polycyclic xanthones offer a variety of potential therapeutic applications, but they haven't been assessed yet," said McHardy. "With the new synthesis process, we're hoping to rapidly access a unique class of chemical building blocks, structural analogs and new compounds."

The team plans to use the process to discover more effective tetracycline antibiotics and safer anthracycline treatments with fewer side effects. Blumberg and McHardy also hope to create synthetic polycyclic xanthones that can mimic natural analogues while delivering new mechanisms of action or new ways of fighting infections.

PLUTO-CHARON FORMED BY 'KISS AND CAPTURE'

IMAGE COURTESY SwRI/ADEENE DENTON/ROBERT MELIKYAN 110231



A NASA postdoctoral researcher at SwRI has used advanced models that indicate that the formation of Pluto and Charon may parallel that of the Earth-Moon system. Both systems include a moon that is a large fraction of the size of the main body, unlike other moons in the solar system. The scenario also could support Pluto's active geology and possible subsurface ocean, despite its location at the frozen edge of the solar system.

"We think the Earth-Moon system initiated when a Mars-sized object hit the Earth and led to the formation of our large Moon sometime later," said Dr. Adeene Denton, who led the research published in Nature Geoscience. "In previous models, when proto-Charon hit proto-Pluto, you have a massive shearing effect of fluids that looks like two blobs in a lava lamp that bend and swirl around each other. Adding in structural properties allows friction to distribute the impact momentum, leading to a 'kiss-and-capture' regime."

When Pluto and Charon collide, they stick together in the shape of a snowman. They rotate as one body until Pluto pushes Charon out into a stable orbit. And this collision scenario supports the formation of other moons, such as Pluto's four other tiny, lumpy satellites.

This new model tells us how the impact may have happened but not when, which is significant, particularly because Pluto is thought to be geologically active and may have a liquid ocean beneath its icy surface.

SwRI-LED PUNCH MISSION

SCIENCE TEAM

- **40** members
- **4** continents
- **7** countries

- **90°** field of view
- **180,000,000** miles across
- **3** dimensions

SwRI'S WFI

- Views from **18 to 180 solar radii**, or **45 degrees**, away from the Sun in the sky
- Images the faint outermost portion of the solar corona and the solar wind itself
- Reduces direct sunlight by over **16 orders** of magnitude or a factor of **10 million billion** — the ratio between the mass of a human and the mass of a cold virus

Measuring **1,500,000°F** plasma
Traveling **250** miles/second

110247

IMAGES COURTESY NASA'S CONCEPTUAL IMAGE LAB/KIM DONGJAE, WALT FEIMER

EVERY SECOND, OVER 300,000 TONS OF MATERIAL LEAVE THE SUN AND STREAK OUTWARD INTO SPACE.

This solar wind impacts everything in the solar system, including Earth, causing the beautiful northern and southern lights. It also creates space weather, which threatens our power grids, satellites and astronauts. NASA's Polarimeter to Unify the Corona and Heliosphere (PUNCH) mission will integrate our understanding of the Sun's corona as it transitions into the solar wind. Four suitcase-sized spacecraft, designed and built by Southwest Research Institute, are synchronized to serve as a single "virtual instrument" to capture roughly a quarter of the sky, centered on the Sun. PUNCH will continuously track the solar wind in 3D for the first time, to help us better understand the Sun, the solar wind and their effects on humanity.

110297

MISSION

4 spacecraft =
1 virtual instrument
~**8,000** miles across

3 carry Wide-Field Imagers (WFIs)

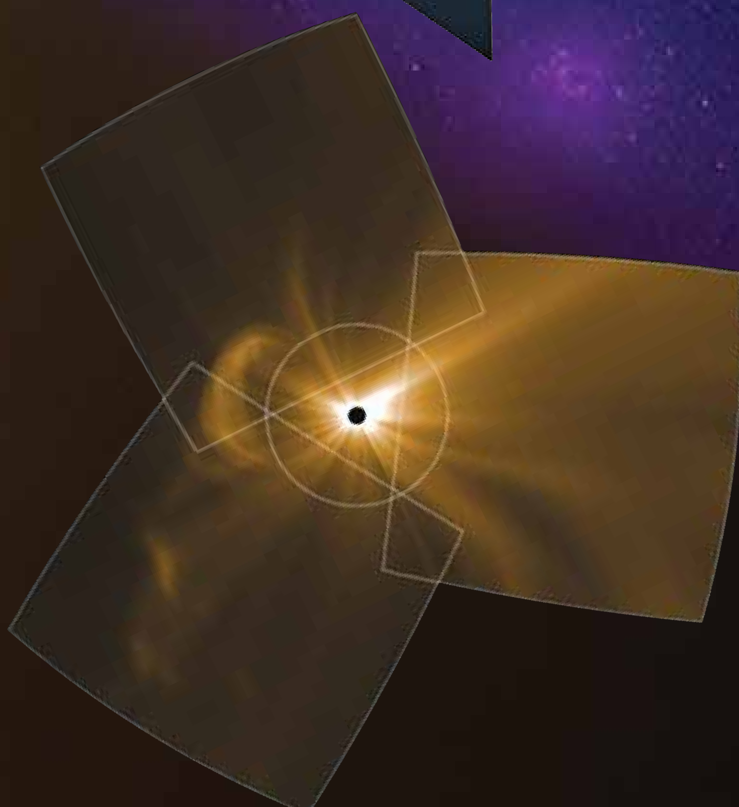
1 carries a Narrow Field Imager

110277

3D DATA

As electron particles scatter sunlight, the waves of light become aligned in a particular way — this is polarized light. Using polarizing filters allows scientists to measure motion in 3D to discern the trajectory and speed of coronal mass ejections as they move through the inner solar system.

- **3** raw images every **4** minutes
- **3** polarizing filters
- Unpolarized calibration image every **8** minutes
- **4** spacecraft working together
- Synchronized to **1** second



110224

Making Waves

6 TARGETED BRAIN RESEARCH INITIATIVES

The brain is the most critical and complex organ in the human body. Three pounds of gray matter nestled in the human skull are the source of our intelligence, senses, movement and behavior — the qualities that define our humanity.

110251

In 2024, Southwest Research Institute launched a brain health working group to bring together multidisciplinary specialists studying everything from how neurons grow and connect, to screening and preventing brain injuries and assessing decline.

The group's goal is to create multifunctional and multidisciplinary tools and resources at SwRI to support brain health research and development. The team wants to build platform-based technology that uses machine learning to create tools using data from multiple research initiatives and sources. Examples include traumatic brain injury (TBI) screening tools and techniques, sensor systems and various measurement and diagnostic tools. The goal is to combine objective data to find patterns across tools, integrating with electronic charting and patient tracking systems to provide a continuity of care while continuing to evolve and improve through expanded data learning algorithms.

The team aims to provide an adaptable platform that provides accessible, relevant and understandable information quickly and reliably through all phases of care.

This feature outlines just a few projects underway across SwRI. For instance, machine learning specialists are looking at how neuronal networks form in the brain and how that could affect brain health as well as understanding how cognitive load, the amount of mental effort needed to perform a task, affects function. Chemists are looking at new and creative ways to screen for TBIs that are less expensive and invasive, while mechanical engineers are looking at high-tech helmets designed to prevent injury. And human performance engineers are looking at how to detect cognitive decline using the kinematics of gait.

Research into TBIs is a particular focus, in part because the effects vary so widely, from minor to lifechanging and everything in between. And TBIs — caused by a forceful bump, blow or jolt to the head or body or from an object entering the brain — are common. In the U.S., TBIs result in 200,000 hospitalizations and 70,000 deaths a year. Some TBIs cause temporary or short-term problems with brain function, including problems with cognition, comprehension, movement, communication and actions. More serious TBIs can lead to severe or permanent disability and even death. Causes include falls, motor vehicle crashes, sports injuries, blasts, battlefield trauma or blows by an object.

Explore the following six targeted research programs making waves in brain research.

1 NEURAL CONNECTIONS

Dr. Courtney Rouse, a senior research engineer in SwRI's Intelligent Systems Division, led research to develop a computational method to improve techniques to track brain cell development over time.

110240

Understanding how neurons evolve and form networks in the brain could lead to new drug treatments for people suffering from neurological disorders. A team led by SwRI developed a computational method to improve techniques to track brain cell development over time.

SwRI collaborated with The University of Texas at San Antonio (UTSA) to track individual brain cells undergoing neurogenesis, the process where new neurons grow and connect to neuronal networks. UTSA researchers developed novel methods to grow human stem cells that form networks, such as those that regulate sleep, temperature and mood. As the neuronal networks developed, their activity was captured by confocal microscopy. SwRI then used the visual data to train algorithms to track the neurons. In the future, these algorithms could automatically classify the health of growing neuronal networks to study various neurological diseases and help develop and test associated therapies.

Conventional neuron-tracking methods frequently rely on images of labeled cells in fixed tissue, a process that can obscure cellular dynamics. The SwRI-led analysis overcomes technological gaps in prior computational methods by capturing unlabeled cells and fine structures in dense, live cultures. This allows for complex analysis over longer time spans. Each video of the neuronal network cultures consists of timestamped images with hundreds to thousands of neurons per image. SwRI trained a U-Net machine learning algorithm to detect the shape and location of individual neurons in the images.

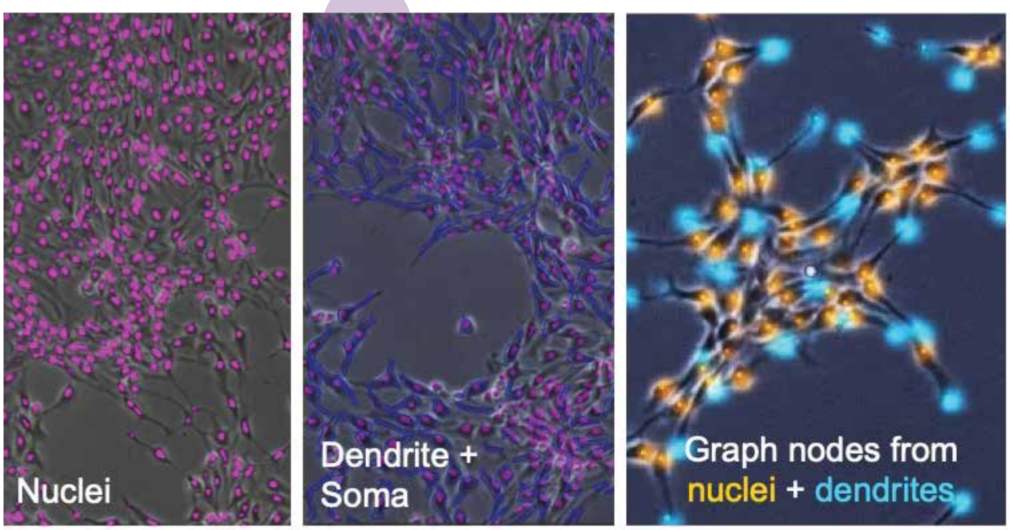
SwRI trained the algorithm to recognize two of the main parts of a neuron — the soma, which contains the nucleus, and dendrites, root-like structures connecting with other neurons, forming neuronal networks that send and receive signals.

The team focused on tracking the somas, because each neuron has one soma, while dendrite numbers vary. The algorithm applied a tracking number to a key point on each soma to match neurons in consecutive images based on proximity within a pixel. When detecting somas, the algorithm achieved a 93.8% precision rate and a 99.1% recall rate.

When detecting dendrites, the smaller branch-like structures, the algorithm achieved an 88.3% precision rate and an 80.9% recall rate. Overall, the algorithm had an 85.7% probability of correctly tracking a single neuron in consecutive images.

The team plans future research to identify connections between soma and dendrites, test neurons exposed to various environmental stresses — such as low oxygen or circadian disruption — and correlate neuron electrical activity to tissue health.

The research helped bridge technological gaps in computational neural research. The algorithm accurately tracked individual soma across timeframes, a fundamental step toward classifying the health of a developing neuronal network. The project was funded by a $200,000 award from the San Antonio Medical Foundation.



110221

Using UTSA's video data of developing neurons, SwRI trained various algorithms to detect neurons and their components. From left, the team trained a U-Net algorithm to detect somas (pink) and an instance-aware semantic segmentation algorithm to detect whole neuron contours (blue) overlaid on the somas (pink). They used a convolutional neural network based on Inception V3 to detect somas and dendrites.

2 COGNITIVE LOAD

Dr. Katelyn Fry-Hilderbrand, a research engineer in SwRI's Intelligent Systems Division, developed a fieldable system to assess cognitive performance in diverse settings.

110259

Cognitive load refers to the mental effort needed to process information, and consequently, excessive loads can hinder learning and performance. For example, a student struggling to solve a complex math problem while simultaneously learning the underlying concepts for the first time illustrates high cognitive load.

The concept of cognitive load is central to understanding how the brain allocates its working memory resources, vital for generating thoughts and solving problems. When overwhelmed, cognitive overload hampers the ability to think, learn, remember and solve problems. The ability to assess cognitive load is essential to some professions, particularly for the military, surgeons, long-distance drivers and welding, to name a few.

As part of an internal research program, Southwest Research Institute explored psychophysiological measurements to assess cognitive load, aiming to create a field-ready cognitive load assessment tool. Traditionally, getting these measurements required controlled environments, limiting their broader applicability. SwRI created a data collection system using off-the-shelf components to assemble data similar to those gathered by traditional lab-based systems, including electrocardiography sensors, voice recorders and eye-tracking cameras.

Using this system, subjects underwent tasks designed to increasingly challenge cognition until they reached an overloaded state. The team then trained predictive models using data from both setups to predict cognitive performance and compared the accuracy of these models to validate the fieldable system. Models trained using the traditionally gathered dataset and the fieldable dataset had similar predictive powers, validating the use of the fieldable system.

Additionally, the team found that individualized models improved accuracy significantly compared to generalized models. Larger training datasets could enhance the accuracy of general models, while individualized models promise better predictions with fewer samples. The successful implementation of the fieldable system enables SwRI to assess cognitive performance in diverse settings.

As part of a continuing research effort, the team used the fieldable system to analyze the impact of various stressors on cognitive performance, including how cognitive performance changed with the introduction of physical stress. The team evaluated cognitive performance before and after physical loading tasks to understand the impact of physical exertion. Analysis revealed a general decline in cognitive performance after physical tasks, though not uniformly, suggesting a nuanced relationship between physical load and cognitive capability, where moderate physical exertion might benefit cognitive performance. Upcoming research will examine the relationship between cognitive performance and other stressors such as fatigue, emotional stress, etc.

110257

Fry-Hilderbrand explored psychophysiological measurements to assess cognitive load, which is central to understanding how the brain allocates its working memory resources and vital for generating thoughts and solving problems.

3 TBI SCREENING KIT

Kreg Zimmern, a senior research engineer in the Chemistry and Chemical Engineering Division, championed the AMMO field-ready TBI screening kit, with potential uses from the battlefield to the football field. The test identifies the inability to smell, which correlates highly with a TBI.

110245

Traumatic brain injuries (TBIs) can have profound and sometimes long-term effects that can dramatically change the course of lives. They are also notoriously difficult to diagnose, and multiple TBIs can be catastrophic.

To address this, SwRI developed a field-ready screening tool for TBIs. The Advanced Military Measure of Olfaction (AMMO) kit includes an array of scents, deployable anywhere from the battlefield to the football field, to help screen for TBIs in minutes.

The AMMO test kit is not intended as a diagnostic test but as a screening tool. The kit includes six sealed vials that release a range of odors, such as fruity and spicy aromas. When squeezed, a test vial turns blue to indicate a smell has been released and is ready for use. Patients are asked to identify the odor from four possible choices on an attached card. Answers are documented onto a separate answer card with the correct answers hidden behind a sticker. Research indicates that failing to identify the scents correctly correlates highly with positive results for TBI on an MRI exam.

Someone exposed to a blast on the battlefield could be screened immediately with AMMO instead of waiting for the onset of signs or symptoms of TBI. The inability to identify the scents could be used as rationale to justify an MRI. Similarly, someone in a rural area or at a sports tournament could be AMMO tested to determine if a trip to an emergency room is warranted.

AMMO is currently undergoing stability studies to determine how long the kit can be stored and remain effective. SwRI is developing AMMO in compliance with relevant Food and Drug Administration and ISO guidelines. It's the only olfactory test kit to undergo such rigorous controls.

The kit is inexpensive, compact, has no special storage conditions and doesn't need electricity. This makes it a potential screening tool in emergency rooms as well as at workplaces, nursing homes and youth, collegiate and professional sports games. While AMMO doesn't require any specialized training to administer, the results can inform the decision-making process for first responders and doctors.

SwRI collaborated with the Henry M. Jackson Foundation for the Advancement of Military Medicine and the Air Force Research Laboratory to develop AMMO.

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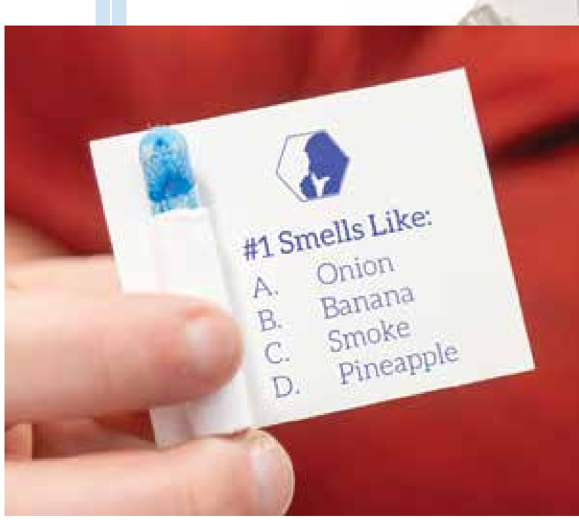

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110238/110239

4 BREATH-BASED BIOMARKERS

Dr. Mark Libardoni, a staff scientist in the Space Science Division, has been working on breath-based biomarkers as part of SwRI's Brain Health Working Group. Libardoni has developed novel methodology that allows organic compounds in breath to be analyzed by gas chromatography and mass spectrometry.

110272

Globally, traumatic brain injuries (TBIs) affect approximately 50 million people and are a leading cause of cognitive and behavioral decline. To address this pressing issue, researchers are striving to develop diagnostic tools that are rapid, sensitive and accurate. SwRI is exploring the use of metabolic biomarkers in breath to create a noninvasive diagnostic solution for TBIs as part of its Brain Health Working Group.

Human breath is abundant with organic compounds that form an individual's unique "breathprint." This breathprint reflects the levels of metabolites — small molecules like amino acids and lipids — produced through the body's chemical processes. Breath analysis, a practice rooted in ancient Chinese medicine, has more recently been employed to diagnose and manage diseases such as lung cancer, prostate cancer, breast cancer and even Parkinson's and age-related dementia such as Alzheimer's. Over the past five decades, advances in analytical instruments and computing have enabled scientists to decode the composition of breath and link it to specific health conditions.

In medical applications, breath analysis can differentiate between healthy and diseased states and monitor health changes over time. It offers remarkable sensitivity and detectability, complementing traditional blood and urine tests while enhancing research capabilities as a non-invasive screening tool.

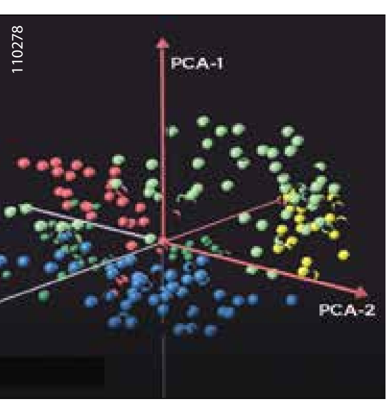
SwRI collaborated with the University of Texas at San Antonio (UTSA) to identify breath biomarkers linked to mild TBIs, including concussions and sub-concussions. The research involved equipping participants with accelerometer-embedded mouthguards to measure impact forces as they repeatedly headed a soccer ball. Researchers collected breath and blood samples at multiple intervals — before the activity, immediately after and over the following seven days. While UTSA analyzed blood samples for known brain inflammation markers, SwRI examined breath samples for various organic compounds. The data were then integrated and processed using machine learning to pinpoint biomarkers associated with brain inflammation.

SwRI's expertise in breath analysis began with developing technology to monitor air quality and astronaut breath biomarkers on the International Space Station. For the TBI research, scientists captured organic compounds from breath samples in sorbent tubes, which were thermally desorbed and analyzed in the lab. Gas chromatography-mass spectrometry (GCMS) separates and identifies organic compounds in the sample. Concurrently, materials scientists and engineers worked on miniaturized sensors tailored to detect TBI-specific biomarkers in breath.

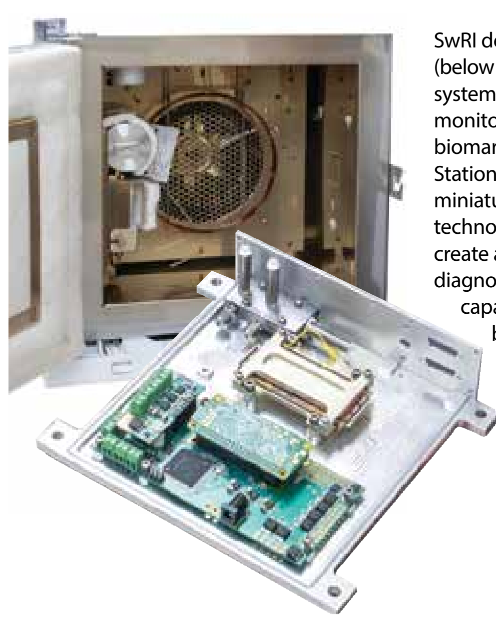
Breath contains a wealth of information, with upwards of 1,500 detectable compounds. Using GCMS data analysis tools, researchers isolated key compounds based on factors such as concentration and chemical structure. These data were then shared with biostatisticians and modelers to identify the most relevant TBI biomarkers, both visually and numerically.

The ultimate goal is to create portable, handheld diagnostic devices capable of detecting these biomarkers. Such devices would allow users to simply exhale into them, enabling rapid, on-site and highly accurate TBI diagnoses.

110278



After collection and processing, biostatisticians use mathematical tools to determine the statistical relevance of identified compounds. With hydrocarbons in blue, ketones in yellow, aldehydes in green and fatty acids in red, the biomarkers are represented as a function of their chemical family and amount of variance between healthy and injured states. From here, scientists can determine the compounds specific to TBI.



SwRI developed small, rugged technology (below center) to perform GCMS (conventional system shown in background left) analyses to monitor the air quality and astronaut breath biomarkers on the International Space Station. The team is now miniaturizing that technology further to create a handheld diagnostic device (right) capable of detecting TBI biomarkers in the field.

110253, 110245, 110254

5 TBI PREVENTION

Dr. Daniel Portillo, a research engineer in SwRI's Mechanical Engineering Division, is studying how new helmet designs and high-tech pad materials can provide the best protection against battlefield injuries.

110235

Incidents of TBIs are prevalent in military personnel as a result of blast exposures, blunt trauma and ballistic impacts encountered in combat and training scenarios. These profound injuries affect not only the physical health of the service members but also their mental health, cognitive functioning and quality of life.

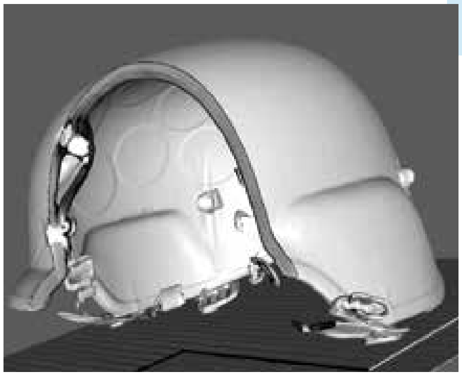
Helmets, the primary form of protection against these threats, have undergone significant improvements over the last 70 years. Emerging technologies and materials provide new options for improving a helmet's ability to reduce the risk of TBI among service members. SwRI is currently focused on the padding within military helmets, where efforts aim to reduce injury by developing pads that adapt to forces applied. For instance, protecting against blunt impact forces needs a softer pad, something like foam, while ballistic impact forces are best mitigated by stiffer pads, like rubber. The goal is to engineer a material that changes its behavior based on the type of impact. The outer shape of the pad and helmet reduces the force of blast impact.

Computational modeling allows engineers to explore novel helmet padding materials and geometries to be optimized for specific cases like blunt, ballistic and blast impacts. SwRI has a history of conducting high-fidelity and experimentally validated simulations for a range of dynamic events. The team uses a variety of software tools to model these events, including the Elastic Plastic Impact Computation, or EPIC, dynamic finite element code. EPIC is managed and distributed by SwRI to model wave propagation, elastic-plastic flow, material failure, fragmentation and complex interfaces.

Over the past 20 years, SwRI has also developed high-fidelity computational models of the human body to investigate numerous aspects of human biomechanics and performance, injury assessment and mitigation, and musculoskeletal disease and joint replacement. Currently, engineers are incorporating a high-fidelity brain model into the existing full-body finite element model. Combining both types of simulations will predict how the helmet pad performs and what level of injury a user would sustain during an actual event.

While models are extremely useful in understanding the exact mechanics and interaction between an impact event and the human body, they are often validated and fine-tuned using experimental data. SwRI has decades of experience in the ballistic and explosive testing required to validate the computational models of the helmet pads.

Ballistics tests are often conducted using powder guns or compressed gas guns, which launch a wide variety of projectiles at a wide range of speeds. Explosive tests are often conducted in blast chambers, at various open-air test sites or replicated using shock wave-generating devices. SwRI uses these tests to study how materials, armors and protection systems respond to impacts. SwRI is combining its experience in cutting-edge materials, computer simulations and experimental validations to rapidly create new helmet pads and other technologies to better protect those who protect us.



110258

To develop better military helmets, SwRI uses CT imaging to visualize and characterize how composite materials halt ballistic projectiles.

To improve helmet padding materials, Portillo (left) collaborated with the University of Texas at San Antonio's Morteza Seidi, evaluating military helmet protection against small arms fire.

110223

6 DETECTING DECLINE

110235

Dr. Dan Nicolella , an Institute Engineer in SwRI's Mechanical Engineering Division, co-leads the team that developed SwRI's ENABLE™ markerless motion capture technology. Engineers use ENABLE to assess the full range of human performance, including early signs of cognitive decline using biomechanical assessments of gait.

Gait analysis, the way a body moves through space, can be used to diagnose neurodegeneration. Subtle shifts in the way we walk can serve as an early indication of cognitive decline. Traditional clinical assessments have relied on basic spatiotemporal measures such as gait speed and stride length gathered from instrumented mats. However, these methods often fall short of capturing the intricate details of motor impairments. The focus on the effects of altered motor control potentially overlooks subtle gait anomalies. Plus, clinical settings can affect natural behavior.

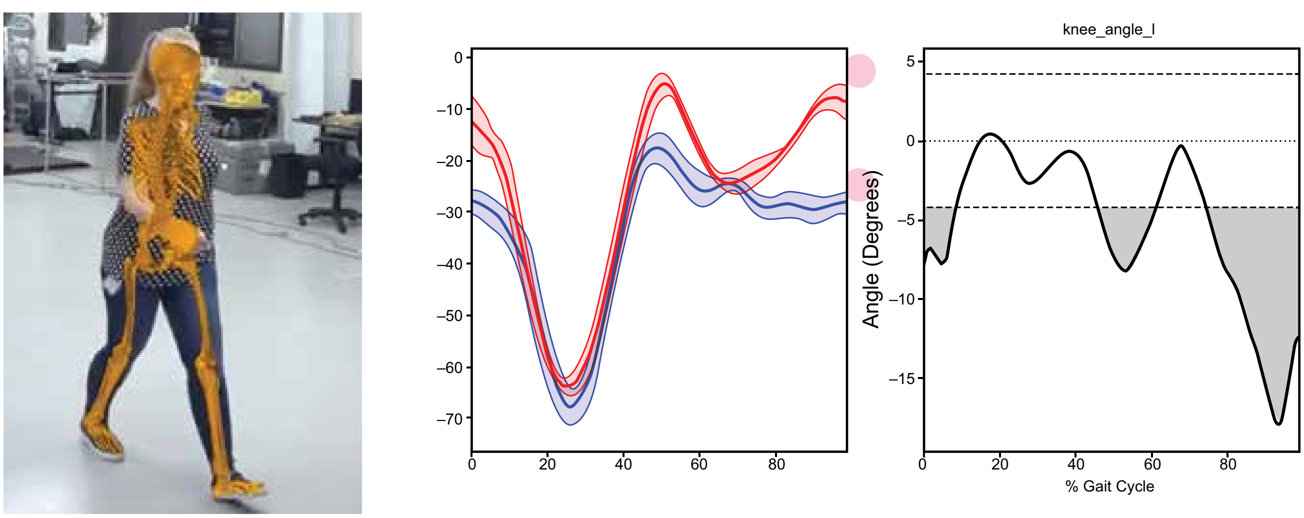
SwRI is applying its ENABLE markerless biomechanics system to accurately and automatically quantify a person's detailed 3D movement from video alone, providing a comprehensive full-body gait analysis. It captures kinematic variables in the hips, knees, ankles, shoulders, elbows, etc. The system also captures joint angles, body sway and trunk rotation, offering a far more sensitive assessment of neuromotor dysfunction.

The ENABLE system produces full-body biomechanical analyses from standard video equivalent to laboratory-grade marker-based motion analysis systems. ENABLE offers the same high-fidelity data without the cumbersome markers and specialized, expensive cameras. By measuring full-body biomechanics simultaneously with traditional spatiotemporal data from an instrumented walkway, researchers can gain unprecedented insights into the mechanics of neurodegeneration.

ENABLE's advanced, noncontact and noninvasive approach promises several transformative benefits, including early diagnosis detection of changes and tracking changes over time. Detecting subtle motor control and gait abnormalities will identify neurodegenerative conditions early on. Tracking changes in detailed kinematic gait patterns over time allows more precise monitoring of disease progression. Using ENABLE facilitates the development of customized treatment strategies tailored to the specific needs of each patient and quantifies new treatment methods for neuromuscular control in high fidelity.

With SwRI's ENABLE markerless biomechanics system, the future of neurodegeneration research and patient care looks promising. This innovative approach not only uncovers the hidden complexities of gait but also paves the way for more accurate diagnoses, better disease monitoring and personalized treatment plans, marking a significant leap forward in our understanding and management of neurodegenerative diseases.

110269/ 110271



Using the ENABLE markerless biomechanics system, SwRI can accurately and automatically quantify a person's detailed 3D movement from video. This comprehensive full-body gait analysis can capture kinematic variables in the hips, knees, ankles, shoulders, elbows, etc.

SUSTAINING AGING AIRCRAFT

Under two U.S. Air Force contracts totaling $23 million, SwRI engineers will address aging aircraft structures and material degradation. The Institute will help the Air Force modernize methods to sustain the T-38 Talon, the A-10 Thunderbolt and the B-52 Stratofortress, three military platforms nearly 50 years old.

"SwRI will assist with the full spectrum of structural sustainment for these aircraft," said Luciano Smith, manager of SwRI's Structural Integrity Section. "Our analyses will help the Air Force know when, where and how often to inspect the aircraft to determine when structural repairs are necessary."

For several decades, SwRI has provided technical engineering support to the Air Force to extend the life of aircraft that came into service in the '60s and '70s and have exceeded their design life.

"SwRI has worked with the Air Force to maintain the structural integrity of the A-10 for more than 20 years and the T-38 for more than 40," said David Wieland, who oversees the Institute's Aerospace Structures Section. "Under these new contracts, we will perform design, analyses, testing and nondestructive inspections. We will also evaluate flight data recording, usage monitoring and individual aircraft tracking systems."

The structural integrity and performance of all three fleets of aircraft are evaluated under simulated real-world conditions.

The A-10 Thunderbolt, a close air support attack aircraft first introduced in the 1970s, is one of three aging military fleets that SwRI is helping the U.S. Air Force maintain under a pair of new contracts.

110244

FLOW FEATURES ON AIRLESS WORLDS

In collaboration with NASA's Jet Propulsion Laboratory, SwRI scientists found evidence to explain the presence of mysterious flow features on the surfaces of airless celestial bodies, such as the asteroids Vesta and Ceres.

The SwRI-JPL team studied how post-impact conditions, such as from a meteoroid strike, could produce liquid brines that temporarily flow on the surface long enough to etch curved gullies and deposit fans of debris in the walls of newly formed craters.

The project investigates a previously proposed idea that an impact could excavate and melt subsurface ice, which then flows along the walls of the impact crater to form distinct surface features. The team wanted to understand how long the liquid could potentially flow before refreezing. The team modified a JPL test chamber to simulate dramatic pressure drops on an airless body like Vesta. Dissipation of this temporary post-impact atmosphere could help determine how it affects liquids.

"Through our simulated impacts, we found that the pure water froze too quickly in a vacuum to effect meaningful change, but saltwater mixtures, or brines, stayed liquid and flowing for a minimum of one hour," said SwRI's Dr. Michael J. Poston, lead author of a new paper published in The Planetary Science Journal about this work. "This is sufficient for the brine to destabilize slopes on crater walls on rocky bodies, cause erosion and landslides, and potentially form other unique geological features found on icy moons."

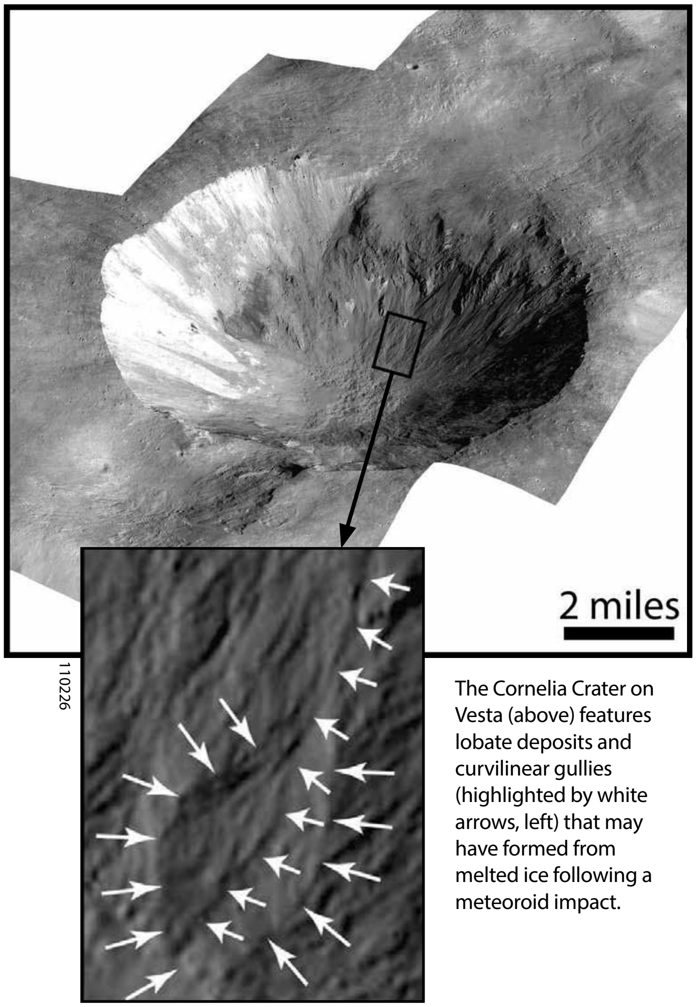


IMAGE COURTESY JET PROPULSION LABORATORY

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The Cornelia Crater on Vesta (above) features lobate deposits and curvilinear gullies (highlighted by white arrows, left) that may have formed from melted ice following a meteoroid impact.

NEW SOLAR COMPOSITION RATIOS

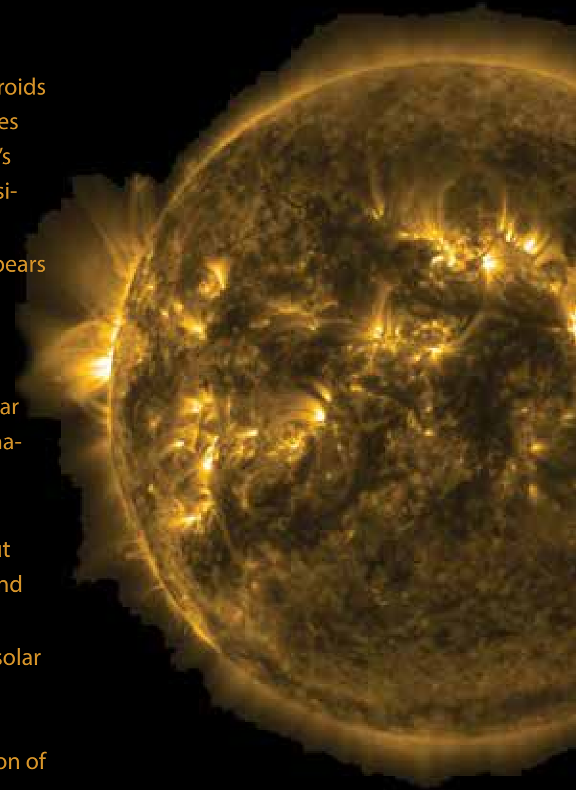
An SwRI-led team combined compositional data of primitive bodies like Kuiper Belt objects, asteroids and comets with new solar data sets to develop a revised solar composition that potentially reconciles spectroscopy and helioseismology measurements for the first time. Helioseismology probes the Sun's interior by analyzing the waves that travel through it, while spectroscopy reveals the surface composition based on the spectral signature produced by each chemical element.

A paper about this research, which addresses the long-standing "solar abundances" problem, appears in the AAS Astrophysical Journal.

"This is the first time this kind of interdisciplinary analysis has been done, and our broad dataset suggests more abundant levels of solar carbon, nitrogen and oxygen than previously thought," said Dr. Ngoc Truong, an SwRI postdoctoral researcher. "Solar system formation models using the new solar composition successfully reproduce the compositions of large Kuiper Belt objects (KBOs) and carbonaceous chondrite meteorites, in light of the newly returned Ryugu and Bennu asteroid samples from JAXA's Hayabusa-2 and NASA's OSIRIS-REx missions."

To make this discovery, the team combined new measurements of solar neutrinos and data about the solar wind composition from NASA's Genesis mission, together with the abundance of water found in primitive meteorites that originated in the outer solar system.

"With this research, we think we finally understand the mix of chemical elements that made the solar system," said SwRI's Dr. Christopher Glein, an expert in planetary geochemistry. "It has more carbon, nitrogen and oxygen than what is currently assumed. This new knowledge gives us a firmer basis for understanding what element abundances in giant planet atmospheres can tell us about the formation of planets. We already have our eyes on Uranus — NASA's next target destination — and beyond."



110244 IMAGE COURTESY NASA/SDO/AIA

CLINICAL SUPPLY FACILITY UNDER CONSTRUCTION

SwRI broke ground on a new 21,000-square-foot Clinical Supply Facility to support government and industry clients with integrated pharmaceutical and bioengineering research and development.

"The new facility expands our bioengineering laboratory footprint and adds dedicated bioengineering production suites with filtered air and low airborne particulate counts," said Darrel Johnston, director of SwRI's Pharmaceutical and Bioengineering Department. "The Clinical Supply Facility will allow us to produce in vitro stem cells, certain types of vaccines and small molecule therapeutics in a clean environment at scales able to facilitate clinical trials for our clients."

SwRI plays an important role in San Antonio's highly collaborative biomedical ecosystem. As a pioneer in microencapsulation, bioengineering and pharmaceutical development, the Institute can assist clients with important research and development projects of all sizes, including small batches of therapeutics for rare diseases involving fewer than 200 units.

"We help develop clinical supplies both for active pharmaceutical ingredients and as the formulated products needed for clinical studies," said Dr. Joe McDonough, vice president of SwRI's Chemistry and Chemical Engineering Division. "SwRI can guide clients step-by-step from the initial concept phase through drug discovery and the FDA approvals process. Using our expansive facilities, we support our clients with the development of their clinical supplies."

The new facility will provide three Current Good Manufacturing Practices (CGMP) pilot plant suites and quality control labs all under one roof. This will improve workplace and regulatory efficiency while providing the space needed to serve more clients locally, nationally and internationally, Johnston added.

The Institute adheres to CGMP in Food and Drug Administration- and Drug Enforcement Administration-inspected facilities.

110290 IMAGE COURTESY ALAMO ARCHITECTS

CHARACTERIZING CHEMICAL EXPOSURES

SwRI collaborated with the Environmental Protection Agency (EPA) to characterize the chemical makeup of 81 common household items. Researchers also evaluated the potential risk to users.

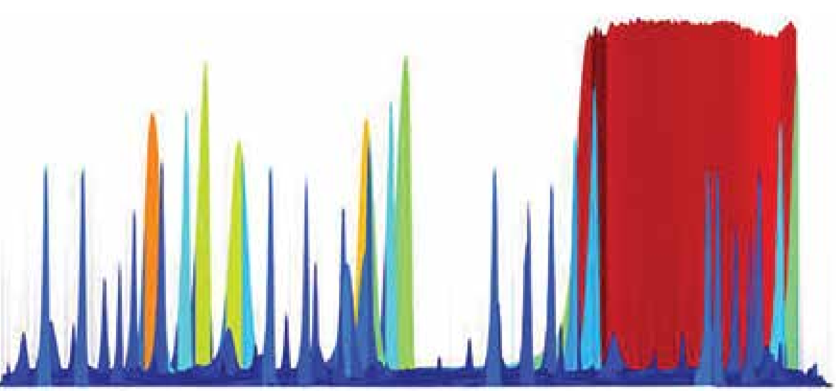
Exposure to certain chemicals can cause negative health effects, according to the Centers for Disease Control and Prevention. Building on previous research to identify chemicals in consumer goods, SwRI and EPA analyzed how samples of rubber, plastic, clothing, upholstery and fabric responded to environmental factors, such as a hot car or being worn.

The study, published in the Environmental Science & Technology journal, examines four years of non-targeted analysis data captured with two-dimensional gas chromatography and mass spectroscopy and analyzed with SwRI's Highlight™ machine-learning software. Instead of screening a sample against individual known compounds, this method allows scientists to identify, characterize and evaluate a large library of chemicals through "suspect-screening" analysis. The method identified 88,795 unique chemical features and 1,883 compound groups from 13 analytical batches.

"Highlight leverages machine learning algorithms for rapid pattern matching, which accelerated the workflow," said William Watson, a research engineer in SwRI's Intelligent Systems Division and the study's lead author.

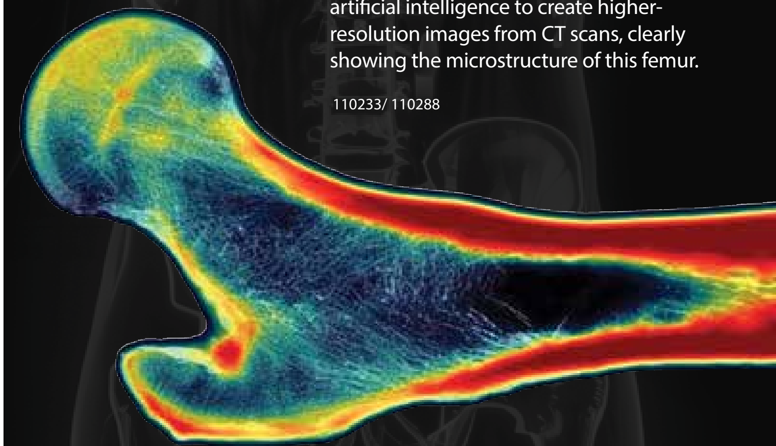
SwRI captured data from samples of clothing, upholstery, fabrics, rubber and plastics in three ways — two vapor emissions (one at human body temperature and the other at hot car temperatures) and one extraction using a liquid solvent. The researchers wanted to determine and compare which chemicals consumers might be exposed to in different environments, such as in a hot car or from a child chewing on a product. The study also explored how tools like Highlight can be used to explore datasets collected over many years.

"Along with helping to advance our understanding of the risk chemical exposure poses to the public, this study also demonstrates our capability to use machine learning and Highlight findings to retrospectively analyze and understand older datasets," said Watson.



SwRI used chromatography (illustrated) and its machine-learning method Highlight to characterize and evaluate a large library of chemicals in consumer products and evaluate potential risks to users.

110229



SwRI's super-resolution technology uses artificial intelligence to create higher-resolution images from CT scans, clearly showing the microstructure of this femur.

110233/ 110288

SwRI Tool Predicts Fracture Risk

SwRI has developed new technology to enhance clinical bone imaging and decrease osteoporotic fractures in the elderly. Described in a new SwRI-led study, the tool uses artificial intelligence (AI) to create super-resolution (SR) images showing the inner structures of bones in exquisite detail to better determine risk for fracture.

SwRI found that in almost all cases, the SR-enhanced images were more accurate than X-rays or CT scans in quantifying bone characteristics indicative of strength and fracture risk.

Osteoporotic fracture in the elderly is a widespread problem. Half of all women over 55 suffer some sort of fracture at some point. Of the millions of people who break a hip each year, 50% never walk again on their own, and 20% die within a year.

"Engineers and orthopedic clinicians are trying to identify people at risk because interventions can make bones stronger. It's all about identifying who is at risk," said SwRI's Dr. Lance Frazer, the study's lead author. "Currently, an X-ray or CT scan is the most common method to diagnose fracture risk, but the resolution of both imaging techniques is too low to really determine the structural strength of the bone."

For this study, SwRI used SR technology, a set of AI techniques that make low-quality images sharper and more detailed.

"Once we have that high-resolution image data, we can better predict just how strong the bone actually is," Frazer said. "Once we identify bones susceptible to fracture, a doctor can recommend medication or exercises to strengthen vulnerable bones and prevent injury."


110230

EV FIRE MITIGATION TECHNIQUE

SwRI successfully customized and conducted a full-scale evaluation of a novel fire mitigation method designed to safely store damaged electric vehicles (EVs) and batteries. SwRI supports government and industry clients with novel projects to overcome challenges associated with emerging technologies where no standardized testing exists.

“SwRI established the nation’s first fire-focused research program 75 years ago, so our extensive capabilities allow us to develop novel tests to evaluate emerging technologies. For this project, we created a customized test because no standardized test exists yet for EV containment enclosures,” said Senior Research Engineer Kyle Fernandez, who led the experiment.

As the popularity of electric vehicles rises, the likelihood of accidents involving EVs increases. The various makes and models of lithium-ion batteries that power electric and hybrid vehicles can be hazardous when compromised.

“With a lot of emerging industries, the test standards haven’t caught up with the new technologies,” said Karen Carpenter, director of SwRI’s Fire Technology Department.

Transporting or storing damaged EVs for repairs comes with inherent fire risks due to a phenomenon called thermal runaway, which can cause an electric battery to heat up so quickly it sparks a chain reaction that can lead to an out-of-control fire.

“Once an EV gets into an accident, the vehicle is potentially compromised and can catch fire at any point,” said Fernandez.

Using cameras, engineers monitored the fire from a safe location while collecting corresponding temperature and air quality data. While the interior wall reached nearly 2,000 degrees Fahrenheit at the height of the flames, the exterior wall remained cooler at just over 350° F at the peak when the team flooded the container with an extinguishing agent to test its watertight seal. The customized experiment provided valuable data about the enclosure’s effectiveness.

JUICE Instrument Nails Flight Test

As the European Space Agency (ESA)’s Jupiter Icy Moons Explorer (Juice) spacecraft hurtled past the Moon and Earth in mid-August to provide its first gravity assist maneuver, the SwRI-led Ultraviolet Spectrograph (UVS) instrument imaged the UV emissions radiating from the Earth and Moon.

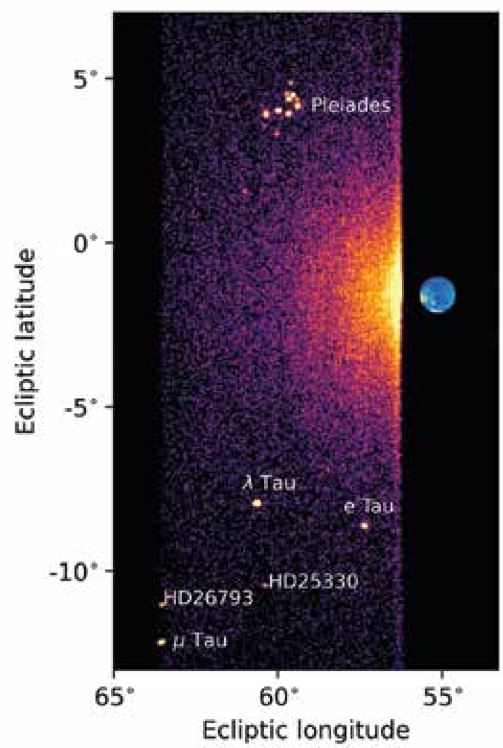
The team analyzed the UVS data collected and confirmed that the instrument is working under conditions that couldn’t be replicated in a laboratory setting.

“This high-fidelity test confirmed what the instrument is supposed to do. We can now be confident that the data we will get from Jupiter’s moons will be just as accurate,” said SwRI’s Steven Persyn, Juice-UVS project manager.

Weighing just over 40 pounds and drawing only 7.5 watts of power, UVS is smaller than a microwave oven, yet this powerful instrument will determine the relative concentrations of various elements and molecules in the atmospheres of Jupiter’s moons once in the Jovian system.

Aboard Juice, UVS will get close-up views of the Galilean moons Europa, Ganymede and Callisto, all thought to host liquid water beneath their icy surfaces. UVS will record ultraviolet light emitted, transmitted and reflected by these bodies, revealing the composition of their surfaces and tenuous atmospheres and how they interact with Jupiter and its giant magnetosphere. Additional scientific goals include observations of Jupiter itself as well as the gases from its volcanic moon Io that spread throughout the Jovian magnetosphere.

The Juice spacecraft is now on its way to Venus, where it will complete another gravity assist maneuver before heading back to Earth for another boost to attain the momentum needed for its eight-year, 4-billion-mile journey to the Jovian system.



110228

UPCOMING

WEBINARS, WORKSHOPS and TRAINING COURSES HOSTED by SwRI:

Turbine Case Design with ASME VIII-2, May 7, 2025, virtual.
Rotordynamics Tutorial, May 21, 2025, virtual.
Blade Aeromechanic Analysis, June 4, 2025, virtual.
Space Fluids Webinar, June 11, 2025, virtual.
Keeping Score on the Shop Floor, San Antonio, August 27, 2025, in person.
Lean Manufacturing Certification Program, Oct. 7, 2025, virtual.
Penetration Mechanics Short Course, March 2, 2026, San Antonio, in person.

TRADESHOWS:

Microencapsulation Industrial Convention, San Antonio, May 12, 2025.

Automate, Detroit, May 12, 2025, Booth 5607.

Cyber-Physical Systems Security Summit, Rochester, MI, May 13, 2025.

Army Aviation Mission Solutions Summit, Nashville, TN, May 14, 2025, Booth 3132.

Energy Projects Conference & Expo, Houston, June 11, 2025, Booth L15.

ASME Turbo Expo, Memphis, TN, June 16, 2025, Booth 723.

American Society for Microbiology (ASM) Microbe, Los Angeles, June 19, 2025, Booth 2041.

NSMMS and CRASTE Symposium, Norfolk, VA, June 23, 2025, Booth 605.

NDE in Nuclear, Hollywood, CA, June 24, 2025.

Hydrogen Technology Expo North America, Houston, June 25, 2025, Booth 940.

E-Fuels Summit, Houston, July 9, 2025.

Institute of Food Technologists Conference, Chicago, July 14, 2025, Booth S3340.

Controlled Release Society Annual Meeting, Philadelphia, July 14, 2025, Booth 307.

Electromagnetic Spectrum Operations Research Conference, Atlanta, July 23, 2025.

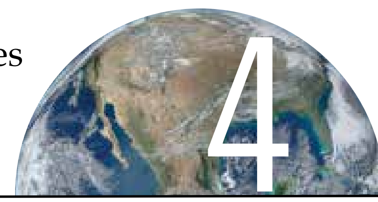
Specialty & Agro Chemicals America, Savannah, Georgia, July 29, 2025, Booth 703.

BY THE NUMBERS

Fall 2024 — March 2025

36 presentations given in

11 states



4 COUNTRIES &

5 virtual conferences

21 papers published in 14 PUBLICATIONS

5 patents awarded


110276

Nathan Andrews has been named an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA), recognized for overseeing important engineering or scientific work and outstanding contributions to his field. AIAA selects only one Associate Fellow for each 150 members each year. A program manager in SwRI's Propulsion and Energy Machinery Section, Andrews specializes in modeling liquid-fueled space launch vehicle pressurization systems, developing propellant slosh and device solutions.


110294

SwRI Executive Vice President and COO **Walt Downing, P.E.**, received the prestigious IEEE Members and Geographic Activities (MGA) Leadership Award, an international recognition, honoring "…individuals who have exhibited exemplary and substantive leadership of an extraordinary nature" in implementing IEEE member activities. An IEEE Life Member, Downing has held various leadership positions over decades of membership. He currently serves as IEEE Region 5 government activities coordinator and chair of the Lone Star Section, representing Central and South Texas.


110273

Dr. Lisa Upton has received the American Astronomical Society's Solar Physics Division 2025 Karen Harvey Prize, which recognizes outstanding contributions made by early career solar scientists. A lead scientist in SwRI's Solar System Science and Exploration Division in Boulder, Colorado, Upton was honored for advancing our understanding of the Sun and exceptional leadership in the solar science community. Her contributions to a state-of-the-art solar surface flux transport model have advanced our understanding of the solar corona and improved solar cycle predictions.


110270

Dr. James Walker has received the Distinguished Scientist Award from the Hypervelocity Impact Society. This honor recognizes a significant and lasting contribution to the field of hypervelocity science, studying impacts at speeds above 4,475 miles per hour. The award cited Walker's research and applications in penetration modeling. His impact-focused research includes developing body and ground vehicle armor, characterizing ballistic and blast protection, and shielding the International Space Station against hypervelocity impact by orbital debris.

TECHNOLOGY
TODAY

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Technology Today® (ISSN 1528-431X) is published three times each year and distributed free of charge. The publication discusses some of the more than 4,000 research and development projects under way at SwRI.

EMPLOYMENT

Southwest Research Institute's staff of more than 3,000 employees provides client services in the areas of communication systems, modeling and simulation, software development, electronic design, vehicle and engine systems, automotive fuels and lubricants, avionics, geosciences, polymer and materials engineering, mechanical design, chemical analyses, environmental sciences, space science, industrial engineering and more.

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